

Australian/New Zealand Standard™

Wheelchairs

Part 28: Requirements and test methods for stair-climbing devices



AS/NZS ISO 7176.28:2013

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee ME-067, Assistive Technology Products for Persons with Disability. It was approved on behalf of the Council of Standards Australia on 23 July 2013 and on behalf of the Council of Standards New Zealand on 5 August 2013. This Standard was published on 30 August 2013.

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Australian/New Zealand Standard™

Wheelchairs

Part 28: Requirements and test methods for stair-climbing devices

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME-067, Assistive Technology Products for Persons with Disability.

The objective of this Standard is to specify requirements and test methods for electrically powered stair-climbing devices. It is applicable to stair-climbing chairs and stair-climbing wheelchair carriers where the stair-climbing device climbs backwards up the stairs, with the occupant facing downstairs, and climbs forwards down the stairs with the occupant also facing downstairs. It is also applicable to stair-climbing devices which are intended for the transport of adults and those intended for the transport of children. It is not applicable to stair-climbing devices that are intended to be operated by children as operating occupants or assistants, or to manually powered stair-climbing devices.

This Standard is identical with, and has been reproduced from ISO 7176-28:2012, *Wheelchairs, Part 28: Requirements and test methods for stair-climbing devices*.

As this Standard is reproduced from an International Standard, the following applies:

- (a) In the source text 'this part of ISO 7176' should read 'this Australian/New Zealand Standard'.
- (b) A full point substitutes for a comma when referring to a decimal marker.

References to International Standards should be replaced by references to Australian or Australian/New Zealand Standards, as follows:

<i>Reference to International Standard</i>	<i>Australian/New Zealand Standard</i>
ISO	AS/NZS
7176 Wheelchairs	3696 Wheelchairs
7176-1 Part 1: Determination of static stability	3696.1 Part 1: Determination of static stability
7176-2 Part 2: Determination of dynamic stability of electric wheelchairs	3696.2 Part 2: Determination of dynamic stability of electric wheelchairs
7176-3 Part 3: Determination of effectiveness of brakes	3696.3 Part 3: Determination of effectiveness of brakes
7176-8 Part 8: Requirements and test methods for static, impact and fatigue strengths	3696.8 Part 8: Requirements and test methods for static, impact and fatigue strengths
	AS
7176-13 Part 13: Determination of coefficient of friction of test surfaces	3696.13 Part 13: Determination of coefficient of friction of test surfaces
ISO	AS/NZS ISO
7176-9 Part 9: Climatic tests for electric wheelchairs	7176.9 Part 9: Climatic tests for electric wheelchairs
7176-11 Part 11: Test dummies	7176.11 Part 11: Test dummies
7176-14 Part 14: Power and control systems for electrically powered wheelchairs and scooters—Requirements and test methods	7176.14 Part 14: Power and control systems for electric wheelchairs and scooters—Requirements and test methods
7176-26 Part 26: Vocabulary	7176.26 Part 26: Vocabulary
	AS/NZS
7176-19 Part 19: Wheeled mobility devices for use as seats in motor vehicles	3696.19 Part 19: Mobility devices for use as seats in motor vehicles (ISO 7176-19:2008, MOD)
7176-22 Part 22: Set-up procedures	3696.22 Part 22: Set-up procedures

Only international references that have been adopted as Australian or Australian/New Zealand Standards have been listed.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the annex to which they apply. A ‘normative’ annex is an integral part of a Standard, whereas an ‘informative’ annex is only for information and guidance.

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INTRODUCTION

This part of ISO 7176 was written in response to the need for common terminology in the field of stair-climbing devices, to give a means of evaluating important safety features, and to establish a means of qualifying and quantifying the performance of stair-climbing devices under the various conditions and environments encountered in their operation. It allows occupants and manufacturers to compare the pertinent safety and utility issues of all functions and features of a given stair-climbing device.

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

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 whether a given variation conforms to this part of ISO 7176.

Other parts of ISO 7176 might be applicable to stair-climbing devices that can also be used as wheelchairs. All technical aspects which are relevant for wheelchairs and covered in ISO 7176 are adapted, modified and/or extended for the various needs of the different operational modes of a stair-climbing device.

NOTES

AUSTRALIAN/NEW ZEALAND STANDARD

Wheelchairs**Part 28:****Requirements and test methods for stair-climbing devices****1 Scope**

This part of ISO 7176 is applicable to stair-climbing chairs and stair-climbing wheelchair carriers where the stair-climbing device climbs backwards up the stairs, with the occupant facing downstairs, and climbs forwards down the stairs with the occupant also facing downstairs.

This part of ISO 7176 is applicable to stair-climbing devices which are intended for the transport of adults and those intended for the transport of children. It is not applicable to stair-climbing devices which are intended to be operated by children as operating occupants or assistants.

This part of ISO 7176 specifies requirements and test methods for electrically powered stair-climbing devices. It is not applicable to manually powered stair-climbing devices.

NOTE 1 Some clauses in this part of ISO 7176 might be useful for testing manually powered stair-climbing devices.

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 declared by the manufacturer. It also includes ergonomic, labelling and disclosure requirements.

NOTE 2 When the stair-climbing device is tested in driving mode as specified this part of ISO 7176, the device need not be tested a second time for the same aspects as a wheelchair.

NOTE 3 Some requirements apply only for a specified range of rated loads.

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, *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 dimensions, mass and manoeuvring space*

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

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

ISO 7176-8, *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 7176-10, *Wheelchairs — Part 10: Determination of obstacle-climbing ability of electrically powered 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, *Wheelchairs — Part 14: Power and control systems for electrically powered wheelchairs and scooters – Requirements and test methods*

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

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

ISO 7176-19, *Wheelchairs — Part 19: Wheeled mobility devices for use as seats in motor vehicles*

ISO 7176-21:2009, *Wheelchairs — Part 21: Requirements and test methods for electromagnetic compatibility of electrically powered wheelchairs and scooters, and battery chargers*

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

ISO 7176-26, *Wheelchairs — Part 26: Vocabulary*

ISO 14971, *Medical devices — Application of risk management to medical devices*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3880-1, ISO 7176-5, ISO 7176-7, ISO 7176-15, ISO 7176-26 and the following apply.

NOTE This part of ISO 7176 makes use of some terms in ISO 3880-1 that are defined in relation to horizontal stairs. Since this part of ISO 7176 uses these terms for test stairs that can be tilted, the terms are redefined in this clause.

