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National Standard of the People's Republic of China

GB 8408-2018

Replaced GB 8408—2008

大型游乐设施安全规范

Large-scale amusement device safety code

Issued on May 14, 2018 Implemented on December 01,2018

This standard is proposed by the State Administration Market Regulation.

Standardization Administration of the People's Republic of China

Contents

Foreword

5.1.1,5.4.3,5.4.4,6.4.1,6.4.4,6.5,6.6.2.8,6.6.3.3,6.7.1.4,6.7.1.7,6.7.1.11,6.7.2.3,6.7.2.5,,6.8.2.1.2,6.8.2.2.1,6.8.3.1,6.8.4.1,6.9.9.3,6.9.11.1,7.1.5,7.2.1.4,7.2.3.5,7.2.4.4,7.2.6.3,7.3.3,7.4.3.3,7.8.10,Chapter 8,Annex A,Annex D,Annex E and Annex F of this standard are recommended clauses, others are compulsory clauses.

This standard was drafted according to the rules given in GB/T 1.1 – 2009

This standard replaced GB 8408-2008 Amusement device safety code, compared with GB8408-2008, there are the following major technical changes besides the editorial changes:

The standard name "Amusement device safety code "is changed to "Large-scale amusement device safety code";

- Rearrange Chapter 4 “Basic design requirements”, Chapter 5 “Drive system”, Chapter 6 “Electrical”, Chapter 7 “Safety requirements and safety measures”, Chapter 8 “Manufacturing and installation”, and Chapter 9 “Operation and management” of the 2008 edition; the revised standard structure is as follows: Chapter 4 “General”, Chapter 5 “Materials and fasteners”, Chapter 6 “Design”, Chapter 7 “Manufacturing and installation”, Chapter 8 “Operation management and maintenance”;
  - In Chapter 4, add solutions to new processes, new methods, new materials, and new amusement devices which go beyond the requirements of standard; increase the requirements for risk assessment;
  - In Chapter 5 “Materials and fasteners”, increase the requirements for common non-ferrous metals; specifies the requirements for chemical composition and mechanical properties of aluminum and aluminum alloys, copper and copper alloys, and titanium alloys; increase the requirements of fasteners;
  - In 6.1 “Basic design requirements”, increase the requirements for saving of information on the design of amusement devices; change the requirements for the service life of amusement devices; increase the requirements for the contents of operation and maintenance instructions; increase the requirements for temperature load, ice load and other loads; modify the requirement of impact load factor; increase the requirements for working condition analysis; modify the contents of load combinations, and list the examples of load combinations in Annex D;
  - In 6.2 “Design calculation”, increase the requirements of the limit state design method for some materials; update the requirements for fatigue strength calculation and stability calculation;
  - In 6.4 “Welding design”, update and increase the requirements for welding design, increase the requirements for welded joint forms, weld classification, welding node construction, weld strength calculation, and weld inspection;
  - In 6.7 “Electrical and control systems”, increase the requirements for motor selection, speed governing, electromagnetic compatibility; increase the data monitoring and storage for amusement devices; increase the requirements for control circuit power supply; update and increase the requirements for electrical protection; increase the requirements for electrical inspection;
  - In 6.8 “Riding system”, increase the requirements for seat belt buckle assembly; increase

the selection requirements of restraint devices, arrange 5-class restraint devices according to the acceleration area, detail the technical requirements of each class of restraint device; update and increase the requirements for safety distance of passengers;

- In 6.9 “Safety protection devices and measures”, update and increase the requirements of braking device; increase the requirements of bumpers of the unclosed track; increase the requirements of safety factor for anti-roll back means; update and increase the requirements of overspeed limit device, anemometer and protective cover; increase the requirements of safety net; delete the safety requirements for water amusement equipment;
- In Chapter 7 “Manufacturing and installation”, update and increase the requirements for welding materials, welding procedure qualification, welding procedure, etc.; update the relevant requirements for castings and forgings, increase the requirements for heat treatment; update and increase the requirements for assembling of pin and fastener; increase the requirements for in-plant testing; update and increase the coating requirements; increase the requirements for packaging and transport; update and increase the relevant requirements for non-destructive testing; update and increase the requirements for inspection;
- In Chapter 8 “Operation management and maintenance”, increase the the requirements for passengers; update and increase the requirements for lawful registration, training evaluation, operation, inspection, monitoring and measurement equipment management, file management, life extension and discarding; update the requirements for emergency rescue exercise; update the requirements for maintenance system; increase the requirements for repair and reconstruction;

The Annexes have deleted Annex A, Annex B, Annex C, Annex D of original standard; added 4 informative Annex A, Annex D, Annex E, Annex F, and 2 normative Annex B and Annex C.

This standard was proposed and under the jurisdiction of the State Administration Market Regulation.

Chief drafting organizations of this standard: China Special Equipment Inspection and Research Institute, Jiangsu Province Special Equipment Safety Supervision and Inspection! Institute,Zhongshan Golden Horse Technology Entertainment Co., Ltd., Wenzhou Nanfang Amusement Equipment Engineering Co., Ltd., Shenzhen Huaqiang Fantawild Technology Co., Ltd., Zhejiang giant horse entertainment equipment Limited, Shanghai Xi Du amusement equipment factory, Beijing Wanda Culture Industry Group Co., Ltd., Beijing SBL Amusement Equipment Co., Ltd., Wanda culture-oriented travel Planning and Research Institute Limited, Shandong Special Equipment Inspection and Research Institute, Guangzhou Dalang Water Amusement Park Equipment Co., Ltd., Guangdong Daxin amusement Intelligent Technology Co., Ltd.

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Issuing of previous versions of the standard is as follows:

——GB 8408-2000, GB 8408 -2008.

Large-scale amusement device safety code

1 Scope

This standard specifies basic safety requirements for large-scale amusement device (hereinafter referred to as amusement device), including general provisions, materials and fasteners, design, manufacture and installation as well as use management and maintenance.

This standard is applicable to large-scale amusement device.

This standard is not applicable to competitive sports facilities and fitness facilities.

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.

GB/T 699 Quality Carbon Structural Steels

GB/T 709-2006 Dimension, Shape, Weight and Tolerances for Hot-rolled Steel Plates and Sheets

GB/T 715 Hot-rolled Round Carbon Steel Bars for Standard Parts

GB/T 983 Stainless Steel Covered Electrodes

GB/T 085.1 Recommended joint preparation for gas welding, manual metal arc welding, gas-shield arc welding and beam welding

GB/T 985.2 Recommended Joint Preparation for Submerged Arc Welding

GB/T 1173 Casting Aluminium Alloys

GB/T 1176 Casting Copper and Copper Alloys

GB/T 1231 Specifications of High Strength Bolts with Large Hexagon Head, Large Hexagon Nuts, Plain Washers for Steel Structures

GB/T 1243 Short-pitch Transmission Precision Roller and Bush Chains, Attachments and Associated Chain Sprockets

GB/T 1527 Drawn Tube of Copper and Copper Alloys

GB/T 2040 Copper and Copper Alloy Sheet

GB/T 2059 Copper and Copper Alloy Strip

GB 2894 Safety Signs and Guideline for the Use

GB/T 3077 Alloy Structure Steels

GB 3096 Environmental Quality Standards for Noise

GB/T 3098 (All Parts) Mechanical Properties of Fasteners

GB/T 3190 Wrought Aluminium and Aluminium Alloy - Chemical Composition

GB/T 3191 Aluminium and Aluminium Alloys Extruded Bars, Rods

GB/T 3621 Titanium and Titanium Alloy Plate and Sheet

GB/T 3624 Titanium and Titanium Alloy Seamless Tubes

GB/T 3766 Hydraulic Fluid Power - General Rules and Safety Requirements for Systems and Their Components

GB/T 3811-2008 Design Rules for Cranes

GB/T 3880 (All Parts) Wrought Aluminium and Aluminium Alloy Plates, Sheets and Strips for General Engineering.

GB/T 4423 Copper and Copper-alloy Cold-drawn Rod and Bar

GB 4706.1-2005 Household and Similar Electrical Appliances - Safety - Part 1: General Requirements

GB/T 4842 Argon

GB/T 5117 Covered Electrodes for Manual Metal Arc Welding of Non-alloy and Fine Grain Steels

GB/T 5118 Covered Electrodes for Manual Metal Arc Welding of Creep-resisting Steels

GB 5226.1-2008 Electrical Safety of Machinery - Electrical Equipment of Machines - Part 1: General Requirements

GB/T 5293 Carbon Steel Electrodes and Fluxes for Submerged Arc Welding

GB/T 5313 Steel Plate with Through-thickness Characteristics

GB 5725 Safety Nets

GB/Z 6829 General Requirements for Residual Current Operated Protective Devices

GB/T 6892 Wrought Aluminium and Aluminium Alloys Extruded Profiles for General Engineering

GB/T 6893 Aluminium and Aluminium Alloy Cold Drawn （Rolled）Seamless Tubes?

GB/T 7134 Poly (Methyl Methacrylate) Cast Sheets

GB/T 8110 Welding Electrodes and Rods for Gas Shielding Arc Welding of Carbon and Low Alloy Steel

GB/T 8918 Steel Wire Ropes for Important Purposes

GB/T 9438 Aluminium Alloy Castings

GB/T 10045 Carbon Steel Flux Cored Electrodes for Arc Welding

GB/T 12470 Low-alloy Steel Electrodes and Fluxes for Submerged Arc Welding

GB/T 13384 General Specifications for Packing of Mechanical and Electrical Product

GB 13495.1-2015 Fire Safety Signs - Part 1: Signs

GB/T 13808 Extruded Rod and Bar of Copper and Copper Alloys

GB/T 13955 Installation and Operation of Residual Current Operated Protective Devices

GB/T 14957 Steel Wires for Melt Welding

GB/T 15115 Die Casting Aluminum Alloys

GB 15763(All Parts) Safety Glazing Materials in Building

GB/T 17493 Low Alloy Steel Flux Cored Electrodes for Arc Welding

GB/T 19418 Arc-welded Joints in Steel - Guidance on Quality Levels for Imperfections

GB/T 20306 Amusement Devices Terminology

GB/T 34370.1 Nondestructive Testing of Amusement Equipment - Part 1: General Requirement

GB/T 34370.2 Nondestructive Testing of Amusement Equipment - Part 2: Visual Examination

GB/T 34370.3 Nondestructive Testing of Pressure Equipment - Part 3: Magnetic Particle Testing

GB/T 34370.4 Nondestructive Testing of Pressure Equipment - Part 4: Penetrant Testing

GB/T 34370.5 Nondestructive Testing of Amusement Equipment - Part 5: Ultrasonic Testing

GB/T 34370.6 Nondestructive Testing of Amusement Equipment - Part 6: Radiographic Testing

GB 50005 Code for Design of Timber Structures

GB 50007 Code for Design of Building Foundation

GB 50009 Load Code for the Design of Building Structures

GB 50010 Code for Design of Concrete Structures

GB 50011 Code for Seismic Design of Buildings

GB 50017 Code for Design of Steel Structures

GB 50057 Design Code for Protection of Structures against Lightning

GB/T 50065 Code for Design of AC Electrical Installations Earthing

GB 50135 Code for Design of High-rising Structures

GB 50169 Code for Construction and Acceptance of Grounding Connection Electric Equipment Installation Engineering

GB 50202 Code for Acceptance of Construction Quality of Building Foundation

GB 50204. Code for Acceptance of Constructional Quality of Concrete Structures

GB 50206 Code for Acceptance of Construction Quality of Timber Structures

GB 50231-2009 General Code for Construction and Acceptance of Mechanical Equipment Installation Engineering

GB 50545 Code for Design of 110 kV~750 kV Overhead Transmission Line

GB 50661-2011 Code for Welding of Steel Structures

JB/T 3223 Welding Material Quality Management Specifications

JB/T 5000.12 Heavy Mechanical General Techniques and Standards - Part 12: Paint

NB/T 47014 Welding Procedure Qualification for Pressure Equipment

NB/T 47015-2011 Welding Specification for Pressure Vessels

TSG Z6002 Examination Rules for Welding Operators of Special Equipment

3 Terms and Definitions

For the purposes of this document, the terms and definitions given in GB/T 20306 apply.

4 General Provisions

4.1 Basic Requirements

4.1.1 The design, manufacture, installation and usage of amusement devices shall ensure the personnel safety.

4.1.2 All those requirements not mentioned in this standard shall be in accordance with the national relevant laws and regulations as well as safety technical regulations and standards.

4.1.3 Product nameplate of amusement device shall be arranged at prominent position, and the content shall at least include manufacturer name and manufacturing site, manufacturing license No., equipment model, product No., manufacturing date and main technical parameters.

4.1.4 Entities engaged in manufacturing, installation, modification and repairing of amusement device shall obtain legal permission before carrying out corresponding activities and be held responsible for their manufacturing, installation, modification and repair quality. Amusement

device operator must be responsible for the use safety of amusement devices.

4.1.5 When new process, new method, new material or new amusement device which are not listed in or not in the specified scope of this standard are adopted, design or manufacturer shall prepare enterprise standard, which shall not be applied until passing the review by experts organized by National Technical Committee on Ropeway and Entertainment Facilities of Standardization Administration of China, to which relevant technical data is applied and submitted.

4.2 Risk assessment

4.2.1 Risk evaluation for amusement device is carried out to identify its hazardous source, reduce the risk and ensure the safe operation of amusement device. Risk evaluation shall be carried out at design stage and it is encouraged to do so continuously at application stage.?

4.2.2 The risk evaluation includes determination of evaluation object and factor, information collection, hazard identification, risk assessment and risk control.

4.2.3 For evaluation object and factor, things such as feature, performance, intended use and reasonably foreseeable misuse of amusement device shall be made definite with consideration of device factor, person factor, environmental factor and the like in full life cycle of amusement device at all stages.

4.2.4 The hazard identification of amusement device shall be combined with the specific structure and characteristics of the device, as well as typical hazardous source, damage, fault and failure mode, so as to identify possible relevant hazards at stages such as manufacture, installation, maintenance and repair.

4.2.5 Based on the damage severity and occurrence probability of each hazard, risk assessment, risk evaluation and rating are carried out.

4.2.6 If the risk assessment result needs to reduce the risk, risk control measures should be taken and reevaluation should be performed so that the risk is kept under control.

5 Materials and fasteners

5.1 Common steels

5.1.1 The steels used for amusement devices shall conform to the requirements of relevant current national standards. Their chemical composition, mechanical properties, heat treatment properties and welding performance shall meet the requirements for operation under working conditions. The standards for common steel products are shown in Annex A.

5.1.2 The rimmed steels are prohibited for structural parts of amusement devices. Grade A steels should not be used.

5.1.3 Impact toughness of steel should meet the following requirements:

a) The welded structural steel to bear impacting load directly should have conformity certificate document of impact toughness at normal temperature. When the operating environment temperature is not higher than 0℃ but higher than -20℃: Q235 steel and Q345 steel should have conformity certificate document of 0 ℃ impact toughness, Q390 steel and Q420 steel should have conformity certificate document of -20℃ impact toughness; When the operating environment temperature is not higher than -20℃: Q235

steel and Q345 steel should have conformity certificate document of -20 ℃ impact toughness, Q390 steel and Q420 steel should have conformity certificate document of -40 ℃ impact toughness .

b) The non welded structural steel to bear impacting load directly also should have conformity certificate document of impact toughness at normal temperature. When the operating environment temperature is not higher than -20 ℃, Q235 steel and Q345 steel should have conformity certificate document of 0 ℃ impact toughness, Q390 steel and Q420 steel should have conformity certificate document of -20 ℃ impact toughness.

5.1.4 When the load-bearing structure for welding is steel plates with through-thickness characteristics which are not less than 40 mm in order to prevent lamellar tearing of the steels, the certification for materials confirming to the requirements of GB/T 5313, and the section shrinkage in the direction of plate thickness is not less than Class-Z15 allowable limits, or a Z-direction performance test report shall be provided.

5.2 Common nonferrous metal

5.2.1 Basic Requirements

The material, chemical composition, mechanical properties and dimensional tolerances of non-ferrous metals should meet the requirements of national standards. The wear-resisting property, good corrosion resistance and lubricating performance of nonferrous metals should meet the requirements of working conditions.

5.2.2 Aluminium and aluminum alloy

5.2.2.1 The chemical composition of aluminium and aluminum alloy shall conform to the provisions in GB/T 3190, the mechanical properties of wrought products shall conform to the provisions in GB/T 3191, GB/T 3880 (all parts), GB/T 6892 and GB/T 6893 .

5.2.2.2 The chemical composition and the mechanical properties of casting aluminium alloy shall conform to the provisions in GB/T 1173.The chemical composition and the mechanical properties of die-casting aluminium alloy shall conform to the provisions in GB/T 15115. Aluminum alloy castings shall conform to the provisions in GB/T 9438.

5.2.3 Titanium and Titanium Alloy Plate and Sheet

The mechanical properties of titanium and titanium alloy plate and sheet shall conform to the provisions in GB/T 3621. The mechanical properties of titanium and titanium alloy tubes shall conform to the provisions in GB/T 3624.

5.2.4 Copper and copper alloy

5.2.4.1 The chemical composition and the mechanical properties of copper and copper alloy plate and sheet shall conform to the provisions in GB/T 2040 and GB/T 2059.The chemical composition and the mechanical properties of tubes shall conform to the provisions in GB/T 1527. The mechanical properties of bar shall conform to the provisions in GB/T 4423 and GB/T 13808.

5.2.4.2 The chemical composition and the mechanical properties of cast copper alloy shall conform to the provisions in GB/T1176.

5.3 Non-metallic materials

5.3.1 Basic Requirements

The selected non-metallic materials should comply with the relevant national standards, its mechanical properties, ageing resistance, environmental performance and flammability should meet the requirements of working conditions.

5.3.2 Wood

The wood materials for primary load-bearing members should choose the dry timbers that have less natural defects and good strength and is not easy to crack. Wood materials used in important parts, if necessary, flame retardant and anti-corrosion treatment shall be performed. The design of timber structure should comply with the requirements of GB 50005, and the construction quality should comply with the requirements of GB 50206.

5.3.3 Engineering plastic

Engineering plastics for structural shall conform to the relevant national standards, its strength, impact resistance, heat-resistant parts, hardness and ageing resistance should meet the requirements of actual working conditions.

5.3.3.2 When the driving wheels and supporting wheels are used in nylon material，its mechanical properties should comply with the requirements of Table B.1 in Annex B.

