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Risk Assessment for Amusement Ride - Hazard

游乐设施风险评价 危险源

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Risk Assessment for Amusement Ride - Hazard

1 Scope

This document specifies the basic principle for the identification of hazards of amusement ride and provides the main factors that generate hazards and commonly seen hazards, including equipment hazards, personnel hazards, environmental hazards and other hazards.

This Standard is applicable to the identification of hazards of amusement ride.

2 Normative References

The following documents are indispensable to the application of this document. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB 8408 Large-scale Amusement Device Safety Code

GB/T 20306 Amusement Devices Terminology

GB/T 34371 Risk Assessment for Amusement Ride - General Principles

3 Terms and Definitions

What is defined in GB/T 20306 and GB/T 34371, and the following terms and definitions are applicable to this document.

3.1 safety

A state free from unacceptable risks.

[GB/T 20002.4-2015, Definition 3.14]

3.2 hazard

A potential source of injury.

[GB/T 20002.4-2015, Definition 3.2]

3.3 damage

An irreversible process, in which, the performance of components gradually deteriorates due to various reasons, until failure.

b) The stroke of the safety lever cannot be adjusted;

c) The safety lever has insufficient strength, and may deform or crack;

d) Corrosion of the safety lever;

e) Wear of the safety lever;

f) When the automatic control of the safety lever fails, it cannot be manually opened;

g) The locking force of the safety lever is insufficient or the locking fails, and may be opened while the equipment is operating;

h) The locking device of the safety lever may be opened by passengers themselves;

i) When the safety lever is in a compressed state, the end movement is too large;

j) The safety lever closing detection sensor manifests a failure or fault, and the interlocking function fails.

6.1.4 Hazards of safety stop lever

The manifestations of the hazards of the safety stop lever include, but are not limited to the following aspects:

a) The safety stop lever has insufficient strength, and may deform or crack;

b) Corrosion of the safety stop lever;

c) Wear of the safety stop lever;

d) The structural type of the safety stop lever is unreasonable, causing the impossibility of effective restraint of passengers;

e) The locking mode of the safety stop lever is unreasonable, and passengers can open it by themselves while the equipment is operating.

6.2 Hazards of Safety Protection Devices

6.2.1 Hazards of braking device

The manifestations of the hazards of the braking device include, but are not limited to the following aspects:

a) The braking mode and structural type selection of the braking device are unreasonable;

b) After the power is cut off, the equipment whose shutdown process takes a relatively long time or requires precise positioning is not equipped with a reliable braking device;

c) The braking performance of the braking device decreases, resulting in the braking

distance being too long;

d) The braking device generates excessive impact when braking, causing obvious vibration, shaking or damage to the structure;

e) The braking of the braking device fails, causing the equipment to fail to safely stop.

6.2.2 Hazards of limiting device

The manifestations of the hazards of the limiting device include, but are not limited to the following aspects:

a) When the end point of the stroke of the hydraulic cylinder or air cylinder of the amusement ride, the lifting arm rotating around the fixed shaft, the components swinging around the fixed shaft, and the end position of the stroke, etc. exceed the pre-determined position and may lead to hazards, no corresponding limiting device is set;

b) Sensor failure leads to limit failure;

c) Logic program error or control system fault leads to limit failure;

d) The passenger-riding part may appear in a stationary state (dead point) at the highest point, and no measures of preventing or dealing with this state have been considered;

e) The arrangement of proximity switches and stroke switches is unreasonable, resulting in loss or failure of the limiting function;

f) The sensor malfunctions due to environmental reasons, etc.

6.2.3 Hazards of anti-collision device

The manifestations of the hazards of the anti-collision device include, but are not limited to the following aspects:

a) When two or more sets of unmanned carriages are operating, such as: scooter-type amusement rides or slides, no corresponding automatic anti-collision devices are installed;

b) Sensor failure leads to anti-collision failure;

c) Faults and errors of the logic program or control system lead to anti-collision failure.