3.1
actuator
part of a climbing mechanism that is intended to transmit the load of the stair-climbing device to the stairs during climbing

NOTE An actuator can be a track, wheel, leg, finger or other part. In clusters, actuators are called cams.

3.2
angle of recline
rearward inclination of a manually stabilized stair-climbing device while it is climbing stairs

3.3
assistant
person operating the stair-climbing device but not being transported by the stair-climbing device

3.4
assistant-operated stair-climbing device
stair-climbing device intended to be operated by an **assistant** (3.3)

3.5
cam
actuator (3.1) of a **cluster** (3.8)

NOTE If the cam is a wheel, it can be freely rotating, have a unidirectional freewheel function, be temporarily braked or be driven. If the cam is eccentric, it usually has a curved or spiral shape of varying diameter. Some cams might consist of hinged posts or “shoes”.

3.6
climbing
ascending or descending stairs

3.7
climbing mechanism

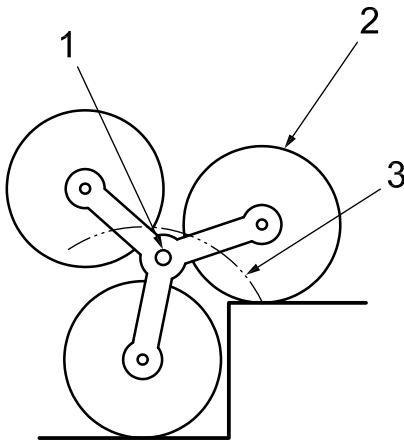
part of the stair-climbing device that provides the ability to climb stairs

3.8
cluster

type of **stepwise climbing mechanism** (3.49) in which cams revolve around a common axis

NOTE 1 For details and examples, see Figures 1 and 2.

NOTE 2 The usual number of cams in a cluster ranges from 2 to 5. During climbing, each cam can perform the function of a lower actuator and an upper actuator as the cluster rotates.



Key

- 1 common axis
- 2 cam (wheel)
- 3 path of lowest points of cams relative to the common axis

Figure 1 — Cluster details

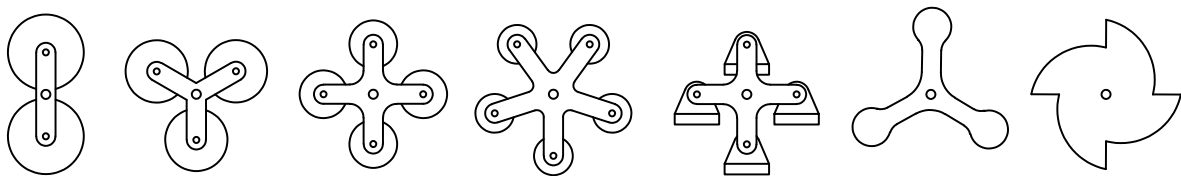
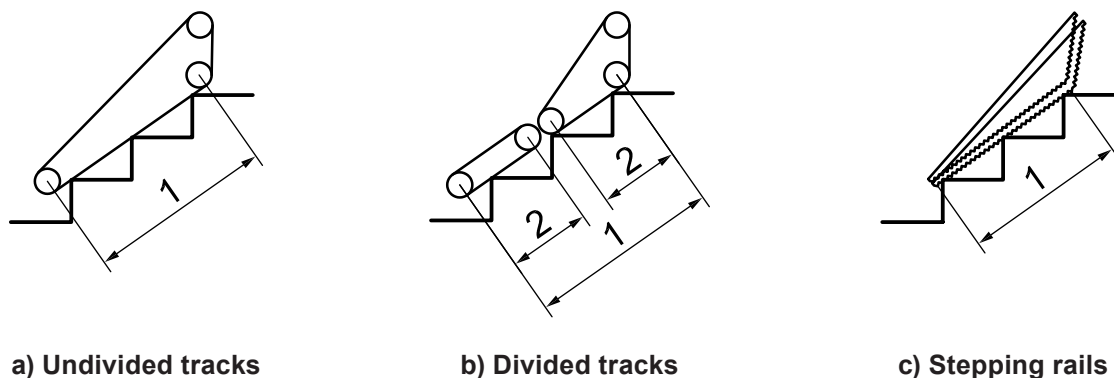


Figure 2 — Examples of clusters

3.9
continuous climbing mechanism

type of climbing mechanism that extends over several steps and moves along their pitch line in a continuous fashion

EXAMPLE Climbing mechanisms which appear to have a nearly flat bottom when viewed from the side, such as tracks or stepping rails. Figure 3 shows the most common types.

**Key**

- 1 overall length of the stair-contacting area of a continuous climbing mechanism
 2 section length of the stair-contacting area of one section of a divided continuous climbing mechanism

Figure 3 — Continuous climbing mechanisms**3.10****crawling**

moving on landings

NOTE Any means provided by a stair-climbing device 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**direct operating force**

manual force exerted by the **operator** (3.33) between the stair-climbing device and its surroundings to cause operation in accordance with the manufacturer's instructions for use

EXAMPLE Forces acting on push handles of a stair-climbing device or on handrails of stairs.

NOTE Forces due to the weight of the stair-climbing device, test wheelchair and occupant are not direct operating forces.

3.12**docking**

attaching (a wheelchair) to a stair-climbing wheelchair carrier

3.13**driving**

use of the stair-climbing device to provide wheeled mobility on driving surfaces

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

3.14**driving surface**

surface on which a wheelchair is typically driven in normal use

EXAMPLES Level floors, inclined floors, smooth floors, carpeted floors, edging strips, thresholds, sidewalks, kerbs, small obstacles, uneven ground.

3.15**dynamically controlled stair-climbing device**

manually stabilized stair-climbing device (3.26) that, when in climbing mode, controls the operation of its climbing mechanism in response to changes in **direct operating forces** (3.11) and/or movement of the centre of mass of the occupant and/or changes in the contact points between the stair-climbing device and the surfaces that support it

3.16**edge stop**

device intended to stop forward movement of a stair-climbing device when it is on a landing above stairs and approaching the nosing of the top step

3.17**exaggerated test set-up**

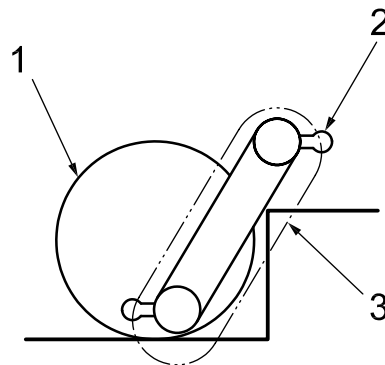
configuration of the stair-climbing device under test that simulates foreseeable adverse distribution of the occupant's mass and any additional masses

3.18**finger drive**

type of stepwise climbing mechanism where the lower actuator is fixed to the stair-climbing device and the upper actuator is movable relative to the stair-climbing device

NOTE Finger drives are known where the lower actuator is a wheel and the upper actuator is a finger. The lowest point of the finger moves along an oval path. Each actuator remains in its function as the lower or upper actuator.

