CODE OF PRACTICE

FOR

Amusement Rides

EMSD

CODE OF PRACTICE

FOR

AMUSEMENT RIDES

Electrical and Mechanical Services Department
The Government of the Hong Kong Special Administrative Region
2003 Edition

Table of Contents

Foreword

This Code of Practice is issued by virtue of Section 49 of the Amusement Rides (Safety) Ordinance, Cap.449. Unless the Director of Electrical and Mechanical Services (the Director) states otherwise, this Code is applicable to the design, construction, installation and testing of the amusement rides under the purview of the Ordinance.

As regards the engineering design and the operation of the amusement ride, this code intends to provide a reasonable standard and sets out the general requirements for design and operation of the rides for the safety of the public. The ride owner and practitioner in the trade shall take necessary steps to ensure relevant requirements stipulated in this Code are complied with, or in special circumstances where departure is deemed necessary for safety reasons, the design shall be in compliance with other appropriate international standards, specifications and guidelines such as HSE 175, DIN 4112, ASTM F-24 and AS 3533 with prior approval by the Director.

Apart from the general requirements laid down in various sections of this Code, the more specific and detailed requirements for individual category of amusement rides or some special operations would be issued in form of technical guidelines which shall also be observed by the relevant personnel. Meanwhile, there are 10 modules of technical guidelines, namely

Module 1	Bungee Jumping (Bungee Cord)
Module 2	Fairground Karting
Module 3	Coin-operated Amusement Rides
Module 4	Tethered Balloons
Module 5	Aquatic Amusement Rides
Module 6	Ferris Wheels
Module 7	Carousels
Module 8	Roller Coasters
Module 9	Trains
Module 10	Inflatable Structures

It shall be noted that these technical guidelines may need updates with emerging technology and experience. Therefore, it is expected that these documents will be reviewed from time to time and new modules for other special subjects will also be added where situation warrants. Any person to whom it may concern shall contact the General Legislation Division of Electrical & Mechanical Services Department (EMSD) to obtain the latest requirements on the above subjects.

1 General

1.1 Scope

This Code specifies the safety requirements for design, construction, installation and testing of amusement rides to be operated for use by members of the public in Hong Kong. It covers the general design requirements, specification of the materials and related equipment, provisions of redundancy and emergency arrangement, as well as testing and commissioning of the amusement rides.

1.2 Definitions

In addition to those interpretations stated in section 2 of the Ordinance, the following definitions will also be used in this Code:

COMPETENT PERSON, QUALIFIED PERSON, OWNER, SURVEYOR
: The statutory personnel defined under the Amusement Rides (Safety) (Operation and Maintenance) Regulation.

REGISTERED PROFESSIONAL ENGINEER (RPE)
: The registered professional engineer, within the meaning of the Engineers Registration Ordinance (Cap. 409), who is qualified to practice in a particular engineering discipline in Hong Kong.

SAFETY FACTOR
: Safety factor is the ratio of the ultimate breaking load of a component against the maximum allowable load which may be imposed on that component.

SAFETY-CRITICAL COMPONENT OR SYSTEM
: A component or system whose failure will result in uncontrolled operation or movement of the ride or failure of the restraint system, or where there is a real risk of failure leading to injury.

1.3 Process and Submission

The aim of this Section is to elaborate on the current approach of regulatory control on the safety of amusement rides within the ambit of the Amusement Rides (Safety) Ordinance, Cap. 449 (the Ordinance), and to provide a practical guidance on the licensing requirements for the amusement ride owner or his agent/organizer or any person, who wishes to operate any amusement ride or organize any fairground activity for use by members of the public in Hong Kong.

For the purpose of illustrating the application of the Ordinance, the operation of any powered-driven device, which could render any form of movement to its patrons who are members of the general public and riding on it for amusement purposes, are regulated under the Ordinance for which Electrical & Mechanical Services Department (EMSD) is the regulating authority.

However, it should be borne in mind that the guidance hereunder only outlines the requirements within the context of the Ordinance and is not exhaustive. For other issues related to the operation of the rides or the fairground activity, for instance, associated building works for installation of the rides, necessary fire service installation, and specific requirements on admission of the general public to the premises for entertainment, etc, which fall within the regulatory regime of other ordinances in force in Hong Kong, the ride owner or his agent/organizer should also seek to consult the relevant authorities and comply with all the specific statutory requirements.

1.3.1 Licensing Process for Amusement Rides

To illustrate the licensing process of amusement rides, a flow chart showing the sequence of events and the key milestones of the process from the design submission to the operational stage is given in Figure 1. In brief, the licensing process can be divided into three stages, namely:-

(a) Stage 1: Design Approval

Before commencement of any installation work on site, the ride owner is required to demonstrate, with proper supporting documents, the adequacy of the engineering design as well as the design approach in addressing the possible safety-related issues during the ride operation. A design document, which contains sufficient details of the mechanical, electrical and structural design, safety specification and operating instruction, shall be submitted to the Director. As regards the materials to be included in the design document, a list of the typical information to be accompanied with **FORM 1** of the ride application is given below : -

(1) General

- Particulars of manufacturer, ride model, unique serial number and date of manufacture.
- Motive power and rating.
- Duration of a normal ride cycle.
- Maximum number of passengers, number of passenger carrying units and maximum weight to be carried on the ride.
- Location map of the proposed amusement ride.

(2) Description of Construction and Operation

- Total weight of amusement ride, foundation and anchorage requirement.
- Description of ride motion with the data of maximum speed, maximum acceleration and deceleration.
- Description of ride components and drive system from motive power source to passenger seats.
- The principle of the ride control system together with a comprehensive list of safety devices or sub-systems which may be operational in normal use or exceptional cases. The list shall include the purpose and function of these devices as well as the details of possibilities of inspection.
- Signaling and communication equipment.
- Means of braking and stopping.
- Passenger containment system including restraints, safety devices and redundancy provisions.
- Outline description on the key ride operational issues including the functional and operating procedures, the setting of the safety gear, operation of controls, calibration and adjustment of the overload sensing device, etc.
- Outline description on the passenger flow and crowd control issues. Detailed description of guest loading and unloading processes as well as the duties of individual operators during the normal and emergency situations.

(3) Drawings

- Layout plan showing dimensions of amusement ride and all round clearance from nearby objects, especially the safety envelope along the ride path.
- Plan showing the passenger queuing and control arrangement, the positions of the control consoles, signs, chief operator and other operatives.
- Mechanical assembly drawings of the ride including the drawings of ride track, lifting and swiveling mechanism, bearings and support, vehicle, grab device, locking and safety systems, buffers, devices for prevention of roll-back, derailment and overturning, etc..
- Drawings and schematic of other ride related facilities including electrical

supply, show set elements, pneumatic and hydraulic system, CCTV, PA system.
- The complete ride control design and wiring diagrams including details of interface, intrusion detection, overload sensing device, alarm, and other safety protection system. The specifications of sensor and field control equipment.

(4) Design Calculation
- Design calculation and stress analysis of amusement ride including the properties, design strength and safety factors of materials to be used.
- Design and calculation of all safety-critical mechanical parts including safety devices, overspeed governor, driving machine and its brake, and wire rope suspension, etc.
- Design calculations made using computer systems shall include details of the software (author and version number of the software) and a clearly identifiable list of inputs and outputs with explanatory notes. For calculations involving finite element analysis, system plots with a list of the conditions assumed shall be provided.
- Overall risk assessment and other design tools for the safety critical parts like fault tree analysis, failure mode and effect analysis.

(5) Others
- An outline of the warning notice (in Chinese and English) to the riders in respect of the prohibited behaviours and restrictions on physique of patrons.
- A workable rescue plan for evacuation of passengers under different scenarios by the operator within a reasonable time. Such plan shall include the details of rescue equipment/facilities to be provided within or in the vicinity of the attraction and the plan for mobilization of the staff for rescue operation.
- Quality assurance documentation if available.
- Previous inspection certificate or approval issued by other government agencies or authorities within the amusement ride industry.
- Method and programme of installation and dismantling.
- Fire Safety.
- Insurance policy and the extent of coverage provided.

For ride with structure higher than 5m or where the circumstance warrants, the owner shall appoint a Registered Professional Engineer (RPE) in structural discipline to verify whether the structural design is sound and the calculations are correct such that it can safely carry all the static and dynamic loads under the designed operating conditions.

Also for high-rise or special indoor ride where the rescue operation might require the assistance of Fire Services Department (FSD) in disastrous or emergency situations, the owner shall consult FSD on the provision of the rescue facilities including the requirements of emergency vehicular access.