6.2.4 Hazards of buffer device

The manifestations of the hazards of the buffer device include, but are not limited to the following aspects:

a) Buffer device failure;

6.3.1.1.1 The surface wear of the shaft of the amusement ride mainly includes adhesive wear, abrasive wear, surface fatigue wear and corrosive wear, etc. Different wear corresponds to different performances and causes.

6.3.1.1.2 The manifestations of surface wear of shaft include, but are not limited to the following aspects:

a) The main characteristic of adhesive wear is that the contact of asperities on the contact surface causes local adhesion, tearing and obvious traces of mutual adhesion;

b) The main manifestation of abrasive wear is striped groove scratches on the surface layer;

c) The main manifestations of surface fatigue wear are surface fatigue peeling, crushing and pits;

d) The main manifestations of corrosive wear are uniform wear marks or punctate, filamentous wear marks or small pits along the sliding direction of the contact surface, accompanied by gray-black, reddish-brown oxide fine particles, or filamentous wear products.

6.3.1.1.3 The causes of surface wear of shaft include, but are not limited to the following aspects:

a) The main cause of adhesive wear is gluing caused by poor lubrication during low-speed heavy loads or high-speed operation;

b) The main cause of abrasive wear is the intervention of harder impurities;

c) The main cause of surface fatigue wear is the variable stress on the shaft and poor lubrication;

d) The main cause of corrosive wear is the tiny sliding of the contact surface in the environment of highly oxidizing and corrosive gas or liquid medium, or under the action of external load or vibration when the parts are closely matched.

6.3.1.2 Shaft fracture

6.3.1.2.1 The shaft fracture of the amusement ride mainly includes fatigue fracture, brittle fracture and ductile fracture, etc. Before the shaft fracture failure, there will be generation and extension of cracks. Different fractures correspond to different manifestations and causes.

6.3.1.2.2 The manifestations of shaft fracture include, but are not limited to the following aspects:

a) The main manifestation of fatigue fracture is the signs of new and old development that can be seen in the crack traces on the surface layer or deep of the fracture;

b) The main manifestation of brittle fracture is that fracture extends from the crack

source in a fishbone or herringbone pattern;

c) The main manifestation of ductile fracture is traces of plastic deformation process and extrusion deformation on the fracture or necking or fiber distortion.

6.3.1.2.3 The causes of shaft fracture include, but are not limited to the following aspects:

a) The causes of fatigue fracture include the local stress concentration due to the effect of alternating stress, and the gradual expansion of micro cracks inside the material;

b) The causes of brittle fracture include excessively low temperature of working environment, rapid loading, or certain surface treatment processes (for example, electroplating) that allow hydrogen to penetrate into the high-strength shaft, which increases the brittleness of the shaft;

c) The main causes of ductile fracture are as follows:

---unidirectional severe overload or rapid loading;

---the load is insufficiently estimated during design, or the material strength is insufficient;

---the cold working or heat treatment process reduces the ductility of the shaft and increases the brittleness;

---some alloy materials are particularly sensitive to notches, fillets, holes and scratches;

---high-temperature creep and strength reduction;

---the ductility of some alloys decreases at low temperatures.

6.3.1.3 Excessive shaft deformation

6.3.1.3.1 The excessive shaft deformation of the amusement ride mainly includes excessive elastic deformation and excessive plastic deformation, which correspond to different manifestations and causes.

6.3.1.3.2 The manifestations of excessive shaft deformation include, but are not limited to the following aspects:

a) The main manifestations of excessive elastic deformation are excessive bending, torsion and vibration when loaded, and the deformation basically disappears after unloading. Elastic deformation always appears in the loaded section or on the entire shaft;

b) The main manifestations of excessive plastic deformation are irrecoverable bending and twisting of the whole, or local plastic deformation at the contact with other parts.

a) The raceway surface is blurry and dull;

b) Discoloration of the raceway surface;

c) The inner bore of the bearing seat is worn;

d) The contact parts of the roller cage are worn.

6.3.2.1.3 The causes of bearing wear include, but are not limited to the following aspects:

a) There are abrasive objects in the bearing;

b) Operation without lubricant or lubricant deterioration;

c) Bearing creep due to improper clearance adjustment;

d) The inner ring or outer ring of the bearing is not correctly installed;

e) The bearing is poorly lubricated and the impurity content in the lubricating oil is excessively high.