5.3.4 Rubber

When the driving wheels and supported wheels are made of rubber, their performance should comply with the relevant national standards, and their mechanical properties shall be in accordance with those specified in Table B.2. When the inflatable rubber wheels are used, the inflation pressure shall take into account the influence of temperature and comply with the pressure range specified by the product.

5.3.5 Polyurethane

When using polyurethane wheel, its performance should comply with the relevant national standards. The mechanical properties should comply with the provisions of table B.3.

5.3.6 Glass

5.3.6.1The glass doors and windows of the cabin shall be made of unbreakable materials, including organic glass and safety glass (inorganic glass).

5.3.6.2 The mechanical performance of organic glass plates should comply with the provisions of GB/T 7134. Its mechanical properties should comply with the provisions of Table B.4.

5.3.6.3 Safe glass should comply with the provisions of GB 15763 (all parts).

5.3.7 Fibre reinforced plastic (FRP) parts

5.3.7.1 The resin used to make the FRP parts should have favorable water resistance and aging resistance. Glass fiber should be made of alkali-free glass fiber, and the fiber surface must have good wettability.

5.3.7.2 FRP should meet the following requirements:

a) Defects such as poor impregnation, poor curing, blisters, delamination of cutting surface, and non-uniform thickness are not permitted;

b) The surfaces should be free of cracks, damage, obvious repair marks, exposed cloth marks, wrinkles, unevenness, inconsistency, etc., and the corner transitions should be smooth and have no burrs;

c) The FRP parts shall have sufficient strength when directly connected to the stressed parts, otherwise the metal parts meeting the strength requirements should be embedded;

d) The mechanical properties of FRP parts shall be in accordance with the requirements of Table B.5.

5.4 Fasteners

5.4.1 Fastener should comply with the provisions of GB 3098 (all parts) and the relevant national standards.

5.4.2 The pretension and tightening torque of Grade 6.8, Grade 8.8, Grade 10.9 bolts shall be calculated according to the design requirements, and the maximum shall not exceed those specified in Table C.1 of Annex C.

5.4.3 For bolted connection of major steel structures, hexagon bolts with large head, hexagon nuts with large width across flat and washers for steel structures should be used. The technical conditions shall meet the requirements of GB/T 1231. High-strength bolts for steel structures subjected to impact loads should not directly bear shearing force. The maximum allowable preload of bolts shall not exceed those specified in Table C.2.

5.4.4 For bolted connection of space truss structures, high-strength bolts for space trusses should be used, and the material properties should conform to the national standards.

5.4.5 The rivets shall be made of BL2 or BL3 steels specified in GB/T 715.

5.4.6 The conversion formula of pretension and tightening torque of the high-strength bolts is given as follows:

$$T = kFd / 1\ 000$$

Where:

T – Tightening torque, in Newton meters (N • m);

k – Tightening torque coefficient, in accordance with the requirements of Table C.3;

F – Pretension, in Newton (N);

d – Norminal diameter of the thread, in millimeters (mm).

6 Design

6.1 Basic design requirements

6.1.1 Basic Requirements

6.1.1.1 The design of the amusement devices shall have design specifications, calculation sheets, maintenance instructions and a complete set of drawings in accordance with relevant national standards, risk assessment reports and design verification master plans. The above information shall be kept at least until the amusement devices are discarded.

6.1.1.2 The design of the amusement devices and their auxiliary facilities shall provide correct calculation and rational structure which can ensure passenger safety. When accurate calculations are not possible, validation and verification may be performed through experiment.

6.1.1.3 The user or client shall provide the designer and manufacturer local meteorological, power supply, earthquake and geological data in writing.

6.1.1.4 The materials shall be selected in comprehensive consideration of the importance of the structures, load characteristics, structural form, stress state, manufacturing process, connection method, working environment and other factors.

6.1.1.5 For the metal materials used in major mechanical parts, their mechanical properties, heat treatment properties and welding performance shall meet the requirements of operating conditions.

6.1.1.6 For the amusement devices the design service life of the complete machine and its main components shall be specified. The design life of the complete machine should be no less than 35 000 h, including the loading/unloading time.

6.1.1.7 The operation and maintenance instructions should be in simplified Chinese. For multi-language versions, the Simplified Chinese version shall prevail, and the following shall be included at least:

a) Equipment Overview and brief introduction of structure;

b) Technical performance and parameters, operation conditions;

c) Operating instruction and precautions;

d) Passengers notice;

e) Maintenance instructions;

f) Common faults and elimination method;

g) The design service life of the complete machine and main components;

h) Requirements for management, operation and maintenance service personnel;

i) List of easily worn parts, discarding requirements and recommended replacement cycles;

j) Evacuation measures and methods of passenger under abnormal condition;

k) Limitations on the number of passengers, height, age range, physiological conditions, and whether children need to ride under adult supervision, and other safety requirements;

l) Items and requirements of daily inspection, weekly inspection, monthly inspection (including seasonal inspection and semi-annual inspection), annual inspection (including multi-year inspection), corresponding inspection, detection (including non-destructive testing) and test methods, and proportion of inspection and testing, etc.;

m) For traveling amusement devices, the installation and commissioning methods, site requirements, etc.;

n) The total assembly drawing, electrical schematic diagram and hydraulic and pneumatic schematic diagram of amusement devices, the schematic diagrams of mechanical components used to direct the maintenance, inspection and testing, the schematic diagrams of important welds pins needing the non-destructive testing;

o) The name of manufacturer and detailed mailing address, service or supervision hotline number, email address and website, etc.

6.1.2 Loads of amusement device

6.1.2.1 Permanent loads

The loads with their application points, magnitude and directions that do not vary with respect to time, such as the structural dead weight of amusement device, are expressed in G_k.

6.1.2.2 Live loads

Live loads refer to passenger loads, expressed in Q_1 and defined as follows:

a) a)not less than 750 N per person for 1~2 adults, not less than 700 N per person for more than 2 persons;

b) b)not less than 400 N per person for children (height not exceeding 1.2 m or below 10 years old).

Note: The calculated number of persons of members is calculated according to the design person capacity, e.g., not less than 750 N per person for the single-seat system of a flying chair. The design capacity of the overall pylon is calculated by no less than 700 N per person.

6.1.2.3 Supporting force and constraint reaction

The design of supports shall consider the forces exerted by the passengers on the handrails, supports, footrest, side walls and other devices during normal operation and start-up, braking and emergency of the ride devices. These forces should not be less than 500 N per person for adults and 300 N per person for special children amusement devices, expressed in Q_2.

6.1.2.4 Uniformly-distributed live loads in the personnel activity areas, expressed in Q_3

The uniformly-distributed live loads in the personnel activity areas such as platforms, stairs, entrances and exits of the amusement devices are valued as follows:

- common areas for person standing such as platforms, stairs, entrances and exits: 3.5 kN/m^2;

densely populated stands, stairs and other densely standing areas: 5 kN/m^2;

- non-open areas such as floors, stairs, entrances and exits that are not open to the public: 1.5 kN/m^2;
- If the passenger capacity is specified in a certain area of an amusement device, the uniformly-distributed live load in this area shall be calculated by concentrated live load of the number of passengers.

6.1.2.5 Horizontal thrust in the personnel activity areas, expressed in Q_4

The horizontal thrust applied on the fences, handrails, wallboards and other similar places of the amusement devices is valued as follows:

in the non-densely populated areas, the point of action is located at the high point of the fence: 0.5 kN/m;

in the non-densely populated areas, the point of action is located at the half of height point of the fence: 0.1 kN/m;

in the densely populated areas, the point of action is located at the high point of the fence: 1 kN/m;

in the densely populated areas, the point of action is located at the half of height point of the fence: 0.15 kN/m;

in the non-open areas, the point of action is located at the high point of the fence: 0.3 kN/m;

in the non-open areas, the point of action is located at the half of height point of the fence: 0.1 kN/m;

6.1.2.6 Driving force and braking force

The force that drives a ride device to move or forces it to stop (or decelerate) is expressed in Q_5.

$$Q_5 = (m_1 + m_2)a$$

Where:

m_1——the mass of a driven coponent, in kilograms (kg);

m_2——the total mass of the live loads, in kilograms (kg);

a – the maximum starting/braking acceleration, in meters per square second (m/s^2).

6.1.2.7 Friction

Friction is a force generated by the friction between two surfaces of the relatively moving objects that are in contact, expressed in Q_6.

$$Q_6 = \mu P$$

Where:

μ ——Static friction coefficient

P – the positive tension applied on the friction surface, in Newton (N).

6.1.2.8 Inertia force

The force generated due to changes in velocity of movement (value and direction) shall be calculated at full load, expressed in Q_7.

$$Q_7 = ma$$

Where:

m - the mass of the moving parts and live loads subject to acceleration, in kilograms (kg);

a – the acceleration, in meters per square second (m/s^2).

6.1.2.9 Collison force

The force of collision during the movement, which is generally checked on the components that directly collides, assumed to occur in the most unfavorable position, and should not be less than 0.3 mg in any case, shall be calculated according to full load and expressed in Q_8.

$$Q_8 = mg\sin\alpha$$

Where:

m - the mass of the components subject to collision and the loads, in kilograms (kg);

g – the free fall acceleration, in meters per square second (m/s^2).

a——the angle of collision， in °.

6.1.2.10 Wind loads

Wind loads are divided into loads under normal and limited working conditions. The amusement devices shall be designed to calculate the wind loads under normal working condition based on a maximum operating wind speed of 15 m/s. For amusement devices used indoors, wind loads may not be calculated. The amusement devices under static condition (limited condition) shall be able to withstand the wind loads provided by local meteorological data. The wind loads are expressed in Q_9. The value of wind loads and their calculation method shall comply with the requirements of GB 50009.

6.1.2.11 Snow loads

The amusement devices shall be designed to withstand the snow load under static condition. When the depth of snow does not exceed 80 mm, the snow load applied to the overall surface of the amusement device is calculated by the snow pressure of 0.2 kN/m^2. When the depth exceeds 80 mm, the load calculation method shall comply with the requirements of GB 50009. The snow loads are expressed in Q_{10}. If operated in snow-free areas or measures are taken to prevent snow accumulation, the effect of snow may not be considered.

6.1.2.12 Temperature loads

The value of temperature loads and their calculation shall comply with the requirements of GB 50009, expressed in Q_{11}.

6.1.2.13 Earthquake loads

For amusement devices in the large, high-rise structures and buildings, loads generated due to earthquake shall be considered during the design, expressed in T. The calculation method shall comply with the requirements of GB 50011.

6.1.2.14 Ice loads

For amusement devices with a height of more than 40 m and installed outdoors, it is possible to be

covered ice on the structural parts, so ice loads shall be calculated, expressed in Q_{12}. The calculation method shall comply with the requirements of GB 50135.

6.1.2.15 Impact loads

6.1.2.15.1 When impact is possible to occur during the movement of the amusement devices, resulting in impact loads (for coaster type of rides, which may come from a track joint or a pit formed by a worn track), loads (permanent loads, live loads and inertia force) borne by a moving part shall be multiplied by an impact factor not less than k_1= 1.2. For amusement devices less than 2 m/s, impact loads may not be calculated.

6.1.2.15.2 If the moving part has a greater impact force during actual operation and cannot reduce it to the design range, then the impact factor shall be increased accordingly to make corrected calculation.

6.1.2.15.3 For amusement devices running on the track, when the running speed exceeds 20 km/h, the load applied on the track structure during operation shall be multiplied by a vibration factor (not less than k_2=1.2). Vibration is not considered under following conditions:

a) supports or suspensions of the track structure (e.g., track backbone, columns, etc.);

b) ground pressure;

c) settlement.

6.1.2.15.4 When an anti-roll back means with anti-reverse gears shown in Figure 1 is used, the impact factor shall be considered during design. If no other precise calculation is made, the impact factor is at least half of the maximum vertical height (h, measured in centimeters, dimensionless) in case of backward travel, and is not less than 2.0.

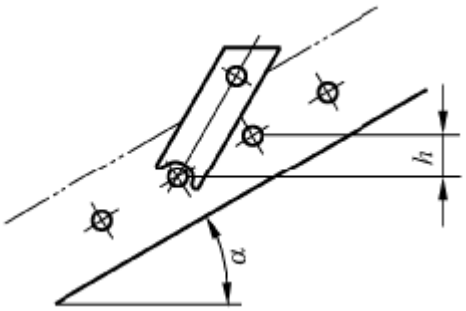


Figure 1 Schematic diagram for maximum vertical height of backward traveling anti-roll back means

6.1.2.16 Other loads

Where necessary, other loads of the amusement devices include but are not limited to:

a) air resistance;

b) fluid force;

c) additional force generated by the decorative elements attached to the amusement device.

6.1.3 Analysis of working conditions

6.1.3.1 The working conditions of the amusement devices include normal operating conditions, abnormal operating conditions and limit state conditions.

Notes: For normal operating conditions, refer to different conditions such as no load, bias load, and full load under the designed service conditions of amusement devices;

For abnormal operating conditions, refer to different conditions such as emergency stop, emergency

rescue, maintenance of the amusement facilities;

For limit state conditions, refer to different conditions such as extreme wind speed, earthquake and other local extreme conditions of the amusement devices.

6.1.3.2 Kinematics and dynamics analysis of the amusement devices shall be performed to obtain data such as traveling speed, acceleration, force and traveling posture.

6.1.3.3 The analysis of working conditions shall consider at least the following:

a) different stages of equipment operation, such as loading/unloading, normal operation, braking status, maintenance, etc.;

b) different distributions of loads, such as full load, bias load, etc.;

c) different postures of the equipment;

d) Possible abnormal operating and limit state conditions, etc.

6.1.4 Load combinations

6.1.4.1 According to the analysis of different equipment and working conditions, the permanent loads and other loads in the structure of amusement device are combined into one calculated load, which are separately analyzed and calculated. Refer to Appendix D.

6.1.4.2 The load combinations shall be carried out according to the specific conditions such as abnormal operating conditions and limit state conditions, which shall not cause damage and permanent deformation of the structure.

6.2 Design calculation

6.2.1 Basic Requirements

The design calculation of the amusement devices includes: static strength calculation, stiffness calculation, fatigue strength calculation, stability calculation, anti-overturning calculation, anti-sideslip calculation and others, which shall be selected according to the specific structure and working conditions. Among them, the calculation of static strength of the Q345, 20#, 45#, 40Cr, Q390 steel structures may be carried out according to the limit state design method specified in Appendix E.

6.2.2 Stress calculation

The components and welds shall be subjected to stress calculation. The ratio of the ultimate stress of the materials to the maximum stress to which they are exposed means the safety factor. The obtained safety factor n shall meet the requirements of Table 1.

$$n = \frac{\sigma_b}{\sigma_{max}} \geqslant [n]$$

Where:

σ_b - Ultimate stress of the materials, in MPa;

σ_{max} - Maximum calculated design stress, in MPa;

[n] - Allowable safety factor (see Table 1)

Table 1 Allowable safety factor

Names	Safety factor [n]
Critical shafts, pins, Level I and Level II welds	≥5
General members	≥3.5 (≥8 for brittle materials)

Note 1: Critical shafts and pins: refer to shafts and pins that directly relate to the safety of people and equipment, such as: spindle of amusement device, center shaft, support shaft of ride device, suspension shaft of ride device, wheel spindle, upper and lower pins of lifting hydraulic cylinder (cylinder), upper and lower pins of ride device lifting arm, shoulder-type lever shaft, vehicle coupling shaft, pins of anti-rollback and anti-overturning devices, etc.

Note 2: The Level I and Level II welds are defined in Table 5.

Note 3: General members: moving parts (except major driving shaft), and shaft, support arm, column, frame, truss, track and other members that do not directly relate to personal safety.

6.2.3 Fatigue strength calculation

6.2.3.1 The fatigue calculation of steel structural members and their connections shall comply with the requirements for calculation of fatigue strength in GB 50017.

6.2.3.2 The Level I and Level II welds of the amusement devices shall be checked for fatigue strength, and the fatigue strength may not be calculated for the parts where tensile stress does not occur in the stress cycle.

6.2.3.3 The safety factors for allowable fatigue strength of the shaft shall meet the requirements of Table 2.

Table 2 Safety factors for allowable fatigue strength of the shaft

Parts and components	$[n_{-1}]$ (symmetric cycle)	$[n_0]$ (fluctuating cycle)
Relatively uniform materials and accurate load and stress calculation	$\geq$1.3	$\geq$1.73
Material is not uniform enough and poor accurate load and stress calculation	1.5~1.8	$\geq$2.0∽2.4
Very poor material uniformity, very poor calculation accuracy	$\geq$1.8 ∽2.5	$\geq$2.4 ∽3.3

6.2.3.4 When the maximum calculated stress of cyclic load is less than the fatigue limit of the material, the parts and components have an infinite life; when the maximum calculated stress is greater than the fatigue limit of the material, the useful life of the parts and components is calculated using the fatigue load spectrum.

6.2.3.5 For components that cannot be designed as removable structures, the design life shall not be less than the design life of the complete machine.

6.2.4 Stiffness calculation

For certain parts that have deformation requirements for amusement devices, stiffness calculations should be performed.

6.2.5 Calculation of stability

To prevent structural instability, calculation of overall and local stability is required for slender, thin-walled structural members. The stability calculation of the slender members shall conform to the relevant requirements of GB 50017; the stability calculation of the plates and casings shall meet the requirements of 5.7 in GB/T 3811 - 2008.

6.2.6 Anti-overturning calculation

During operation of the amusement devices, this calculation shall be carried out if overall overturning is possible.

$$\sum M_1 \geqslant \sum \gamma M_2$$

Where:

γ - Safety factor (see Table 3)

M_1 - Value of steady moment;

M_2 - Value of overturning moment.

6.2.7 Anti-sideslip calculation

During operation of the amusement devices, this calculation shall be carried out if overall side slippage is possible.

$$\sum \mu N \geqslant \sum \gamma H$$

Regulating:

γ - Safety factor (see Table 3)

μ ——Static friction coefficient

N – Normal load component;

H – Horizontal load component.

Table 3 Safety factors for anti-overturning and anti-sideslip γ

S.N	Load	γ
1	Static load is a favorable factor	1
2	Static load is an unfavorable factor	l.1
3	Wind load is an unfavorable factor	1.2
4	Other loads excluding above items 2 and 3 are unfavorable factors	1.3

6.3 Speed and accelerations

6.3.1 Allowable values of speed

6.3.1.1 The relative traveling speed of the amusement devices running while loading/unloading shall be no more than 0.3 m/s.

