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**Wheelchairs —**

Part 24:

**Requirements and test methods for user-  
operated stair-climbing devices**

*Fauteuils roulants —*

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*Partie 24: Exigences et méthodes d'essai pour les monte-escalier  
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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 7176-24 was prepared by Technical Committee ISO/TC 173, *Technical systems and aids for disabled or handicapped persons*, Subcommittee SC 1, *Wheelchairs*.

ISO 7176 consists of the following parts, under the general title *Wheelchairs*:

- *Part 1 Determination of static stability*
- *Part 2 Determination of dynamic stability of electric wheelchairs*
- *Part 3 Determination of effectiveness of brakes*
- *Part 4 Energy consumption of electric wheelchairs and scooters for determination of theoretical distance range*
- *Part 5 Determination of overall dimensions, mass and turning space*
- *Part 6 Determination of maximum speed, acceleration and deceleration of electric wheelchairs*
- *Part 7 Measurement of seating and wheel dimensions*
- *Part 8 Requirements and test methods for static, impact and fatigue strengths*
- *Part 9 Climatic tests for electric wheelchairs*
- *Part 10 Determination of obstacle-climbing ability of electric wheelchairs*
- *Part 11 Test dummies*
- *Part 13 Determination of coefficient of friction of test surfaces*
- *Part 14 Power and control systems for electric wheelchairs — Requirements and test methods*
- *Part 15 Requirements for information disclosure, documentation and labelling*
- *Part 16 Resistance to ignition of upholstered parts — Requirements and test methods*

- *Part 19 Wheeled mobility devices for use in motor vehicles*
- *Part 21 Requirements and test methods for electromagnetic compatibility of electrically powered wheelchairs and motorized scooters*
- *Part 22 Set-up procedures*
- *Part 23 Requirements and test methods for attendant-operated stair-climbing devices*
- *Part 24: Requirements and test methods for user-operated stair-climbing devices*
- *Part 26: Vocabulary*

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## Introduction

This part of ISO 7176 is written as a response to the need for a common language in the field of stair-climbing devices, to give a means of evaluating important safety issues, and to establish a means of qualifying and quantifying the performance of user-operated stair-climbing devices under the various conditions and environments encountered in their operation. Other relevant wheelchair standards of the ISO 7176 series might be applicable to stair-climbing devices that can also be used as wheelchairs. This allows users and manufacturers to compare the pertinent safety and utility issues of all functions and features of a given stair-climbing device.

The tests given in this part of ISO 7176 are used to gather comparative information about factors relating to the safety and performance of a user-operated stair-climbing device whilst in climbing mode on stairs and in climbing mode or crawling mode on landings as well as in driving mode on level ground. They include identification of suitable operating environments for each device and indications of various performance criteria in climbing mode for on-stairs operations and on level ground.

This part of ISO 7176 specifies tests for the “reference configuration” of the stair-climbing device. Since some stair-climbing devices have adjustable components and/or alternative parts, testing in different configurations may be needed to determine if a given variation conforms to this part of ISO 7176.

This part of ISO 7176 calls for the use of procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the manufacturer or test house from legal obligations relating to health and safety at any stage.

A Technical Report, ISO/TR 13570:2001, *Guidelines for the application of the ISO 7176 series on wheelchairs*, is also available giving a simplified explanation of these parts of ISO 7176.

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# Wheelchairs —

## Part 24:

# Requirements and test methods for user-operated stair-climbing devices

## 1 Scope

This part of ISO 7176 is applicable to user-operated stair-climbing chairs and user-operated stair-climbing wheelchair carriers where the stair-climbing device climbs backwards up the stairs, with the user facing downstairs, and climbs down the stairs in a forward position with the user facing downstairs.

This part of ISO 7176 specifies requirements and test methods for electrically powered stair-climbing devices that are user-operated. It also includes ergonomic, labelling and disclosure requirements.

This part of ISO 7176 specifies tests to demonstrate the stair-climbing device's ability to perform safely on stairs with a pitch of 35° or higher, if claimed by the manufacturer.

NOTE Attendant-driven stair-climbing devices are dealt with in ISO 7176-23.

