IS 17900 – Part 7 / Section 7 : 2024

Indian Standard

Lifts for the Transport of Persons and Goods

Part 7 Lifts for Special Applications

Section 7 Lifts under Seismic Conditions

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FOREWORD

This Indian Standard was finalised by the Bureau of Indian Standards, after the draft finalized by the Lifts, Escalators and Moving Walks Sectional Committee had been approved by the Electrotechnical Division Council.

This Indian Standard is a part of series of Indian Standards on 'Lifts for the transport of persons and goods'. Other parts of this series of standards cover various requirements like safety rules, design calculations, specifications for control devices, buttons, signals, indicators, and other fittings; specifications for planning and selection, guide for inspection and maintenance of lifts, lifts for special applications, dumbwaiters etc. Other parts of this series are under development.

This standard is to be read in conjunction with IS 17900 (Part 1) : 2022 and IS 17900 (Part 2) : 2022

This standard is largely based on EN81-77:2018 'Safety rules for the construction and installations of lifts - Particular applications for passenger and goods passenger lifts - Part 77: Lifts subject to seismic conditions". In order to suit the Indian market requirements and considering provisions of enhanced safety, changes have been made in the standard.

1. Introduction

1.1 General

The machinery concerned and the extent to which hazards, hazardous situations and events are covered, are indicated in the scope of this standard.

This document is a Type C Standard as stated in IS 16819. When provisions of this C standard are different from those which are stated in type A or B standards, the provisions of this Type C standard take precedence over the provisions of the other standards, for machines that have been designed and built according to the provisions of this Type C standard.

1.2 General remarks

1.2.1 The object of this standard is to define additional safety rules related to passenger and goods lifts with a view to safeguarding persons and objects against the risks described below associated with the use, maintenance, inspection and emergency operation of lifts subject to seismic conditions.

1.2.2 The aim of this Indian Standard is to:

— avoid loss of life and reduce the extent of injuries;
— avoid people trapped in the lift;
— avoid damage;
— avoid environmental problems related to oil leakage;
— reduce the number of lifts out of service.

1.3 Principles

Risk analysis, terminology and technical solutions have been considered taking into account the methods of ISO 12100 and ISO 14798 standards.

1.4 Assumptions

It is assumed that negotiations have been made for each contract between the customer and the supplier/installer about the design acceleration (a_d) to be considered and the most effective position of the seismic detection system, if any, and of the primary wave detection system, if any. The building designer or the lift owner should provide the design acceleration (ad) which will be documented in the information for the owner provided by the installer.

This Indian Standard covers only the effects of earthquakes on lifts and not the nature of them.

2. Scope

This document specifies the special provisions and safety rules for passenger and goods passenger lifts where these lifts are permanently installed in buildings.

This document defines additional requirements to IS 17900-1 and IS 17900-2.

It applies to new passenger lifts and goods passenger lifts. However, it can be used as a basis to improve the safety of existing passenger and goods passenger lifts.

This document does not introduce any additional special provisions and safety rules for lifts which are in Seismic lift category 0 as defined in Annex A, Table A.1.

This document does not address other risks due to seismic events (e.g. fire, flood, explosion).

3. References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IS 17900 Part 1:2022 - Lifts for the transport of persons and goods - Part 1: Safety Rules

IS 17900 Part 2:2022 - Lifts for the transport of persons and goods - Part 2: Design rules, calculations, examinations and tests of lift components

IS 17900 Part 7/Section 6:2024 - Lifts for the transport of persons and goods: Occupant Evacuation lifts

IS 17806:2022 - Passenger lifts and service lifts - Guide rails for lift cars and counterweights - T-type

IS 1893 Part 1:2016 – Criteria for Earthquake Resistant design of structures – General provisions & Buildings

SP 7:2016 – National Building Code of India

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

ISO 14798:2009 - Lifts (elevators), escalators and moving walks — Risk assessment and reduction methodology

4. Terminology

For the purposes of this Standard, the following terms and definitions as well as terms and definitions given in IS 17900 Part 1, IS 17900 Part 2 & IS 16819 apply.

4.1 Snag point - Point of interference between flexible elements and fixed elements

Note 1 : Examples of flexible elements are ropes, CSBs & travelling cable.
Note 2 : Examples of fixed elements are guide rail brackets, guide rail clip bolts, fishplates, vanes, and similar devices.

4.2 Design acceleration (a_d) - Horizontal acceleration to be used for calculation of forces – moments acting on lift systems and arising from seismic events

Note : See Annex B.

4.3 Seismic lift categories - Categories in which lifts have been divided, taking into account the design acceleration (ad)

Note : Table A.1 shows the seismic lift categories.

4.4 Primary wave - Compressional wave that is longitudinal in nature

Note : Earthquake advance warning is possible by detecting the non-destructive primary waves that travel more quickly through the Earth's crust than do the destructive secondary waves. The amount of advance warning depends on the delay between the arrival of the primary wave and other destructive waves, generally in the order of seconds for distant, large quakes.

4.5 Secondary wave - Shear wave that is transverse in nature, its motion being perpendicular to the direction of wave propagation

Note : Secondary waves move through solids, unlike surface waves. They are destructive and arrive later than primary waves.