6.3.1.2 For fairy train type of amusement devices, the allowable values of speed are shown in Table 4.

Table 4 Allowable values of speed

S.N	Names	Traveling features	Traveling speed / (km/h)	Example
1	Fairy train type	Travel on the ground track	≤10	Children fairy train
2	Bumper car type	Bump on the fixe site	≤10	Bumper
3	Racing car type	Travel on the fixed ground line	≤20	Racer
4	Summer toboggan run	Travel in the chute or on the track	≤40	Summer run

6.3.2 Allowable values of accelerations

6.3.2.1 Basic Requirements

In order to protect the passengers from injury, the passenger accelerations of the amusement devices shall be limited to a certain range. Figure 2 shows the coordinate axes for human body. The allowable values of accelerations are shown in Figures 3 to 6 (indicated by the ratio of the actual acceleration to the gravitational acceleration g).

6.3.2.2 Measurement position

The reference point for calculating or measuring accelerations is typically located 600 mm above the seat (or the approximate location of the adult heart). The acceleration with a duration less than or equal to 0.2 s is the impact acceleration, and the acceleration with a duration greater than 0.2 s is the steady-state acceleration.

6.3.2.3 Acceleration in x direction

The maximum acceleration in +x direction does not exceed 6g, and the maximum acceleration in -x direction does not exceed 3.5g.

6.3.2.4 Acceleration in y direction

The lateral (y-direction) acceleration shall be in accordance with the requirements of Figure 3.

6.3.2.5 Acceleration in z direction

The vertical acceleration shall be in accordance with the requirements of Figure 4. For example, the allowable acceleration limits for 0.3 s are a_z = -1.7g and a_z = +6.0g. The above values should be reduced by 10% when there is an impact load.

6.3.2.6 Combination of accelerations

When the lateral acceleration a_y and vertical acceleration a_z exist simultaneously, the ratios $a_y/[a_y]$ and $a_z/[a_z]$ shown in Figure 5 should also be satisfied. Where:

a_y and a_z are actual lateral and vertical accelerations; $[a_y]$ and $[a_z]$ are allowable values of lateral and vertical accelerations.

a_y and a_z are the maximum accelerations sustained within 0.3 s, that is, the maximum value that occurs within a time difference of 0.3 s, which needs to be synthesized.

Figure 6 shows the combined allowable accelerations a_y and a_z.

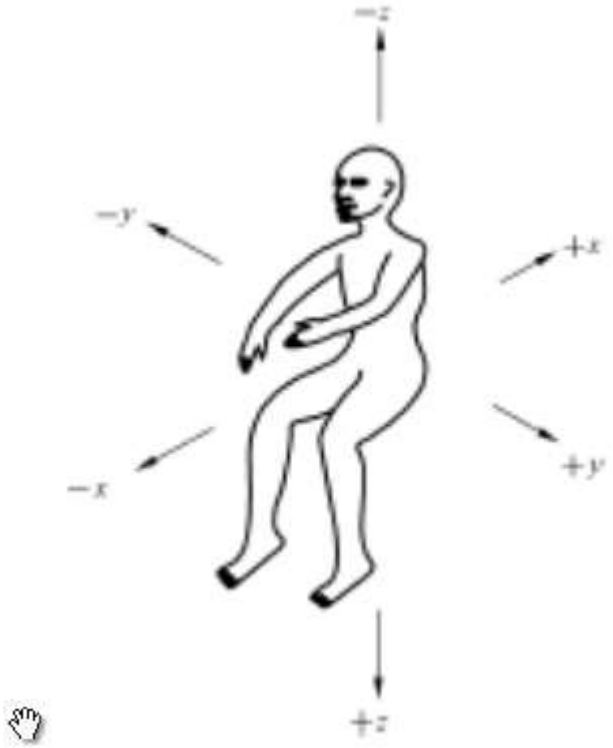
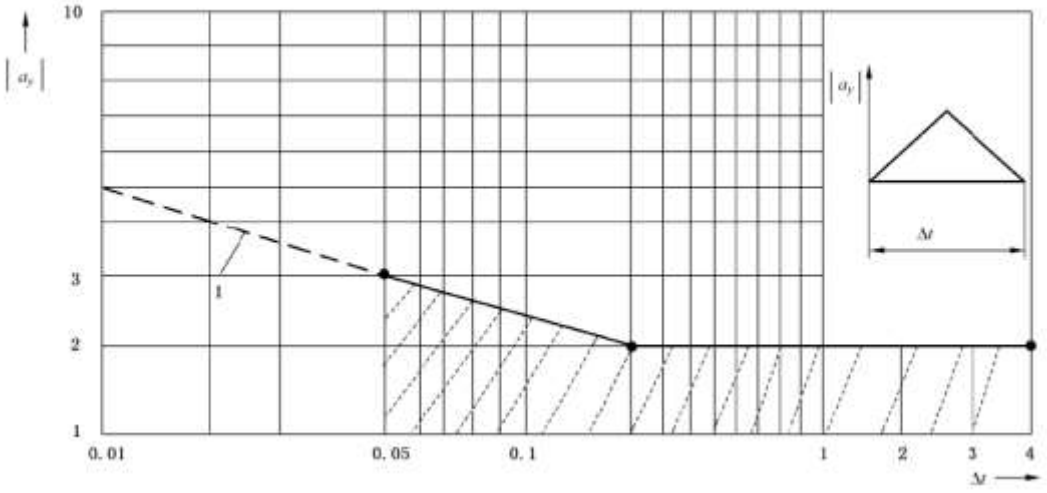


Figure 2 Coordinate axes for human body



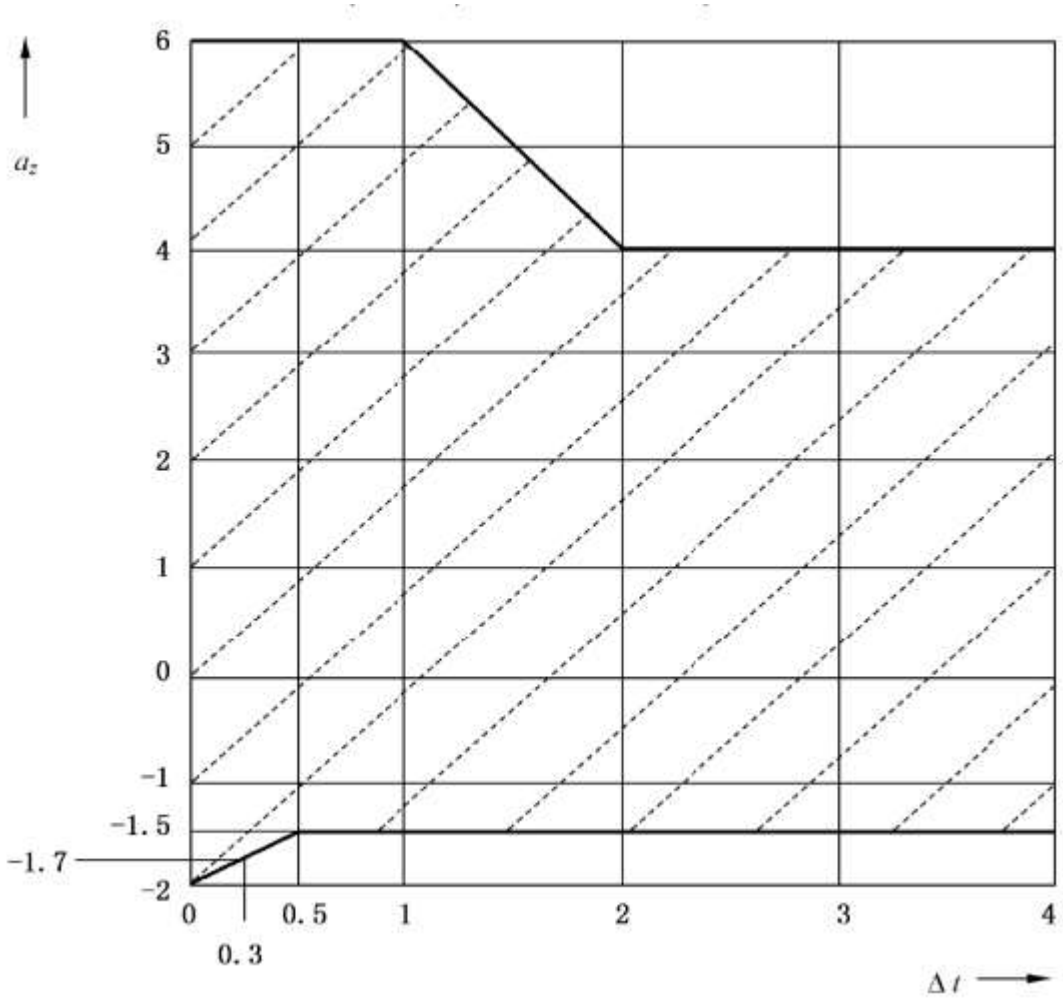
Note 1: 1 is an area with a frequency above 10 Hz.

Note 2: Δt is the acceleration duration (s).

Note 3: The area above 4 s has not been verified and needs further testing.

Note 4: The shaded portion shows the allowable acceleration.

Figure 3 Allowable acceleration a_y (g) relating to duration

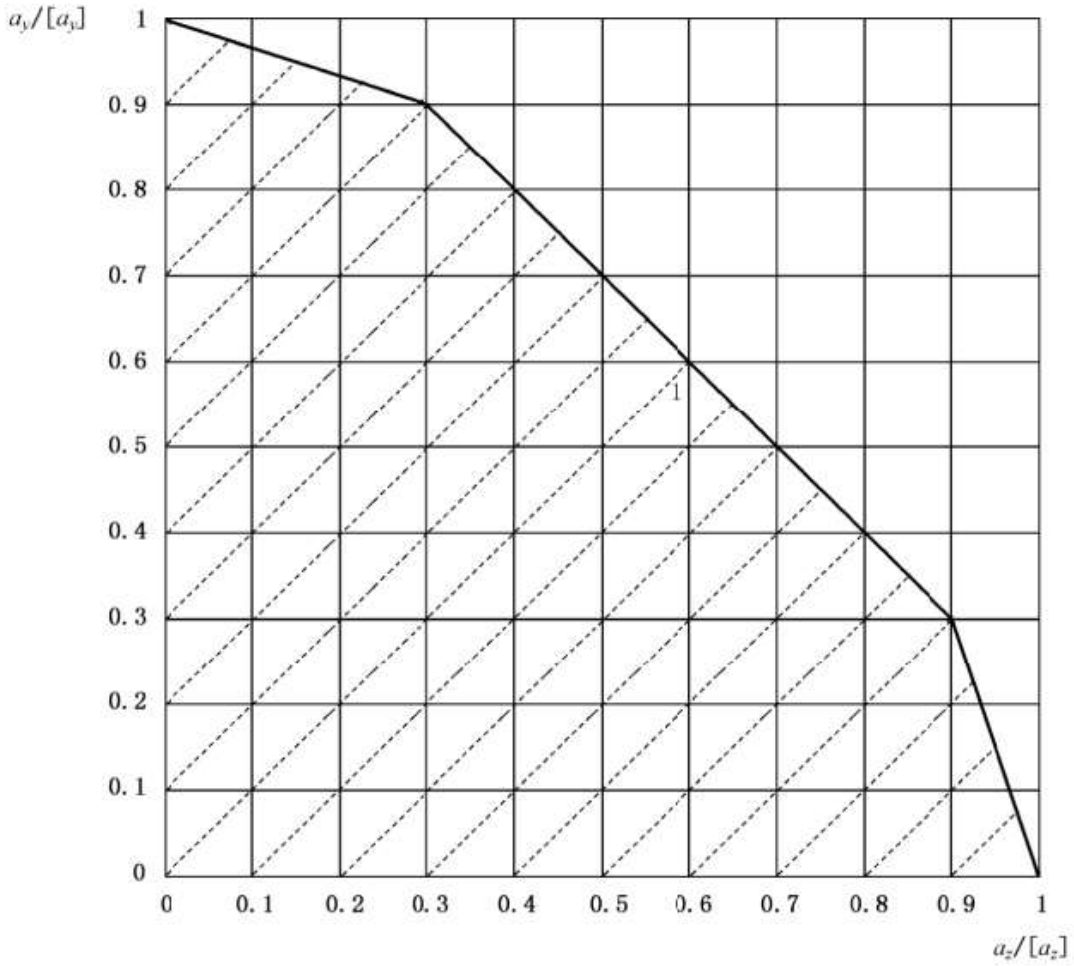


Note 1: The area above 4 s has not been verified and needs further testing.

Note 2: Δt is the acceleration duration (s).

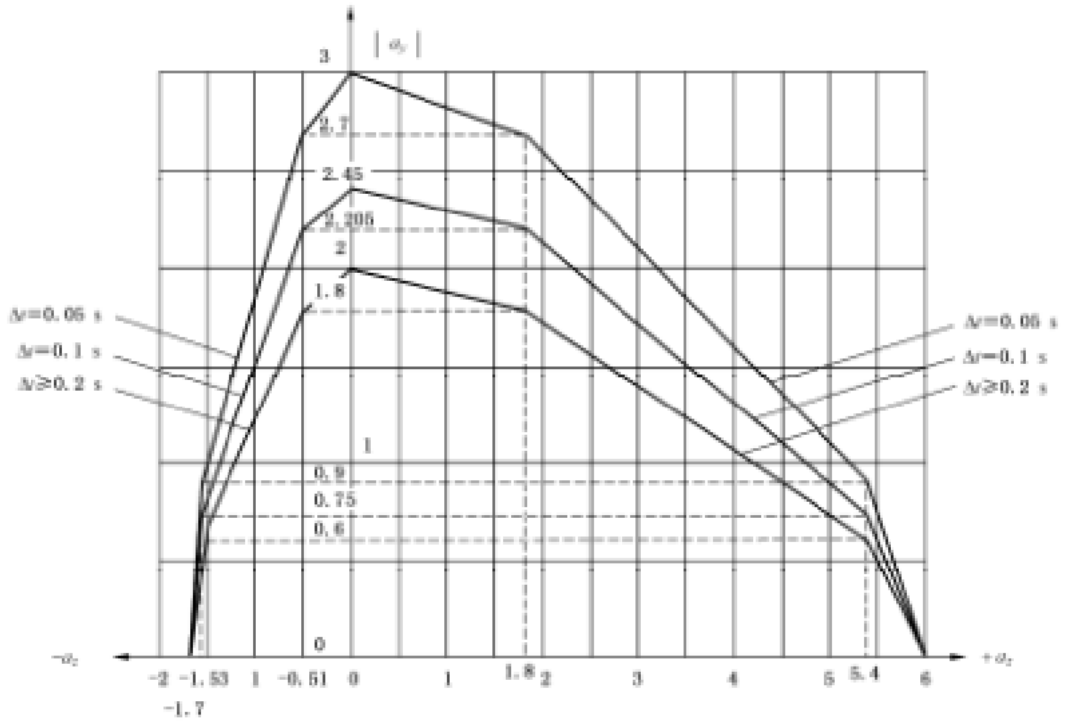
Note 3: The shaded portion shows the allowable acceleration.

Figure 4 Allowable acceleration a_z (g) relating to duration



Note: The dashed area is the allowed area.

Figure 5 Combination of accelerations a_y and a_z



Note: The three broken lines indicate the maximum allowable accelerations a_z, a_y when a_z and z_y coexist and the duration is 0.05 s, 0.10 s, > 0.20 s. For example, if the acceleration duration is 0.05 s, when a_z is 1.8 g, the maximum allowable a_y is 2.7 g.

Figure 6 Allowable acceleration a_y and a_z combination (g)

6.4 Welding design

6.4.1 Design principles for welded joints

6.4.1.1 The weld metal shall be compatible with the base metal. When steels of different strengths are connected, it is advisable to use welding materials suitable for low-strength steel.

6.4.1.2 The groove and size of the welded joints shall meet the requirements of GB/T 985.1 and GB/T 985.2.

6.4.1.3 Welding of weldments with unequal thickness or width: when the difference between both is more than 4 mm on one side, an oblique angle with a slope of not more than 1:4 shall be made on one side or both sides in the width or thickness direction. See Figure 7.

a) Different width b) Different thickness

Figure 7 Splicing of steel plates of different width or thickness

6.4.1.4 On the premise that the design is satisfied, the number of welds and regions of stress concentration should be reduced, dense, cross, two-way, three-way intersect welds should be avoided, and the locations, machined surfaces on the structures having high working stress shall be kept away.

6.4.1.5 There should be sufficient space around the weld to facilitate welding operations and post-weld inspection.

6.4.2 Form of welded joints

The form of welded joints refers to Annex F.

6.4.3 Weld classification

6.4.3.1 Principle

6.4.3.1.1 Welds shall be assessed for their classes by risk assessment. During risk assessment, consideration shall be given to the possibility of weld failure, severity of failure consequences, testability of welds, and other factors.

6.4.3.1.2 The possibility of weld failure is related to load characteristics, weld form, working environment and state of stress.

6.4.3.1.3 The severity of the consequences of weld failure refers to whether it is directly related to personal safety.

6.4.3.1.4 Testability refers to whether a weld is convenient for inspection and testing.

6.4.3.2 Basis of weld classification

As shown in Table 5, welds are divided into four classes by risk assessment.

Table 5 Weld classification

Weld class	Severity of failure consequences	Possibility of failure (stress and form of joint)
Class I	Directly related to personal safety	Butt welds or combinations of T-butt welds and fillet welds that are subjected to tensile forces and applied force is perpendicular to the length of welds
Class II	Directly related to personal safety	Other welds other than the above ones
Class III	Not directly related to personal safety	Butt welds or combinations of T-butt welds and fillet welds that are subjected to tensile forces and applied force is perpendicular to the length of welds
Class IV	Not directly related to personal safety	Other welds other than the above ones
Note 1: If welds are inconvenient for routine inspection or involve special conditions such as welding of dissimilar materials, the weld class is appropriately raised. Note 2: Class I and II are important welds, and the rest are general welds.		

6.4.4 Requirements for welding node construction

6.4.4.1 The requirements for welding nodes of the assembly welding member shall comply with the requirements of 5.4 in GB 50661-2011.

6.4.4.2 Nodes prevented from lamellar tearing of the plates shall comply with the requirements of 5.5 in GB 50661-2011..

6.4.4.3 Fabrication and installation of the structural welding nodes shall comply with the requirements of 5.6 in GB 50661-2011.

6.4.4.4 Welding construction subjected to dynamic load and resistant to earthquake shall comply with the requirements of 5.7 in GB 50661-2011.

6.4.5 Welding seam strength calculation

6.4.5.1 Strength calculation of butt welds

6.4.5.1.1 For butt welds subjected to axial tension or pressure, the longitudinal tensile and compressive stresses shall be calculated.