See Figure 4.

**Key**

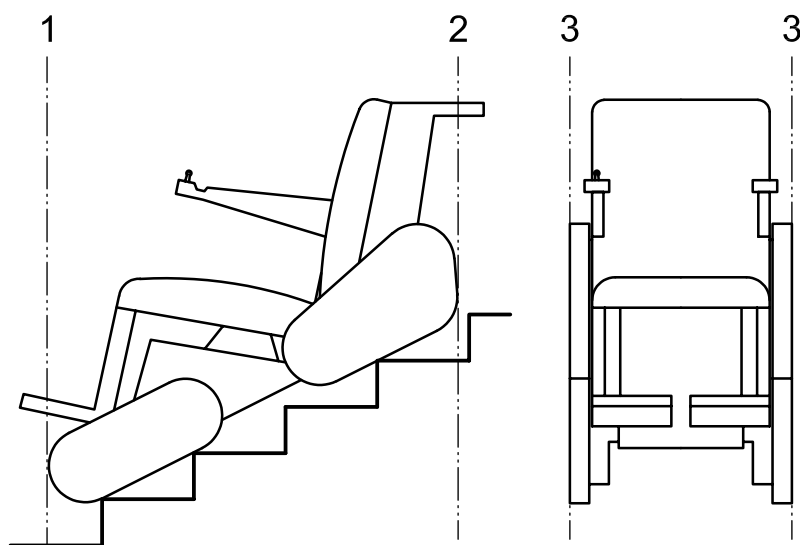
- 1 lower actuator (wheel)
- 2 upper actuator (finger)
- 3 path of lowest point of finger relative to climbing mechanism

Figure 4 — Example of a finger drive

3.19**front vertical plane**

vertical plane which is perpendicular to the horizontal component of the forward direction of travel and tangential to the most forward point of the climbing mechanism when the stair-climbing device is in climbing mode and placed on stairs with a pitch of $(35 \pm 5)^\circ$

See Figure 5.

**Key**

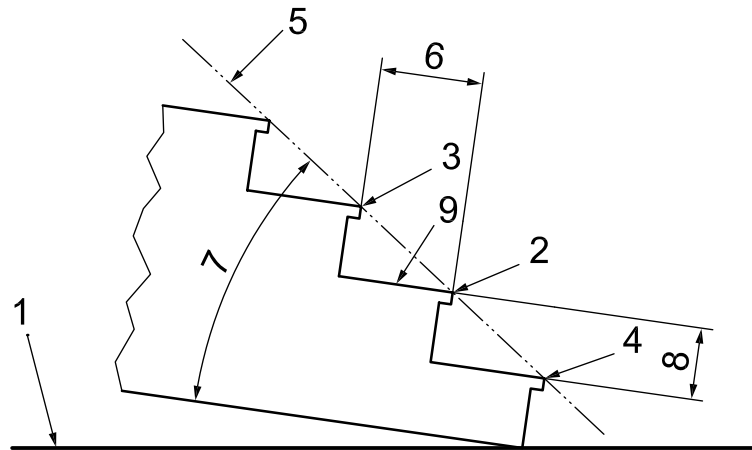
- 1 front vertical plane (3.19)
- 2 rear vertical plane (3.35)
- 3 side vertical plane (3.40)

Figure 5 — Reference planes**3.20
going**

distance between the nosing of a step and the nosing of the next higher step, measured perpendicular to the nosing of the measured step and parallel to its tread

NOTE Adapted from ISO 3880-1.

See Figure 6.

**Key**

- 1 horizontal test plane
- 2 nosing of measured step
- 3 nosing of next higher step
- 4 nosing of next lower step
- 5 pitch line
- 6 going (3.20)
- 7 pitch (3.34)
- 8 rise (3.37)
- 9 tread (3.51)

Figure 6 — Measurement of going, pitch and rise (example with tilted stairs)

3.21**hazardous situation**

circumstance in which people or animals are exposed to one or more potential source(s) of physical injury or damage to health, or property or the environment is exposed to one or more potential source(s) of damage

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

3.22**least stable configuration**

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

3.23**least stable position**

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

3.24**locating**

placing (the stair-climbing device) on stairs so that, where the **span** (3.42) has an odd number of steps, a particular step is the middle step of the span, or, where the span has an even number of steps, a particular step is immediately below the middle of the span

3.25**lower actuator**

actuator of a stepwise climbing mechanism that is below the upper actuator when both actuators are in contact with two adjacent steps

3.26**manually stabilized stair-climbing device**

stair-climbing device that is stabilized by the application of **direct operating forces** (3.11) during climbing

NOTE A stair-climbing device that is self-standing when in driving mode can be a manually stabilized stair-climbing device when in climbing mode.

3.27**mean climbing speed**

average velocity of a stair-climbing device while climbing on stairs

NOTE Mean climbing speed is expressed in steps per minute.

3.28**minimum inner stair radius**

minimum distance between the central axis of the winding test stairs and any part of the stair-climbing device during the whole climb

3.29**minimum outer stair radius**

maximum distance between the central axis of the winding test stairs and any part of the stair-climbing device during the whole climb

3.30**occupant**

person being transported in the stair-climbing device

3.31**occupant-operated stair-climbing device**

stair-climbing device intended to be operated by the occupant

3.32**operating occupant**

occupant (3.30) operating the stair-climbing device

3.33**operator**

assistant or operating occupant

3.34**pitch**

angle between the pitch line and a plane parallel to the treads of the steps

NOTE 1 The tread is horizontal when the stairs are not tilted.

NOTE 2 Adapted from ISO 3880-1.

See Figure 6.

3.35**rear vertical plane**

vertical plane which is perpendicular to the horizontal component of the forward direction of travel and tangential to the most rearward point of the climbing mechanism when the stair-climbing device is in climbing mode and placed on stairs with a pitch of $(35 \pm 5)^\circ$

See Figure 5.