4.6 Seismic trigger level - Seismic acceleration which activates a seismic detection system

4.7 Seismic mode - Special mode in which the lift operates after detection of seismic trigger level

4.8 Seismic stand-by mode - Special mode in which the lift operates after detection of primary wave without the activation of the seismic detection system

4.9 Normal operation - Operation mode in which the lift operates when not in seismic mode or in seismic stand-by mode

4.10 Retaining device - Mechanical device securely fixed to a structural member of the lift car, counterweight or balancing weight frame, designed to retain the lift car and counterweight (balancing weight) within its guide rails during seismic activity

4.11 Expansion joint - Assembly designed to safely absorb the heat-induced expansion and contraction of various construction materials, to absorb vibration, or to allow movement due to ground settlement or earthquakes

5. List of significant hazards

This clause contains all the significant hazards, hazardous situations and events, as far as they are dealt with in this standard, identified by risk assessment as significant for this type of machinery and which require action to eliminate or reduce the risk (see Table 1).

Table 1 — List of significant hazards

No	Hazards as listed in ISO 12100:2010, Annex B	Relevant clauses
1	Acceleration, deceleration	6.4.1, 6.5, 6.8.2
	Angular parts	6.2
	Approach of a moving element to a fixed part	6.4.2, 6.5
	Machinery mobility	6.3, 6.9
	Moving elements	6.4.1, 6.4.3
	Rotating element	6.6.1, 6.6.2, 6.9
2	Failure of the power supply	6.10.2, 6.10.3.5
3	Human behaviour	Clause 6, Clause 7
4	Pollution	6.7, 6.9
	Failure of the control circuit	6.10.3.4, 6.10.3.5

6. Safety requirements and/or protective measures

6.1 General

Passenger and goods passenger lifts shall comply with the safety requirements and/or protective measures of the following clauses when the lifts are subject to seismic conditions. In addition, passenger and goods passenger lifts shall be designed according to the principles of ISO 12100 for hazards relevant but not significant that are not dealt with by this document.

If not differently specified, the following requirements apply to Seismic lift category 1, 2 and 3.

6.2 Lift well

In order to prevent that suspension ropes, overspeed governor ropes, travelling cables, compensation ropes and chains, swaying in the well get entangled with fixed equipment, snag points created by brackets, sills, devices and other equipment mounted in the well shall be protected according to Table 2.

Table 2 — Protection of snag points

Height of the well	Horizontal distance between snag points and lift parts	Lift parts	Protective measures	Remarks
≤ 20 m			Not necessary	
> 20m ≤ 60 m	< 900 mm	Travelling cables	Install protection measures for example a protection wire in the corner of the rail bracket or other snag points near the travelling cables	Required if any portion of the loop is smaller than 900 mm from a snag point
	< 750 mm	Compensating Chain(s) Compensating rope(s) Counterweight Overspeed governor rope	Install protection measures for example a protection wire in the corner of the rail bracket or other snag points	Full travel
	< 500 mm	Car overspeed governor rope	Install protection measures for example a protection wire in the corner of the rail bracket or other snag points	Full travel
	< 300 mm	Suspension ropes	Install protection measures for example a protection wire in the corner of the rail bracket or other snag points	Full travel

> 60 m	Protect all snag points independently from horizontal distance	Travelling cables Compensating Chain(s) Compensating rope(s) Counterweight overspeed governor rope Car overspeed governor rope Suspension ropes	Install protection measures for example a protection wire in the corner of the rail bracket or other snag points	Full travel

6.3 Machinery and pulley spaces

Where buildings are designed with expansion joints subdividing the structure into dynamically independent units, all the lift machinery including the landing entrances and the well of the lift shall be located on the same side of an expansion joint (see IS 17900-1:2022, 0.4.2).

6.4 Car

6.4.1 Mass of the car for lift design calculations

For lift design calculations, the forces generated by the design acceleration (a_d) shall be calculated taking into account:

— for passenger lifts, the mass of the car plus 40 % of the rated load evenly distributed;
— for goods passenger lifts, the mass of the car plus 80 % of the rated load evenly distributed.

6.4.2 Car retaining devices

For lifts in lift categories 2 and 3, the car frame shall be provided with upper and lower retaining devices able to hold the car frame on its guide rails.

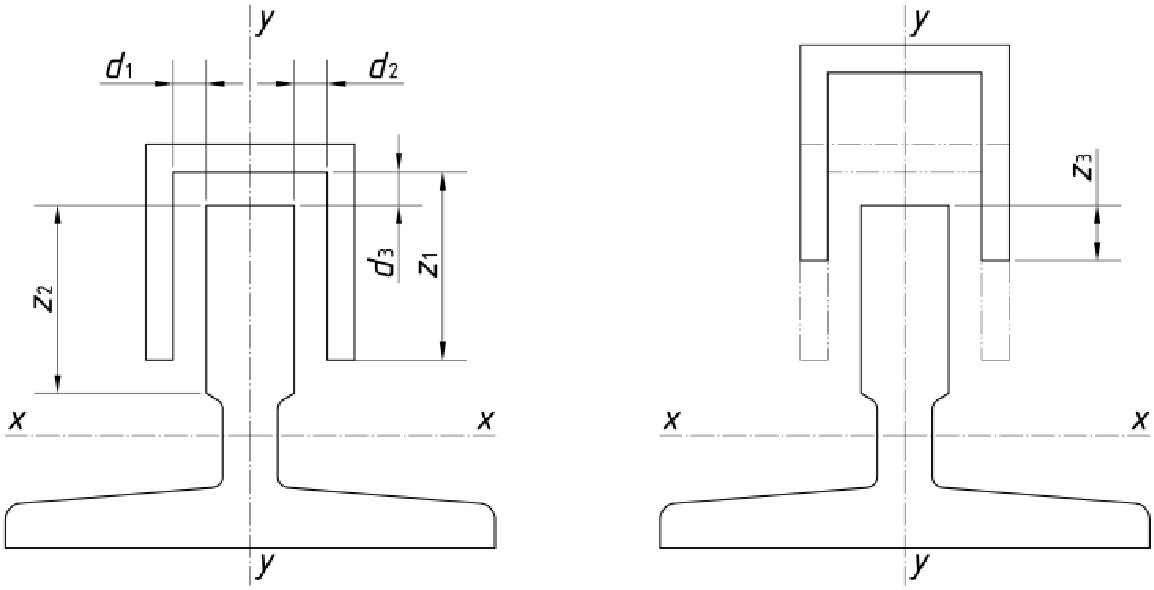
The retaining devices shall be placed in such a way to distribute loads in a similar way as the guide shoes. The retaining devices shall either be integrated or mounted close to the fixing of the guide shoes.