6.4.5.1.2 For butt welds subjected to combined action of bending moment and shear force, the

maximum normal stress and maximum shear stress at the danger points shall be calculated.

6.4.5.2 Strength calculation of fillet welds

For fillet welds, the shear strength shall be calculated. When a fillet weld is subjected to a composite internal force, the combined stress shall be calculated.

6.4.5.3 Safety factors for welds

The safety factor is the ratio of the calculated breaking stress (selected in Table 6) to the maximum calculated stress sustained. The determined safety factor n shall meet the requirements of Table 1.

Table 6 Expressions of calculated breaking stress of welds

welds Class	Joint type (σ_b)								
	Butt weld				Combination of butt and fillet welds				Fillet weld
	Compression	Tensile	Shear	Combined stress	Compression	Tensile	Shear	Combined stress	Tensile, compression and shear
I	σ_b	σ_b	$\sigma_b / \sqrt{2}$	σ_b	σ_b	σ_b	$\sigma_b / \sqrt{2}$	σ_b	-
II	σ_b	$0.8\sigma_b$	$0.8\sigma_b / \sqrt{2}$	$0.8\sigma_b$	$0.8\sigma_b / \sqrt{2}$				
III									
IV									
σ_b is the breaking strength of the base metal. When the strength grades of the base metal are different, the low strength shall prevail.									

6.4.6 Weld inspection requirements

6.4.6.1 Weld appearance inspection requirements

All welds shall be visually inspected in accordance with GB/T 34370.2, and the quality grades meet the following requirements:

a) The appearance quality of Class I welds shall not be less than Grade B given in GB/T 19418;

b) The appearance quality of Class II welds shall not be less than Grade C given in GB/T 19418;

c) The appearance quality of Class III and IV welds shall not be less than Grade D given in GB/T 19418;

6.4.6.2 Non-destructive testing requirements for welds

6.4.6.2 Non-destructive testing requirements for welds see Table 7.

Table 7 Weld inspection requirements

Weld class	Testing requirement
I	100% visual inspection, 100% surface non-destructive testing, 100% internal non-destructive testing
II	100% visual inspection, 100% surface non-destructive testing, 20% internal non-destructive testing for butt welds
III (Mild)	100% visual inspection, 20% surface non-destructive testing
IV	100% visual inspection
Welds shall be witnessed by detailed welding records and pictures if internal non-destructive testing is technologically impossible.	

6.5 Structural design

6.5.2 The testability of the amusement devices shall be considered. For structures that cannot be inspected, measures should be taken to ensure their safety. For parts components that require regular inspection and non-destructive testing during use, it shall be convenient for their inspection and testing, and for disassembling if needed.

6.5.3 Structural units shall be classified according to conditions such as stress, transportation, storage and hoisting.

6.5.4 The geometrical dimensions of the inspection hole and manhole shall meet the inspection requirements, and measures shall be taken to prevent water accumulation.

6.5.5 The drainage measures for structural parts shall be effective, and there shall be no leakage or residual water in the outer surface and structural parts.

6.5.6 The lifting points for installation of the structural parts shall be located to ensure that no plastic deformation occurs during the lifting process.

6.5.7 The supports, cages, vehicles and other frames under stress of the passenger cabins shall be made of metal materials or other non-metallic materials of high strength and shall have a solid structure as a whole.

6.5.8The important bolted connection shall meet the load requirements, and measures should be taken to prevent the bolts from loosening. The installed bolts should have an obvious locking mark.

6.5.9 The pin connection between major parts should be protected against dropping.

6.5.10 For major shafts and pins, the roughness of their mating surfaces shall meet the working conditions.

6.5.11 The major shafts and pins shall be kept from stress concentration, e.g., minimum change of cross section, rounded corner of shaft shoulder as large as possible.

6.5.12 When necessary, measures should be taken to avoid resonance.

6.6 Drive system

6.6.1 Basic requirements

6.6.1.1 The drive system shall be designed to ensure that the amusement devices is in a safe state in the event of system failure.

6.6.1.2 Friction drives shall have means or measures that the compacting force is adjustable.

6.6.2 Mechanical drives

6.6.2.1 The design or selection of gears shall be in accordance with the actual working conditions of the amusement devices and comply with the relevant national standards.

6.6.2.2 When using belt and chain drives, a tensioning mechanism with adjustable belt or chain shall be provided.

6.6.2.3 The roller chains for power transmission shall meet the requirements of GB/T 1243.

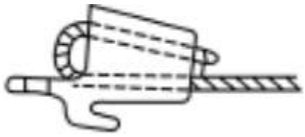
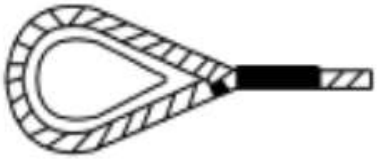
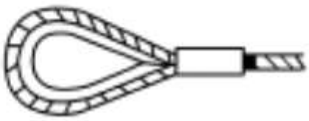
6.6.2.4 For chains used for lifting and suspending of passenger carrying devices, the ratio of the minimum breaking load to its sustained maximum static load shall not be less than 8.

6.6.2.5 The diameter of the wire ropes for friction drives shall be not less than 10 mm, and the diameter of the wire ropes for reel drives shall be not less than 6 mm.

6.6.2.6 The maximum load on the wire ropes used for lifting and suspending the passenger carrying devices shall take into account the efficiency of end fixing. See Table 8. The ratio of the minimum breaking load to their sustained maximum static load shall be not less than 10 (except

summer toboggan run).

Table 8 End fixing methods of wire ropes

Fixing method	Names	Efficiency / %	Remarks
	Fixed with Babbitt metal	100	Generally called the battitting method
	Fixed with clips	80~85	Clip processed improperly, efficiency 50% or less
	Fixed with chocks	65~70	Chock processed improperly, efficiency 50% or less
Fixing method	Names	Efficiency / %	Remarks
	Peach-shaped ring weaving method	80~90	Diameter of wire rope / mm ϕ Less than 16,90% ϕ 16 ∽26,85% ϕ 28∽38,80%
	Peach-shaped ferrules	90~100	

6.6.2.7 The wire ropes for passenger cabins shall meet the requirements of GB/T 8918.

6.6.2.8 The wire ropes for reels and pulleys should be linear contact lay steel wire rope. The galvanized wire ropes shall be used in corrosive environments. The performance and strength of the wire ropes should meet the requirements for working conditions the mechanism

6.6.2.9 The ratio of the diameter of the reels and pulleys for lifting the passenger carrying devices to the diameter of the wire ropes shall not be less than 30. When the wrap angle of the wire rope to the pulley is not more than 90°, the ratio of the diameter of the pulleys to the diameter of the wire ropes shall not be less than 20 times. The useful life of the wire ropes shall be specified.

6.6.2.10 For non-metallic elasticized parts, collars, load carriers and other suspensions, the ratio of the minimum breaking load to the sustained maximum static load shall not be less than 10.

6.6.2.11 Bearing design and selection should conform to the actual working conditions, with consideration of bearing capacity, speed, life, lubrication and temperature rise.

6.6.2.12 Bearings shall have sufficient design service life. For bearings that are difficult to disassemble, the design service life is not lower than the useful life of the complete machine; for the bearings that can be replaced as wearing parts in use, the design service life can be lower than the useful life of the complete machine, but the clear replacement requirement shall be proposed in the maintenance instructions.

6.6.2.13 Where there is relative movement between the bearing and the contact surface, lubrication shall be provided. If it is necessary to add lubricant, it should be easy to handle.

6.6.3 Hydraulic and pneumatic systems

6.6.3.1 To ensure the safety of use, all components in the system shall be selected to ensure that they operate reliably when the system is put into use. In particular, attention should be paid to the reliability of components that may cause danger due to failure or malfunction.

6.6.3.2 The systems shall be designed to prevent their pressure from exceeding the maximum pressure allowed by the systems and the rated pressure of any component. When pressure is lost or critical pressure is reached, personnel shall not be at risk.

6.6.3.3 The hydraulic or pneumatic systems shall be designed to minimize impact. Impact pressure and loss of pressure shall not cause danger.

6.6.3.4 The passenger cabins are lifted and lowered by an oil or air cylinder. When the pressure pipelines, hoses or pumps fail, the lowering speed of passenger cabins shall not exceed 0.5 m/s; otherwise, an effective bumpers or protection device shall be provided.

6.6.3.5 The oil temperature shall meet the requirements of GB/T 3766: When the ambient temperature is highest, the inlet oil temperature of an oil pump shall not exceed 60 ℃. The equipment shall work properly at the lowest ambient temperature.

6.6.3.6 In hydraulic or pneumatic systems, an overpressure protection device not exceeding 1.2 times the rated working pressure shall be provided.

6.6.3.7 The design of the hydraulic cylinder shall meet the requirements of GB/T 3766. Installation and commissioning should be considered in design so that the reaction force of loads passes through the center line of the hydraulic cylinder.

6.6.3.8 One-way piston cylinders shall be designed with exhaust ports in appropriate place to prevent the injected liquid from posing a hazard to personnel.

6.6.3.9 For hydraulic systems with gas-loaded accumulators, the following applies:

a) when shut down, the oil pressure of the accumulator shall be automatically released, or the accumulator can be reliably isolated, except in special cases where pressure is still required after shutdown;
b) There should be a text warning sign, the same content shall also be marked on the hydraulic schematic;
c) if the components or pipe fittings in the gas-loaded accumulator system fail, appropriate protective measures shall be taken, or danger will be caused;
d) The rated pressure of the pipeline, pipe fittings, hoses and other components shall not be less than the maximum operating pressure of the system where they are located;
e) The hose assemblies shall meet the requirements of GB/T 3766.

6.7 Electrical and control systems

6.7.1 Electrical system

6.7.1.1 The design of the electrical system shall be correct and reasonable, in accordance with the relevant national electrical technical codes and standards.

6.7.1.2 The equipment power supply shall meet the requirements of GB 5226.1-2008.

6.7.1.3 The selection of the devices shall meet the following requirements:

a) The electrical system design shall be risk assessed and important electrical components and wearing parts should be identified in the light of risk assessment. The service cycles of important electrical components shall be determined according to the frequency of use;

b) The electrical components (such as switches, contactors, relays) in the main circuit shall at least meet the capacity requirements;

c) The operation buttons, control handles and software operation interface shall have obvious Chinese signs. The color marking of buttons, signal lights and others shall conform to the requirements of GB 5226.1-2008.

6.7.1.4 The electrical system shall have a display of operating voltage and current of the amusement devices.

6.7.1.5 The selection and design of conductors and cables shall conform to the requirements of GB 5226.1-2008.

6.7.1.6 The selection of the motor shall meet the following requirements:

a) The selection of the motor shall conform to the requirements of GB 5226.1-2008;

b) In the case of full load and allowable design bias load, the operating current of the asynchronous motor running continuously shall not be greater than the rated current of the motor;

c) For asynchronous motors started frequently and directly, the starting current shall be not more than 4.5 times the rated current.

6.7.1.7 Where the motor is required for speed governing, the governor and driver shall meet the requirements for motor acceleration and deceleration conditions.

6.7.1.8 The electromagnetic compatibility (EMC) of the equipment shall meet the requirements of GB 5226.1-2008.

6.7.1.9 The insulation resistance between the live circuit with an RMS voltage greater than 50 V and the earthing device shall be not less than 1 MΩ.

6.7.1.10 The electrical equipment installed in wet locations such as pump houses and swimming pools, and decorative lighting equipment using unsafe voltages shall be equipped with residual current operated protective devices. The technical conditions, installation and operation of the residual current operated protective devices shall meet the relevant requirements of GB/Z 6829 and GB/T 13955, and the technical rating shall match the technical parameters, installation and operation environment of the protected lines or equipment; when used in protection against direct contact electric shock, a 0.1 s, 30 mA high sensitivity quickly-operated residual current protective device shall be selected. For protection against indirect contact, an automatic power-off residual current protective device shall be used, which shall be properly matched with the system grounding type of the power grid.

6.7.1.11 For large-scale amusement devices with high risk, measures for operation data monitoring should be taken. For equipment installed outdoors, consideration should be given to monitoring the operating environment. When conditions permit, the data monitored in operation should be stored, recorded and analyzed.

6.7.1.12 The arrangement of electrical equipment and components and the laying of conductors shall comply with the requirements of the national construction and acceptance specifications for electrical installations.

6.7.1.13 The amusement devices shall have corresponding lighting and emergency lighting equipment according to the operating conditions. The illuminance of the passenger passages shall be not less than 60 lx, and the illuminance of emergency lighting shall be not less than 20 lx.

6.7.2 Control and protection systems

6.7.2.1 The control circuit power supply should meet the requirements of GB 5226.1-2008. In case

of power interruption, the operation data may be lost, and the entire system is difficult to recover quickly, so a UPS power supply unit shall be provided.

6.7.2.2 The control system shall satisfy the operating conditions of the amusement devices and the passenger safety. The control logic shall be reliable and reasonable.

6.7.2.3 When using automatic control or interlock control, there should be a repair (maintenance) mode, and each action should be controlled separately.

6.7.2.4 For automatic control or interlock control, in case of false operation, the equipment must not endanger the passenger safety.

6.7.2.5 When the wireless and non-mechanical sensors are used for control, full consideration shall be given to resistance to external interference and sensitivity to operating environment of the emission and receiving sensor components, and a fault monitoring and alarm system should be provided. When there is an error in signal transmission, no personal injury shall occur.

6.7.2.6 Where the operating limits (speed, pressure, torque, position) are exceeded and danger may be caused, corresponding protection control shall be triggered in excess of operating limits.

6.7.2.7 When the amusement devices in operation exceed the preset position and there might be a danger,When the ride is more dangerous than the predetermined position during operation, the limit control and extreme position control devices shall be provided, and they shall be safe and reliable.

6.7.2.8 The amusement devices driven by reels and traction machines shall be provided with control and extreme position control devices that prevent over-winding and slack of steel wire ropes. In normal operation, the multi-wire drive system that is invisible to the operator shall be provided with rope break detection control device.

6.7.2.9 An emergency stop button shall be set on the operation console (it should also be set on the platform if necessary), and the button shall be of raised manual reset type. Danger caused due to pressing the emergency stop button is not allowed.

6.7.2.10 During installation, maintenance and inspection, when it is necessary to enter a dangerous area or a certain part of the human body (e.g. an arm) reaches into the dangerous area, there should be control measures to prevent starting by mistake. Generally, the following measures can be taken:

a)The control or interlock components are placed in a hazardous area and can only be locked or activated here;

b)A withdrawable switch key is provided.

6.7.2.11 The control system shall validate and judge the operating conditions of the equipment (including the testing of air pressure, hydraulic pressure, power supply, passenger and equipment safety protection, etc.) before startup. Starting is permitted only if the equipment meets the operating conditions. The signal devices such as audio that prompt the passengers to pay attention to safety before starting shall be provided.

6.7.2.12 The operation buttons of the amusement devices shall meet the requirements of 9.2.5 of GB 5226.1-2008; the start button shall be placed in an area that is inaccessible to passengers, or isolated by a protective cover in special circumstances.

6.7.2.13 Where it is accessible to passengers (in a range with a height less than 2.5 m or a distance less than 500 mm), the decorative lighting voltage shall be a save voltage of not more than 50 V.

6.7.2.14 The electric switches handled by the passengers shall operate at a safe voltage of not more than 24 V. For equipment whose operating voltage is difficult to meet the above

requirements, the operating lever, handle or similar structure of its switch shall conform to the requirements of 8.1.1, 8.1.4, 8.1.5, and 8.2 in GB 4706.1-2005.

6.7.2.15 Under normal operating conditions, if the amusement devices travel on the ground with tracks energized, corresponding safety precautions shall be taken when the supply voltage of the slide line is greater than 50 V. The following measures may be referenced:

a) Provide safety fences and safety signs;

b) A passenger restraint is provided in the cabin;

c) Close the live area of the track.

6.7.2.16 For overhead travelling amusement devices, such as aerial trains, the safety fences and safety signs shall be provided in the areas where the slide line is less than 2.5 m high.

6.7.3 Grounding and lightning protection

6.7.3.1 The grounding type of the low-voltage distribution system of the amusement device shall adopt the TN-S or TN-C-S system; the metal casing, metal pipe trough, cable metal protective covering and transformer secondary circuit and others that are normally not energized in the electrical equipment shall be reliably connected to the the ground wire (PE) of the power line. The protective grounding resistance of the low-voltage power distribution system shall be not more than 10 Ω. The The design and construction of the grounding device shall meet the requirements of GB/T 50065 and GB 50169.

6.7.3.2 The amusement devices above 15 m high, strop stations, and wire ropes shall be provided with lightning protection devices, measures against lightning surge on incoming services shall be taken. If above 60 m high, the lightning protection system against lateral lightning strikes shall also be provided. The lightning protection system shall meet the requirements of GB 50057.

6.7.3.3 The amusement devices shall not be located in the high-voltage overhead transmission and distribution line corridors. If the long track type of amusement devices must be located under the existing high-voltage line, they shall meet the relevant requirements of GB 50545 and be approved by the local electric power administration department.

6.8 Riding system

6.8.1 Basic Requirements

6.8.1.1 The amusement devices shall, based on the performance, mode of operation, speed and structure and with consideration of physical characteristics of the passengers, be provided with appropriate riding systems. The riding system includes a passenger carrying device and a passenger restraint. The passenger restraints may use seat belts, lap-bars, shift levers, and the like.

6.8.1.2 When the amusement devices are in operation, the passenger restraints shall be provided if the passengers might be moved, collided in or thrown out or slipped out of the passenger carrying devices.

6.8.1.3 The riding system shall be reliable and comfortable. The riding system shall be designed to prevent passengers from being pinched or crushed, and easy to adjust and operate.

6.8.1.4 During the movement, due to the effects of tumbling, impact or inertia, the reaction force of the riding system shall not cause damage to the passengers.

6.8.1.5 The riding system shall be securely fixed to the structural members of the amusement device and have sufficient strength to withstand the maximum forces occurring in various operating conditions.

6.8.1.6 The seat structure and type of the passenger carrying device shall provide a certain restraining function. For equipment that the passengers have tumbling during the operation, an

effective obstructing structure shall be provided on both sides and the middle of the passenger seat surface to appropriately increase the inclination angle of the seat surface.

6.8.1.7 The latching device of the passenger restraint can maintain its latching state in the event of a functional malfunction or emergency stop brake of the amusement device, unless emergency measures are taken to dispatch passengers.