## 2 Normative references

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

ISO 3880-1, *Building Construction — Stairs — Vocabulary*

ISO 7176-1, *Wheelchairs — Part 1: Determination of static stability*

ISO 7176-2:2001, *Wheelchairs — Part 2: Determination of dynamic stability of electric wheelchairs*

ISO 7176-3, *Wheelchairs — Part 3: Determination of effectiveness of brakes*

ISO 7176-4, *Wheelchairs — Part 4: Energy consumption of electric wheelchairs and scooters for determination of theoretical distance range*

ISO 7176-5, *Wheelchairs — Part 5: Determination of overall dimensions, mass and turning space*

ISO 7176-6:2001, *Wheelchairs — Part 6: Determination of maximum speed, acceleration and deceleration of electric wheelchairs*

ISO 7176-7:1998, *Wheelchairs — Part 7: Measurement of seating and wheel dimensions*

ISO 7176-8:1998, *Wheelchairs — Part 8: Requirements and test methods for static, impact and fatigue strengths*

ISO 7176-9, *Wheelchairs — Part 9: Climatic tests for electric wheelchairs*

ISO 7176-11, *Wheelchairs — Part 11: Test dummies*

ISO 7176-13, *Wheelchairs — Part 13: Determination of coefficient of friction of test surfaces*

ISO 7176-14:1997, *Wheelchairs — Part 14: Power and control systems for electric wheelchairs — Requirements and test methods*

ISO 7176-15, *Wheelchairs — Part 15: Requirements for information disclosure, documentation and labelling*

ISO 7176-16:1997, *Wheelchairs — Part 16: Resistance to ignition of upholstered parts — Requirements and test methods*

ISO 7176-21:2003, *Wheelchairs — Part 21: Requirements and test methods for electromagnetic compatibility of electrically powered wheelchairs and motorized scooters*

ISO 7176-22, *Wheelchairs — Part 22: Set-up procedures*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3880-1, ISO 7176-7, ISO 7176-15 and the following apply.

**3.1**  
**stair-climbing device**  
non-fixed device intended to transport a person and/or occupied wheelchair by climbing up or down stairs

NOTE A hierarchic system of various types of stair-climbing devices is given in Annex A.

**3.2**  
**user-operated stair-climbing device**  
stair-climbing device operated by the user while seated in it

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**3.3**  
**self-standing** (adjective)  
stable while at rest on a surface (test plane, stairs or landing) when subjected only to the force of gravity

**3.4**  
**balancing** (adjective)  
maintaining a position of unstable equilibrium through the application of other forces in addition to the force of gravity

**3.5**  
**stair-climbing chair**  
stair-climbing device that includes a seat for the user

**3.6**  
**stair-climbing wheelchair carrier**  
stair-climbing device that carries an occupied wheelchair

**3.7**  
**docking system**  
means of attaching a wheelchair to a stair-climbing wheelchair carrier

**3.8**  
**climbing**  
ascending or descending stairs



**3.9****driving**

performing wheelchair functions with electric power

NOTE 1 Typical wheelchair functions provide wheeled mobility over level ground, moderate slopes and small obstacles.

NOTE 2 Some stair-climbing chairs and some stair-climbing wheelchair carriers include such wheelchair functions.

**3.10****crawling**

moving on landings

NOTE Any means by which a stair-climbing device provides for moving on landings is considered crawling, including: manual propulsion, power-assisted manual propulsion and driving. Using the climbing mechanism to move on a landing is also considered crawling.

**3.11****winding stairs**

stairs built in a curved construction

**3.12****user**

person being transported in and operating the stair-climbing device

**3.13****U-shaped stairs**

two stairs at an angle of 180° to each other and connected by an intermediate landing

**3.14****skew angle**

angle of deviation between the pitch line of the stairs and the longitudinal axis of the stair-climbing device when viewed from above

**3.15****minimum reserve battery charge**

minimum battery charge sufficient for ascending a minimum of 20 steps and descending a minimum of 20 steps when loaded with the maximum load

**3.16****external force**

force that acts on the system consisting of a stair-climbing device, a test wheelchair (if used) and the user

EXAMPLE To apply forces by holding onto handrails.

**3.17****climbing mode exit restriction**

means that prevent the movement of a stair-climbing device by an operational mode other than climbing mode whilst on stairs

**3.18****safe stairs indicator**

means used to assess whether stairs are safe to climb

**3.19****cluster**

type of climbing mechanism where some cams revolve around the central axis of the cluster

NOTE The usual number of cams in a cluster ranges from 2 to 5. Some examples of types of clusters are shown in Figure 1.