3.36**reclined position**

position of the stair-climbing device intended for manoeuvring on stairs

3.37**rise**

distance between the nosing of a step and the nosing of the next lower step, measured perpendicular to its tread

NOTE Adapted from ISO 3880-1.

See Figure 6.

3.38**self-standing stair-climbing device**

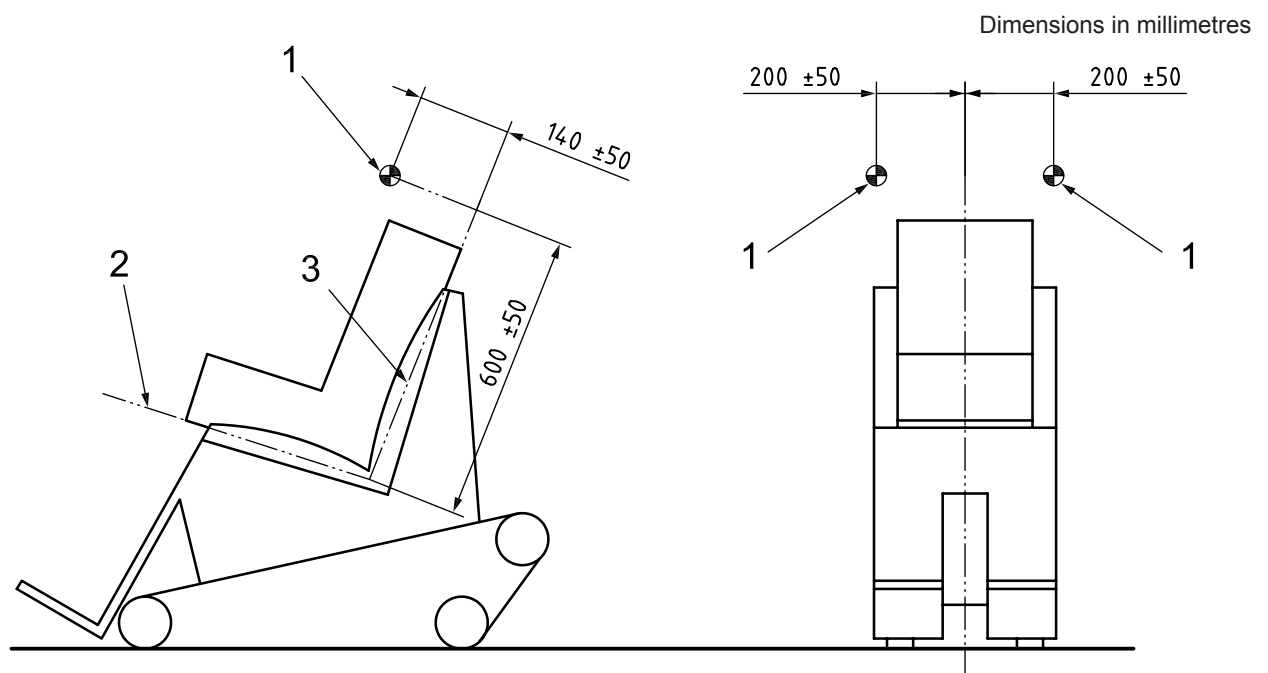
stair-climbing device that is statically stable while at rest on a horizontal surface, stairs or a landing when subjected only to the force of gravity

3.39**shoulder point**

one of a pair of application points for **direct operating forces** (3.11) applied by an operating occupant

NOTE The shoulder points are located at a distance of (600 ± 50) mm above the intersection between the seat reference plane and the back support reference plane when measured parallel to the back support reference plane, a distance of (140 ± 50) mm in front of the back support reference plane when measured perpendicular to it, and a distance of (200 ± 50) mm to each side of a plane bisecting the body support system.

See Figure 7.

**Key**

- 1 shoulder point
- 2 seat reference plane
- 3 back support reference plane

Figure 7 — Location of shoulder points

3.40**side vertical plane**

vertical plane which is parallel to the horizontal component of the forward direction of travel and tangential to the outermost point of the stair-climbing device when in climbing mode and placed on stairs with a pitch of $(35 \pm 5)^\circ$

See Figure 5.

3.41**skew angle**

angle of deviation between a vertical plane through the pitch line of the stairs and the longitudinal axis of the stair-climbing device

3.42**span**

set of steps having treads with which the climbing mechanism is in contact, together with any steps between

3.43**stair**

succession of stages (steps or landings) which makes it possible to pass on foot to other levels

NOTE Adapted from ISO 3880-1.

3.44**stair-climbing chair**

stair-climbing device that includes a body support system for the occupant

3.45**stair-climbing device**

device intended to transport a person or an occupied wheelchair by climbing up or down stairs, but that is not fixed to the stairs

NOTE A hierarchical system for classification of the various types of stair-climbing devices is given in Annex A.

3.46**stair-climbing wheelchair carrier**

stair-climbing device that carries an occupied wheelchair

3.47**stair indicator**

means used to assess the pitch and/or the dimensions of steps

3.48**step**

part of a stair including a tread on which the foot is placed to go upstairs or downstairs

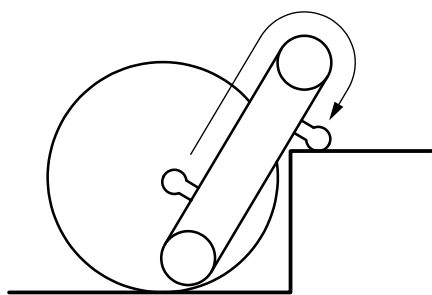
NOTE Adapted from ISO 3880-1.

3.49**stepwise climbing mechanism**

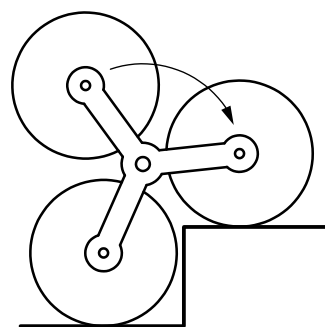
type of climbing mechanism which climbs using a cyclic action for each step

EXAMPLES **Finger drives** (3.18), **clusters** (3.8), **two-stroke stepping mechanisms** (3.52) or **three-stroke stepping mechanisms** (3.50).

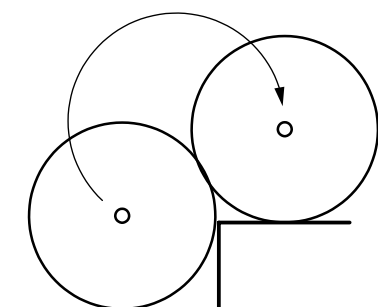
See Figure 8.