When the car is centre located between the guide rails, the clearances d_1, d_2 and d_3 (Figure 1 a) between the retaining device and the guide rail shall not exceed 5 mm and the dimensions chosen shall not cause accidental tripping of the safety gear during an earthquake.

The depth of the retaining device (z_1) shall be limited to avoid collision with guide rail attachments or other fixed devices, but long enough to guarantee a minimum overlapping length between retaining devices and the guide rail blade during an earthquake. The required depth of the retaining devices is also correlated with the type of guide rail through the allowable deflection of the guide rail (see 6.8.2).

During an earthquake, the minimum overlapping length (z_3) between retaining devices and the guide rail blade shall be at least 5 mm (Figure 1 b).

The car structure and retaining devices shall withstand the loads and forces imposed on them including forces generated by the design acceleration (a_d), without permanent deformation.



a) Nominal position and clearance of retaining device

b) Minimum required overlapping length of retaining device during earthquake

Figure 1 — Retaining device

d_1	Clearances between the retaining device and the guide rail
d_2	Clearances between the retaining device and the guide rail
d_3	Clearances between the retaining device and the guide rail
x	Guide rail x-axis
y	Guide rail y-axis
z_1	Depth of the retaining device
z_2	Blade height
z_3	Overlapping length of retaining device during earthquake (≥5 mm)

6.4.3 Car door locking devices

To prevent the opening of car doors, for lifts in Seismic lift category 2 and 3, the car doors shall be provided with a car door locking device which shall be designed and operate as described in IS 17900-1:2022, 5.3.9.2.

6.5 Counterweight or balancing weight

The counterweight or balancing weight shall be provided with upper and lower retaining devices able to hold the frame in between its guide rails.

The retaining devices shall be placed in such a way to distribute loads in a similar way as the guide shoes. The retaining devices shall either be integrated or mounted close to the fixing of the guide shoes.

The clearances d_1, d_2 and d_3 (Figure 1 a) between the retaining devices and the guide rails shall not exceed 5 mm. When a safety gear is present, the dimensions chosen for the clearances d_1, d_2 and d_3 shall not cause accidental tripping of the safety gear.

During an earthquake, the minimum overlapping length (z3) between retaining devices and the guide rail blade side shall be not less than 5 mm (Figure 1 b).

The counterweight or balancing weight structure and retaining devices shall withstand the loads and forces imposed on them including forces generated by the design acceleration (ad), without permanent deformation.

The strength of the retaining devices and the counterweight frame or balancing weight frame shall be calculated taking into account the vertical mass distribution of the assembly of the counterweight frame or balancing weight including filler weights.

If the counterweight or the balancing weight incorporates filler weights, necessary measures shall be taken to prevent their movement outside the frame considering the design acceleration value.

6.6 Suspension and compensation

6.6.1 Protection for traction sheaves, pulleys and sprockets

The devices for preventing the ropes from leaving the grooves of traction sheaves and pulleys shall include one retainer within 15° of the points where the ropes enter and leave the pulleys and at least one intermediate retainer every 90° of the angle of wrap. The strength and stiffness of the retainers and their distance to the traction sheaves and pulleys compared to the diameter of the ropes shall be such that they are effective.

The devices for preventing the chains from leaving the sprockets shall include one retainer within 15° of the points where the chains enter and leave the sprockets.

6.6.2 Compensation means

Compensation means provided according to IS 17900-1:2022, 5.5.6 shall be guided in the pit in order to limit them from swaying and reaching snag points.

6.7 Precaution against environmental damage

Hydraulic lifts shall be provided with a rupture valve. The rupture valve shall comply with the requirements of IS 17900-1:2022, 5.6.3.

6.8 Guide rail system

6.8.1 General

The guide rails, their joints and attachments shall comply with the requirements of IS 17900-1:2022, 5.7 and they shall also withstand the loads and forces generated by the design acceleration (a_d).

Where retaining devices are provided, car and counterweight or balancing weight retaining devices shall be used as frame supporting points in the guide rail verification.

NOTE Annex D describes an example method for selecting guide rails.

6.8.2 Permissible stresses and deflections during seismic event

6.8.2.1 Where retaining devices are not provided, the maximum permissible deflections of the car guide rail system shall comply with the requirements of IS 17900-1:2022, 5.7, taking into account the load and the forces generated by the lift system including the forces generated by the design acceleration (a_d).

6.8.2.2 Where retaining devices are provided, the requirements stated below shall be fulfilled. The safety factors for guide rails shall satisfy Table 3.

Table 3 — Safety factors for guide rails

Elongation (A_5)	Safety factor
$A_5 \geq 12$ %	1.8
8 % $\leq A_5 < 12$ %	3.0

For guide rails in accordance with IS 17806:2022, the values of Table 4 shall be used.