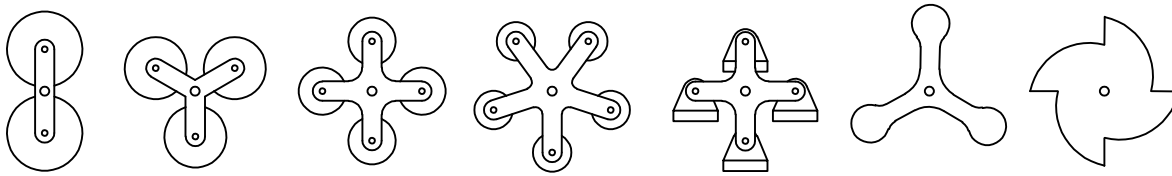


Figure 1 —Examples of clusters

**3.20**

**cam**

that part of the cluster which is intended to come into contact with the stairs or the ground

NOTE If the cam is a wheel, it could be freely rotating or have unidirectional freewheel function or be temporarily braked or even driven. If the cam is an eccentric or notch, it usually has a nearly circular or spiral shape of varying diameter. Some cams may consist of hinged posts or “shoes”.

**3.21**

**adverse situation**

any situation that is likely to cause harm to the user, attendant or nearby person

NOTE This includes tipping, sliding, tumbling, squeezing, trapping or any other situation that is reasonably considered to be dangerous.

**3.22**

**front vertical plane**

vertical plane that is perpendicular to the horizontal component of forward direction of travel and tangential to the most forward point of the climbing mechanism when the stair-climbing device is in its climbing mode and positioned on stairs with a pitch of  $30^\circ \pm 5^\circ$

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See Figure 2.

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**3.23**

**rear vertical plane**

vertical plane that is perpendicular to the horizontal component of forward direction of travel and tangential to the most backward point of the climbing mechanism when the stair-climbing device is in climbing mode and positioned on stairs with a pitch of  $30^\circ \pm 5^\circ$

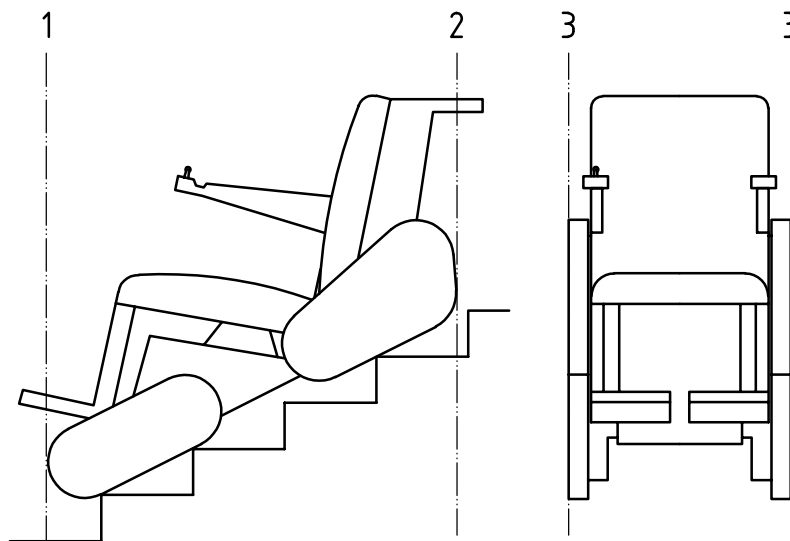
See Figure 2.

**3.24**

**side vertical plane**

vertical plane that is parallel to the horizontal component of forward direction of travel and tangential to the outermost point of the stair-climbing device when in climbing mode with its seat reclined and positioned on stairs with a pitch of  $30^\circ \pm 5^\circ$

See Figure 2.

**Key**

- 1 front vertical plane
- 2 rear vertical plane
- 3 side vertical plane

Figure 2 — Reference planes

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**3.25  
speed**

mean velocity of a stair-climbing device as it moves along the pitch of the stairs whilst climbing

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**3.26  
exaggerated test set-up**

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configuration of the stair-climbing device under test when the stair-climbing device is in its least stable configuration with respect to the test direction for each test that simulates foreseeable adverse behaviour of the user

**NOTE** Foreseeable adverse behaviour of the user is considered to be either: leaning forward in a situation where the stair-climbing device is at its least stable position and most sensitive to forward or downward stability or placing a backpack at the backrest of the stair-climbing device in a situation where it is at its least stable position and most sensitive to backward or upward stability.