6.8.1.8 When the maximum height of the chair to the ground is less than 5 m, the gondolas depth shall be not less than 550 mm, and the chair-back height shall be not less than 300 mm. When the maximum height of the chair to the ground is more than 5 m, the gondolas depth shall be not less than 800 mm, and the chair-back height shall be not less than 400 mm. When there are facilities such as safety levers and seat belts, the gondolas depth may be appropriately reduced. For adults, the seat width shall be not less than 400 mm per person; if exclusively for children, it shall be not less than 250 mm per person.

6.8.1.9 The riding device shall be clearly identified with the number of rated passengers, and out-of-rule and overload operation must be strictly forbidden.

6.8.1.10 If the cabin structure is closed by FRP, there should be inspection holes or corresponding maintenance measures.

6.8.1.11 Exposed sharp edges, sharp corners, burrs and dangerous protrusions are not allowed where passengers can reach.

6.8.2 Passenger restraints

6.8.2.1 Seat belt

6.8.2.1.1 Seat belts may be used alone on devices that are slightly swaying or slow in lifting speed, are not tumbled, and there is no risk of being thrown out. Seat belts are generally provided with an auxiliary handle. For highly sporty equipment, the seat belt can be used as a supplementary restraint device.

6.8.2.1.2 Seat belts should be made of high-strength belts suitable for outdoor use, such as nylon braids, their width shall be not less than 30 mm, and the breaking force shall be not less than 6 000 N. Seat belts shall be reliably connected to the machine body, which can withstand the forces generated by the foreseeable passengers' various actions. If directly fixed on the FRP parts, the fixing points shall be firm and reliable, or else strengthening measures such as embedding of metal members shall be taken.

6.8.2.1.3 The seat belt buckle assemblies shall be made of metal material. The breaking force of the seat belt buckle assemblies themselves, and between the buckle assemblies and the seat belts shall be not less than 6 000 N. These assemblies shall be securely locked and shall not be unlocked by itself without external force. If necessary, security means shall be provided to prevent the passenger from unlocking them.

6.8.2.1.4 The replacement cycle or conditions of the seat belts shall be clearly specified.

6.8.2.2 Lap-Bar

6.8.2.2.1 A lap-bar itself shall have sufficient strength, locking force and suitable structural form to ensure that the passenger is not thrown out or falls and shall always be latched before the equipment stops operating.

6.8.2.2.2 The latching and unlatching devices may be controlled automatically or manually. When the automatic control device fails, they shall be opened manually.

6.8.2.2.3 Passengers shall not be able to open the unlatching device at will, but the operator may access the position conveniently and quickly to operate the unlatching device.

6.8.2.2.4 The travel of lap-bar shall be adjustable. When the bar is pressed down, the free movement of the end shall be not more than 35 mm. The pressing process of lap-bar shall be slow, and the maximum force applied to the passengers: not more than 150 N for adults and not more than 80 N for children.

6.8.3 Selection of restraint devices

6.8.3.1 The restraint devices should be selected with reference to the five areas of the design accelerations in Figure 8. The accelerations indicated in the figure are “sustained accelerations” rather than “impact accelerations”. For directions of accelerations, refer to the coordinate axes for human body in Figure 2.

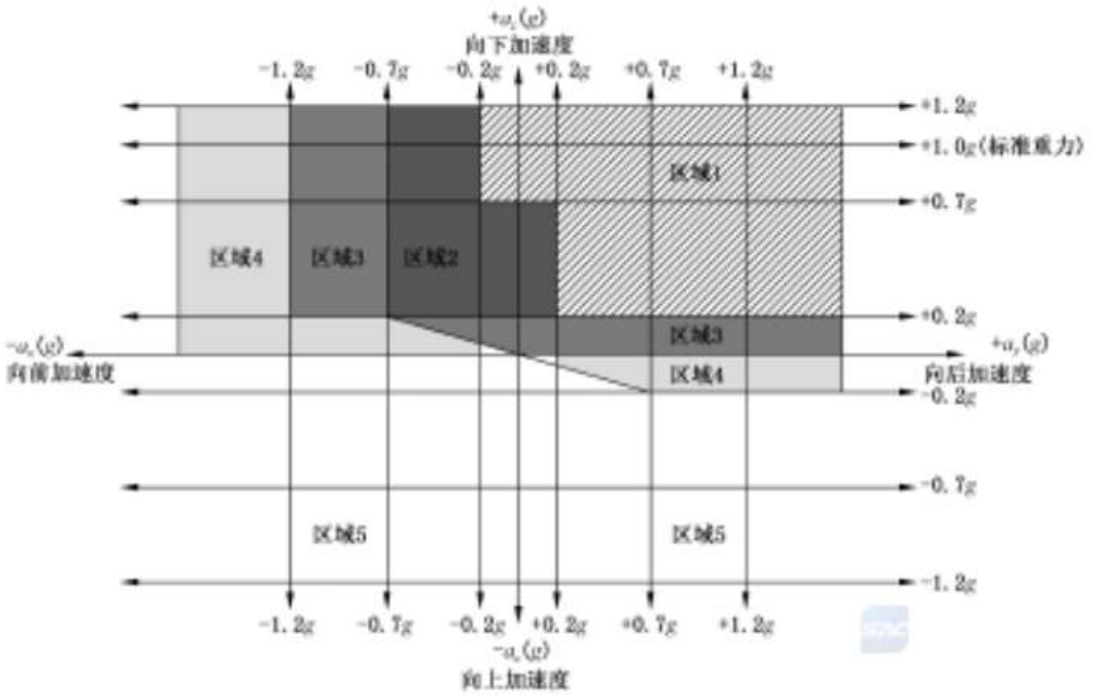


Figure 8 Five areas for accelerations in design stage

6.8.3.2 The selection of restraint devices shall be considered in connection with the specific condition of equipment, such as:

a) Direction, magnitude, point of action, duration of the acceleration, and angular acceleration, etc.;

b) Structural form and restraint of the riding system, structural form of the chair surface, and friction;

c) Passenger posture, e.g., tumbling, inclination;

d) Lateral accelerations, for example, where sustained lateral acceleration is equal to or greater than 0.5 G, special consideration shall be given to the design of seats, backrest, headrest, padding, and so on.

6.8.3.3 Referring to 5 areas shown in Figure 8, the restraint devices should be provided respectively in accordance with those specified in Table 9, and these devices may be combined for use.

Table 9 Restraint criteria

Type	Different requirements	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 5 Redundancy
Number of passengers per restraint device	1. No restraint device is required.	*					
	2. A restraint device may be used for one or more passengers.		*	*			*
	3. A restraint device may only protect one passenger.				*	*	
Latching position (restraint device)	1. The latching position may be fixed or variable in relation to the passenger.		*				*
	2. The latching position may be variable in relation to the passenger.			*	*	*	
Type	Different requirements	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 5 Redundancy
Type of latching (latching device)	1. The passenger or operator may latch the restraint device.		*				
	2. The passenger or operator may manually latch the restraint device or it may be automatically latched. The operator shall verify the restraint device is latched.			*			*
	3. The restraint device should be latched automatically,				*	*	
Type of unlatching (latching device)	1. The passenger or operator may unlatch the restraint device.		*				
	2. The passenger may manually unlatch the restraint device or the operator may manually or automatically unlatch the restraint device.			*			*
	3. The operator is only allowed to manually or automatically unlatch the restraint device				*	*	
External indication	1. No external indication is required,		*				
	2. No external indication is required. The design shall allow the operator to perform a visual or manual check of the restraint device each ride cycle.			*	*		*
	3. As required, the external indicating device should be provided with an interlocking control function that can be activated only after the passenger restraint is effectively latched. The design shall allow the operator to perform a visual or manual check of the restraint device each ride cycle.					*	
Means of latching and unlatching	1. Latching and unlatching may be manually or automatically controlled.		*	*	*	*	*

(restraint device)							
Redundancy of latching device	1. Redundancy is not required.		*	*			*
	2. Redundancy shall be provided for the latching device.				*	*	
	3. Redundancy is not required. Latching and unlatching of the secondary restraint device shall be independent of the primary one.						*
Restraint configuration	1. Two independent restraints or one fail-safe restraint device					*	
Note 1: A higher class restraint device may also be provided according to the ride analysis of specific equipment. Note 2: A fail-safe restraint device means that any part of the passenger restraint fails and does not cause the passenger to disengage from the restraint device. Note 3: * denotes the technical requirements corresponding to this class of restraint device.							

6.8.3.4 Area 1 – Corresponding to the Class-1 restraint device, is required as follows:

a) A Class-1 restraint device is defined as unrestrained or no restraint at all;

b) Based solely on Area-1 dynamic forces, no restraint is required; however, the ride analysis may require a higher class restraint device.

6.8.3.5 Area 2 – Corresponding to the Class-1 restraint device, is required as follows:

a) Number of passengers per restraint device - one or more passengers;

b) Latching position (restraint device) - The final latching position may be fixed or variable;

c) Type of latching (latching device) – The passenger or operator may latch it;

d) Type of unlatching (latching device) – The passenger or operator may open it;

e) Means of latching and unlatching (restraint device): The restraint device may be manually or automatically opened and closed;

f) Redundancy of latching device— Redundancy is no required;

g) Type of external correct or incorrect indication – No external indication is required.

Note: According to the specific equipment condition, the safety restraint may not be required if passengers are provided sufficient support and protection by the handrails, footrest, or other devices.

6.8.3.6 Area 3 – Corresponding to the Class-1 restraint device, is required as follows:

a) Number of passengers per restraint device - one or more passengers;

b) Latching position (restraint device)—The final latching position should be variable;

c) Type of latching (latching device)—Manually or automatically latched, the operator shall verify the restraint device is latched;

d) Type of unlatching (latching device)—The passenger may manually unlatch the restraint device or the operator may manually or automatically unlatch the restraint device;

e) Means of latching and unlatching (restraint device)—Latching and unlatching may be manually or automatically controlled;

f) Redundancy of latching device— Redundancy is no required;

g) Type of external correct or incorrect indication – No external indication is required. The design shall allow the operator to perform a visual or manual check of the restraint device each

ride cycle.

6.8.3.7 Area 4 – Corresponding to the Class-4 restraint device, is required as follows:

a) Number of passengers per restraint device—A restraint device only protects one passenger;

b) Latching position (restraint device)—The final latching position should be variable;

c) Type of latching (latching device)—Only automatic latching is allowed;

d) Type of unlatching (latching device)—The operator is only allowed to manually or automatically unlatch the restraint device

e) Means of latching and unlatching (restraint device)—Latching and unlatching may be manually or automatically controlled;

f) Redundancy of latching device— The latching device should be redundant;

g) Type of external correct or incorrect indication – No external indication is required. The design shall allow the operator to perform a visual or manual check of the restraint device each ride cycle.

6.8.3.8 Area 5 – Corresponding to the Class-5 restraint device, is required as follows:

a) Number of passengers per restraint device—A restraint device only protects one passenger;

b) Latching position (restraint device)—The final latching position should be variable;

c) Type of latching (latching device)—The restraint device should be latched automatically;

d) Type of unlatching (latching device)—The operator is only allowed to manually or automatically unlatch the restraint device

e) Means of latching and unlatching (restraint device)—Latching and unlatching may be manually or automatically controlled;

f) Redundancy of latching device— The latching device should be redundant;

g) Restraint configuration: Two independent restraints or one fail-safe restraint device;

h) Type of external correct or incorrect indication –The device should be provided with an interlocking control function that can be activated only after the passenger restraint is effectively latched. The design shall allow the operator to perform a visual or manual check of the restraint device each ride cycle.

6.8.3.9 The Class-5 restraint should be provided with a redundant device which is an independent restraint device. The requirements are given as follows:

a) Number of passengers per restraint device - one or more passengers;

b) Latching position (restraint device) - The final latching position may be fixed or variable;

c) Type of latching (latching device)— The passenger or operator may manually latch the restraint device or it may be automatically latched. The operator shall verify the restraint device is latched.

d) Type of unlatching (latching device)—The passenger may manually unlatch the restraint device or the operator may manually or automatically unlatch the restraint device;

e) Means of latching and unlatching (restraint device)—Latching and unlatching may be manually or automatically controlled;

f) Redundancy of latching device— Redundancy is not required. Latching and unlatching of the secondary restraint device shall be independent of the primary one.

g) Type of external correct or incorrect indication – No external indication is required. The

design shall allow the operator to perform a visual or manual check of the restraint device each ride cycle.

6.8.4 Safety distance and protection

6.8.4.1 The safety distance for passengers shall be determined during the design of amusement devices to prevent the passengers from coming into contact with other objects during the movement. The following shall be considered:

a) Restriction for passenger height;

b) Shape and size of the riding system, including

1) Seats, handrails, seat back and sides, footrest, etc.;

2) Designed restraint devices, for example, lever, seat belt, shoulder restraint, etc.;

3) Allowable range of passengers to extend beyond the perimeters as limited by the riding system.

c) Objects that might be contacted or relative speeds and directions that contact might take place;

d) Moving devices or components within the area. Any moving system or device that encroaches a safe distance, loading/unloading platforms, decks or other device;

e) The possibility of variations in the position or orientation of the passenger carrying device (for example, angular movement, side movement, unrestrained or undampened motion, or free swinging).

6.8.4.2 For amusement devices running while loading/unloading, the entrance and exit of the passenger cabin shall not exceed 300 mm above the platform. For other amusement devices, the height from the entrance and exit of the passenger cabin to the platform shall be convenient for passenger loading/unloading.

6.8.4.3 Where the passenger's body can extend beyond the cabin, a safety means shall be provided to prevent the passenger from colliding with the surrounding obstacles during operation, or a safety distance of not less than 500 mm shall be left. When the overall or partial traveling speed is not more than 1 m/s, the safety distance can be appropriately reduced, but shall not be less than 300 mm. The distance from the seat surface to the upper obstacle shall be not less than 1 400 mm, not less than 1 100 mm for amusement devices exclusively ridden by children.

6.8.4.4 When a rotating platform is provided, in order to prevent the passengers' feet being hurt, the clearance the rotating platform and the fixed part shall not be more than 30 mm in the horizontal direction. If platform is higher than the surface, the vertical clearance shall be appropriate and shall not cause a danger to the passengers' feet.

6.9 Safety protection devices and measures

6.9.1 Basic Requirements

Based on the specific form and risk assessment of the amusement devices, appropriate safety protection devices shall be provided or safety protection measures shall be taken, such as passenger restraints, braking systems, limiting devices, anti-collision devices and bumpers, anti-roll back means, speed limiting devices, anemometers, protective covers, safety signs, and the like.

6.9.2 Braking system

6.9.2.1 The amusement devices may use different braking methods and brake structures (such as mechanical, electric, hydraulic, pneumatic and manual) depending on their form of motion, speed

and structure.

6.9.2.2 The amusement devices shall be equipped with a braking system in case of a long stop process or accurate positioning when the power supply is cut off. After the brake is stopped, the equipment shall keep the moving parts stationary; if necessary, an auxiliary locking device shall be provided.

6.9.2.3 During the operation of the amusement devices, if the power source is cut off or the control of braking system is interrupted, the amusement devices shall be safely stopped.

6.9.2.4 The braking torque (force) of the braking system shall be set according to the actual situation, which shall not cause safety problems and equipment damage. The applied force of the operating force of a manually controlled braking system shall be 100 N ~ 200 N.

6.9.2.5 The components of the braking system shall have sufficient strength (and fatigue strength shall be checked if necessary). The braking travel of the braking system shall be adjustable.

6.9.2.6 Braking shall be stable and reliable and shall not cause the passenger to feel obvious impact or cause obvious vibration and swaying of the device structure. In the case of no passenger restraint, the absolute value of braking acceleration is generally not more than 5.0 m/s^2 under normal operating conditions. A deceleration brake can be added if necessary.

6.9.2.7 The maximum braking distance of the amusement devices shall be limited to a reasonable range. For racers, it shall be not more than 7 m; for toboggans in the summer toboggan run, it shall be not more than 8 m; for bicycles, internally combusted or electric bikes, it shall be not more than 6 m; for aerial trains, it shall be not more than 15 m.

6.9.3 Limiting device.

6.9.3.1 A danger might occur during the operation of the amusement device if going beyond the preset position (e.g., stroke end of the oil or air cylinder, lifting arms rotating around the fixed axis, members swinging around the fixed axis, end position of the stroke, etc.), a limiting device shall be provided to prevent the amusement device from running in an unsafe direction. If necessary, a limit switch that can cut off the main power supply shall be installed.

6.9.3.2 For amusement devices that rotate around a horizontal axis and are equipped with a counterweight, when a standstill (dead point) may occur at the highest point of the passenger cabin, measures shall be taken to prevent or deal with this condition.

6.9.4 Anti-collision devices and bumpers

6.9.4.1 When there are more than two groups (including two groups) of unmanned bicycles or trains running on the same track, skidway, and dedicated lane, the anticollision autocontrol devices and bumpers shall be provided. In case of manned operation, effective bumpers shall be provided.

6.9.4.2 When necessary, a bumpers shall be provided at the limit position of the lifting device.

6.9.4.3 When necessary, a bumpers shall be provided at the limit position of travel of the unclosed track.

6.9.4.4 The equipment such as strops running along the wire rope shall be provided with a bumpers at the end of the sliding.

6.9.5 Anti-roll back devices

6.9.5.1 A lifting system that makes upward traction along the slope shall be provided with devices to prevent the passenger carrying devices running back (except for special modes of operation).

6.9.5.2 The running back distance of the anti-running back device shall be designed to minimize the impact load and perform reliable anti-roll back at the maximum impact load. The safety factor for anti-roll back devices shall be not less than 4.

6.9.6 Speed limiting devices

In case that overspeed is possible, the amusement devices shall be equipped with safe and reliable speed limiting devices or measures.

6.9.7 Anemometers

An outdoor amusement device more than 20 m high shall be equipped with an anemometer. When the wind speed is greater than 15 m/s, it shall be stopped. The anemometer shall have a data display device and an alarm which is convenient for operator observation, and the minimum installation height is 10 m.

6.9.8 Protective covers

6.9.8.1 Mechanical transmission parts (such as gears, pulleys, couplings, etc.) accessible to passengers shall be provided with protective covers or other protective measures.

6.9.8.2 For vehicles driving on the ground, the drive and transmission parts and the wheels shall be covered.

6.9.9 Safety fences, platforms, operating rooms, safety passages, safety nets

6.9.9.1 The amusement devices shall be provided with effective isolation measures to prevent personnel from unauthorized admission. The entrance and exit shall be provided respectively.