Table 4 — Permissible stresses σ_{perm}

Rm (Tensile strength of guide rail) (N/mm^2)	370	440	520
σ_{perm} (Permissible stresses) (N/mm^2)	205	244	290

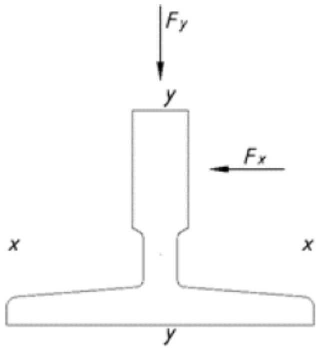
The maximum permissible deflection of car or counterweight (balancing weight) guide rail in y direction (see Figure 2) shall be such that the overlapping length between the blade of the guide rail and the retaining devices is not less than 5 mm (see Figure 1 b).

The maximum permissible deflection of the car guide rail, counterweight or balancing weight guide rail in x direction (see Figure 2) shall also be applied in y direction.

The maximum permissible deflection includes the deflections of the guide rail, it's fixing brackets and separation beams, if used. For T-profile guide rails the maximum permissible deflection in millimetres (see Figure 1) is:

$$\delta_{perm} = z_1 - 2d_3 - 5 \qquad (1)$$

but never more than 40 mm.



F_x Force exerted to the guide rail by the guide shoes or by the retaining devices in the x-axis
F_y Force exerted to the guide rail by the guide shoes or by the retaining devices in the y-axis
x-x Guide rail x-axis
y-y Guide rail y-axis

Figure 2 — Guide rail axis and forces

6.9 Machinery and other lift equipment

All machinery, pulleys and associated overhead beams and supports, rope attachments, overspeed governor, tension pulleys and compensation rope tension devices shall be designed and anchored to prevent overturning and displacement as a result of the forces imposed on them including forces generated by the design acceleration (a_d).

Hydraulic lifts shall preferably use flexible pipe work but where the use of rigid pipe is essential it shall use flexible pipe at the end of each rigid length.

6.10 Electric installations and appliances

6.10.1 Electric installations in the lift well

The fixing of landing switch devices or final limit switches, vanes or similar devices fixed in the well shall be designed and installed to withstand the loads and forces imposed on them including forces generated by the design acceleration (ad). In addition, the devices mentioned above shall be protected against damage caused by ropes and cables swaying in the well.

6.10.2 Behaviour of the lift in case of failure of the mains power supply

For lifts in Seismic lift category 2 and 3, in order to avoid people to be trapped in the car in case of failure of the normal power supply, the lift has to be able to move automatically the car to the next landing in up or down direction.

At landing the lift shall operate as described below:

a) a lift with automatic power operated doors, when parked at a landing, shall open the doors, remove the lift from normal operation and keep the door open;

b) for a lift with manually operated doors, when the car arrives at the designated landing, its door(s) shall be unlocked and the lift removed from normal operation.

Where IS 17900-1:2022 clause 5.12.5 applies or local regulations do not permit the doors to remain open, a means shall be provided to open the doors (even with the electrical power on) enabling the rescue service to check whether the car is present and persons are not trapped (see IS 17900-1:2022, 0.4.2).

The automatic dispatch to the lowest landing as defined in IS 17900-1:2022, 5.12.1.10 a) shall be rendered inoperative.

The behaviour of the lift in case of failure of the normal power supply shall not override any of the following:

— the electric safety devices;
— the inspection operation (IS 17900-1:2022, 5.12.1.5);
— the emergency electrical operation (IS 17900-1:2022, 5.12.1.6);
— the fireman's lift switch (IS 17900-1:2022, 5.12.5.1.15, 5.12.5.1.16 & 5.12.5.1.17).

6.10.3 Seismic detection system

6.10.3.1 A seismic detection system shall be provided for lifts with counterweight or balancing weight in Seismic lift category 3.

6.10.3.2 Where the seismic detection system is used exclusively to send information to the lift it may be placed in the pit of the lowest lift in the building. In case of expected interference with other vibration sources, alternative locations of the seismic detection system are allowed (see assumption in the Introduction).

6.10.3.3 The seismic detection system shall comply with the following specifications:

— detection of tri-axial acceleration;

— seismic trigger level ≤ 1.00 m/s^2 in any direction including vectors;

NOTE "Vector" relates to the resulting acceleration from combined reactions in x, y and z planes.

— frequency response between 0.5 Hz to 10 Hz;

— system reaction time ≤ 3 s (6.10.3.5);

— automatic system test ≤ 24 h (6.10.3.4);

— emergency power supply back-up system for ≥ 24 h (6.10.3.6);

— manual reset of alarm trigger (6.10.3.7).

6.10.3.4 Availability and diagnostics:

The seismic detection system shall be able to operate at all times when the lift is intended to be available to users.

The seismic detection function, including interface between seismic detector and lift controller, shall be tested every 24 h. If a failure is detected during the test or the interface between the seismic detector and the lift controller is interrupted, the lift shall remove itself from normal operation on its next stop at a landing and park with its doors open.

6.10.3.5 System reaction time:

The system reaction time shall not exceed 3 s. The system reaction time describes the maximum allowed time between the point in time when the seismic wave exceeds the selected seismic trigger level for the first time and the point in time when the lift switches into the seismic mode described in 6.10.4.

6.10.3.6 Emergency electrical power supply:

The operation of the seismic detection system shall not be lost even in case of electrical power supply switching or mains power supply failure. When an emergency electrical power supply is used it shall be able to provide at least 24 h of power supply.

6.10.3.7 Resetting of the seismic detection device:

The resetting of the seismic detection device and the return of the lift to normal operation shall only be made by operation of a manual reset device.

The manual reset device of the lift shall be placed outside of the well, clearly identified, and accessible to authorized persons only, e.g. inside a locked cabinet.

NOTE In case of application of IS 17900-1:2022, firefighters are considered as authorized persons.