(b) Stage 2: Permit to Use and Operate

After the ride installation has been completed and before being opened for use by the public for amusement purposes, the ride owner shall arrange and demonstrate the following to the satisfaction of the Director.

(1) Provision of Operational, Maintenance and Emergency Manual

Manuals with sufficient details covering all the daily operation and maintenance issues to be carried out by the crew, as well as procedures for handling emergency situations must be in place.

(2) Ride Examination by Surveyor

All construction/installation procedures shall be in conformance with the design and/or manufacturer's recommendation. To this effect, especially for those complicated or highly dynamic rides, the ride owner shall make necessary

arrangement for the Surveyor to witness and certify all the crucial procedures during the construction, testing and commissioning stages as deemed required for drawing up a conclusion as to the integrity of the ride in the Surveyor's report. Such pre-inspections are particularly necessary in circumstances involving works or tasks which could not be carried out again later on (For example, some safety-critical components may become inaccessible for examination after the ride installation is fully completed). In all cases, it should be the judgment of the Surveyor to decide the level of checking and supervision required during the construction stage.

Upon completion of all physical construction/installation, Testing and Commissioning (T&C) works, the Surveyor shall carry out a detailed examination and finally compile a Surveyor Report certifying the integrity of the ride and its fitness for public use.

The detailed examination shall include, but not limited to

- An assessment of conformity of the ride operation to the design document including the overall ride operational sequence, individual mechanical, electrical, hydraulic and pneumatic assembly performance.
- Testing of all safety-critical components, stability of the ride, safety envelopes, and all the relevant functional and performance tests laid down in Section 4 of this Code or any other tests deemed necessary by the nature of the ride.

Where any part of the examination, for instance the NDT (Non-destructive testing) on the structural works, is carried out by a recognized body other than the Surveyor nominated by the ride owner, all findings supplied by the other party appended to the Surveyor Report shall be scrutinized and endorsed by the Surveyor so as to ensure the procedures are appropriate and the findings are correct.

(3) **Ride Inspection by EMSD**

Based on the installation programme given in the design submission, EMSD inspectors may carry out surveillance visits to site from time to time during the construction stage. Nevertheless, a final inspection with EMSD inspectors on the ride must be arranged upon completion of all installation and T&C works.

(4) **Competent Person**

Before opening the ride to the public, the ride owner shall nominate one of his employees, who has appropriate technical background and relevant experience, to apply for approval as the Competent Person of the ride. During the operational phase, such person shall be the key person responsible for the management and safe operation of the ride. In this respect, an assessment which comprises a written test and a site test, will be conducted to ascertain whether the applicant has possessed a sound engineering knowledge and an understanding on the details of the construction, operation and maintenance of the ride given in the above-mentioned Design Document and the three Manuals mentioned in 1.3.1(b)(1) above.

(5) **Rescue Drill**

Also, upon completion of the installation and T&C works, a rescue drill shall be performed by the operational crew to demonstrate, in the presence of EMSD inspectors, the adequacy of the rescue arrangement. For high-rise or special mechanical ride, where FSD may be called on to assist in emergency situations, a rescue drill in collaboration with FSD must be arranged.

(c) Stage 3: Annual In-service Examination

The licensing processes on "Design Approval" before construction and "Permit to Use and Operate" upon completion of installation of any amusement ride are required on a "one-off" basis. Renewal or re-submission is not necessary until such time that a major alteration involving modifications on the safety-critical elements is required. In all circumstances, the ride owner is obliged to maintain the ride in a safe condition and appoint a Surveyor to carry out detailed in-service examination once a year.

1.3.2 Additional Requirements for the Temporary Rides of Carnivals

Basically, all the foregoing licensing requirements are applicable for amusement ride, which is either designed as a fixed structure or temporary ride (mobile ride with built-in features to facilitate quick assembly and dismantling work). Whenever a temporary ride is brought back into service from a decommissioned state, the same application process for the "Permit to Use" shall be required before it can be operated for public use in a new location. Similarly, the Competent Person who was previously appointed and permitted in overseeing the operation and maintenance of the ride shall confirm in writing to undertake the duties of Competent Person for that ride in the new location/event. The requirement of annual examination by a Surveyor may be waived if the operational period, which has been declared in the application for "Permit to Use & Operate", is less than 12 months. Nevertheless, the ride owner is still obliged to maintain the ride in a safe condition in accordance with Maintenance Manual even if it is in a decommissioned state or has not been in use for a long time. For mobile ride which is intended to have intermittent operation in Hong Kong and in other countries, every time when the ride is put up in Hong Kong, the application shall be accompanied by an overseas pre-inspection scheme as outlined below as an initial screening.

When a ride owner or event organizer wishes to bring in a non-brand-new mobile ride which has been used for a period of time in other countries, a pre-inspection, before shipment to Hong Kong, by an independent inspection body (not necessarily a Surveyor) in that country certifying the latest ride conditions as regard to structural integrity, E&M safety and adequacy of routine maintenance shall be made so as to substantiate the application for "Permit to Use and Operate". Nevertheless, it shall be noted that all other requirements such as Design Approval and ride examination by Surveyor upon completion of the works in Hong Kong are still required for this kind of overseas mobile ride.

For large-scale carnival, the ride owner or event organizer shall also observe and comply with the following requirements:-

(a) A master layout plan showing the positions of various temporary rides and other attractions, the crowd control measures and the emergency vehicular accesses to individual mechanical rides shall be submitted for acceptance by EMSD and relevant government departments.

(b) The actual ground conditions of the site and its fitness for supporting these mechanical rides, the anchorage requirements for putting up the ride, the adequacy of footing, designed soil pressure and the provisions against lateral sliding shall be reviewed by a Registered Professional Engineer (in structural discipline) prior to the commencement of any ride installation work.

(c) The design of the overall temporary power supply and earthing system shall be submitted for approval by the Director.

1.3.3 Major Alteration

Major Alteration refers to modification of any safety-critical components or system changes involving loading (e.g. changes in seating arrangement), speed, operating range (e.g. height), safety envelope, major load-bearing structure, drive mechanism, control mechanism (e.g. brakes, shock absorbers, speed limiters), software, passenger harness and protection system.

Ride owner shall not carry out any major alteration to an amusement ride without the prior approval of the Director. When the modification is completed, the owner shall arrange a detailed examination on the ride by a Surveyor and apply for the permission from the Director for re-opening the ride for public use. Basically, similar procedures as required for licensing of a new amusement ride shall be followed.

1.3.4 Kiddie Rides

By definition, kiddie rides are amusement rides with power rating less than 1.1kW, for children under the age of 12 and with total carrying capacity not exceeding 100kg.

As compared with other amusement rides, a simpler regulatory approach has been adopted for kiddie rides in which the above-mentioned requirement for Design Approval and Competent Person are not mandatory. In short, the licensing process and regulation of kiddie rides include : -

(a) "Permit to Use & Operate"

This involves a pre-operation examination on the ride by independent statutory personnel who may be either a Qualified Person or Surveyor registered under the Ordinance. Similar to other amusement rides, the Surveyor or Qualified Person is required to compile a report certifying the fitness of the kiddie ride for public use.

(b) Examination at six-month interval

Similar to the requirements for other amusement rides, the kiddie ride owner shall appoint a Qualified Person or Surveyor to examine the kiddie ride once every six months.

2 Design Requirements

2.1 Risk Assessment

In the design of amusement rides, the following steps are required to be followed : -

(a) Identification of hazards in association with the use of the rides, with due consideration given to the aspects of height, velocity and acceleration;

where velocity *is the maximum speed attained by the patron;*
height *is the maximum elevation of the patron on the ride;*
acceleration *is the maximum acceleration attained by the patron.*

(b) carrying out an assessment to determine the risks associated with such identified hazards; and
(c) design and implementing measures to either eliminate or minimize the identified risks.

Risk analysis shall be conducted in accordance with EN 1050 and prEN 954-1; otherwise, the methodology and process of risk assessment should be documented properly.

For safety critical engineering design, where single point failure or double point failures involving sensitive equipment or undetectable failures might happen and lead to injury, further detailed assessment by fault tree analysis and/or failure mode and effect analysis should be carried out.

2.2 Design Loading

Paragraphs 2.2.1 to 2.2.5 hereunder set out various modes of loading that shall be taken into account in performing design calculation and stress analysis of the amusement ride. Where departure from the below-stated design consideration is necessary for special applications involving uncommon ride operation or other reasons, a set of appropriate and proven design procedures shall be followed with the details of calculation documented on how to determine the design loading.

2.2.1 Dead Loads

Dead loads are those permanently applied loads on the ride including the following

(a) The weight of the structural components of the ride.
(b) The weight of all fixed or moving parts associated with the ride.