6.9.9.2 The platforms surrounding the amusement device and more than 500 mm above the ground shall be provided with safety fences or other effective isolating devices. The height of outdoor safety fences shall be not less than 1 100 mm; for indoor children amusement devices, the safety fences shall be not less than 650 mm high. The gaps between the fences and the gaps from the ground shall be not more than 120 mm. The safety fences shall have a structure that is not easily climbed by children, except the fences for staff channels or platforms.

6.9.9.3 The safety fences shall be provided with entrances and exits respectively, and guiding fences should be located at the entrances. The platforms shall be antiskid.

6.9.9.4 The opening direction of safety fence doors shall be consistent with the traveling direction of the passenger (except in special circumstances). To prevent injury to the person's hand when opening and closing the doors, the clearance between the door frames and the columns should be appropriate, or other protective measures shall be taken.

6.9.9.5 The step width of the entrance and exit of the amusement devices shall be not less than 240 mm, the height shall be 140 mm ~ 200 mm, and the slope of the steps shall be consistent. When the entrance and exit have a ramp, the slope shall be not more than 1:6; for a ramp with anti-skid patterns, the slope shall be not more than 1:4.

6.9.9.6 The operating room of the amusement device shall be set separately, with a wide vision and full space and lighting. For blind areas where the operator cannot observe the operation, safety measures such as surveillance system shall be available when there is a possible danger. If all passenger loading/unloading can not be observed and the passenger safety restraint device is not interlocked with the startup, a safety confirmation button shall be added at the corresponding position and interlocked with the startup.

6.9.9.7 A safety passage shall be provided along the slope upgrading section or the aerial railway, which shall be firm and reliable, and convenient for passenger dispatching or overhauling.

6.9.9.8 For amusement device itself, running passage and passed culvert, the female surfaces shall use materials that are not easy to fall off, and the decorative objects and others shall be fixed firmly.

6.9.9.9 Where there is a possibility that the human body or object may fall to cause injury, a safety

net shall be provided. The safety net shall be connected reliably, and its performance shall meet the requirements of GB 5725.

6.9.9.10 The ladders, passages and platforms for inspection and maintenance shall be firm and reliable, and their space shall meet the working requirements. Ladders above 3 m high shall be guarded or equipped with seat belt attachments.

6.9.10 Safety signs

If necessary, the prominent safety signs shall be placed in the obvious location of the amusement devices. The safety signs are divided into prohibitory signs (red), warning signs (yellow), direction signs (blue), and information signs (green). The graphical patterns of the safety signs shall meet the requirements of GB 2894 and GB 13495.1-2015.

6.9.11 Other safety requirements

6.9.11.1 The passenger cabins of amusement devices running in the air shall be firm and reliable structurally, and insurance measures should be taken for their important parts.

6.9.11.2 The number of wire ropes or chains used for suspending the passenger cabins shall not be less than two. The connection to the chairs shall be able to keep balance when one is disconnected.

6.9.11.3 The terminal of the wire rope shall have a margin of not less than three turns on the reel. When a pulley is used for driving or guiding, consideration shall be given to construction that prevents wire rope from falling off the pulley.

6.9.11.4 The doors of closed cabins more than 1 m above the ground shall be provided with two latching devices that cannot be opened inside by passengers or one latching device with security means. The obstructions at the entrance and exit of unclosed cabins shall also be provided with latching devices with security means.

6.9.11.5 Vehicles running along aerial railways shall be provided with anti-overturning devices. The vehicle connectors shall have a rational structure, flexible rotation, and safety and reliability.

6.9.11.6 Amusement devices moving along the wire ropes shall have a security means that prevents the passenger cabins from falling off. The security means shall have sufficient strength.

6.9.11.7 When the amusement devices are in operation, the automatic or manual emergency stop devices shall be provided if sudden outage of the power supply or failure of equipment endangers passenger safety.

6.9.11.8 Measures shall be taken to dispatch passengers after the amusement devices failed during operation.

6.9.11.9 The construction of amusement devices shall comply with the relevant national regulations on fire safety. When necessary, the closed cabins running overhead shall be equipped with fire extinguishing devices.

6.9.11.10 The noise effect on the reginal environment generated by the amusement devices shall meet the requirements of GB 3096.

7 Manufacturing and installation

7.1 Basic Requirements

7.1.1 The organizations in charge of manufacturing and installation of the amusement devices shall obtain corresponding qualifications in accordance with the relevant national laws and regulations, establish a complete quality assurance system, and strictly implement it.

7.1.2 After the installation and commissioning are completed, the user should be provided with the operation and maintenance instructions and related maintenance drawings, product certificates and necessary spare parts and special tools. During the use of the product, if the instructions involve any safety related modification, the user shall be notified in time and renewed with new instructions.

7.1.3 The manufacturers shall train the operation and maintenance personnel for the user, provide good after-sales service for the user, and supply spare parts to the user in a timely manner.

7.1.4 For important outsourced parts, the manufacturers shall develop detailed acceptance requirements.

7.1.5 Materials should be cut by advanced technology to avoid causing changes in material properties. For materials used for important parts, material identification should be transplanted after cutting.

7.1.6 A reasonable machining process shall be established to ensure that the machined parts meet the requirements of the design documents.

7.1.7 Reasonable forming processes such as sheet metal processing, pipe bending, plate rolling and stamping shall be established to ensure that the parts meet the requirements of the design documents. Cracks, folds, mechanical damage, and other defects are not allowed. When cold work hardening occurs after stamping and drawing, the stamping parts with required toughness shall be hardened.

7.1.8 Important forgings may be processed after being accepted by ultrasonic testing. The testing criteria shall comply with GB/T 34370.5. Cracks and residual shrinkage are not allowed inside the forgings. Surfaces are not allowed to have visible cracks, folds, and other defects that affect strength and appearance. If necessary, the forgings shall be heat treated after forging.

7.2 Welding

7.2.1 Welding Materials

7.2.1. 1 Welding materials, including electrodes, wires, fluxes, gas, etc., shall meet the relevant requirements of GB/T 983,GB/T 5117,GB/T 5118, GB/T 5293,GB/T 8110,GB/T 10045,GB/T 12470,GB/T 14957 and GB/T 17493 ; the argon gas for gas shielded welding shall meet the relevant requirements of of GB/T 4842, and its purity shall not be lower than 99.95%.

7.2.1.2 The selection principle of welding materials for all kinds of steel products shall conform to the requirements of 4.1 in NB/T 47015-2011.

7.2.1.3 The management of welding materials should comply with the requirements of JB/T 3223.

7.2.1.4 Before welding, the welding wires shall be cleaned of oil and rust, and the shield gas shall be kept dry. In addition to vacuum packaging, the electrodes and fluxes shall be re-dried according to the specifications specified in the product instruction. After drying, they can be placed in an incubator (100 ℃ ~ 150 ℃) for use. For electrodes with a drying temperature exceeding 300 ℃, the cumulative number of drying should not exceed 3.

7.2.2 Welding procedure qualification

7.2.2.1 Before welding, important welds, welds welded with important welds, tack welds fused into important welds, build-up welding and repair welding on the surface of important weld base metal, and repair welds of above mentioned welds shall be subjected to welding procedure qualification in accordance with NB/T 47014 or be supported by a qualified welding procedure.

7.2.2.2 The test pieces for welding procedure qualification shall be welded by welding personnel who are qualified according to TSG Z6002 and meet the requirements of welding procedure

specifications.

7.2.2.3 The welding procedure shall be prepared in accordance with a qualified welding qualification procedure report.

7.2.2.4 The technical documents for welding procedure qualification shall be kept until the procedure qualification fails. The test specimens for welding procedure qualification shall be stored for a period of not less than 5 years.

7.2.3 Preparation before welding

7.2.3.1 The basic form and dimensions of the welding groove shall meet the requirements of the drawings.

7.2.3.2 The groove preparation shall conform to the requirements of 4.3 in NB/T 47015-2011.

7.2.3.3 Assembling of welded joints shall conform to the requirements of 7.3 in GB 50661-2011.

7.2.3.4 Tack welding shall conform to the requirements of 7.4 in GB 50661-2011.

7.2.3.5 Preheating and preheating temperature measurement shall meet the requirements of 3.5.7 in NB/T 47015-2011. The maximum preheating temperature and interpass temperature of carbon steel and low alloy steel should not exceed 300 ºC.

7.2.3.6 The selection of the run-on plates, run-off plates and backing shall conform to the requirements of 7.9 in GB 50661-2011.

7.2.4 Welding

7.2.4.1 Welders who weld important welds (including tack welds and repair welds) shall be examined in accordance with the requirements of TSG Z6002, and only after the "Special Equipment Operator Certificate" is obtained, may undertake the welding work in the scope of the qualified project within the validity period.

7.2.4.2 Welders shall carry out welding according to the welding procedure. After the important welds are welded, the weld surfaces shall be cleaned, and the welders' steel seal numbers shall be stamped on the designated positions near the welds after self-inspection. If stamping is impossible, a reliable recording method shall be offered to ensure the traceability of the welders.

7.2.4.3 Welding shall meet the requirements of 3.6 in NB/T 47015-2011.

7.2.4.4 In the welding process, the minimum interpass temperature shall not be lower than the preheating temperature; for austenitic stainless steel, the maximum interpass temperature should not be greater than 150 ℃. When the dynamic load structure required for fatigue calculation is welded, the maximum interpass temperature should not exceed 230 ℃.

7.2.4.5 The control of welding deformation shall meet the requirements of 7.11 in GB 50661-2011.

7.2.5 Welding inspection

7.2.5.1 Welding inspection and inspection contents shall cover the items described in 3.8 of NB/T 47015-2011.

7.2.5.2 Visual inspection of the welds shall be performed in accordance with the requirements for design quality grades.

7.2.6 Welding repair

7.2.6.1 For defects that need weld repair, their causes shall be analyzed, and the improvement measures shall be proposed. The documents of weld repair procedures shall be prepared according to the qualified welding procedures.

7.2.6.2 The repair weld performance and quality shall be the same as the original welds. The weld repair shall meet the requirements of 7.12 in GB 50661-2011.

7.2.6.3 The number of repairs of the same part of a weld shall not exceed 2. If more than twice, the repair plan shall be re-established before the repair.

7.2.7 Post-weld heat treatment

Post welding heat treatment shall meet the requirements of 4.6 in NB/T 47015-2011 or the design documents.

7.3 Heat treatment

7.3.1 A heat treatment quality file shall be established. The workpiece job process records, inspection records, physical and chemical test reports, and other original records shall be kept as traceability information.

7.3.2 The important shafts and pins should be quenched and tempered and meet the requirements of GB/T 699 and GB/T 3077. After quenching and tempering, non-destructive testing shall be carried out. An impact test shall be performed if necessary.

7.4 Assembling

7.4.1 General Requirements

7.4.1.1 All parts that enter the assembling, including purchased and outsourced parts, may be assembled after being accepted according to the relevant inspection procedures. Before assembling, pre-treatment shall be carried out in accordance with the relevant requirements of 5.1 in GB 50231-2009.

7.4.1.2 The processing surfaces that are fit with the seals on the assembled parts shall be protected against bumping during cleaning and assembling.

7.4.1.3 Prior to assembling, the main fit dimensions of the parts, especially the interference fit dimensions and related accuracy, shall be checked.

7.4.1.4 After assembling, an appropriate amount of lubricating oil (grease) shall be injected into each lubrication point.

7.4.2 Assembling of pins and fasteners

7.4.2.1 The bolted connection having pre-tightening requirement shall meet the requirements of 5.2.4 in GB 50231-2009.

7.4.2.2 Assembling of the high-strength bolts shall meet the requirements of 5.2 in GB 50231-2009.

7.4.2.3 For various tab washers, the tabs shall be bent after the nuts are tightened. The bolt head locking wires shall be penetrated and wrapped firmly in the revolving direction.

7.4.2.4 When the tapered pins are assembled, the smear test shall be performed on the holes; the contact rate shall be greater than 60% of the length of fit, and they shall be evenly distributed.

7.4.2.5 Assembling of bolts, keys, pins, locating pins, and other connectors should be in accordance with the requirements of 5.2 of GB 50231 - 2009.

7.4.3 Other requirements

7.4.3.1 The assembling of sliding bearings, rolling bearings, clutches, brakes, couplings, gears, chains and interference fits shall meet the relevant requirements of Chapter 5 in GB 50231-2009.

7.4.3.2 Prior to installation of pneumatic systems, the connectors, pipes, valves, and all internal channels shall be purged thoroughly with dry and clean compressed air.

7.4.3.3 Prior to installation of hydraulic systems, the inner surfaces of connectors, pipelines and tanks shall be cleaned and must be free of any dirt. The used hydraulic fluid shall be clean and free

of impurities. The tanks are well sealed. Care shall be taken to minimize (reduce) the following conditions during installation:

a) Excessive deformation of the hydraulic cylinder structure due to pushing or pulling loads;

b) Loads resulted in lateral bending;

c) The upper and lower pins of the hydraulic cylinder shall be fully lubricated.

7.5 In-plant testing

7.5.1 Each transmission component, security means that can be tested first, and component that test run can be performed independently shall be tested and commissioned first.

7.5.2 For in-plant test run, the commissioning conditions may refer to 7.10.

7.5.3 The first equipment shall be tested, recorded and judged according to the design verification test plan, and all indexes shall meet the design requirements.

7.6 Coating

7.6.1 Anti-corrosion coating shall be carried out using appropriate process materials according to different materials and different working environments.

7.6.2 Before coating, all surfaces of metal parts to be coated shall be removed from dust, scale, grease, dust and others. If the welded parts need heat treatment, the rust removal process shall be carried out after the heat treatment process. The dust removal method, grade and scope of application shall comply with the relevant requirements of JB/T 5000.12.

7.6.3 The unpainted bare steel parts and standard parts in the equipment must be treated by other anti-corrosion technology.

7.6.4 The paint films damaged during installation shall be repaired, and the surfaces shall be cleaned before repair. The color of the touch-up part and the thickness of coating shall be consistent with the surrounding color and coating thickness.

7.6.5 Coating construction requirements shall comply with the relevant requirements of JB/T 5000.12.

7.6.6 The non-machined surfaces of the castings shall be sandblasted. In case of shot blasting, the primer shall be applied within 6 hours after blasting. Before primer application, the dust on the castings shall be cleaned up.

7.7 Packaging and transportation

7.7.1 Packaging of products and their parts and components shall comply with the requirements of GB/T 13384.

7.7.2 The transportation of products shall comply with the relevant requirements for railway, highway, and sea transportation.

7.7.3 In disintegrating transportation, the long and freely movable parts shall be cushioned and tied firmly to prevent deformation, displacement and collision during transportation.

7.8 Equipment foundation and ancillary facilities

7.8.1 The manufacturer shall offer the foundation drawing of amusement device to the qualified civil engineering design agency. The design agency shall design according to regional climatic conditions, geological survey reports and other requirement and issue construction drawings.

7.8.2 The foundation drawing of amusement device shall cover foundation ground layout, trenches and embedded pipes and parts, lightning rod and earth electrodes, foundation load diagram, safety

factors, layout of ancillary facilities, parameters and external dimensions of corresponding equipment and clearance envelopes, loads of major embedded parts, and other instructions and related requirements.

7.8.3 The civil engineering foundation or building of the amusement devices shall be constructed according to the design drawings and technical documents, and the equipment shall be installed only after the relevant organizations have accepted the inspection.

7.8.4 During installation of the amusement devices, the installation reference shall be established and measurement and inspection shall be carried out according to the requirements of the design drawings and technical documents

7.8.5 Foundation engineering of other amusement devices shall comply with the requirements of GB 50010 and GB 50007.

7.8.6 The quality requirements of the foundations shall comply with the requirements of GB 50202 and GB 50204.

7.8.7 Permissible variations in dimensions and positions of the amusement device foundations should meet the requirements of Table 10.

Table 10 Permissible variations of foundations

Items		Permissible deviations (mm)
Coordinate position		20
Elevation of different planes		0.-20
External dimensions of planes		±20
External dimensions of planes on the boss		0.-20
Indentation size		+20,0
Horizontality of plane	Per meter	5
	Full length	10
Perpendicularity	Per meter	5
	Full-height	10
Built-in foundation bolt	Elevation	+20,0
	Center distance	± 2
Built-in foundation bolt hole	Position of center line	10
	Depth	+20,0
	Verticality of hole wall	10
Built-in movable foundation bolt anchor plate	Elevation	+20,0
	Position of center line	5
	Horizontality of slotted anchor plate	5
	Horizontality of anchor plate with threaded hole	2

7.8.8 The oil stains, gravels, mud and accumulated water on the foundation surfaces and in the foundation bolt holes shall be cleaned out. The threads and nuts shall be well protected, and the surfaces on which the iron cushions are placed shall be levelled.

7.8.9 Pad irons shall meet the requirements of 4.2 in GB 50231-2009.

7.8.10 The foundation bolts should not be used for bearing the transverse shearing force at the bottom. The force shall be borne by the friction between (the friction factor is 0.4) the baseplate and the concrete foundation or by the shear structure.

7.8.11 The mounting surfaces of the foundation bolts shall be higher than the surrounding ground to avoid corrosion caused by accumulated water. In case of conditional restrictions, effective anti-corrosive measures shall be taken for bolts.

7.8.12 The foundations shall not have any abnormalities such as differential settlement, cracking and loosening that affect the normal operation of the amusement devices. The foundations of mobile amusement devices shall be flat and solid and meet the equipment installation requirements.

7.8.13 The foundations that need preloading shall provide records of preloading acceptance and settlement.

7.8.14 Ancillary facilities such as rockeries and artistic modeling of amusement devices shall maintain a standard safety distance with the equipment to prevent damage to the equipment itself and passengers because of accidental falling, collapsing or dumping

7.9 Field installation

7.9.1 The installation company shall prepare an installation plan according to the design requirements and the requirements of the manufacturer. The installation plan shall include the construction organization plan, quality control requirements, installation equipment and tools, safety measures and emergency response plan, and the like.

7.9.2 The datum plane for equipment installation (such as the upper surface of the equipment base) shall have a horizontality tolerance of no more than 1/1 000.

7.9.3 After the important columns are installed and positioned, the verticality tolerance to the horizontal plane shall be not more than 1/1 000.

7.9.4 Measures shall be taken to prevent looseness of the foundation bolts shall meet the requirements of 4.1 in GB 50231-2009.

7.9.5 The allowable errors of the track gauge shall meet the following requirements: the allowable error of the guide wheel inside the track is -3 mm ~ 5 mm, and it is -5 mm ~ 3 mm when outside the track.