6.10.3.8 Visual indicator:

6.10.3.8.1 Seismic mode shall be visually indicated. The indicator shall be located close to the manual reset device.

5.10.3.8.2 In case of application of IS 17900-1 Fireman's lift (5.12.5.1.15 to 5.12.5.1.17, the indicator shall also be located at the firefighters access level, close to the firefighters lift switch where it shall also be indicated where the manual reset device is located.

6.10.4 Behaviour of the lift in seismic mode:

After activation of the seismic detection system, the lift shall perform as described below:

a) all registered car and landing calls shall be cancelled. New calls shall be ignored;

b) a lift in motion shall reduce the speed or stop and proceed to the next possible landing away from the counterweight or balancing weight with maximum 0.3 m/s car speed;

c) when lift is at landing:

   1) a lift with automatic power operated doors shall open the doors, remove the lift from service and keep the doors open;

   2) a lift with manually operated or non-automatic power operated doors shall remain in this condition and be removed from service with the doors unlocked;

   3) in case of a fireman's lift under phase II operation, the automatic power operated door shall function as defined in IS 17900-1:2022, 5.12.5.1.16 (k).

Where local regulations do not permit the doors to remain open, a means shall be provided to open the doors (even with the electrical power on) enabling the rescue service to check whether the car is present and persons are not trapped (see IS 17900-1:2022, 0.4.2).

In case of failure of the normal power supply and in case of activation of the seismic detection system, the lift shall operate as described above.

NOTE In case of application of IS 17900-1 & SP, there is always a secondary power supply.

The seismic mode shall not override any of the following:

— the electric safety devices;

— the inspection operation (IS 17900-1:2022, 5.12.1.5);

— the emergency electrical operation (IS 17900-1:2022, 5.12.1.6);

— the firefighters lift phase 2 operation (IS 17900 Part 7 / Section 5).

7 Verification of the safety requirements and / or protective measures

7.1 Technical compliance documentation

Technical compliance documentation shall be provided to facilitate the verification according to 7.2. The technical compliance documentation shall contain the necessary information to ascertain that the constituent parts are correctly designed and the installation is in conformity with this Indian Standard.

7.2 Verification of design

Table 5 indicates the methods by which the safety requirements and/or protective measures described in Clause 6 shall be verified. Secondary sub clauses which are not listed in the table are verified as part of the quoted sub clause. For example, sub 6.8.2 is verified as part of sub 6.8

Table 5 — Means of verification of the safety requirements and/or protective measures

Sub clause	Safety requirements	Seismic lift category	Visual inspection [a]	Drawing/ Calculation [b]	Performance check/test [c]	Measurement [d]	User Information [e]
6.2	Prevention or protection of snag points	1-3	X	X		X	
6.3	Machinery spaces and well located on the same side of an expansion joint	1-3	X				
6.4.2	Car retaining devices	2	X	X		X	
6.4.3	Car door locking devices	2	X	X	X		
6.5	Counterweight or balancing weight retaining devices	1-3	X	X		X	
6.6.1	Protection for traction sheaves, pulleys and sprockets	1-3	X			X	
6.6.2	Compensating means guides	1-3	X				
6.7	Precautions against environmental damage	1-3	X				
6.8	Guide rail system	1-3	X	X		X	
6.9	Machinery	1-3	X	X			
6.10.1	Electric installations in the lift well	1-2-3	X	X			X
6.10.2	Behaviour of the lift in case of failure of the normal power supply	2-3	X	X	X		X
6.10.3	Seismic detection system	3	X	X	X		X
6.10.4	Lift operation in seismic mode	3	X	X	X		X
Clause 7	Information for use	1-2-3	X	X			X
Annex C	Primary wave detection system (optionally)	3	X	X	X		X

a Visual inspection will be used to verify the features necessary for the requirement by visual examination of the components supplied.
b Drawings/calculations will verify that the design characteristics of the components provided meet the requirements.
c A performance check/test will verify that the features provided perform their function in such a way that the requirement is met.
d Measurement will verify by the use of instruments that the requirements are met, to the specified limits.
e Verify that the relevant point is dealt with in the instruction manual or by marking.

8 Information for use

Maintenance instruction to be provided by the installer shall take into account the information for maintenance personnel to properly make periodical checks of the lift operation, in particular the seismic equipment (i.e. car and counterweight frame retainer devices, seismic detection system, protection of snag points).

Maintenance instruction to be provided by the installer shall take into account the information for lift maintenance personnel to safely check the lift after an earthquake, including the physical well situation (fallen debris, etc.) before resetting the device and putting the lift into normal operation.

In case of application of IS 17900-1 Fireman's lift 5.12.5.1.15 to 5.12.5.1.17, the information considered in the instruction manual according to IS 17900-1:2022, 7.2.2 shall also contain the necessary information for firefighters concerning the position and functionality of the manual resetting device of the seismic detection system, if any.

Instructions have to be passed to the building owner in the instruction handbook (owner documentation) of the lift describing the behaviour of the lift in the event of earthquake and the need to maintain and to periodically test that the seismic equipment is in working order.

Design acceleration (a_d) shall be documented in the information for the owner provided by the installer.

Annex A
(Normative)

Seismic lift categories

For the purpose of this Indian Standard, lifts have been divided into categories, taking into account the design acceleration (ad). Table A.1 shows the lift categories.

Table A.1 — Seismic lift category

Design acceleration (m/s^2)	Seismic lift category	Comment
$a_d \leq 1$	0	The requirements of IS 17900-1 and IS 17900-2 are adequate therefore no additional action is required
$1 < a_d \leq 2.5$	1	Minor corrective actions required
$2.5 < a_d \leq 4$	2	Medium corrective actions required
$a_d > 4$	3	Substantial corrective actions required

Annex B
(Informative)

General information and determination of the design acceleration

B.1 General

Design acceleration (a_d) is a function of ground acceleration, soil behaviour, importance of the non-structural elements and other parameter as described below and provided by the building designer/owner (see 1.4). Lifts are considered non-structural elements according to IS 1893 (Part 1) : 2016.