2.2.2 Live Loads

Live loads are those loads applied to the ride on admission of patrons. For the purpose of calculation, mass of patron shall not be less than 75kg and 25kg for adults and children respectively.

For aisles, walkways, platforms or the likes on which patrons and operational staff can access, the uniformly distributed load imposed on these areas shall be not less than 5kPa.

2.2.3 Dynamic Loads

Dynamic Loads shall include the loads applied to the structure or components of the ride due to the motional behaviour of the ride fully or partially loaded with patrons. Usually, they are generated by

(a) acceleration, braking, forces of centrifugal, gyroscopic and Coriolis type; or
(b) release of potential or kinetic energy during the operation of the ride.

A comprehensive analysis of the motional behaviour of a ride, including its anchorage and foundation, shall be made. Forces, moments and their ranges of magnitude and direction on the ride during all operating conditions shall be estimated for all the components and structural members that make up the system.

The analysis shall take into consideration the effects of partial and unbalanced loading. In particular, the effect of emergency braking shall be checked.

In the context of material fatigue, the effect of unusual vibration arising from excitation frequencies on the structures and the ride components shall also be checked.

2.2.4 Wind Loads

For outdoor mechanical rides comprising structures of more than 5m height or where the circumstances warrant, design checking by a Registered Professional Engineer (in structural discipline) in respect of the structural stability against overturning in out-of-service condition for compliance with Hong Kong Wind Code shall be carried out. As regards the design checking for in-service condition, design wind speed of 72 km/hr shall be used.

2.2.5 Other Special Loading

Where appropriate, the following special loadings shall be taken into account in the design calculation.

(a) Thermal stress due to temperature changes.
(b) Pre-tensioning effects on membrane structure and supports.
(c) Weather elements.
(d) Ground unevenness and settlement.
(e) Forces due to assembling or erection.
(f) Forces due to unusual conditions, e.g. perpetual induced vibrations from the neighouring environment.
(g) Hydrostatic forces or wave shocks.
(h) Test loads.

2.3 Stress Analysis and Related Issues

2.3.1 Structural Calculation and Stress Analysis

The design calculations of an amusement ride shall include a comprehensive stress analysis on combination of the loadings (as detailed in paragraph 2.2) exerted on individual

structural element so as to ascertain the entire ride design is structurally sound. Where the use of steel works is involved, the structural design shall conform to the local Code of Practice for the Structural Use of Steel published by the Buildings Department of HKSAR or other international standards accepted by the Director.

In determining the critical loading which a particular element is designed to bear, the designer should consider the following factors.

2.3.2 Mechanical Design and Safety Factors

For mechanical design involving the use of materials other than structural steels, the safety factor(s) used in the design calculations should be consistent with established mechanical/materials handbooks or international standards for the particular materials under the specific design conditions.

Where the relevant standards are at variance over the safety factors required for a particular mechanical design, upon consideration of the following and if the material or mechanical part in question is a critical element to the ride, the requirements of the more conservative standard shall be followed:-

(a) The nature of the amusement ride taking into account of the maximum speed, height and acceleration that would be attained.
(b) Finding of the Risk Assessment and the nature of the possible catastrophic injuries.
(c) The nature of failure of the element in question, whether it is ductile deformation, the initiation of fatigue cracking, a brittle fracture or any combination.
(d) The likelihood of discovery of incipient failure during day-to-day inspection of the ride before such failure has progressed to a stage where a real danger exists.

2.3.3 Fatigue Life

Every amusement ride and any parts thereof shall be designed for prolonged operation under full load conditions before the occurrence of fatigue failure. Proper measures including the following must be put in place to ensure signs of fatigue are continuously being monitored in accordance with the design intent.

(a) Where the designer brings out an inspection requirement, the procedures and frequencies of inspections shall be documented in the operation and maintenance manual.
(b) Where any inspection reveals cracks or other signs of fatigue, the structure/components shall be re-assessed by designer or other qualified engineer, and inspection intervals shall be adjusted accordingly.
(c) Non-destructive testing methods of the following types shall be adopted: visual, dye-penetrant, magnetic particle, ultrasonic and radiographic examination techniques specified according to the appropriate international standards.
(d) The designer shall clearly identify components for non-destructive testing on drawings for inclusion into the operation and maintenance manual.
(e) Where the designer specifies fatigue-prone components for testing, the calculated fatigue life of such components shall determine the service intervals between which the testing shall be carried out.
(f) Repairs to fatigue failures shall be carried out by qualified welders under the supervision of the Competent Person or Surveyor.

2.3.4 Deflection

Unless it is intentionally designed to produce movement for ride effect, deflections under all conditions of maximum loading shall be minimized to eliminate excessive swaying, unnecessary vibrations or movements which could affect the ride safety. In principle, the deflections of simply supported beams shall not exceed span/360 while the deflections of cantilever beams and columns shall not exceed cantilever length/180 as per the Code of Practice for the Structural Use of Steel.

2.4 Stability

The requirements for stability to design against any unintended overturning and lateral sliding are set out as follows and as mentioned earlier (paragraph 2.2.4); design checking by a Registered Professional Engineer (in structural discipline) shall be required for rides having a structure higher than 5m or where the circumstances warrant.

2.4.1 Overturning

The stabilizing moment under operating conditions, with all design loading (paragraph 2.2) being taken into account, shall not be less than 1.5 times the overturning moment along the most critical direction. Whilst, for out-of-service conditions, the stabilizing moment shall not be less than 1.25 times the overturning moment.

Where the stabilizing moment is totally or partially provided by a permanent foundation/anchoring system, the connections between the ride and those foundations shall be designed in such a way that the safety factor shall not be less than 6.

2.4.2 Lateral Sliding

Where a holding force is required to counteract the lateral sliding of the ride as a result of the working loads (e.g. due to unbalance loads, wind loads and the likes), the following requirements shall be satisfied.

(a) For free standing structure (with or without additional dead weight) solely relying on the friction as the holding force against lateral sliding, a safety factor of 1.5 shall be attained.
(b) For anchoring system involving hold-down bolts or other direct connections to hold-down foundations, the strength of the bolted connection shall be calculated in shearing mode, and a factor of safety of 6, in shear (against ultimate strength), shall be maintained.

2.5 Harness and Locking Device

2.5.1 Application

Harness or adequate protection shall be provided where patrons may –

(a) be ejected due to the motion of the ride (further details in paragraph 2.5.6);
(b) be moved suddenly and unexpectedly within the vehicle or may collide with protrusions adjacent to the ride (further details in paragraph 2.5.7); or
(c) pose a danger to themselves or others if they do not remain seated for the entire ride cycle (further details in paragraph 2.5.8).

Remarks : i) Partial restraint and/or protection may be given by the design of the vehicle, seat configuration, and other inherent restraint features. On the other hand, such features may also have negative effects on the protection of the patrons. Designers should carry out an overall review to arrive at the best protection provided to patrons.

ii) Harness using mechanical releases is considered not suitable for waterborne rides.

2.5.2 General

Harness shall be secure and comfortable for the patron. Adjustable harness shall be designed to facilitate easy adjustment. Bars, belts, supports, locks and latches shall be of sufficient strength to withstand the forces applied to them under normal operating conditions.

Harness shall be easy to use and designed to prevent accidental release due to the movement of the patron or the ride.

2.5.3 **Warning Sign**

Where harness and locking devices are not adjustable, signs shall be displayed restricting the minimum and maximum physique of patrons who are permitted to ride on it.

In all cases, if a warning is deemed necessary, it is important to make sure that the consequences of disregarding the warning are not severe. If they are, the ride should be redesigned to eliminate these consequences or else effective measures in the actual operation shall always be in place.

2.5.4 **Harness Position**

Harness shall be securely fastened to structural members of the ride. Where bolts are used, nuts shall be provided with locking devices, e.g. castellated nuts with locking pins or any other means to make the nuts be captive. Use of screws for fastening the harness shall be avoided.

Where the harness forms part of or is attached to an entry door, gate, or the likes, on a vehicle, double lock or latch shall be provided as a redundancy measure.

2.5.5 **Requirements for Interlocking**

Where the ride motion is so vigorous that there is a risk of patrons being ejected from the ride, harness shall be interlocked with the ride controls as follows:

(a) Harness shall be locked in the riding position by positive mean and the release mechanism shall be inaccessible to patrons. Manual release actuators shall be provided in positions accessible to personnel who need to carry out the rescue operation in emergency situations.
(b) During normal operation, release of the harness may be actuated either by automatic means or direct actuation by operational personnel at the loading and unloading points. Automatic release shall occur only when the ride is stationary at the unloading position.
(c) Where practicable, a proving device on each harness, interlocked with the control system to prevent dispatch of the ride from the loading point, should be provided.