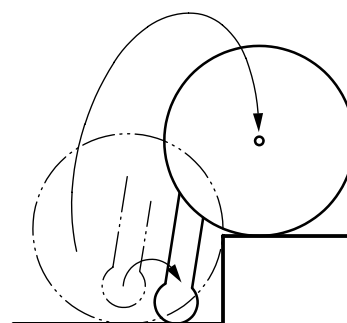
a) Finger drive (3.18)



b) Cluster (3.8)



c) Two-stroke stepping mechanism (3.52)



d) Three-stroke stepping mechanism (3.50)

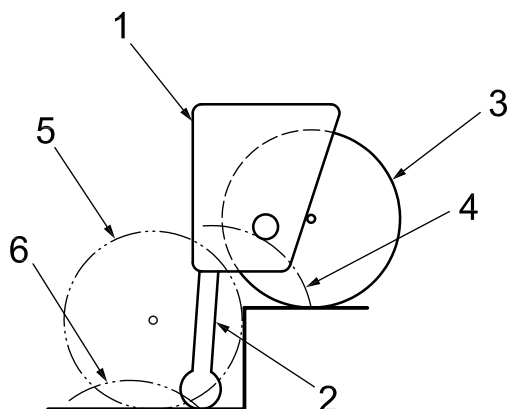
Figure 8 — Examples of stepwise climbing mechanisms

3.50**three-stroke stepping mechanism**

type of stepwise climbing mechanism where the actuators move relative to the frame and perform three strokes to climb one step

NOTE Three-stroke stepping mechanisms are known where the lower actuator is a leg and the upper actuator is a wheel. Each actuator remains in its function as the lower/upper actuator.

See Figure 9.

**Key**

- 1 housing of climbing mechanism
- 2 lower actuator (leg)
- 3 upper actuator (wheel)
- 4 path of lowest point of upper actuator (second stroke)
- 5 position of upper actuator during first stroke
- 6 path of lowest point of lower actuator (first stroke)

Figure 9 — Example of a three-stroke climbing mechanism

3.51**tread**

upper surface of a step

NOTE Adapted from ISO 3880-1.

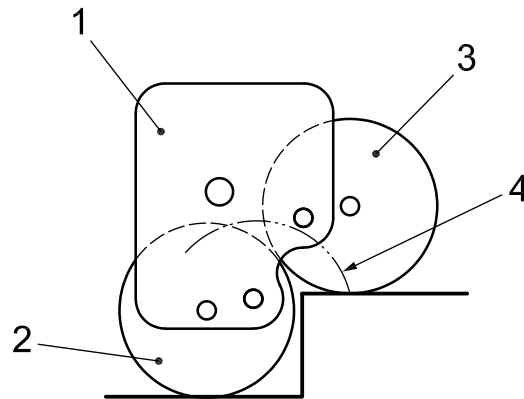
See Figure 6.

3.52**two-stroke stepping mechanism**

type of stepwise climbing mechanism where the actuators move relative to the frame and perform two strokes to climb one step

NOTE Two-stroke stepping mechanisms are known where both actuators are wheels. Each actuator remains in its function as the lower/upper actuator.

See Figure 10.

**Key**

- 1 housing of climbing mechanism
- 2 lower actuator (wheel)
- 3 upper actuator (wheel)
- 4 path of lowest point of upper actuator (first stroke)

Figure 10 — Example of a two-stroke stepping mechanism

3.53**upper actuator**

actuator of a stepwise climbing mechanism that is above the lower actuator when both actuators are in contact with two adjacent steps

3.54**upright position**

position of the stair-climbing device intended for manoeuvring on driving surfaces

3.55**U-shaped stairs**

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

3.56**winding stairs**

stairs built in a helical construction

4 Application of reference standards

4.1 Use of a stair-climbing device in driving mode

Where a stair-climbing device has a driving mode, the following standards apply to the stair-climbing device with respect to use in the driving mode:

- ISO 7176-1;
- ISO 7176-2;
- ISO 7176-3;
- ISO 7176-4;
- ISO 7176-5;
- ISO 7176-6;
- ISO 7176-7;

- ISO 7176-8 (with modifications as specified in 5.8.2);
- ISO 7176-9;
- ISO 7176-10;
- ISO 7176-14;
- ISO 7176-15;
- ISO 7176-16;
- ISO 7176-19;
- ISO 7176-21.

In addition to the information specified in Clause 20, and the test reports from these parts of ISO 7176, the following shall be provided, where applicable:

- a) any of the manufacturer's instructions for use that were disregarded, with reasons why;
- b) any of the tests that could not be carried out, with reasons why.

4.2 Use of a stair-climbing device in other operational modes

ISO 7176-7 also applies to the stair-climbing device when it is used in operational modes other than driving mode.

In addition to the information specified in Clause 20, and the test report from ISO 7176-7, the following shall be provided, where applicable:

- a) the configuration of the stair-climbing device during the tests;
- b) any observation of relevance to the test;
- c) any of the tests that could not be carried out, with reasons why.

5 Requirements

5.1 General

The requirements specified in this part of ISO 7176 apply to all stair-climbing devices except where otherwise stated.

Risk management as specified in ISO 14971 shall be carried out for the stair-climbing device.

5.2 Skew angle

5.2.1 General

Stair-climbing devices cannot always be guaranteed to approach stairs or be positioned on them with perfect alignment. All stair-climbing devices should be able to operate safely with some degree of misalignment to the stairs with which they are used.

5.2.2 Requirements

When the stair-climbing device is tested as specified in Clause 9, using a skew angle of $(4 \pm 1)^\circ$ or the skew angle claimed by the manufacturer, whichever is greater, it shall achieve a score of at least 2 as specified in Table 3, either by correcting its skew automatically or by continuing to climb without giving rise to a hazardous situation.

5.3 Effectiveness of brakes

When the stair-climbing device is tested as specified in Clause 10, none of the following conditions shall occur:

- brake failure;
- hazardous loss of traction or instability;
- any other hazardous situation.

Manually stabilized stair-climbing devices shall require no operating force other than the manual stabilizing force to remain stationary on stairs. Self-standing stair-climbing devices shall require no operating force to remain stationary on stairs.