The following formulae may be used to calculate the design acceleration (a_d) (see also IS 1893-1, clause 6.4):

$$a_d = S_a \left(\frac{\gamma_a}{q_a} \right) g \qquad \text{(B.1)}$$

$$S_a = \alpha \cdot S \cdot \left[\frac{3 \cdot \left(1 + \frac{z}{H}\right)}{1 + \left(1 - \frac{T_a}{T_1}\right)^2} - 0{,}5 \right] \qquad \text{(B.2)}$$

where,

a_d	is the design acceleration, in metres per square second
g	is the free fall acceleration (9.81), in metres per square second
S_a	is the seismic coefficient applicable to non-structural elements (non dimensional);
y_a	is the importance factor of the element (shall be taken equal to 1. For lift used for special safety purposes the value shall be increased according to IS 1893-1. y_a is non dimensional); lift used for special safety purposes are those installed in hospitals and the like for emergency services;
q_a	is the behaviour factor of the element (shall be taken equal to 2; q_a is non dimensional);
α	is the ratio of the design ground acceleration on type A ground (a_g) as calculated in IS 1893-1, to the acceleration of gravity g ($\alpha = a_g/g$ is non dimensional);
S	is the soil factor according to IS 1893-1 (non-dimensional);
T_a	is the fundamental vibration period, expressed in seconds, of the non-structural element ($T_a = 0$ if the lift does not affect the fundamental vibration period of the building. In other cases this value shall be increased according to calculation);
T_1	is the fundamental vibration period, expressed in seconds, of the building in the relevant direction;
z	is the height, in metres, of the non-structural element above the level of application of the seismic action (foundation or top of a rigid basement);
H	is the building height, in metres, measured from the top of foundation system, taking ground as 0 level.

The value of the seismic coefficient S_a shall not be taken less than $\alpha \times S$

NOTE : IS 1893-1 will provide correct updated detailed values coming from: detected seismic events, collected data and statistics elaboration.

B.2 Example of calculation of design acceleration

The purpose of this example is to show the methodology of calculation of design acceleration (a_d) (see Table B.1). Formulae used to evaluate the seismic coefficient (S_a) and the design acceleration (a_d) are those introduced at the beginning of this annex.

Table B.1 — Example numerical input data

Symbol	Value	Unit	Description
a_g	3.2	m/s^2	ground acceleration on type A ground, as calculated in IS 1893-1
α	0.3262	-	ratio ag/g; α is the ratio of the design ground acceleration on type A ground (a_g) to the acceleration of gravity g (α = ag/g is non dimensional)
S	1.15	-	soil factor (according to IS 1893-1:2016, 6.4.2.1)
z	20	m	height of the part of the lift installed in the higher position above the level of application of the seismic action (foundation or top of a rigid basement)
H	20	m	is the building height, in metres, measured from the top of foundation system, taking ground as 0 level
T_a	0	s	maximum among fundamental periods of vibration of the parts of the lift
T_1	1	s	fundamental vibration period of the building in the relevant direction
γ_a	1	-	importance factor of the element (according to IS 1893-1:2016, Table 8)
q_a	2	-	behaviour factor of a non-structural element (according to IS 1893-1:2016, Table 9)
g	9.81	m/s^2	gravity acceleration

The above table shows numerical input values chosen for a specific case representing a building in a high seismic zone (a_g), having a height (H), where structural and non-structural elements are of the same height ($z = H$), with the lift not affecting the fundamental vibration period of the building ($T_a = 0$), importance factor (γ_a) and behaviour factor (q_a) are chosen with the criteria detailed in this Annex.

Using the above numerical values the final results for seismic coefficient (S_a) and design acceleration (a_d) are:

$$S_a = 0.9378 \quad \text{(B.3)}$$

$$a_d = 4.6 \text{ m/s}^2 \quad \text{(B.4)}$$

According to Table A.1, the resultant Seismic lift category is 3.

Annex C
(Informative)

Primary wave detection system

Subject to negotiation, in addition to the seismic detection system, for lifts in Seismic lift category 3, a primary wave detection system may be provided complying with the following specifications:

— primary wave trigger level ≤ 0.25 m/s^2;

— sensing direction: vertical;

— frequency response: 0.5 Hz to 20 Hz.

Where the primary wave detection system is used exclusively to send information to the lift it may be placed in the pit of the lowest lift in the building. In case of expected interference with other vibration sources, alternative locations of the Primary wave detection system are allowed (see assumption in the Introduction).

In case a primary wave detection system is provided, after activation of the primary wave detection system, but no activation of the seismic detection system, the lift shall operate as described below:

— a lift parked at a landing shall remain in this condition for the next 60 s. If, during this time, the seismic detection system is activated, the lift shall go into the seismic mode, as described in 6.10.4, otherwise the lift shall be automatically switched back into normal operation;

— a lift in motion shall reduce the speed or stop and proceed to the nearest floor in up or down direction with maximum 0,3 m/s car speed. At landing: a lift with automatic power operated doors shall open the doors and remain in this condition for 60 s after initiating seismic stand-by mode; a lift with manually operated or non-automatic power operated doors shall unlock the doors and remain in this condition for 60 s after initiating seismic stand-by mode. If, during this time, the seismic detection system is activated, the lift shall operate as described in 6.10.4, otherwise the lift shall be automatically switched back into normal operation.