**3.27  
tread**

horizontal part or upper surface of a step

**3.28  
going**

horizontal distance between the nosings of two consecutive steps, measured perpendicular to the lower nosing

**3.29  
rise**

vertical distance between two consecutive steps

**3.30  
upper transition**

transition between the stairs and the upper landing

**3.31**

**lower transition**

transition between the stairs and the lower landing

**3.32**

**least stable configuration**

set-up of the stair-climbing device that gives least stability in the test direction

**3.33**

**least stable position**

placement of the stair-climbing device on the stairs that gives least stability in the test direction

**3.34**

**reversing width (type 1)**

minimum distance between two vertical and parallel walls between which an occupied stair-climbing device with full differential steering can turn 180° with one single and smooth turning manoeuvre when in driving mode

**3.35**

**reversing width (type 2)**

minimum distance between two vertical and parallel walls between which an occupied stair-climbing device with direct steering or limited differential steering can turn 180° with one initial forward drive, one single backward drive and one final forward drive when in driving mode

**3.36**

**minimum outer stair radius**

smallest possible distance from the central axis of the winding test stairs to that point of the outer excursion of the stair-climbing device, which is most remote from the centre of the stairs while climbing winding stairs

**3.37**

**minimum inner stair radius**

smallest possible distance from the central axis of the winding test stairs to that point of the inner excursion of the stair-climbing device, which is nearest to the centre of the stairs while climbing winding stairs

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## 4 Performance requirements

### 4.1 Skew angle

Stair-climbing devices cannot always approach or be positioned on stairs with perfect axial alignment and therefore all stair-climbing devices shall be able to accommodate skew angle operations.

When tested in accordance with Clause 8, all stair-climbing devices shall achieve a score of 2 or more (see Table 1), either by the stair-climbing device correcting the skew angle automatically or by continuing to climb safely at skew angle.

### 4.2 Braking effectiveness

When tested in accordance with Clause 9, no brake failure, notable loss of traction or instability, nor the occurrence of any other adverse situation shall occur.

### 4.3 Static stability

When tested in accordance with 10.2.2.2 (climbing mode) and 10.2.2.3 (crawling mode), the minimum performance value shall be 7° in forwards, backwards and sideways directions. If the manufacturer claims that the stair-climbing device is capable of negotiating sloped landings, the minimum performance value shall be 7° above the claimed angle in forwards, backwards and sideways directions.

NOTE 1 The angle of 7° is the safety margin.

NOTE 2 The static stability of stair-climbing devices, when in driving mode, may be determined in accordance with 10.2.2.4, although there is no performance requirement.

When tested in accordance with 10.2.3, the stair-climbing device shall remain in a stable position on the straight test stairs without the occurrence of any adverse situation. If the stair-climbing device rolls into another stable position during testing, this shall be deemed to be acceptable.

#### 4.4 Dynamic stability

When tested in accordance with 11.2.2, a score of 2 or more as given in Table A.1 of ISO 7176-2:2001 shall be achieved.

When tested in accordance with 11.2.3, a score of 2 or more as given in Table 1 (see 8.3) shall be achieved.

#### 4.5 Step transition safety

When tested in accordance with Clause 12, the stair-climbing device shall remain stable and shall not induce potential harm to the user or damage to the stairs or to the stair-climbing device.

#### 4.6 Static, impact and fatigue strength

After testing in accordance with Clause 13, the stair-climbing device and the connection(s) between the stair-climbing device and the test wheelchair (where applicable) shall meet all the following requirements.

- a) The stair-climbing device shall be capable of operating as described by the manufacturer.
- b) No component shall be fractured or have visible cracks.

NOTE Cracks in surface finishes, such as paint, which do not extend into the structural material do not constitute a failure.

- c) No nut, bolt, screw, locking pin, adjustable component or similar item shall have become detached after having been tightened, adjusted or replaced once, with the exception that the footrests may be adjusted after each of the two footrest impact tests carried out in accordance with ISO 7176-8.
- d) No electrical connector shall be displaced or disconnected.
- e) All parts intended to be removable, foldable or adjustable shall operate as described by the manufacturer.
- f) All power-operated systems shall operate as described by the manufacturer and all attachable parts shall be attachable/detachable as intended by the manufacturer.
- g) Handgrips shall not be displaced.
- h) No multi-position or adjustable component shall be displaced from the pre-set position, except as permitted in c).
- i) No component or assembly of parts shall exhibit gross deformation, free play or loss of adjustment that adversely affects the function of the stair-climbing device.