5.4 Static stability

5.4.1 Static stability on driving surfaces — Climbing mode

When the stair-climbing device is tested as specified in 11.2.2.2, the minimum performance value shall be 7° in the forward and sideways directions, and 5° in the rearward direction. If the manufacturer declares that the stair-climbing device is capable of negotiating sloped landings, the minimum performance value shall be 7° greater than the declared slope angle in the forward and sideways directions, and 5° greater than the declared slope angle in the rearward direction.

NOTE The angular values specified are the safety margins for the respective directions.

5.4.2 Static stability on driving surfaces – Crawling mode

Where the stair-climbing device has a crawling mode that is separate from climbing mode and driving mode, when it is tested as specified in 11.2.2.3 the minimum performance value shall be 7° in the forward and sideways directions, and 5° in the rearward direction. If the manufacturer declares that the stair-climbing device is capable of negotiating sloped landings, the minimum performance value shall be 7° greater than the declared slope angle in the forward and sideways directions, and 5° greater than the declared slope angle in the rearward direction.

NOTE The angular values specified are the safety margins for the respective directions.

5.4.3 Static stability on stairs

5.4.3.1 Downward direction

If the stair-climbing device is self-standing, the minimum performance value for static stability on stairs in the downward direction shall be 7°. If the manufacturer declares that the stair-climbing device is capable of negotiating stairs with a pitch greater than 35°, the minimum performance value shall be 28° less than the declared angle.

NOTE The angle of 7° is the safety margin.

EXAMPLE If the manufacturer declares an angle of 40°, the minimum performance value would be 12°.

When the stair-climbing device is tested as specified in 11.2.3.2, using the minimum performance value,

- it shall not lose contact with any step with which it initially has contact;
- it shall not make contact with any step with which it does not initially have contact, and
- no hazardous situation shall occur.

5.4.3.2 Upward direction

If the stair-climbing device is self-standing, the minimum performance value for static stability on stairs in the upward direction shall be 7°.

NOTE The angle of 7° is the safety margin.

When the stair-climbing device is tested as specified in 11.2.3.3, using the minimum performance value,

- it shall not lose contact with any step with which it initially has contact,
- it shall not make contact with any step with which it does not initially have contact, and
- no hazardous situation shall occur.

5.5 Dynamic stability

If the stair-climbing device is self-standing, when it is tested as specified in 12.2 it shall achieve a score of 2 or more as specified in Table 3.

5.6 Direct operating forces

If it is necessary for the operator to apply direct operating forces during operation of the stair-climbing device, including manoeuvring on driving surfaces or landings, climbing stairs and making the transition between stairs and landings, when it is tested as specified in Clause 13, the direct operating forces shall not exceed the following limits:

- one combined hand and arm of the operator: 120 N;
- both combined hands and arms of the operator: 240 N;
- combined trunk and arm(s) of the operator: 400 N.

NOTE 1 Test methods for direct operating forces for manually stabilized stair-climbing devices are under consideration at the time of the writing of this part of ISO 7176.

NOTE 2 Recommendations for the reach space of the operator are given in Annex B.

5.7 Step transition safety

When the stair-climbing device is tested as specified in Clause 14, it shall achieve a score of 2 or more as given in Table 4.

5.8 Static, impact and fatigue strength

If the manufacturer claims that the stair-climbing device exceeds the strength requirements specified in this part of ISO 7176, modify the tests to verify the claims.

EXAMPLES Increased static load, increased angle of test pendulum, increased number of cycles, increased slat height, increased drop height.

5.8.1 Static strength

The stair-climbing device shall meet the applicable static strength requirements specified in ISO 7176-8. The stair-climbing device shall also meet the static strength requirements specified in ISO 7176-8 when it is tested as specified in 15.3.

5.8.2 Fatigue strength — Driving

If the stair-climbing device has a driving mode, ISO 7176-8 applies when the stair-climbing device is used in the driving mode, with modifications as specified in Table 1.

Table 1 — Numbers of test cycles

Type of stair-climbing device	ISO 7176-8 (drum test) cycles	ISO 7176-8 (drop test) cycles
Stair-climbing device with driving mode	133 000	4 440

5.8.3 Fatigue strength — climbing

The stair-climbing device shall meet the strength requirements specified in ISO 7176-8, when tested as specified in 15.4, using the number of test steps specified in Table 2.

Table 2 — Numbers of test steps

Type of stair-climbing device	Number of steps (fatigue tests)
Stair-climbing device without driving mode	150 000
Stair-climbing device with driving mode	50 000

5.8.4 Parking brake fatigue strength

If the stair-climbing device has a manually operated parking brake, the provisions specified in ISO 7176-3 for parking brake fatigue apply.

5.9 Climatic tests

If the stair-climbing device has a crawling mode that is separate from climbing mode and driving mode, when it is tested as specified in 16.2.2 it shall continue to function in accordance with the manufacturer's specification.

When the stair-climbing device is tested as specified in 16.2.3 it shall continue to function in accordance with the manufacturer's specification.

5.10 Flammability

The stair-climbing device shall meet the requirements specified in ISO 7176-16.

5.11 Electromagnetic compatibility

The stair-climbing device shall meet the requirements specified in ISO 7176-21 when it is tested as specified in Clause 17.

5.12 Safe operation as the battery becomes depleted

When the stair-climbing device is tested as specified in Clause 18, no hazardous situation shall occur.

It is recommended that the stair-climbing device provides an indication that the battery is becoming depleted and, following such indication, that it has sufficient charge to climb or descend at least 20 steps.

5.13 Safety equipment**5.13.1 General**

The stair-climbing device shall meet the requirements specified in ISO 7176-14.

In addition, the stair-climbing device shall be fitted with the safety equipment specified in 5.12.2 and 5.12.3.

NOTE Recommendations for additional items of safety equipment (anterior trunk support, stairs indicator and head support) are given in Annex C.

5.13.2 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 operator.

When the stair-climbing device is tested as specified in 19.2.1, activating the emergency system while the stair-climbing device is climbing shall bring the stair-climbing device to a complete stop in which it shall remain.

When the stair-climbing device is tested as specified in 19.2.1, after the emergency system has been activated, switching off the stair-climbing device and then switching it on again shall not deactivate the emergency system.

When the stair-climbing device is tested as specified in 19.2.1, the deactivation of the emergency system shall require a set of at least two separate operator actions. The method for deactivation shall be specified in the manufacturer's instructions for use.