The primary wave detection system activation shall not override any of the following:

— the electric safety devices;

— the inspection operation (IS 17900-1:2022, 5.12.1.5);

— the emergency electrical operation (IS 17900-1:2022, 5.12.1.6);

— the fireman's lift phase II operation (IS 17900-1:2022, 5.12.5.1.16 [k]).

Annex D
(Informative)

Proof of guide rails

D.1 General

This annex explains the modification for the calculation of the guide rails system according to IS 17900-1:2022, 5.7 and IS 17900-2:2022, 5.10 and Annex B in order to take into consideration the impact of design acceleration on the car and counterweight and balancing weight.

D.2 Mass of the rated load

Under seismic conditions, the mass of the rated load should be evaluated by using the formula:

$$Q_{SE} = k_{SE} \times Q \quad \text{(D.1)}$$

Where

k_{SE} is the seismic load factor (k_{SE} = 0.4 for passenger lifts ; k_{SE} = 0.8 for goods passenger lifts);

Q is the rated load, in kilograms;

Q_{SE} is the mass of the rated load under seismic conditions, in kilograms.

D.3 Seismic forces

D.3.1 The seismic force generated by the masses of the car subjected to the design acceleration (ad) should be evaluated by using the formula:

$$F_{SE} = a_d\ (P_{EC} + k_{SE} \times Q) \quad \text{(D.2)}$$

Where

a_d is the design acceleration, in metres per square second;

P_{EC} is the mass of the empty car (ignoring the masses of the travelling cables and compensating ropes/chains), in kilograms;

k_{se} is the seismic load factor (k_{SE} = 0.4 for passenger lifts; k_{SE} = 0.8 for goods passenger lifts);

Q is the rated load, in kilograms;

F_{SE} is the seismic force generated by the masses of the car subjected to the design acceleration (a_d), in newtons.

D.3.2 The seismic force generated by the counterweight or balancing weight subjected to the design acceleration (ad) should be evaluated by using the formula:

$$F_{SE} = a_d\ (P_{EC} + q \times Q) \quad \text{(D.3)}$$

Where

a_d is the design acceleration, in metres per square second;

q is the balance factor indicating the amount of counterbalance of the rated load by the counterweight, or amount of counterbalance of the mass of the car by the balancing weight;

Q is the rated load, in kilograms;

P_{EC} is the mass of the empty car (ignoring the masses of the travelling cables and compensating ropes/chains), in kilograms;

F_{SE} is the seismic force generated by the counterweight or balancing weight subjected to the design acceleration (a_d), in newtons.

D.4 Load cases

The loads and forces and the load cases to be taken into consideration are shown in Table D.1.

Table D.1 — Loads and forces to be taken into consideration in the different load cases

Load Cases	Loads and forces	P	P_{EC}	Q	M_{cwt}/M_{bwt}	F_s	F_p	M_g	M_{aux}	WL	F_{SE}
Normal use	Running	x		x	x		x[a]	x	x	x	
	Loading + unloading	x		x		x	x[a]	x	x	x	
Safety Device Operation	Safety devices or similar	x		x	x		x[a]	x	x		
	Rupture valve	x		x			x[a]	x	x		
Seismic condition	Running		x	x[b]	x		x[a]	x	x	x	x
[a] See IS 17900-1:2022, 5.7.2.3.5. [b] The load to be considered is $Q_{SE} = k_{SE}Q$.											

Where

P is the mass of the empty car and components supported by the car, i.e. part of the travelling cable, compensating ropes/chains (if any), etc., in kilograms;

F_p is the push through forces of all brackets at one guide rail in Newton (due to normal settling of the building or shrinkage of concrete);

M_g is the mass of one line of guide rails, in kilograms.

Forces and torques per guide rail due to auxiliary equipment fixed to the guide rail M_{aux} should be considered, except for overspeed governors and their associated parts, switches or positioning equipment.

Windloads (*WL*) should be considered with lifts outside a building with incomplete well enclosure, and be determined by negotiation with the building designer.

For travel heights not exceeding 40 m, the force F_p may be ignored.

The guiding forces of a counterweight or balancing weight (*G*) should be evaluated taking into account:

— the acting point of the mass;

— the suspension; and

— the forces due to compensating ropes/chains (if any), tensioned or not.

On a counterweight or balancing weight, centrally guided and suspended, an eccentricity of the acting point of the mass from the centre of gravity of the horizontal cross area of the counterweight or balancing weight of at least 5 % of the width and 10 % of the depth should be taken into consideration.

For car acting point of the masses, refer to IS 17900-1:2022, 5.7.2.3.2.

D.5 Impact factors

Under seismic conditions, the masses of the car $(P_{EC} + Q_{SE})$ should be multiplied by the impact factor $k_2 = 1.2$

D.6 Acceleration direction

The acceleration should be considered according to the following Table D.2.

Table D.2 — Acceleration to be considered under seismic conditions

Bending stress relative to the x-axis	$a_x = a_d$	$a_y = 0$
Bending stress relative to the y-axis	$a_x = 0$	$a_y = a_d$

D.7 Vertical distribution of masses

The vertical distribution of masses of car and counterweight or balancing weight should be taken into account.