If the risk of patrons either being ejected or falling off or out of the ride is not an issue, while the real concern is potential danger to the patrons colliding with protrusions along the path of ride motion, harness shall be locked in the riding position by a positive means but the release mechanism may be accessible to patrons.

2.5.6 **Harness of Simpler Design**

Where the patrons is expected to remain seated in entire course of ride cycle, but there are no extraordinary movements or protrusions with which patrons could come into contact, a lap-belt harness may suffice and the release mechanism may be accessible to patrons.

2.5.7 **Deletion of Harness**

Where a risk assessment has concluded that, because of the nature of a ride, a safer outcome could be accomplished by enabling the patron to part company with the ride in the event of abrupt stoppage, then harness need not be provided.

2.5.8 **Cushioning Requirement**

Cushioning shall be provided for harness and the surfaces of the rides with which patrons may come into contact through the movement of the ride

2.5.9 **Locks and Latches**

The locks and latches on rides shall be designed to give a clear indication or let the ride attendant to have a clear sense of feeling for distinguishing the latched and unlatched positions in the checking process. Locks and latches shall be located in a proper position so as to prevent inadvertent release by patrons. The loss of any spring tension shall not cause a lock or latch to release.

2.5.10 **Movement of Patrons on Seats**

For single seat without any foot support, the seat shall be designed to have a shape to prevent the patron from sliding under a lap-type bar, belt or chain harness; otherwise, provisions of crotch strap or chain or the likes shall be in place.

2.5.11 **Prevention of Vigorous Head Movement**

Where the ride will induce vigorous lateral motion such that the patron's head will have undue movements relative to his body, the harness shall be designed to mitigate any excessive head movement for protection of the head and neck muscles.

2.5.12 **Strength of Harness**

When the ride is designed to operate in a position with the patrons in an up-side-down position and the patron's body weight is supported by the harness, the harness shall be specially designed to carry the patron's weight for such mode of operation.

2.6 Braking System

The braking system of an amusement ride shall be either one or a combination of the following systems:-

(a) Pressure or mechanically actuated frictional brakes acting in the drive mechanism or directly on a vehicle. For frictional braking applied to a free running vehicle, the braking system shall perform satisfactorily in all weather conditions and possible speeds attainable at its point of application.
(b) Hydraulic regenerative braking or hydraulic relief braking in which a hydraulically powered system may be decelerated by redirecting hydraulic flow into a condition of regeneration or restriction so as to achieve a smooth braking action.
(c) Electrical braking of the regenerative, dynamic, or eddy-current type.

For vertical rides, the braking system should be of fail safe design so that, in the event of power failure or loss of interconnections or control (e.g. hose breakage, wire breakage), the brake will be engaged to stop the ride motion.

Where a ride is able to freewheel and move during the loading of patrons, provisions of parking brake or holding system shall be provided.

Where a sudden application of severe braking may injure the patrons or impair the integrity/stability of the structure as a result of extraordinary movements or collisions, the designer should exercise care in choosing the braking arrangement and controls, particularly the emergency stop provisions.

For rides which rely on inertia or other mechanism as means of stopping the ride motion, an explicit process of risk assessment shall be undertaken to validate the adequacy of the design.

2.7 Lifting System

2.7.1 **General**

Where patrons on an amusement ride are lifted or lowered, means shall be provided to safely return the patron carrying system to its loading or unloading position, or to another designated location for safe disembarkation in accordance with paragraph 3.16 regarding evacuation.

2.7.2 **Hydraulic System**

Hydraulic cylinders or rams used in the lifting system shall –
(a) have a safety factor of not less than 6 against rupture under the most adverse

conditions of acceleration or deceleration;
(b) be designed to prevent buckling at full extension; and
(c) be fitted with a restrictor at its lifting pressure port.

2.7.3 Pneumatic System

Pneumatic cylinder or rams used in lifting system, and which acts either bi-directionally or carries load in both directions (over-centre system) shall –

(a) conform to ISO 4413 and Boilers and Pressure Vessels Ordinance, Cap. 56;
(b) be designed to accommodate the maximum pressure developed in the most adverse condition of acceleration or deceleration;
(c) be designed to prevent buckling at full extension;
(d) be fitted with a quick-action holding valve at its pressure port(s);
(e) where a positive load-holding device cannot be installed, be supported by an independent and automatic system, which may activate under conditions of overspeed but which preferably acts continuously, except while the motion to be restrained is in progress.

2.7.4 Wire Rope Systems

Where patrons are lifted by the hoisting of a cradle, guided by rails and suspended on wire ropes, the wire rope system shall comply with the following generic requirements. Any special design with departure to the following shall be backed by sufficient grounds and shall be consistent to a set of relevant standards on wire rope system.

(a) Minimum Safety Requirements
    (1) In principle, at least four suspension ropes are required. Design with two suspension ropes might be considered for the following exceptional cases only:-
        (i) The risk of falling from height does not exceed 2.5 metres; or
        (ii) Rail-guided cradle coupled with the provisions of fall arrestors, eddy-current brakes or the likes.
(b) Rope loading
    (1) Imposed loading shall be equalized among the ropes.
    (2) Spring equalization shall be only applied where each spring is capable of supporting the total static load without damage (including permanent deformation).
    (3) Beam equalizers shall only be used where movement within the equalizer members is restricted such that, on the loss of one suspension rope, the load is transferred to other ropes but the unbalance load among the remaining ropes shall not be more than 10% of the load carried by any individual rope.
(c) Emergency Brake
    (1) Emergency brake shall operate directly on, or be positively coupled to, either the winding or traction drum or shall operate directly on the suspension ropes.
    (2) The emergency brake shall be capable of arresting the motion within a safe distance under any operating condition of up to 25% overload or 40% overspeed.
(d) Winding drum machinery
    (1) Multi-layered drum is prohibited.
    (2) A roller pressing the wire rope on the drum or other equivalent device shall be provided to prevent the rope from leaving the drum inadvertently.
    (3) Under all operating conditions, the rope anchorage shall be protected by not less than two full dead turns remaining on the drum when the cradle is at its lowest position.
    (4) A wire rope spooling device synchronized mechanically with the rotation of the winch drum shall be provided to guide the wire rope positively so that the wire rope is accurately wound and channeled in the grooves.
    (5) If wire ropes are wound on more than one winch drum, the rotation of the winch drums shall be synchronized mechanically to ensure that the cradle remains level at all operating positions.
    (6) In case of any rope becoming slack or cross over on the drum, it shall positively stop the motion and give an alarm signal.

(7) Operational limit switches and whole-current over travel limit switches at each termination shall be provided for normal and emergency stop control respectively.

(e) Traction drive machinery shall –
   (1) be capable of supporting and accelerating the load in any direction without slippage; and
   (2) be fitted with over-travel limits and controls unless slippage of the drive in the zones of over-travel is ensured by positive reduction in tail tension (e.g. bottoming of a counterweight), in which case over-travel limits may acts as the provisions of backup to operational limits provided they act through independent contacts or relays.

(f) Lifting mechanisms involving wire rope shall –
   (1) be provided with a system to signal and positively stop the motion in the event of breakage of any rope;
   (2) where no means other than the control or braking system of the lift mechanism can control overspeed, incorporate a fall arrestor which would be engaged whenever the speed of descent exceeds 140% of the nominal full speed. Such fall arrestor shall be of fail-safe design. Any failure including speed-measuring transducers, signal processors, control circuit elements or wiring shall trigger the fall arrestor and cease the motion;
   (3) maintain a ratio of sheave or drum diameter to rope diameter of not less than 40:1 for all components in contact with ropes;
   (4) be fitted with a safety gear, unless other positive means are provided to ensure that the free fall of a vehicle is controlled within safe limits of acceleration and velocity in any circumstance of the failure of the elevating system; and
   (5) be fitted with buffering devices to control the motion of a vehicle at any landing platform so as to achieve a safe deceleration in case of fault.

3 General Specification for Materials, Installation and Facilities

3.1 Suspended gondola

Cradles shall be suspended from rigid distributor bars to prevent entanglement of support chains. Redundancy/backup systems shall be provided for all single-point suspensions of vehicles, sways, arms and other patron-carrying components. The backup system may consist of chains, ropes, pins or other structural members of adequate size and strength. Pin or bolting holes of the suspension and backup system, shall be staggered to avoid wrong assembly.