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

5.13.3 Climbing mode exit restriction

If a stair-climbing device has operational modes other than climbing mode, when it is tested as specified in 19.2.2 it shall not be possible to exit the climbing mode or change to an operational mode other than climbing mode while on stairs unless the manufacturer's instructions for use state that this is intended.

5.14 Ergonomic aspects

If the stair-climbing device is intended to be dismantled for ease of carrying:

- any component that has a mass greater than 10 kg shall be provided with suitable handling devices (e.g. handles); or
- the instructions for use shall indicate the points where the component can be lifted safely and/or give a method for handling during assembly.

NOTE Compliance is checked by inspection.

6 Test apparatus

6.1 Straight test stairs, consisting of eight steps, each having a rise of (180 ± 5) mm. The overall pitch shall be $(35^{+1}_0)^\circ$ (see Figure 11). The steps shall be numbered from the lowest step upwards. A riser shall close the front face of each step. All step nosings shall fall within a region contained between two imaginary parallel planes 10 mm apart and inclined at the overall pitch of the stairs.

The step nosings shall be of a rigid material, smooth and rounded to a radius of (8 ± 1) mm. Each step shall be level when the straight test stairs rest on the horizontal test plane (6.4) and shall have a coefficient of friction conforming to ISO 7176-13. The stairs shall be of sufficient width to accommodate the stair-climbing device to be tested, including the occupant, test wheelchair (if used) and assistant (if present).

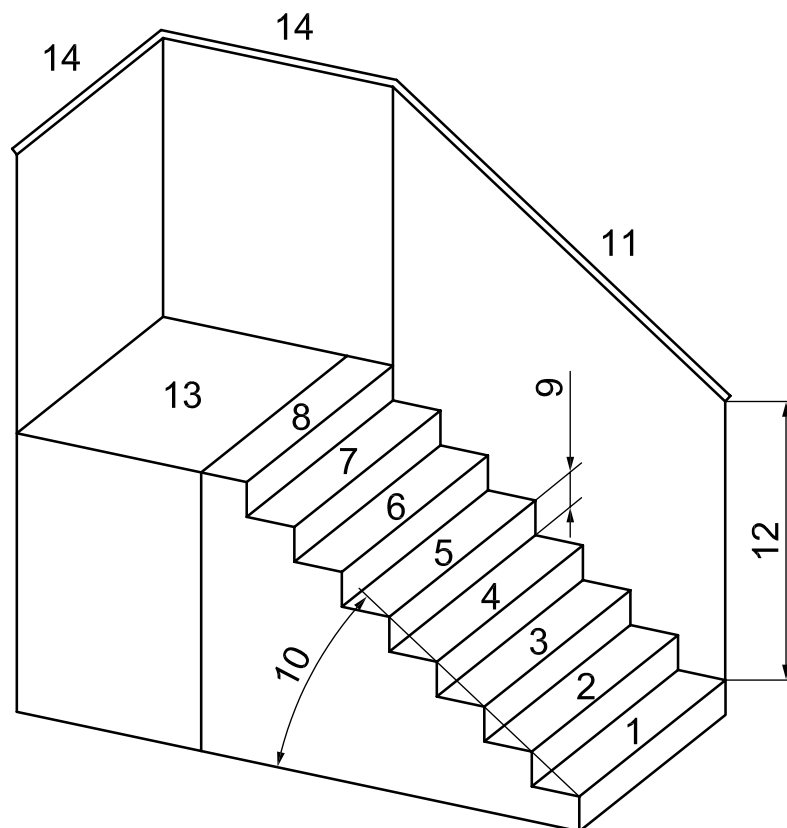
NOTE Stairs that are at least 500 mm wider than the stair-climbing device are recommended.

The straight test stairs shall be capable of being tilted in the downwards and upwards directions by means of the lifting gear (6.10).

The straight test stairs shall be capable of being connected to the upper landing. When the straight test stairs are placed on the horizontal test plane, the test plane represents the lower landing.

At least one handrail shall be mounted on the test stairs. Each handrail shall be capable of withstanding the forces applied to it, shall have a circular grip profile with a diameter of (35 ± 5) mm and have a vertical distance to the step nosings of (900 ± 25) mm when the stairs are placed on the horizontal test plane.

The straight test stairs shall be constructed and secured so that any movement or deflection of the test stairs does not materially affect the test results.



Key

- 1 to 8 step numbers
- 9 rise
- 10 pitch
- 11 handrail for stairs
- 12 vertical distance between handrail and step nosings
- 13 upper landing
- 14 handrail for upper landing

Figure 11 — Straight test stairs with upper landing

6.2 Winding test stairs, consisting of eight steps, each having a rise of (180 ± 5) mm. The winding angle between successive steps shall be $(19 \pm 0,5)^\circ$. The step nosings shall be tangential to a virtual cylinder coaxial with the central axis of the stairs that has a radius of (75 ± 20) mm. The going of each step shall be (257 ± 10) mm when measured perpendicular to the step nosing at a point (760 ± 10) mm from the central axis of the stairs, measured parallel to the step nosing. The inner radius of the stairs shall be (310 ± 10) mm. The steps shall be numbered from the lowest step upwards. A riser shall close the front face of each step (see Figure 12).

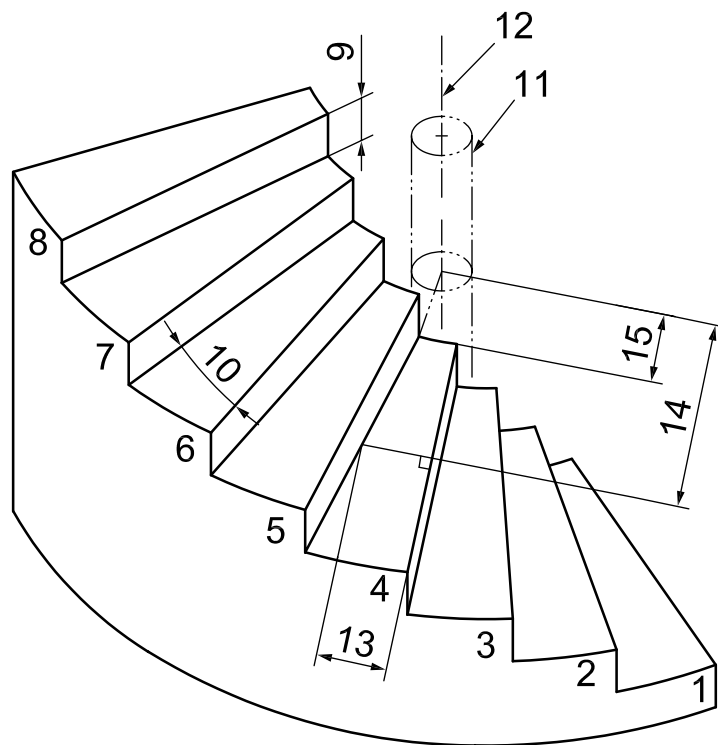
The step nosing shall be of a rigid material, smooth and rounded to a radius of (8 ± 1) mm. Each step shall be level when the winding test stairs rest on the horizontal test plane (6.4) and shall have a coefficient of friction that conforms to ISO 7176-13. The stairs shall be of sufficient width to accommodate the stair-climbing device to be tested, including the occupant, test wheelchair (if used) and assistant (if present).