7.9.6 The end fixing of wire ropes shall meet the following requirements:

- The ends shall be fixed with clamping devices. The end strength (represented by efficiency) varies with the fixing method. The efficiencies of general end fixing methods shall be in accordance with the requirements of Table 8.
- When the rope clips are used for fixing, the U-bolts shall be put on from the short side of the wire rope, as shown in Figure 9.

Correct incorrect

Figure 9 Clip fixing method

- The diameter of wire ropes and the number and spacing of rope clips at the important locations shall be in accordance with those specified in Table 11.

Table 11 Number and spacing of rope clips

Diameter of wire rope / mm	Number of clips / p.c.	Spacing of clips / mm
<9	3	50

9~16	4	80~100
18	5	110
22	5	130
24	5	150
28	5	180
32	6	200
36	7	230
38	8	250

7.9.7 After installation is completed, check that the static data meet the requirements according to the drawings and related documents.

7.10 Field commissioning and test run

7.10.1 Prior to equipment commissioning and test run, the following conditions shall be met:

a) Construction of all equipment, and its auxiliary devices, pipelines and others shall be completed, and the construction records and documentation shall be complete;

b) Test conditions and operating environment meet the requirements;

c) Necessary power, supporting facilities, testing apparatus, security protection facilities and appliances are possessed;

d) The commissioning program and test run plan are developed in accordance with the design requirements;

e) Personnel participating in commissioning and test run shall be familiar with the structure, performance, technical documents of the equipment, understand the technical requirements for equipment commissioning, and master the operating procedures and test run operations.

7.10.2 Before power-on and commissioning the following checks should be carried out: connections of all driving parts and fasteners shall be firm, lubrication and sealing shall be favorable, the phase-to-phase resistance and insulation resistance of each main circuit shall meet the requirements, and other objects inside the equipment and on site have been removed.

7.10.3 Direct the on-site commissioning and record the commissioning results according to the commissioning program. Commissioning shall include the following contents and steps:

a) Inspection and commissioning of electrical (apparatus) control systems and instruments ;

b) The electrical inspection shall meet the requirements of Chapter 18 in GB 5226.1-2008;

c) Inspection and commissioning of lubrication, hydraulic, pneumatic, cooling and heating systems;

d) Joint commissioning of machinery and systems;

e) Commissioning of hydraulic systems shall meet the requirements of 7.4 in GB/T 50231-2009.

7.10.4 The important commissioning contents shall include but are not limited to: safety restraint device inspection, insulation test, current and voltage test, grounding test, safety interlock device, proper limit switch adjustment, emergency stop, power supply failure, emergency dispatching test.

7.10.5 The test run shall be carried out according to the test run plan after equipment commissioning is accepted.

7.10.6 Carry out no-load, full load and bias load tests, and make actual testing records:

a) Equipment startup, reversing, stoping, braking and safety interlocking and other actions shall be correct, sensitive and reliable;

b) The complete machine shall be in normal operation, and there should be no creeping or abnormal vibration, shock, heating and sound;

c) Each driving part shall be stable and have no abnormal vibration, drifting, shock, noise, permanent deformation and wear. The temperature rise of the bearing and the oil temperature of the tank must not exceed the specified maximum temperature of the equipment; when driven by the gears and racks, the percentage of contact patterns shall be: Not less than 40% in the tooth height direction and not less than 50% in the tooth length direction. There should be no partial meshing or partial wear;

d) The temperature rise of the rolling bearing end cover is not more than 30 ℃; the maximum temperature is not more than 65 ℃. The temperature rise of the sliding bearing oil hole is not more than 35 ℃, and the maximum temperature is not more than 70 ℃.

e) All instruments shall work normally;

f) The lubrication, hydraulic, pneumatic and other auxiliary systems shall work normally and have no leakage;

g) Parts and their connections shall be firm and reliable, and permanent deformation and damage shall not be permitted;

h) When measuring the accelerations, a 5 Hz low-pass high-frequency filter (the minimum boundary slope is at least 6 dB/octave) shall be used.

7.11 Non-destructive testing;

7.11.1 Non-destructive testing personnel

Non-destructive testing personnel shall, in accordance with the relevant technical specifications, obtain the corresponding qualification certificates before they can undertake the non-destructive testing work corresponding to the type and technical grade of the qualification certificates.

7.11.2 Non-destructive testing methods

7.11.2.1 Non-destructive testing methods for amusement devices include visual, magnetic particle, penetrant, ultrasonic, radiographic, eddy current, acoustic emission, magnetic flux leakage, infrared testing and others.

7.11.2.2 The non-destructive testing procedures shall be prepared in accordance with the requirements of the design drawings and GB/T 34370 (all parts).

7.11.3 Method selection

7.11.3.1 The testing method for welded joints shall be selected according to the type, shape, size and material of the welded joints. The testing methods, proportions and qualified levels of the raw materials and parts shall comply with the design drawings and the requirements of GB/T 34370 (all parts).

7.11.3.2 For butt joints, radiographic or ultrasonic testing shall apply. Radiographic testing includes film radiographic testing and digital radiographic testing; ultrasonic testing includes recordable ultrasonic testing (phased array ultrasonic, recordable pulse reflection, etc.) and non-recordable pulse-echo based ultrasonic testing. When non-recordable pulse-echo based ultrasonic testing is used, radiographic testing or recordable ultrasonic testing shall also be used as an additional local testing.

7.11.3.3 For welded joint surface of ferromagnetic parts, magnetic particle testing is preferred.

7.11.4 Timing

7.11.4.1 Non-destructive testing of welded joints of the amusement devices shall be carried out after shape and size inspection and visual inspection are accepted.

7.11.4.2 Materials with a tendency for delayed cracking shall be non-destructively tested at least 24 h after the completion of welding. Materials with a tendency for reheat cracking shall be subjected to an additional non-destructive testing after heat treatment.

7.11.5 Visual testing

Visual testing shall be performed before other non-destructive tests. For other non-destructive testing, the testing areas and proportions shall be corrected according to the result of visual testing.

7.11.6 **Ultrasonic and radiographic testing**

7.11.6.1 Ultrasonic testing shall be carried out in accordance with the requirements of GB/T 34370.5. The quality requirements and qualified levels are as follows:

a) For butt joints requiring full non-destructive testing, the technical grade for pulse-echo based ultrasonic testing is not lower than Grade B, and the qualified level is Level I;
b) For butt joints requiring local non-destructive testing, the technical grade for pulse-echo based ultrasonic testing is not lower than Grade B, and the qualified level is Level II;
c) For butt welds of the fillet joints and tee joints, the technical grade for pulse-echo based ultrasonic testing is not lower than Grade B, and the qualified level is Level II;
d) For welded joints tested by time of flight diffraction technique and phased array ultrasonic testing, the qualified level is not lower than Level II;
e) For parts and components, the technical grade for pulse-echo based ultrasonic testing is not lower than Grade B, and the qualified level is Level II.

7.11.6.2 Radiographic testing shall be carried out in accordance with the requirements of GB/T 34370.6. The quality requirements and qualified levels are as follows:

a) For butt joints requiring full non-destructive testing, the technical grade for radiographic testing is not lower than Grade B, and the qualified level is Level II;
b) For butt joints requiring local non-destructive testing, the technical grade for radiographic testing is not lower than Grade B, the qualified level is Level III, and the planar defect is not permitted.

7.11.7 Surface testing

Surface testing shall be carried out in accordance with the requirements of GB/T 34370.3 and GB/T 34370.4. The quality requirements and qualified levels are as follows:

a) For magnetic particle or penetrant testing, the qualified level is Level I;
b) For eddy current testing, the qualified level shall be determined according to the design drawings or the equivalent size agreed by the owner;
c) If having a coat of painting, magnetic particle testing shall be implemented by professionals who have demonstrated appropriate testing capabilities.

7.11.8 Other testing methods

Acoustic emission, magnetic memory, eddy current, guided wave, magnetic flux leakage, and other testing shall comply with the relevant national standards.

7.11.9 Combined testing

When a combination of multiple testing techniques is used for testing, the quality requirements and qualified levels are determined according to their executive standards that and shall be accepted.

7.11.10 Technical documents

The testing organization shall fill in the non-destructive testing record and issue a non-destructive testing report. The manufacturer shall properly keep the testing data (including the defect repair records) such as radiograph, recordable ultrasonic and eddy current data, establish a non-destructive test file of the amusement devices, and save it until the equipment is discarded.

7.12 Inspection

7.12.1General

The manufacturing and installation of the amusement devices shall be inspected in accordance with the requirements of relevant laws, regulations, standards and technical documents. The inspection activities shall retain the inspection data, and the inspection data shall fully support whether the inspection objects meet the requirements and shall be traceable.

7.12.2 Manufacturing inspection

7.12.2.1 The incoming raw materials shall be inspected and qualified by the inspection department before being warehoused or put into use. Important materials shall have quality certification documents and mechanical properties and physical and chemical testing shall be carried out when necessary.

7.12.2.2 The thickness tolerances of important structural steel plates and their finished products shall be in accordance with the requirements of Table 2 (Class A) of GB/T 709-2006.

7.12.2.3 The supporting standard electromechanical products shall be checked for appearance, dimensions and technical parameters, and shall have quality certification documents, operation and maintenance instructions and the like; when necessary, their performance shall be verified and tested.

7.12.2.4 The processing and assembling of important parts shall be carried out in strict accordance with the process documentation. Before entering the next process, inspection shall be carried out in accordance with relevant standards and regulations, including self-inspection, mutual inspection and special inspection.

7.12.2.5 Important welds shall be inspected before entering the next process and may continue to be processed. For important concealed welds, the inspection points shall be established before concealment, and they shall be inspected and accepted by the inspection department and confirmed by the quality assurance engineer before entering the subsequent process.

7.12.2.6 Important shafts and welds relating to personal safety shall be subjected to non-destructive testing and may be put into use if qualified. Other parts shall also be inspected according to the technical requirements of the drawings and relevant standards.

7.12.2.7 Before leaving the factory, each product shall be inspected in accordance with the design drawings, technical documents, relevant standards.

7.12.3 Design verification test

7.12.3.1 For newly developed amusement devices, the manufacturer shall conduct a design verification test to verify whether the sample machine meets the requirements for expected functionality, safety, reliability, durability and others. The design verification test shall include the subtests for components and overall performance test.

7.12.3.2 In design verification test, the test load shall be applied under the conditions of the maximum load and maximum operating parameters specified in the design documents.

7.12.4 Installation self-inspection

7.12.4.1 During installation of the complete machine, the manufacturing and installation

organizations shall perform inspection and make records in accordance with the relevant regulations, standards and technical documents.

7.12.4.2 The self-inspection items and amount of inspection of the manufacturing and installation organizations shall not be less than the statutory supervision and inspection items. Inspection shall be focused on various security means, major shafts and critical welds, insulation and grounding systems, control systems, emergency rescue systems, safety protection and safety distance.

7.12.4.3 The nonconformities in self-inspection of the manufacturing and installation organizations shall be rectified, and the quality certification for installation qualification may be issued after acceptance of re-inspection.

8 Operation management and maintenance

8.1 Safe operation management system of amusement part and responsibilities

8.1.1 Requirements for operation companies

The operation company of the amusement devices shall establish a sound and complete safety management system, set up a safety management department, arrange full-time safety management personnel, and implement various safety management systems and post safety responsibility systems. Based on different features of each equipment and operation and maintenance instructions, the operating procedures and maintenance manuals are prepared.

8.1.2 Requirements for operation companies

The legal representative of the operation company of the amusement devices and the person in charge of each relevant department shall perform their duties in accordance with laws and regulations, national standards and the requirements of the safety management system of their company; safety management personnel and related operators shall obtain the qualifications, and all related staff of the amusement devices shall begin work after being trained by the user and do their duties in accordance with laws and regulations, national standards and the requirements of the safety management system of their company.

8.2 Requirements for passengers

Before going on rides, the staff should remind the passengers to read carefully and consciously abide by the passenger notice and warning signs. Passengers are obliged to follow the instructions of the working and service personnel, do not damage the facilities and act against the safety of themselves and others.

8.3 Jobs and behaviors

8.3.1 Registration by law

The operation company of the amusement devices shall complete preparation of the safety management system, establishment of safety management organization, filing of technical documents of the equipment and other jobs, and go through the registration in the local safety supervision and administration agency for amusement devices according to law.

8.3.2 Training evaluation

The user shall conduct regular on-the-job training and safety education for the operation, management and maintenance personnel, and they can go on duty after passing the examination. The user shall organize evaluation on safety training of the staff periodically. Before training, the

user shall develop a training plan which sets the scope of training personnel and clarifies the training target; in the training process, the employees shall abide by the training discipline and carefully study the training contents; after training, the user shall examine and record the training contents, evaluate the training effect, and propose the improvement measures.

8.3.3 Operation

8.3.3.1 Amusement devices shall be operated in accordance with the regulations. Before the equipment operates every day, operators shall confirm the operating conditions and perform trial operation, and check the safety protection devices; during operation, operators shall strictly follow the operation rules and pay close attention to passenger trends and equipment operation status; after end of operation, operators shall record the operation of the equipment and prepare for next operation. In the early, middle and last stages of operation, the amusement devices shall stop operation in case of any unusual condition and may start new operation after the potential risks are eliminated.

8.3.3.2 The user shall carry out the necessary inspections of various amusement devices before daily operation. Formal operation can be initiated after no problem and test run. Operation records shall be made.

8.3.3.3 Passenger notices shall be published at the obvious point of amusement device. Operation and service personnel shall always disclose the precautions to passengers and stop the dangerous behavior of passengers.

8.3.3.4 For amusement devices that are not exclusively used for children, the user shall specify the age and height of the riding children based on the equipment features.

8.3.3.5 Before each operation of the amusement devices, operators shall confirm that the passenger restraints have been locked, and the operation and service personnel have evacuated to the safe area. There are no other personnel and obstacles in the equipment operation area.

8.3.3.6 Operators, platform service personnel and others must not enter the equipment operation area during operation of the equipment and before the equipment becomes standstill, except for special circumstances (maintenance, emergency rescue, etc.).

8.3.4 Check and inspection

8.3.4.1 The user shall establish a self-inspection working instruction in accordance with the equipment operation and maintenance instructions and relevant laws and regulations and standards.

8.3.4.2 Inspection methods for amusement devices include: spot inspection and tour inspection. During spot inspection, inspectors shall, according to the specified method and frequency, measure the checkpoints using the instruments and record the inspection data, and obtain the result according to the criterion; during tour inspection, inspectors shall judge the operating status of amusement devices by sensing or visual inspection and record the result of tour inspection.

8.3.4.3 Types of amusement device inspection include: regular safety inspection (daily, weekly, monthly, annual) and safety inspection before major holidays or major activities. Prior to regular safety inspection, inspectors shall prepare testing instruments, tooling equipment, and safety protective equipment; during inspection, inspectors shall strictly follow the working instructions for safe operation; after inspection, inspectors shall record the inspection results and timely report the hidden dangers to the safety manager for handling. For safety inspection before major holidays or major activities, the user may appropriately increase items according to the results of regular safety inspection.

8.3.4.4 Inspection of tracks, wheels and shafts of the amusement devices shall meet the requirements of Tables 12 to 14. Replacement shall be made in time if the allowable values are exceeded.

Table 12 Allowable values of track wear

Track shape	Wearing part	Allowable Values
Section steel track	Tread, side	Less than 20% of the original thickness
Steel pipe track		Less than 15% of the original thickness

Table 13 Allowable values of coaster wheel

Category	Allowable Values
Main wheel	Less than 2.5% of the original diameter and not more than 6 mm
Guide wheel and up wheel	Less than 2.5% of the original diameter and not more than 4 mm

Table 14 Allowable values of major shaft wear and rust

Category	Allowable Values
Shaft wear in diameter	Less than 0.8% of the original diameter and not more than 1 mm
Shaft rust	After polishing, less than 1% of the original diameter (including the pit) and not more than 1 mm

8.3.4.5 The wire ropes for transmission and lifting shall be discarded if either of the following conditions exists:

a) Wire break of wire ropes for driving and lifting, and wear in excess of allowable values (see Table 15);

b) Fracture of a complete strand;

c) Fiber core or wire (inner strand of the multi-strand) break results in significant decrease of strands

d) Deep pits on the rope surface caused due to external corrosion, considerable relaxation of wire ropes;

e) Severe internal corrosion;

f) Occurrence of basket deformation;

g) Extrusion of wire rope strand, usually accompanied by basket deformation;

h) Serious increase or decrease in local diameter;

i) Local bend, kink or flattening;

j) Appearance of identifiable color on the outer surface due to the effect of special heat;

k) Excess of useful life specified in the design and related technical procedures

Table 15 Wire break of rope and allowable values of wear

Wear condition	Allowable Values
Wire break is evenly distributed	The number of broken wires per strand in a lay length is 3
Although wire break is evenly distributed, the residual sectional area after wire wear is less than 80% of the original area or severe corrosion	The number of broken wires per strand in a lay length is 2
Wire is broken at one point or concentrated in one strand	The total number of broken wires in a lay length is 10 per 6 strands or 12 per 8 strands
Diameter of worn wire rope	More than 90% of the original diameter of wire rope

8.3.4.6 If necessary, condition monitoring and fault diagnosis techniques may be used to perform monitoring and fault early warning of operating status of the important equipment or components.

8.3.5 Monitoring and measuring equipment management

The user of the amusement devices shall equip a certain number of monitoring and measuring equipment according to the demands for routine maintenance, troubleshooting, and operation safety monitoring to meet the requirements for daily operation safety management of the amusement devices. The user shall perform regular verification and calibration of the monitoring and measuring equipment to ensure the reliability and accuracy of various test values so that the operation status of overall equipment and components may be reflected effectively.

8.3.6 Documents management

Technical documents shall be established for amusement devices. The user shall define the contents of the documents according to laws and regulations and national standards and comprehensively manage collection, creation, filing, sorting, borrow approval, keeping and other matter of the documents.

8.3.7 Life extension and discard

For amusement devices that still have repair and reconstruction value beyond the design life of the complete machine, the user shall, entrust by law the relevant organizations to carry out safety assessment according to the requirements of this standard, confirm the work required for the life extension of the equipment (including: maintenance, repair, reconstruction) and put it into effect, and validate the time limit and conditions for the continued use of the amusement devices. The user shall re-develop the requirements for regular inspection and maintenance, increase the frequency of full self-inspection, and strengthen the safety management of the equipment with an extended life in accordance with laws and regulations, national standards, equipment maintenance and maintenance instructions, and opinions of evaluating organs.