For amusement ride where there is a risk of fall from a height of 2.5 metres or more, the cradles shall be suspended by 4 wire ropes or chains unless other fall protection system such as a fall arresting device and safety gear, etc. is in place. The anchoring position shall be suitably designed such that when one of the wire ropes breaks, the cradle shall remain reasonably stable and the tilting of the cradle shall not cause patrons to fall out.

3.2 Wire Ropes, Shackles and Pulleys

Suspension ropes shall be stranded steel wire ropes complying with BS 302. Each rope shall be in one continuous length and free from joints or repairs. The minimum safety factor, the ratio between the minimum breaking load of the rope to the maximum rope tension, shall be at least 10 but a higher safety factor of up to 14 shall be considered where the circumstances warrant. Both ends of the wire rope shall be securely fastened and the strength of rope terminations shall be not less than 80% of the minimum breaking load of the rope. The wire ropes shall be properly guided throughout the path of travel. Pulleys shall be provided for all bends. All pulleys shall be fitted with self-lubricated bearings. The diameter of each pulley shall be compatible with the wire rope use. Suitable guidance device shall be provided to prevent the wire rope from slipping off the pulley.

3.3 Hydraulic System

All the hydraulic fluid transmission system associated with the amusement ride shall conform to ISO 4413 and the requirements specified hereunder.

3.3.1 Design Information

The circuit diagram in accordance with ISO 1219-2 and the following relevant information in connection with the system design and operation shall be documented and included in the design submission.

(a) Identification of all equipment by name and model number.
(b) Maximum torque and speed required for the intended service of each hydraulic motor.
(c) Flow rate of each pump.
(d) Power and rotational speed of the pump prime mover.
(e) Pressure settings.
(f) Selection of fluid type and viscosity grade.

3.3.2 Installation and Safety Features

Every component of the hydraulic system, which requires regular maintenance and adjustment, shall be accessible without risk from a safe working position. And the following safety features shall be incorporated into the design of the hydraulic circuit.

(a) Safety devices to protect against the effects of failure of a hose in any hydraulic circuit which otherwise could affect the operational stability of the ride.
(b) Overpressure protection on the discharge side of all pumps capable of handling the maximum flow of the pumps.
(c) Overpressure protection of all load bearing hydraulic cylinders.

3.4 Pneumatic System

All the pneumatic system associated with the amusement ride shall conform to ISO 4413 and, where pressure vessel is involved, comply with the requirements in Boiler and Pressure Vessels Ordinance, Chapter 56 in respect of registration, maintenance and examination of the pressure vessels. Circuit diagram and relevant design information listed out in paragraph no. 3.3.1 shall be documented and included in the design submission.

3.4.1 Installation and Safety Features

Every component of the pneumatic system, which requires regular maintenance and adjustment, shall be accessible without risk from a safe working position. And the following safety features shall be incorporated into the design of the pneumatic circuit.

(a) Safety devices to protect against the effects of failure of a hose in any pneumatic circuit which otherwise could affect the operational stability of the ride.
(b) Pressure vessels shall be fitted with appropriate pressure relief valves. The discharge points shall be contained or directed so as to eliminate the risks of contamination of equipment or injury to persons.

3.5 Electrical Requirements

All electrical works associated with the amusement ride shall comply with the Code of Practice for Electricity (Wiring) Regulation, Electricity Ordinance, Cap. 406, IEC364, and the requirements specified hereunder :-

3.5.1 High Voltage Installation

High voltage electrical works (greater than 1000 V(A.C.) or 1500 V(D.C)), with the exception of cold-cathode illumination systems (e.g. neon lights) shall be prohibited for amusement ride installation.

3.5.2 Low Voltage Installation

Where the power supply to an amusement ride is at low voltage (50V to 1000V (A.C. supply) or 120V to 1500V (D.C supply)), it shall pass through an over-current circuit breaker of a rating appropriate to the current consumption of the connected load which may be either –

(a) an isolating switch complying with and being type tested to IEC 947-3; or
(b) a residual current device (RCD) type tested to IEC 755; or
(c) an air circuit breaker (ACB) or moulded case circuit breaker (MCCB) complying with and being type tested to IEC 947-2.

3.5.3 Extra low Voltage

For extra low voltage circuits (less than 50V (AC supply) or 120V (DC supply)), transformers shall either be inherently short-circuit proof or provided with overload and short-circuit protection. Bare conductors for extra low voltage shall not be used.

3.5.4 Equipotential Bonding Requirements

All electrical installations, except at extra-low voltage, shall be earthed in accordance with the following requirements:

(a) Where the power supply is taken from a permanent and fixed sub-main distribution system connected with the grid of the power supply company, all metalwork associated with the electrical installation not forming part of a live conductor, shall be solidly and effectively bonded and earthed in accordance with IEC 364 and the Code of Practice for the Electricity (Wiring) Regulations.
(b) Where power is obtained from a generator mounted on the frame of the amusement ride concerned, the electricity generating set shall comply with ISO 8528-6 in respect of equipotential bonding facilities and connection between main windings and the frame (a removable connection or link between a star point and the generating set need not be provided).
(c) Where the power is generated on site and the generator (complying with ISO 8528) is positioned far from the amusement ride, the star point of the generator and the generator frame shall be solidly bonded to an earthing electrode driven for the purpose. While the ride and the generator frame shall be connected together with an earthing conductor of ample size in accordance with IEC364 as if the source of supply were a mains supply.

3.5.5 Local Wall-mounted Switch Panels

The panels shall be partially type-tested assemblies (PTTA) as defined in BS EN 60439-1 and constructed generally to Form 2 of BS EN 60439-1 (IEC 439-1). The panel enclosure shall be of degree of protection of IP 44 for indoor application to BS EN 60529.

3.5.6 Free-standing Motor Control Switchboard

(a) The motor control switchboard (hereafter called the "Switchboard") shall be a free-standing floor mounted low voltage switchboard to group centrally the motor starters, controls and switchgear for various electrical equipment associated with the amusement rides.
(b) The multi-cubicle type assembled "Switchboard" shall conform to an established type "Switchboard" which has been verified to be in accordance with BS EN 60439-1 by a recognized testing authority.
(c) "Switchboard" shall be constructed generally to Form3b of BS EN 60439-1 and shall be of degree of protection of IP31 for indoor application to BS EN 60529.
(d) The "Switchboard" shall be clearly marked and labeled with the safety signs, circuits controlled and electricity characteristics of the "Switchboard".

3.5.7 Isolating Switch

Every amusement ride that is connected to any power supply shall be provided with an isolating switch in a position readily accessible to the maintenance personnel who are

supposed working in the vicinity of the Main Motor Control Switchboard of the ride in question.

3.5.8 **Emergency Lighting**

Adequate emergency lighting and illuminated exit signs shall be installed for safe operation of the amusement ride in accordance with the Codes of Practice for Minimum Fire Service Installations and Equipment. For rides which need waiver of this statutory requirement because of safety reasons, the ride owner shall apply to Building Department and Fire Services Department for exemption.

3.5.9 **Power Point Below 2.5m**

Where the public is admitted, the electric power supply to motors, equipment, lighting and socket-outlets installed on the moving parts of an amusement ride and to all other lighting outlets less than 2.5m above the floor level or within the arm reach shall be protected by one of the following.

(a) A residual current device (RCD) type-tested to IEC 755; or
(b) an isolating switch complying with and being type-tested to IEC 947-3; or
(c) an extra-low voltage system obtained from the non-earthed secondary of an isolating transformer.

3.5.10 **Other Requirements**

(a) Any cable passing under an amusement ride or within 1000mm of any moving part thereof shall be provided with mechanical protection.
(b) Exposed lamps, except where supplied by extra-low voltage, or protected by a residual current device, shall not be installed within an arm-reach distance of any position accessible to the public.
(c) All electrical terminations and connections shall be capable of withstanding the effects of any expected vibration and movement.
(d) Power supply to the control devices handled by patrons shall be an extra-low voltage supply only.
(e) Pendant, roving controls or any control handled by operating staff shall be either double insulated or designed for connection to an extra-low voltage supply only.

3.5.11 **Flexible Cable and Plug**

(a) The supply cord and other connecting cables shall be of heavy-duty type and shall be mechanically protected where necessary.
(b) The removal of a single access cover to a coin container, coin mechanism, or other similar component shall not cause any live part or basic insulation to be exposed.
(c) Every drive motor and all exposed metal parts of the equipment shall be effectively earthed to the main earth via a circuit protective conductor.

3.5.12 **Electrified Metallic grid**

Where an amusement ride involves an electrified metallic grid installed over an area accessible to the public, the electrified metallic grid shall be installed at a height of at least 2.1m above floor level and the supply voltage shall not exceed 120V d.c..