6.3.2.2 Bearing cracks

6.3.2.2.1 Bearing cracks of the amusement ride mainly refer to cracks generated on the surface or inside the bearing due to the influence of internal stress, external impact or environmental conditions. Different cracks correspond to different manifestations and causes.

6.3.2.2.2 The manifestations of bearing cracking include, but are not limited to the following aspects:

a) Cracks on the inner or outer ring of the bearing;

b) Axial cracks on the inner surface of the inner ring or the outer surface of the outer ring;

c) Circumferential cracks on the inner ring or outer ring of the bearing;

d) Radial cracks on the cross section of the inner ring or outer ring of the bearing;

e) Radial cracks on the end face of the rotating ferrule.

6.3.2.2.3 The causes of bearing cracking include, but are not limited to the following aspects:

a) The fit is too tight and the assembly is uneven;

b) Spinning crawling or fretting abrasion;

c) Deformation of bearing seat;

d) Metal contamination caused by spinning crawling;

e) Collision or friction with the bearing seat or shaft shoulder during operation;

f) The assembly pressure on the ribs is unevenly distributed and hammered during assembly;

g) Insufficient lubricant and dirt sticking.

6.3.2.3 Flaky exfoliation of bearing

6.3.2.3.1 The flaky exfoliation of bearing in the amusement ride mainly refers to pitting caused by fatigue, forming flakes or scale-like peeling. The peeling at different positions corresponds to different manifestations and causes.

6.3.2.3.2 The manifestations of flaky exfoliation of bearing include, but are not limited to the following aspects:

a) The peeling of the isolation part of the raceway;

b) The peeling around the entire raceway;

c) The peeling of radial bearing at two opposite points in the radial direction;

d) The peeling of one side of the raceway surface'

e) The peeling at one end of the roller raceway;

f) The peeling distributed equidistantly from the rolling elements;

g) The inclined peeling on the raceway of the rotating shaft;

h) The inclined peeling on the raceway of the stationary shaft;

i) The peeling on the rolling elements;

j) Eccentrically distributed pitting on the thrust bearing raceway.

6.3.2.3.3 The causes of flaky exfoliation of bearing include, but are not limited to the following aspects:

a) The early stage of fatigue caused by indentations as a result of foreign substances, and scratches or corrosion of the raceway;

b) Improper clearance due to overload, expansion of the inner ferrule or contraction of the outer ferrule, resulting in gradually expanding fatigue failure;

c) The inner bore of the shaft or bearing seat is not round, and when the ring is assembled, the ring is distorted and becomes oval;

d) Improper assembly or excessive axial load;

c) Excessive wear is mainly manifested by tooth-profile shaped damage, very high wear rate, corrosive pitting near the pitch line, and transmission noise and vibration;

d) Abrasive wear is mainly manifested by relatively uniform streaks along the sliding direction on the gear tooth contact surface, and the streaks are serious due to repeated friction;

e) Corrosive wear is mainly manifested by evenly distributed corrosion pits on the tooth surface, and the tooth surface is accompanied by abrasion marks along the sliding direction.

6.3.3.1.3 The causes of gear wear include, but are not limited to the following aspects:

a) Slight wear is related to the mismatch between the roughness of the gear tooth contact surface and the lubrication viscosity, tooth surface working speed and working load;

b) Moderate wear is related to the gear working under interface lubrication and the presence of a small amount of contaminating impurities in the lubrication system;

c) Excessive wear is related to poor lubrication systems and sealing devices. The system generally has severe vibration and impact loads;

d) Abrasive wear is related to foreign matters between the tooth surfaces, which is more serious in open gear transmission;

e) Corrosive wear is related to the working environment.

6.3.3.2 Gear fracture

6.3.3.2.1 Gear fracture in the amusement ride mainly refers to fatigue fracture and overload fracture, which correspond to different manifestations and causes.