8.4 Emergency rescue

The operation company of the amusement devices shall develop an emergency response plan in accordance with laws and regulations, national standards, and equipment maintenance and maintenance instructions, and organize at least one emergency rescue drill every year. The company shall establish an emergency response center to allocate the rescuers, rescue equipment and first-aid items. Rescuers shall be trained to master emergency handling, rescue knowledge and practical operation methods. Rescue equipment shall be in good and available condition.

8.5 Maintenance, repair and reconstruction

8.5.1 Maintenance

8.5.1.1 For maintenance of the amusement devices, a plan shall be developed according to the requirements of the operation and maintenance instructions, and operators shall strictly follow the plan, implement maintenance in conjunction with the equipment safety inspection, and make truthful records.

8.5.1.2 The management of spare parts for amusement devices shall comply with the requirements of the system. The purchased spare parts shall have quality certificates. Operators shall mark the replaced spare parts and monitor them as regular safety inspection items.

8.5.2 Repair and reconstruction

Repair and reconstruction of the amusement devices shall be carried out by the qualified organization. Before repair and reconstruction, the user shall cooperate the organization in charge of repair and reconstruction to submit the local safety supervision and administration agency for amusement device an notification; during repair and reconstruction, the user shall provide the tooling, safety protection measures and other conditions and designate special personnel to do on-site safety work; after repair and reconstruction, the user shall file the documents such as transferred equipment self-inspection reports, supervision and inspection reports, non-destructive testing reports.

8.6 Regular inspection according to law

Regular inspection shall be annually performed on the amusement devices according to law. Prior to inspection, the user shall make a regular inspection plan in accordance with the safety management system, apply on time, and complete full self-inspection of the equipment; during inspection, the user shall provide the inspection conditions, take safety protection measures, and designate a special person to do the coordination work; after inspection, the user shall eliminate the hidden dangers found during inspection in time.

Annex A

(Informative)

Catalogue of national and industry standards for common sheet products

A.1 National and industry standards for common steel products such as Table A.1.

Table A.1 National and industry standards for common sheet products

Standard code	Standard name
GB/T 708	Dimension, Shape, Weight, and Tolerance for Cold-Rolled Steel Plat
GB/T 709	Dimensions, shape, weight and tolerances for hot rolled steel sheets and strips
GB/T 2518	Continuously hot-dip zinc-coated steel sheet and strip
GB/T 3280	Cold rolled stainless steel plate，sheet and strip
GB/T 4237	Hot rolled stainless steel plate,sheet and strip
GB/T 4238	Heat-resting Steel Plate, Sheet and Strip
YB/T 4159	Hot Rolling Checker Plate and Strip

A.2 National and industry standards for common pipe materials such as Table A.2.

Table A.2 National and industry standards for pipe materials

Standard code	Standard name
GB/T 3091	Welded steel pipe for low pressure service
GB/T 3094	Cold-Drawn Shaped Steel Tubes
GB/T 3639	Cold-drawn or cold-rolled precision seamless steel tubes
GB/T 8162	Seamless steel tubes for structural purposes
GB/T 8163	Seamless steel tubes for liquid service
GB/T 12771	Welded stainless steel pipes for liquid delivery
GB/T 13793	Straight seam welded steel pipe
GB/T 14975	Seamless stainless steel tubes for structure
GB/T 14976	Seamless stainless steel pipes for fluid transport
GB/T 17395	Dimensions, shapes, masses and tolerances of seamless steel tubes
Electric-welded steel tubes for cardan shaft	Electric-welded steel tubes for cardan shaft

A.3 National and industry standards for common bars such as Table A.3.

Table A.3 National and industry standards for bars

Standard code	Standard name
GB/T 702	Hot-rolled steel bars - Dimensions, shape, weight and tolerances

A.4 National and industry standards for common forgings such as Table A.4.

Table A.4 National and industry standards for forgings

Standard code	Standard name

GB/T 17107	Structural Steel Grades and Mechanical Property for Forgings
GB/T 6398	Heavy stainless acid resistant and heat resistant steel forings

A.5 National and industry standards for common cast steel products such as Table A.5.

Table A.5 National and industry standards for cast steel products

Standard code	Standard name
GB/T 2100	Corrosion-resistant steel castings for general applications
GB/T 7659	Steel casting suitable for welded structure
GB/T 8492	Heat-resistant steel and alloy castings for general applications
GB/T 11352	Carbon steel castings for general engineering purpose
GB/T 14408	Low alloy steel castings for general engineering and structural purposes
GB/T 6402	Heavy Low Alloy Steel Castings

A.6 National and industry standards for common cast iron products such as Table A.6.

Table A.6 National and industry standards for cast iron products

Standard code	Standard name
GB/T 9437	Heat resistant iron castings
GB/T 9439	Grey iron castings
GB/T 8491	Corrosion resistant high silicon iron castings

A.7 National and industry standards of chemical composition and mechanical performance for common steel products such as Table A.7.

Table A.7 National and industry standards of chemical composition and mechanical performance for common steel products

Standard code	Standard name
GB/T 699	Quality carbon structure steel
GB/T 700	Carbon structural steels
GB/T 1591	High strength low alloy structural steels
GB/T 3077	Alloy Structure Steels
GB/T 1220	Stainless steel bars
GB/T 1221	Heat-resistant steel bars

A.8 National and industry standards for common profile products such as Table A.8.

Table A.8 National and industry standards for profile products

Standard code	Standard name
GB/T 706	Hot rolled section steel
GB/T 6723	Cold forming sectional steel; Open sectional steel for general structure; Damnation, form, weight and permissible deviations
GB/T 6728	Cold Formed Steel Hollow Sections for General Structure - Dimensi
GB/T 11263	The hot-rolled H and cut T section

Annex B

(Normative)

Requirements for mechanical properties of non-metallic materials

B.1 The required mechanical properties of the nylon materials refer to Table B.1.

Table B.1 The mechanical properties of the nylon materials

Items	Index
Tensile strenght /MPa	>73.6
Bending strength /MPa	>138
Impact toughness/(J • cm^{-2})	>39.2
Hardness/HB	>21
Heat distortion temperature/T	>70

B.2 The required mechanical properties of the rubber materials refer to Table B.2.

Table B.2 The mechanical properties of the rubber materials

Items	Index
Tensile strenght /MPa	≥12
Elongation at break	≥400
Wear reduction/[cm^3 • (1.61 km)$^{-1}$]	≤0.9
Rubber and core adhesion strength/MPa	≥1.30
Shore hardness (recommended value)/HA	70~85

Table B.3 Mechanical properties of polyurethane materials

Shore hardness HA	300% tensile strength MPa	Breaking strength MPa	Elongation at break %	Permanent deformation %	Peeling Strength N/m
80 ± 5	≥10	≥35	≥450	≤15	$40X10^3$
90 ± 5	≥12	≥40	≥450	≤20	$50X10^3$
≥95	≥14	≥45	≥400	≤30	$60X10^3$

B.4 The required mechanical properties of the casting type industrial organic glass plates refer to Table B.4

Table B.4 The mechanical properties of the casting type industrial organic glass plates

S.N	Items	Index	
		Colorless	Colored
1	Tensile strength / MPa	≥70	≥65
2	Tensile strain at break / %	≥3	—
3	Tensile modulus of elasticity / MPa	≥3 000	—
4	Charpy impact strength unnotched /(kJ/m^2)	≥17	≥15

5	Vicat Softening Temperature /℃		≥100	—
6	Dimensional change on heating (shrinkage) /%		≤2.5	—
7	Total luminous transmittance /%		≥91	—
8	420 nm luminous transmittance (3 mm thick) /%	Before being illuminated by a xenon arc lamp	≥90	—
		After being illuminated by a xenon arc lamp for 1 000 h	≥88	—

B.5 B.4 The required mechanical properties of the FRP parts refer to Table B.5.

Table B.5 The mechanical properties of FRP parts

Items	Index
Tensile strenght/MPa	≥78
Bending strength/MPa	≥147
Elastic modulus/MPa	≥7.3 X10^3
Impact strength/(J • cm^{-2})	≥11.7

Annex C

(Normative)

Requirements for performance rating of common bolts and nuts

C.1 The maximum permissible pretension and tightening torque of the bolt refer to Table C.1.

Table C.1 The maximum permissible pretension and tightening torque of the bolt

Bolt size	Permissible pretension /kN			Permissible tightening torque / Nm		
	6.8	8.8	10.9	6.8	8.8	10.9
M8	14	16	23	21	25	35
M10	22	26	37	41	49	69
M12	31	37	50	70	84	120
Ml6	60	71	100	176	206	350
M20	94	111	160	338	402	600
M22	116	138	190	456	539	900
M24	135	160	220	588	696	1 100
M27	177	210	290	873	1 030	1 650
M30	216	257	350	1 177	1 422	2 200
M33	275	326	459	1 668	1 977	2 784
M36	323	382	510	2 134	2 524	3 340

C.2 The maximum permissible pretension of the high-strength bolt refers to Table C.2.

Table C.2 The maximum permissible pretension of the high-strength bolt

Performance rating	Nominal diameter /mm					
	M16	M20	M22	M24	M27	M30
Grade 8.8	80	125	150	175	230	280
Grade 10.9	100	155	190	225	290	355

C.3 The tightening torque coefficient refers to Table C.3.

Table C.3 The tightening torque coefficient

Friction surface condition		Finished	General	Surface	Galvanization	Drying rough
k value	Lubricated	0.10	0.13~0.15	0.20	0.18	—
	Non-lubricated	0.12	0.18~0.21	0.24	0.22	0.26~0.30

Appendix D

(Informative Appendix)

Examples of load combinations

When the equipment is in normal operation, the following load combinations shall be considered for strength, stiffness and fatigue calculation of the parts:

a) For moving parts:

$$P_1 = \sum k_1 (G_{k1} + Q_1 + Q_7) + Q_2 + Q_5 + Q_6 + Q_8 + Q_9$$

b) For stationary parts:

$$P_1 = \sum k_1 (G_{k1} + Q_1 + Q_7) + G_{k2} + Q_2 + Q_5 + Q_6 + Q_8 + Q_9$$

c) For track structure:Where:

$$P_1 = \sum k_1 k_2 (G_{k1} + Q_1 + Q_7) + Gk_3 + Q_2 + Q_5 + Q_6 + Q_8 + Q_9$$

Where:

P_1 - Load after combination;

G_{kl} - Permanent load of the moving part;

G_{k2} - Permanent load of the stationary part;

G_{k3} - Weight of the column;

Q_1，Q_2，Q_5 ∽Q_8 —— see 6.1.2;

Q_9 - Wind load (wind speed ≤15 m/s);

k_1 ——impact factor;

k_2 ——vibration factor.

Annex E

(Informative)

Limit state design method

E.1 General Provisions

The limit state design method is a method based on probability theory and expressed by partial coefficients, which does not make the structure exceed a certain limit state. The so-called limit state refers to a specific state in which the entire structure or its component lies; if beyond this state, the entire structure or its component no longer fulfils a certain design function.

For design of the structure, its different limit states shall be calculated respectively; when calculation or checking computation of a certain limit state plays a control role, only the limit state can be calculated.

This Annex is only applicable to the analysis of the static strength limit state of the load bearing structure for the amusement device. Other calculations shall be carried out in accordance with the text of this standard.

E.2 Materials

This Annex is only applicable to Q345, 20#, 45#, 40Cr, Q390 steels for amusement devices, of which the mechanical properties of Q345, 20#, 45#, 40Cr materials shall meet the requirements of relevant national standards, and that of Q390 shall meet the requirements of GB/T 1591.

E.3 Loads

E.3.1 Load types

The load types and values of the amusement devices shall be in accordance with 6.2.1.

E.3.2 Load combinations

E.3.2.1 Principle

The static strength limit state analysis of the amusement device load-bearing structure shall adopt the fundamental combination and accidental combination and corresponding partial coefficients of loads.

E.3.2.2 Fundamental combination

The load design value shall take into account both combinations given in Equations (E.1) and (E.2):

$$F_j = \sum \gamma_G G_k \ (= \sum 1.35\, G_k) \qquad \cdots\cdots (E.1)$$

$$F_j = \sum \gamma_G G_k + \sum \gamma_Q Q_i \ (= \sum 1.1\, G_k + \sum 1.35\, Q_i) \qquad \cdots\cdots (E.2)$$

Where:

F_j - Combined load;

γ_G - Partial coefficient of the permanent load, which is not less than 1.35 in Equation (E.1) and 1.1 in Equation (E.2);

γ_Q - Partial coefficient of the variable load, which is not less than 1.35;

G_k - Standard value of the permanent load;

Q_i - Standard value of the ith variable load.

For a structure or component of the amusement device that may be subjected to an impact

load during operation, the impact factors shall be considered before combination of the borne loads in accordance with the requirements of 6.1.2.15.1, 6.1.2.15.2 and 6.1.2.15.4; for track structure and its connections, the coefficient of vibration shall also be taken into account before combination of the borne loads. The coefficient of vibration shall be attached to the impact factor.

E.3.2.3 Accidental combination

For amusement devices on the large, high-rise structures and buildings, accidental combination given in Equation (E.3) shall be considered:

$$F_i = 1.0G_k + T + \sum 1.0Q_i \qquad \text{(E.3)}$$

Where:

T – Standard value of the earthquake load

Note: Both symbols "Σ" and "+" in the load combinations indicate a combination, that is, to consider the common influence of all loads on the structure but not represent the algebraic addition.

E.4 Design

E.4.1 Principle

The design shall calculate the load-bearing limit state that may result from the combination of loads, check the load effect in the structure or member that will not exceed the corresponding design resistance of the structure or member. If necessary, the structure or component deformation shall also be verified to prevent excessive deformation of the structure or component that is unsuitable for continued bearing.

All checks shall be directed at the most unfavourable load condition. The values and points of the permanent, variable, accidental and dynamic loads shall be assumed to result in the most unfavorable limit state of the structure or component. For structures or components, it shall be determined whether non-permanent fixing facilities or equipment are replaced or removed will cause a more unfavourable state.

When the finite element method is used for the design calculation of the limit state method, the important design input and output data should be complete. The design file shall at least provide the related information such as software name, system of units for calculation, simplifying assumption, structural model, element type, grid scale and quantity, material model, load and constraint, key solution settings, calculation results, analysis conclusion.

E.4.2 Design expression

When the structure or member is designed in the static strength limit state, the requirements of Formula (E.4) shall be met:Where:

$$\gamma_0 S_d \leqslant R_d \qquad \text{(E.4)}$$

Where:

γ_0 - Importance factor for the structure or member, which is not less than 1.5 for important shafts, pins, Class I and II welds and 1.0 for general structure or members;

S_d - Effect of load combination, the generalized load effect includes the stress, strain, deflection, rotation angle, internal force, moment or other limit state control value of the structure and member; refer to stress in this Annex;

R_d - Design value of resistance of the structure or member, selected according to F.4.3.

E.4.3 Design value of resistance

The design value of resistance of the structure or member shall meet the requirements of Formulae (E.5) and (E.6):Where:

$$R_d \leqslant \sigma_s / \gamma_{Ms} \quad \cdots\cdots (E.5)$$

$$R_d \leqslant \sigma_b / \gamma_{Mb} \quad \cdots\cdots (E.6)$$

Where:

γ_{Ms} - Partial safety factor for resistance of the yield strength of the material, which is not less than 1.2;

γ_{Mb} - Partial safety factor for resistance of the tensile strength of the material, which is not less than 2.2;

R_d - Design value of resistance of the structure or member;

σ_a - Lower limit specified in the standard for yield strength of materials;

σ_b - Lower limit specified in the standard for tensile strength of materials

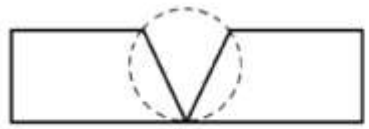
The design values of resistance of the structure or member determined in two formulae shall apply, whichever is less. For shear stresses generated by lateral forces and torques, the design resistance value R_d of the structure or member shall be multiplied by a factor of a = 0.58.

Appendix F

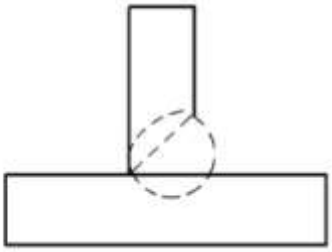
(Informative)

Form of welded joints

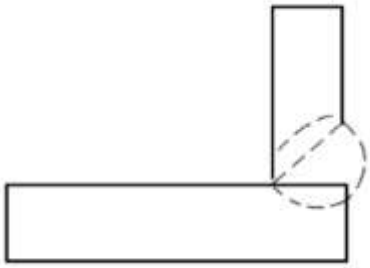
F.1 The relationship between butt welds, fillet welds and welded joints is shown in Figure F.1.



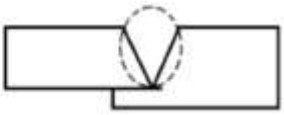
a) Butt joint – Butt weld



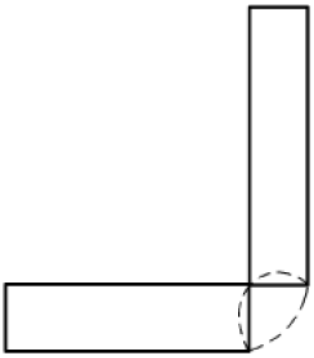
b) Tee joint – Butt weld



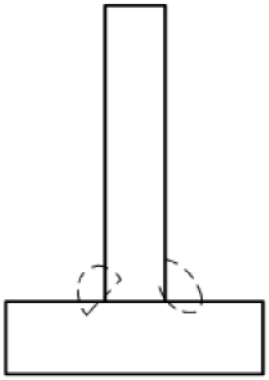
c) Fillet joint – Butt weld



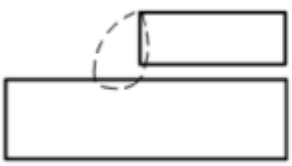
d) Lock joint – Butt weld



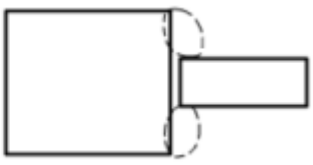
e) Fillet joint – Fillet weld



f) Tee joint – Fillet weld



g) Lapped joint – Fillet weld



h) Butt joint – Fillet weld

Figure F.1 Butt welds, fillet welds and form of welded joints

F.2 The composite welds of the Tee joints are shown in Figure F.2.

a) Combination of butt and fillet welds (complete penetration of cross sections)

b) Combination of butt and fillet welds (incomplete penetration of cross sections)

Figure F.2 Composite welds of the Tee joints