3.5.13 **Electrical installation of Aquatic Rides**

Electrical installation in the vicinity of water pools, which form part of an aquatic ride, shall comply with paragraph no. 26M of Code of Practice for the Electricity (Wiring) Regulations.

3.6 Ride Control Equipment

The control panel and the associated control equipment for the amusement ride shall be designed with due regards to the following:-

(a) The location of control station and the remote annunciation panels shall be carefully selected so as to minimize any interference by the patrons or the passers-by, and to

allow the Chief Operator at the control station to have an unobstructed view of the embarking and disembarking process.

(b) The Chief Operator shall be able to have direct or supervisory control of all functions for embarking, disembarking, interlocking and emergency from the supervisory panel at control point.

(c) Visual indicators should be installed, where necessary, to show the operational status of the equipment. For abnormal status or signal of the safety-related devices, provisions of audible alarms shall be available.

(d) Where an amusement ride has remote areas or areas obscured from the view of the Chief Operator at the main control station, means of observing and communicating with patrons, such as CCTV system, intercom system or public address system, shall be provided, otherwise; a risk assessment has to be conducted if such provisions are considered not practicable.

(e) The controls and indicators on the mimic panel shall be arranged in such a way that the natural directional movement of the signals or physical control actions corresponds with the actual movement of the vehicles.

(f) Any emergency stop action shall bring the ride to a stop in a safe manner. The emergency stop system shall not rely on electronic equipment for its operation and shall only be reset manually. The emergency stop push-button shall be prominent, and located for immediate access by the ride attendants.

3.7 Lightning Protection

For outdoor amusement rides involving tall and massive structures, an assessment on the risk of being struck shall be made in accordance with BS6651. Weighting factors at the higher end shall be used for assessment on mobile rides or where the patrons would expose at the highest levels of the structure. If provisions of lightning protection are determined to be necessary, all the design works shall conform to BS6651.

3.8 Steam and Gas Propelled Equipment

(a) All boilers and steam receivers associated with the amusement rides shall comply with the requirements of Boiler and Pressure Vessels Ordinance, Chapter 56 in respect of registration, maintenance and examination of the pressure vessels.

(b) Only the low-pressure steam or hot water boilers are permitted to use in connection with the amusement ride installation.

(c) Hot water boilers and burners shall be constructed to BS 855 and BS 799 respectively. All the exposed surfaces, including the associated pipeworks and accessories, shall be insulated such that the surface temperature at any location shall not exceed 40°C.

(d) Provisions of safety devices including double safety valves, automatic low water level cutout, over temperature protection thermostat, automatic firing controls shall be provided.

(e) Miniature locomotives and steam engines shall be operated as prescribed by BS 7328.

(f) Where hot air is used in conjunction with an amusement ride other than hot air balloon, all the exposed ducting, diffusers or other delivery system shall be insulated with surface temperature not exceeding 40°C whereas the air heating equipment should be designed, controlled and operated to prevent the temperature of hot air from reaching beyond 60°C.

(g) For operation involving hot air balloon system, prior approval from Director of Civil Aviation shall be sought and where the use of propane or the likes is required, requirements of the Gas (Safety) Ordinance, Cap. 51 shall be complied.

3.9 Fire Protection

For amusement ride where the patron is totally enclosed inside a cabin (which is not considered as a building works under Cap. 123), all upholstered furniture inside the cabin shall meet the appropriate standards of fire resisting properties in respect of fire spread, combustibility of materials and the toxicity control on smoke emission. Subject to the findings of the risk assessment, provisions of automatic fire fighting equipment (e.g. sprinkler heads) should also be considered to be installed inside the cabin of the ride.

3.10 Propulsion System and Associated Protection Mechanism

Propelling machinery of the amusement ride shall comply with the following requirements.

3.10.1 Protection for Overspeed

For the ride (e.g. a vertical ride involving a traction drive in the course of descending), where there is a concern on the overspeed issue, the drive shall be fitted with sensors or devices, which should be able to trigger a mechanism to shut down the drive in a safe manner whenever the designed maximum speed is exceeded. Overspeed sensors and controls shall be fail-safe and able to be positively tested by a regular and simple method, which shall be detailed in the operation and maintenance manual.

3.10.2 Protection for Underspeed

Where an underspeed condition may endanger the patrons (e.g. a vehicle is maintained inverted by centrifugal forces), the drive shall be fitted with an underspeed sensor to trigger a mechanism, which shall prevent the vehicle from reaching a dangerous orientation until the correct speed is attained. The vehicle shall be able to restore to a safe orientation immediately upon loss of speed.

Underspeed sensor and control shall be fail-safe and shall be able to be positively tested by a regular and simple method which shall be detailed in the operation and maintenance manual.

Underspeed sensor and control shall not be able to be reset except by a full shut down and restart of the ride. An alarm signal shall be given when the propelling machinery is tripped.

3.10.3 Manual Winding Retrieval

If patrons may be stranded by the failure of driving system (e.g. loss of power), the ride shall incorporate either a means of manually winding the machinery back to a safe position, or a means of emergency disembarkation in accordance with paragraph 3.16 regarding evacuation.

If the ride is of a size/configuration that manual winding is not a practical mean, an emergency power system shall be installed for patron retrieval.

3.11 Vehicle Body

All the vehicle surfaces with which the riders may come in contact shall be rounded and smooth, free from sharp, rough or splintered edges and corners, and have no protruding studs, bolts, screws or other projections. Adequate padding shall be provided where the patron may be thrown upon or against any part of the vehicle due to the ride motion.

For amusement ride involving more than one vehicle, the body of every vehicle shall be provided with clear, unique and identifiable markings.

3.12 Safety Clearance and Envelope

Any fixed or moving object, structure or special effect, which the vehicles may pass during the operation of the ride, shall be beyond the reach of the rider. Apart from this general principle, some specific requirements on the safety envelope as well as the key dimensions of the seating are set out in the following as guidance. The Director's approval shall be sought if alternative design standard on the safety clearance is adopted.

3.12.1 Fully Enclosed Vehicle

For rides where the patrons are totally enclosed inside a cabinet whilst there are some openings on the casing, the minimum clearance from adjacent objects shall be:-

(a) min. safety clearance = 90mm, where opening size < 9mm;

(b) min. safety clearance = 150mm, where 9mm ≤ opening size < 50mm;

(c) as per paragraph 3.12.2 and 3.12.3, where opening size ≥ 50mm.

3.12.2 Restrained Patrons in Open Type Vehicle

If patrons are not totally enclosed, but are effectively restrained in the seat, the following requirements as to dimensions of the seat and the safety clearances in relation to the seat shall be observed.

(a) The upper safety space, 1500mm extending upwards from the seating surface, shall not be obstructed by any external objects.

(b) The height of seat back (H_{back}), under different angle of seat rest (θ), shall be high enough such that –

(1) min. H_{back} required = 400mm , where $0° \le \theta < 15°$;

(2) min. H_{back} required = 550mm , where $15° \le \theta < 30°$;

(3) min. H_{back} required = 700mm , where $30° \le \theta < 45°$;

(4) min. H_{back} required = 800mm , where $45° \le \theta < 90°$;

(5) min. H_{back} required = 900mm , where $90° \le \theta$;

(where θ is inclination of seat back measured from a vertical plane while H_{back} is the height of the seat back measured from the seating surface to the top edge of the seat back)

(c) If θ exceeds 45° in the course of motion, rigid over-shoulder restraint system shall also be provided.

(d) The lateral safety space, which extends laterally outwards from the edges of the seating frame up to a distance $R_{lateral}$, the value of which shall be determined as a function of the Height of Seat Side (H_{ss}), shall not be obstructed by any external objects.

High of Seat Sides, H_{ss}		$R_{lateral}$
Low seat sides	:200 mm ≤ H_{ss} < 400 mm	1000 mm
Standard seat sides	:400 mm ≤ H_{ss} < 600 mm	750 mm
High seat sides	:600 mm ≤ H_{ss}	450 mm

(e) For vehicle speed exceeding 3 m/s, low seat sides shall be avoided.

(f) Where patrons are restrained but their legs are hanging free as in the suspension rides, a further bottom safety space, 900mm extending downwards from the bottom of the seating and lateral safety space, shall be maintained.

3.12.3 Unrestrained Patrons in Open Type Vehicle

For open type vehicle where patrons are not totally restrained in their seats, the following safety clearances shall be maintained.

(a) The vertical safety space, 2100mm extending upwards from the floor, shall not be obstructed by any external objects.

(b) The lateral safety space, 750mm extending outwards from the outermost envelope of the vehicle, shall not be obstructed by any external objects.