6.3.3.2.2 The manifestations of gear fracture include, but are not limited to the following aspects:

a) Fatigue fracture originates from broken tooth caused by fatigue crack expansion at the tooth root;

b) The fracture surface of overload fracture is rough and has no characteristics of fatigue fracture.

6.3.3.2.3 The causes of gear fracture include, but are not limited to the following aspects:

a) The causes of fatigue fracture include multiple effects of high alternating stress, excessively small corner radius of the tooth root, excessively high surface roughness, strain during rolling-cut, inclusions in the material and the influence of residual stress, etc.;

b) The causes of overload fracture include severe stress concentration caused by short-

term accidental overload, excessively large dynamic load and the entrance of large hard foreign matters to the meshing part.

6.3.3.3 Corrosive pitting of gear

6.3.3.3.1 The corrosive pitting of gear of the amusement ride mainly refers to tooth surface fatigue damage caused by pitting on the tooth surface, including early-stage corrosive pitting and destructive corrosive pitting, etc., both of which correspond to different manifestations and causes.

6.3.3.3.2 The manifestations of corrosive pitting of gear include, but are not limited to the following aspects:

a) Early-stage corrosive pitting is mainly manifested by small-sized and a small number of pits;

b) Destructive corrosive pitting is mainly manifested by corrosive pitting on the tooth root surface close to the pitch line, and continuous expansion of the pits.

6.3.3.3.3 The causes of corrosive pitting of gear include, but are not limited to the following aspects:

a) The causes of early-stage corrosive pitting include partial overload on the meshing tooth surface, tooth profile error, uneven tooth surface, and eccentric load caused by axis deflection;

b) The causes of destructive corrosive pitting include excessively large contact stress on the tooth surface, changes in the direction of the sliding speed near the pitch line, and difficulty in forming an oil film.

6.3.3.4 Plastic deformation of gear

6.3.3.4.1 The plastic deformation of gear of the amusement ride mainly refers to crushing plastic deformation, scale wrinkles, ridges, tooth body plastic deformation, etc. Different plastic deformations correspond to different manifestations and causes.

6.3.3.4.2 The manifestations of plastic deformation of gear include, but are not limited to the following aspects:

a) The crushing plastic deformation causes flash to appear on the tooth top edge and tooth end, the tooth top is rounded, and there are grooves and ridges near the pitch line;

b) The tooth surface of the scale wrinkles is subjected to plastic deformation and becomes fish scale-like wrinkles, which are perpendicular to the sliding direction;

c) The ridges are on the entire working tooth surface and form an obvious ridge along the sliding direction;

b) Bolt joints are subject to greater impact and vibration;

c) The bolt bears excessively large shear force, which leads to shear failure (it is not designed to withstand shear force);

d) The material has defects, such as: segregation, looseness and inclusions, resulting in insufficient strength of the bolt itself;

e) The root fillet processing does not comply with the requirements, resulting in stress concentration, fatigue cracks or even fracture;

f) The bolt connection is loose, and there are no effective anti-loosening measures.

6.3.4.3 Bolt slippage and seizure

6.3.4.3.1 The bolt slippage of the amusement ride is mainly manifested by that the threads are worn and cannot bite, and the threaded connection cannot be tightened; the bolt seizure is mainly manifested by the difficulty and impossibility to disassemble the bolt, cutting and other destructive means need to be adopted to remove the bolt. Stainless steel bolts often have seizures.

6.3.4.3.2 The causes of bolt slippage and seizure include, but are not limited to the following aspects:

a) The main causes of slippage are as follows:

---improper size matching of bolts and nuts;

---thread damage;

---improper use.

b) The main causes of seizure are as follows:

---the thread and nut clearance does not comply with the requirements;

---the surface roughness of the thread is poor and there are foreign matters;

---the lubrication before assembly is not in place.

6.3.4.4 Bolt corrosion

See 6.3.1.4.2 and 6.3.1.4.3 for the manifestations and causes of bolt corrosion of the amusement ride.

6.3.5 Hazards of steel wire rope

6.3.5.1 The hazards of steel wire rope of the amusement ride include local damage and overall breakage.

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