#### 4.7 Climatic safety

After testing in accordance with Clause 14, the stair-climbing device shall continue to function properly.

#### 4.8 Power and control systems

All stair-climbing devices shall conform to ISO 7176-14, with the following modifications and additions.

- a) The stair-climbing device shall be prepared for testing as described in Clause 6, with the exception that the tests shall be carried out without a test wheelchair, test dummy or human test person having been loaded.
- b) All tests shall be carried out at maximum recommended speed (see 6.5.2).
- c) The stair-climbing device shall be tested:
  - on the horizontal test plane in climbing mode, in driving mode (if applicable) and in crawling mode (if applicable);
  - on the straight test stairs in climbing mode.

**WARNING — The tests given in ISO 7176-14 can be hazardous. It is essential that precautions be taken to protect test personnel.**

- d) In addition to ISO 7176-14:1997, Clause 11, list items a), b), c), d), e) and h), the following shall be included in the test report:
  - a statement as to which requirements were met by the stair-climbing device, the battery and its charger;
  - a statement as to which requirements were not met by the stair-climbing device, the battery and its charger;
  - any reasons for terminating the test; [ISO 7176-24:2004](https://standards.iteh.ai/catalog/standards/sist/aec70fde-c803-45fb-bc66-1264f8834687/iso-7176-24-2004)
  - any observations of relevance to the tests.

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#### 4.9 Flammability

All stair-climbing devices shall conform to ISO 7176-16, with the following modifications and additions.

- a) The stair-climbing device shall be prepared for testing as described in Clause 6, with the exception that the tests shall be carried out without a test wheelchair, test dummy or human test person having been loaded.

**WARNING — The tests given in ISO 7176-16 can be hazardous. It is essential that precautions be taken to protect test personnel.**

- b) In addition to ISO 7176-16:1997, Clause 5, the following shall be included in the test report:
  - a statement as to whether the stair-climbing device met the requirements of ISO 7176-16;
  - any observations of relevance to the tests.

#### 4.10 Electromagnetic compatibility

When tested in accordance with Clause 15, the stair-climbing device shall meet the requirements of ISO 7176-21.

## 4.11 Safety equipment

### 4.11.1 General

The stair-climbing device shall be fitted with the items of safety equipment specified in 4.11.2 to 4.11.6.

NOTE Recommendations for additional items of safety equipment (anterior thoracic supports, safe stairs indicators and headrests) are given in Annex B.

### 4.11.2 On/off switch

There shall be at least one means to:

- switch on the stair-climbing device;
- switch off the stair-climbing device.

NOTE These means may be combined into a single device.

When the on/off switch is turned off, the control device shall not cause any driven wheels or driven climbing mechanisms to move.

### 4.11.3 “Key off” power

When the stair-climbing device is turned off, internal circuits or leakage paths shall not drain the battery excessively.

With the on/off switch turned off, the stair-climbing device shall not draw from the battery set any current greater than the rated 20 h capacity of the smallest capacity battery specified for the stair-climbing device, corresponding to a four-month discharge period.

### 4.11.4 Emergency system

The stair-climbing device shall be equipped with an emergency system. The means to activate the emergency system shall be readily accessible to the user.

Activating the emergency system while the stair-climbing device is climbing shall bring the stair-climbing device to a complete stop at which it shall remain.

When the emergency system has been activated, turning-off power shall not override the emergency system.

The deactivation of the emergency system shall require a set of at least two sequential user actions specified by the manufacturer.

NOTE The on/off switch and the means to activate the emergency system need not be separate switches, although provisions should be included to prevent accidental activation of the emergency system. Emergency systems that can be deactivated by the user when the emergency situation is resolved would allow the stair-climbing device to be driven off the stairs.

### 4.11.5 Battery charge indicator

The stair-climbing device shall be equipped with a battery charge indicator capable of informing the user when the minimum reserve battery charge has been reached.

The stair-climbing device shall have the capacity to ascend a minimum of 20 steps plus descend a minimum of 20 steps after the battery charge indicator discloses that the minimum reserve battery charge has been reached.