3.12.4 Maintenance and Inspection Requirements

If a ride needs to be serviced and inspected by maintenance personnel during operation, the clearance beyond the surface profile of any moving vehicles shall not be less than 350mm.

3.13 Passenger Gates

Gates, used for blocking the public's access, shall be positively locked to prevent any unauthorized entry. Entry to an amusement ride that is operating shall be delineated with a gate openable only from the inside, unless the entry is manned and defined by a barrier, drop-bar, chain or the like.

Exits with proper indications and directional signs, including those used for emergency evacuation to enable the patrons to leave the ride in a smooth manner, shall be provided.

Exit points, which is independent of entry points, shall either be manned and delineated as for an entry point, or shall be fitted with a gate secured against entry from outside but equipped with an obvious mean for opening from inside.

3.14 Maintenance Access

The fixed platforms, walkways, stairways and ladders, which are used by the crew for operation, inspection, maintenance or servicing purposes, shall be designed and constructed in accordance with BS 4592. Provisions of guarding and restraint systems shall be provided for prevention of fall from height.

3.15 Fences and Barriers

Fences, handrails, guards and temporary barriers, or other control measures as appropriate, shall be provided to –

(a) ensure the safety of the crew in carrying out the maintenance works;
(b) confine the crew and patrons inside a safety zone within the boundaries of the ride; and
(c) protect the safety of the spectators, passers-by and those queuing in the vicinity of the ride.

The height of fences, which are used for delineating the zones for controlling purpose, shall be not less than 1000mm and not more than 1150mm with intermediate rails at the middle. Where there is hazard of falling object which may injure people at a lower level, toeboards of 200mm high shall be extended from the floor.

Machine guards shall be installed where there are moving machinery component.

3.16 Evacuation Facilities

Appropriate means (hereunder called "assisted evacuation facilities") shall be provided to facilitate the safe emergency disembarkation of patrons from the ride in cases of power failure, malfunction, fire or any unintended stoppage through –

(a) facilities to bring the ride to the loading/unloading points or other position where patrons can disembark in a safe manner;
(b) fixed walkways, stairs, platforms or hatchways that are readily accessible from all sections of the ride, with signs as appropriate; or
(c) a combination of the above two means.

Where an amusement ride is located within a building, provisions of fire services installation and the means of escape shall in principle comply with the statutory requirements under the Building Ordinance, Cap. 123, irrespective of whether the building in question is specifically designed to accommodate the ride or not. The

above-mentioned assisted evacuation facilities may be standalone structures, or form parts of the ride or the building works. However, the provisions of the assisted evacuation facilities shall be sufficient for use by an average man with the assistance of the operation staff or firemen in case of emergency disembarkment.

3.17 Welding

All welding works shall be carried out in accordance with the manufacturer's welding procedures by qualified welders with recognised certificate of proficiency, and to the satisfaction of the Surveyor. On-site welding shall never be carried out under unfavourable site or weather conditions. Any doubts as to the implications of the welding works on structural elements which may affect the integrity of the ride shall be referred to the designer/manufacturer or the Surveyor.

All welding works, unless other equivalent standards such as DIN or AWS are specified by manufacturer/designer, shall comply with the following requirements.

(a) All load-bearing welds on steel structures shall be produced in accordance with BS 5135 to at least Quality Category B. Welding of steels not covered by BS 5135, e.g. wear-resistant or hardening steels used in specific applications, e.g. pins, shafts, tracks, shall only be carried out if consideration has been given to the metallurgical effects of the welding on the component.
(b) Welding procedures shall be approved in accordance with BS 4870, and welders approved in accordance with BS 4871.
(c) Butt welds shall be made using procedures which will give both yield and tensile strengths in the weld metal not less than those of the parent metal.
(d) Welds subject to dynamic stress, i.e. fatigue conditions, shall be to Quality Category A of BS 5135.

4. Testing and Inspection Related Matters

Apart from the type tests and detailed quality assurance checks of the major components and assemblies in shops, every amusement ride shall be examined by the Surveyor upon completion of the installation works, and thereafter regularly at a frequency not less than once every 12 months. Ride examination shall cover any structure, electrical, mechanical and safety equipment which may affect the integrity and safe operation of the ride. The following tests and verifications, as appropriate, shall be conducted on site.

(a) Overall visual inspection with regard to proper construction/installation as specified in the design drawing and this Code.
(b) Conformity of the main dimensions, safety-envelopes, clearances necessary for safe and free running of the moving parts.
(c) Full load test.
(d) Functional tests of the control and speed-limiting devices.
(e) Checking the performance of the brakes and other provisions for safe operation of the ride.
(f) Testing of the pneumatic and hydraulic systems.
(g) Electrical tests.
(h) Non-destructive tests for welding and structural works.
(i) Observations and measurements of the performance of the ride under normal loading and foreseeable unbalanced loading in all the configurations permitted in the operation manual.
(j) Measurements of speeds, accelerations and forces to check the validity of the design calculations as necessary.
(k) Tests of the function and performance of safety-critical systems in normal operation and under foreseeable fault and emergency conditions.

4.1 Full Load Test

Full load test shall be carried out by operating the ride at the nominal speed and under the designed service conditions, with equivalent dummy load fixed onto the vehicles of the ride. Continuous running of the ride at full load for a prolonged period shall be arranged if the situation warrants.

4.2 Test for Unbalanced Load

If the design of an amusement ride can accommodate certain degree of unbalanced loading, the designer shall specify the appropriate test under unbalanced loads to ascertain whether the strength and stability of the ride that has been put up does conform to the original design. All the details of the test for unbalanced load shall be properly documented. If such permissible out-of-balance is a feature of the design intent, the limits for out-of-balance operation shall be specified explicitly in the operation and maintenance manual.

If specific details, however, is not provided by the designer, or is not specified in the operation and maintenance manual, the Surveyor or a qualified engineer shall assess the ride and establish appropriate limits for unbalanced loading which shall then be verified with an actual unbalanced load test under the established limiting conditions. The Surveyor shall not accede to such unbalanced operation if there is any adverse vibration, harmonic oscillation or movement relative to footings and foundations during the test.

4.3 Test for Electrical Installation

Electrical works shall be inspected and tested in accordance with the requirements of IEC 364 and Code of Practice for the Electricity (Wiring) Regulations. In particular, the following electrical tests, in sequence, shall be conducted where appropriate.

4.3.1 Visual Inspection

Before any testing on a ride is made, a visual inspection on the electrical works shall be carried out in accordance with paragraph no. 21A of the Code of Practice for Electricity (Wiring) Regulations.

4.3.2 Continuity of Protective Conductors

Every protective conductor, including all conductors and any extraneous conductive parts used for equipotential bonding, shall be tested for continuity.

4.3.3 Insulation Resistance

The insulation resistance of the electrical works shall be measured and shall be not less than the following values when tested with a 1000V insulation tester.

(a) Insulation resistance to the earth 1 MΩ
(b) Insulation resistance between poles or phase 1 MΩ
(c) Insulation resistance of equipment 0.5 MΩ

4.3.4 Verification of Polarity

A test of polarity shall be carried out to verify that -

(a) every fuse and single-pole control and protective device is connected in the phase conductor only;
(b) centre-contact bayonet and Edison-type screw lampholders in circuits having an earthed neutral conductor, have their outer or screwed contacts connected to that neutral conductor; and
(c) wiring works are sound and correctly connected.

4.3.5 **Earth Fault Loop Impedance**

A test shall be carried out to verify the effectiveness of the earthing by means of a phase-earth loop tester. The value of impedance for each loop shall not exceed the requirements as stipulated in paragraph 11 of the Code of Practice for Electricity (Wiring) Regulations.

4.3.6 **Residual Current-operated Circuit Breaker (RCCB)**

Every residual current-operated circuit breaker shall be tested for proper and satisfactory operation. The test shall be carried out by applying an AC voltage not exceeding 50V r.m.s. across the neutral and earth terminals.

4.3.7 **Lightning Protection System**

The lightning protection system shall be tested as per paragraph no. 3.7 of this Code.

4.4 Tests for Hydraulic and Pneumatic System

The following basic items, which are pertinent to typical hydraulic and pneumatic system, shall be checked and attended to.

(a) Ram and cylinder condition.
(b) Leveling switches.
(c) Pipeworks, joints, bolts and fixings; stop valve; oil reservoir; pump and motor.
(d) Control valves, pilot and leveling valves; overrun and cut-off devices; overload relief valve.
(e) Air release cock and anti-siphon valve.
(f) Pressure vessel.