The load on guide shoes or retaining devices should be calculated taking into account the maximum value of the result of the following formulae:

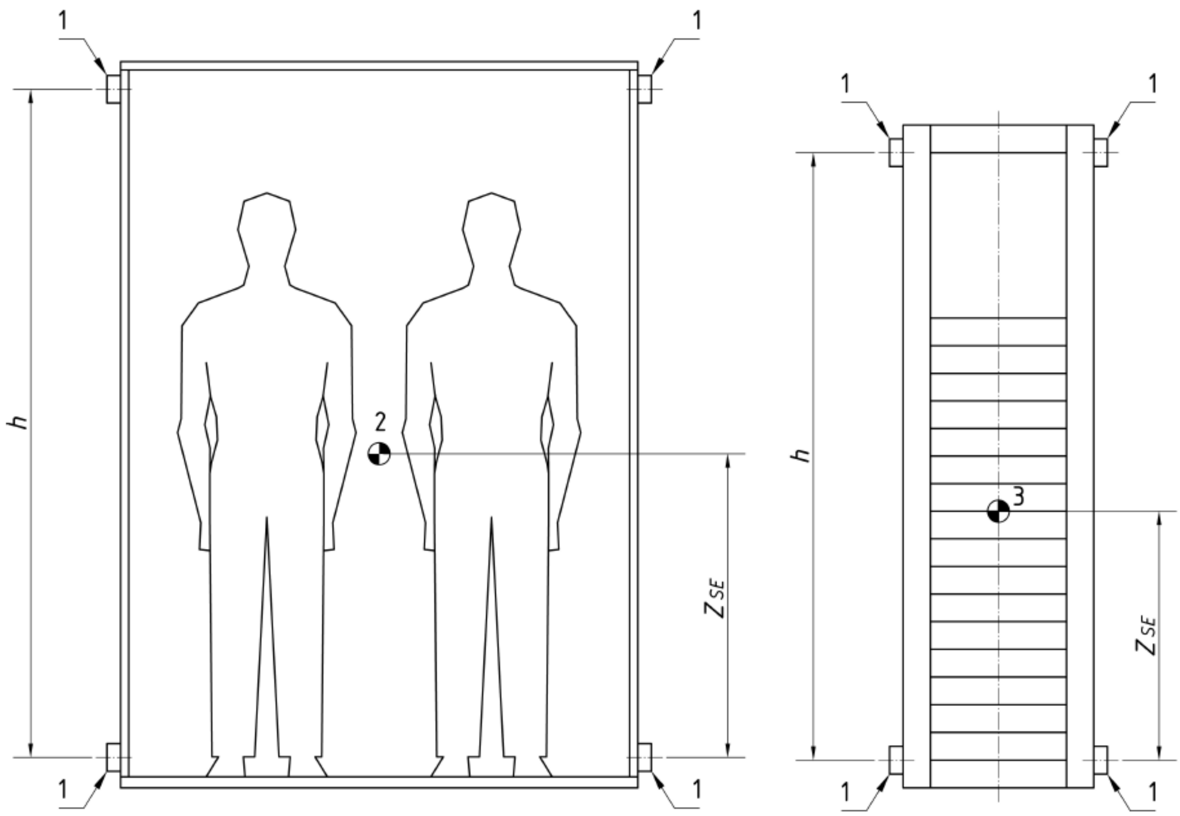
X_{SE} is the maximum value of $\frac{Z_{SE}}{h}$ and $\frac{h-Z_{SE}}{h}$ (D.4)

Where

Z_{SE} is the distance in Z-direction measured from the bottom retaining devices to the centre of gravity of car or counterweight or balancing weight including the load QSE, that is the point of application in Z-direction where the seismic force F_{SE} is applied (see Figure D.1), in metres;

h is the distance between guide shoes or retaining devices, in metres;

X_{SE} is the load ratio of guide shoes or retaining devices.



Where

1 guide shoe or retaining device
2 centre of gravity of the car (calculated considering the mass Q_{SE})
3 centre of gravity of the counterweight or balancing weight
h distance between guide shoes or retaining devices
Z_{SE} distance from the bottom retaining devices to the centre of gravity

Figure D.1 — Clarification of parameters

D.8 Car guide rail bending force

Under seismic conditions, the bending force of guide rail should be evaluated by using the formulae (for the meaning of the symbols see IS 17900-2:2022, Annex B):

a) Bending force relative to the y-axis of the guide rail:

$$F_x = \frac{k_2 g_n \left[Q_{SE(x_Q - x_s)} + P_{EC}\left(x_p - x_s\right) \right]}{nh} + \frac{a_x \left(P_{EC} + Q_{SE}\right) X_{SE}}{n} \quad \text{(D.5)}$$

b) Bending force relative to the x-axis of the guide rail:

$$F_y = \frac{k_2 g_n \left[Q_{SE(y_Q - y_s)} + P_{EC}\left(y_p - y_s\right) \right]}{\frac{n}{2} h} + \frac{a_y \left(P_{EC} + Q_{SE}\right) X_{SE}}{\frac{n}{2}} \quad \text{(D.6)}$$

D.9 Counterweight or balancing weight guide rail bending force

Under seismic conditions, the bending force of guide rail should be evaluated by using the formulae (for the meaning of the symbols see Is 17900-1 and IS 17900-2):

a) Bending force relative to the y-axis of the guide rail:

$$Fx = \frac{k_2 g_n \left(P_{EC} + qQ\right) e_x D_x}{nh} + \frac{a_x \left(P_{EC} + qQ\right) X_{SE}}{n} \quad \text{(D.7)}$$

b) Bending force relative to the x-axis of the guide rail:

$$Fy = \frac{k_2 g_n \left(P_{EC} + qQ\right) e_y D_y}{\frac{n}{2} h} + \frac{a_y \left(P_{EC} + qQ\right) X_{SE}}{\frac{n}{2}} \quad \text{(D.8)}$$

Where

e_x is 10 % eccentricity of the acting point of the mass from the centre of gravity in x-direction;

e_y is 5 % eccentricity of the acting point of the mass from the centre of gravity in y-direction;

D_x is the counterweight or balancing weight dimension in x-direction;

D_y is the counterweight or balancing weight dimension in y-direction.