Besides, the following tests shall be carried out to establish the integrity of a hydraulic or pneumatic system and its components as per the designer or manufacturer's specifications.

(a) Functional test to ascertain the correct operation of the system and all safety devices.
(b) Pressure tests to every part of the hydraulic or pneumatic system at the maximum working pressure sustained under all conditions of intended use.

4.5 Non-Destructive Testing

Non-destructive testing (NDT) referred hereunder comprises a variety of methods for locating cracks or discontinuities on the surface or inside the metal body of the ride. The presence of these cracks or discontinuities may be detrimental to the structural or functional integrity of that part and hence affecting the overall integrity of the ride. The cracks may be in the form of inclusions in the welds or castings, or variations in structural properties which can lead to loss of mechanical strength resulting in failure of the components during service. The essential feature of NDT is that the test process itself produces no deleterious effects on the material or structure under test.

NDT ranges from simple techniques such as visual examination of surfaces, through the well-established methods of radiography, ultrasonic testing, magnetic particle crack detection (MPI), to the specialized methods such as the measurement of Barkhausen noise and positron annihilation. Every test method has attributes and limitations that shall be considered when choosing a NDT program for a ride. The factors that shall be taken into account include the manufacturing process, the intended service, and the service environment of the object.

Aspects of NDT methods such as terminology, equipment and working principles should be complied with CEN-TC138 or CEN-TC121. The technician carrying out the NDT shall be familiar with the standards relevant to the particular method used. The person shall be well experienced in the method of testing, and the particular techniques required for testing the

component or structure under examination. The qualification of such technician shall be accredited according to ISO 9712, PCN (Personnel Certification in NDT), ASNT (American Society of NDT) or other internationally recognized certification scheme.

The Surveyor or the appointed technician carrying out NDT shall be able to distinguish between original manufacturing flaws and flaws developing during ride operation, and to distinguish between significant and insignificant indications. Therefore, the Surveyor or the appointed technician shall acquaint himself with the fabricating method, the stresses acting on that part of the ride, and the type, size and orientation of flaw which is significant under those conditions of stress, material or geometry.

Manufacturer should recommend a schedule and components for testing on a ride in terms of running hours of the ride. Nevertheless, in the absence of any explicit recommendation on the NDT program by the manufacturer, the owner shall ensure that all critical welds are checked with ultrasonic or magnetic particle inspection once every ten years or at a frequency determined by the state of the ride (ie. any frequent pre-mature failure of components). NDT should cover elements like structural supports, ride tracks, wheel assemblies, shafts & spindles, sweep arms, vehicle frames & attachments, steel cables, structural columns, chains, pins and bolts etc.. Unless it is otherwise specified or materials other than carbon steel are involved, the acceptance criteria should be in accordance with BS 5135.

4.6 Certification and Documentation of Test Record

Under the Ordinance, the Surveyor is the person, who is appointed by the Ride Owner, be responsible for examination of the ride, and certification on the integrity and safe operation of the ride. Documentation relating to the tests on individual parts or sub-system of ride performed by manufacturers or others inspection bodies is acceptable if reasonable steps have been taken to verify that the tests are relevant, the procedures used are appropriate and the results reliable. Such documentation of testing on individual parts or sub-system includes :

(a) Type test certificates of standard products;
(b) Valid test certificates issued by an independent testing institute for wire ropes, pressure vessels, safety gears, buffers, etc.
(c) Non-destructive testing on welding and structural works.

Although the Surveyor may make reference to above-mentioned information as he thinks fitted, the Surveyor shall always exercise his due diligence to check the accuracy of these test data and have a thorough examination on the ride and check on its fitness for use by members of the public. Any tests performed by Surveyor or critical information that underlies his/her conclusion shall be documented in the Surveyor's Report. Apart from a conclusion on the integrity and safe operation of the ride, the Surveyor shall also report on wider safety-related matters and recommend on improvement measures for the ride.

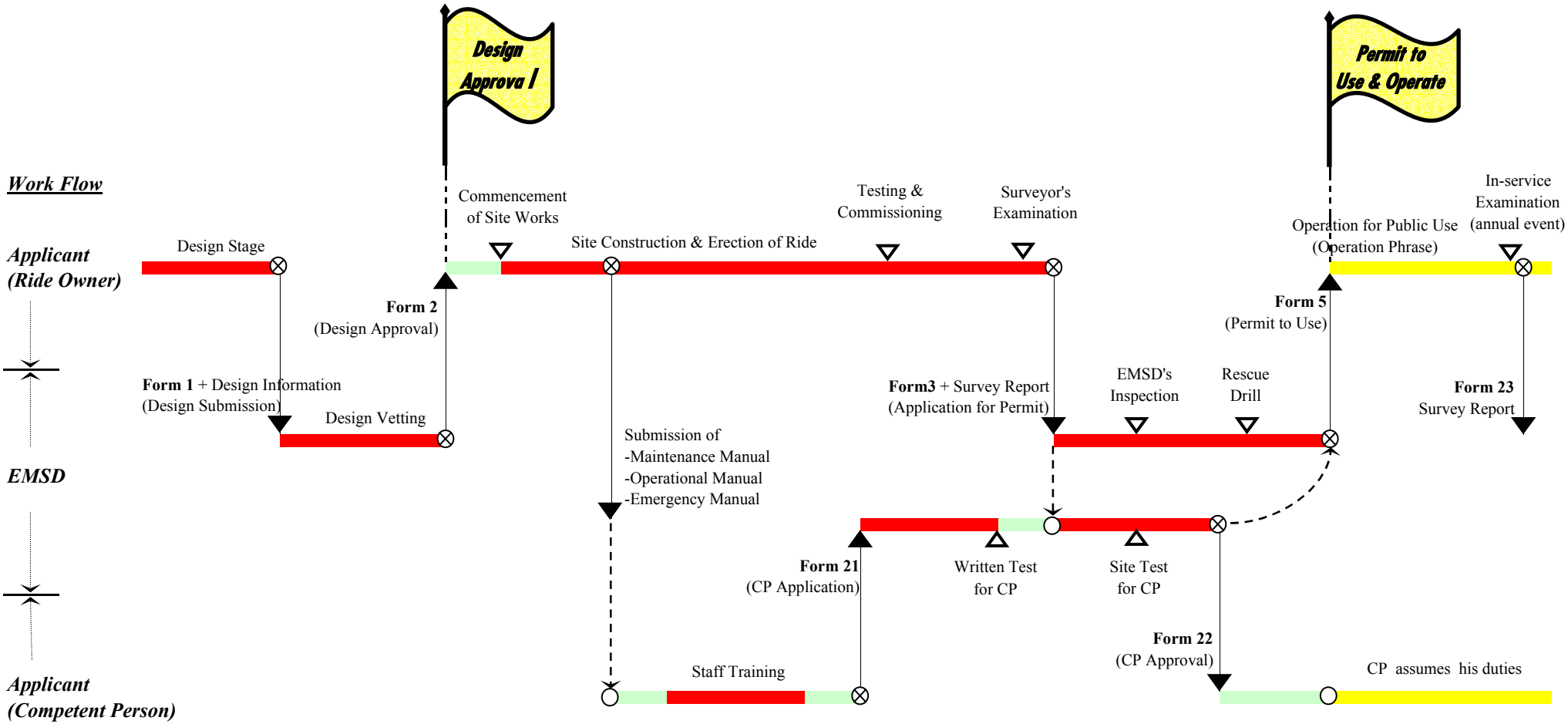

Figure 1 : Sequence of Events and Key Milestones for a Typical Licensing Process under Amusement Rides (Safety) Ordinance, Cap. 449

Reference

(a) Amusement Rides (Safety) Ordinance (CAP. 449)
(b) Amusement Rides (Safety) (Operation and Maintenance) Regulation
(c) Boilers and Pressure Vessels Ordinance, Cap. 56
(d) Building Ordinance, Cap. 123
(e) Electricity Ordinance, Cap. 406
(f) Engineers Registration Ordinance, Cap. 409
(g) Gas (Safety) Ordinance, Cap. 51
(h) Code of Practice for Electricity (Wiring) Regulation
(i) Code of Practice for Fire Resisting Construction 1996
(j) Code of Practice for Minimum Fire Service Installations and Equipment
(k) Code of Practice for the Provision of Means of Escape in Case of Fire
(l) Code of Practice for the Structural Use of Steel
(m) Hong Kong Wind Code

Enquiry

General Legislation Sub-division
Electrical and Mechanical Services Department
98 Caroline Hill Road, Causeway, Hong Kong

Telephone No. : (852) 2808 3867
Fax No. : (852) 2577 4901
Web Site : www.emsd.gov.hk