NOTE Stairs that are at least 500 mm wider than the stair-climbing device are recommended.

The winding test stairs shall be capable of being connected to the upper landing. When the winding test stairs are placed on the horizontal test plane, the test plane represents the lower landing.

If needed to conduct a test or for the safety of test personnel, at least one handrail shall be mounted on the test stairs. If used, each handrail shall be capable of withstanding the forces applied to it, shall have a circular grip profile with a diameter of (35 ± 5) mm and have a vertical distance to the step nosings of (900 ± 25) mm.

The winding test stairs shall be constructed and secured so that any movement or deflection of the test stairs does not materially affect the test results.



Key

1 to 8	step numbers
9	rise
10	winding angle
11	virtual cylinder coaxial with the central axis of the stairs
12	central axis of the stairs
13	going
14	distance from central axis of the stairs for measuring going
15	inner radius of the stairs

Figure 12 — Winding test stairs

6.3 Upper landing, consisting of a level platform with a height equal to the height of the top steps of the straight test stairs (6.1) and the winding test stairs (6.2), with a tolerance of ± 5 mm. The top surface shall have a coefficient of friction that conforms to ISO 7176-13. The landing shall be capable of being securely connected to the straight test stairs or winding test stairs. Handrails shall be mounted on the upper landing. Each handrail shall be capable of withstanding the forces applied to it, shall have a circular grip profile with a diameter of (35 ± 5) mm and have a vertical distance to the top surface of (900 ± 25) mm (see Figure 11).

6.4 Horizontal test plane, rigid and of sufficient size to accommodate the stair-climbing device, the straight test stairs, the winding test stairs and/or the upper landing as needed during testing. The plane shall be flat such that the whole surface lies between two imaginary horizontal planes 5 mm apart per 1 000 mm of excursion in any direction and 25 mm apart per 6 000 mm of excursion in any direction. The surface of the plane shall have a coefficient of friction conforming to ISO 7176-13.

6.5 Adjustable barriers, capable of detecting the maximum excursion and/or operating area of the stair-climbing device on each step of the straight test stairs (6.1) and the winding test stairs (6.2), on the upper landing (6.3) and on the horizontal test plane (6.4). The detecting surface of each barrier shall be flat and vertical and perpendicular to the step nosing when the barrier is placed on a step.

NOTE Adjustable barriers may be physical planes, lights or any other appropriate means for detecting the maximum excursion of the stair-climbing device.

6.6 Test wheelchair, of the type or model recommended for transport in the stair-climbing wheelchair carrier by the manufacturer of the stair-climbing wheelchair carrier. If the manufacturer recommends several wheelchairs, the heaviest wheelchair shall be used. If no wheelchair is recommended, the surrogate wheelchair conforming to Annex D shall be used.

6.7 Test dummy, conforming to ISO 7176-11.

6.8 Energy consumption instrumentation, as specified in ISO 7176-4.

6.9 Means for measuring time, (e.g. stopwatch) with an accuracy of 0,1 s.

6.10 Lifting gear, capable of lifting the straight test stairs (6.1) so that they can be tilted downwards [see Figure 13 a)] and upwards [(see Figure 13 b)] and capable of lifting the combined mass of the straight test stairs and the loaded stair-climbing device.

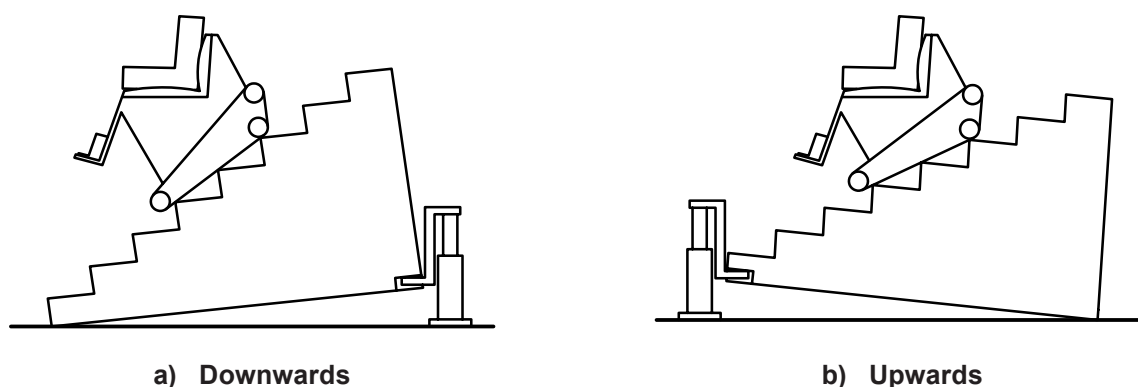


Figure 13 — Example of lifting gear with test stairs tilted

6.11 Means for measuring linear dimension, (e.g. tape measure) capable of measuring up to 500 mm with an accuracy of ± 1 mm and 500 mm to 5 000 mm with an accuracy of ± 10 mm.

6.12 Handrail barrier, with a width of (400 ± 10) mm and a minimum height of 1 000 mm, to be placed at the side of, and flush with, the nosing of step 1 of the straight test stairs (see Figure J.1).

NOTE The handrail barrier is intended to represent interior handrails at an intermediate landing of U-shaped stairs.

6.13 Acceleration rig, capable of applying a force of (100 ± 10) N in a substantially horizontal and forward direction, to pull or push the stair-climbing device across the upper landing.

NOTE Examples of acceleration rigs are shown in Figures 21 and 22.

6.14 Tyre pressure gauge, capable of measuring tyre pressure up to 6 bar with an accuracy of $\pm 0,2$ bar.

6.15 Dummy securement, capable of restraining the test dummy as specified for each test procedure without deforming the stair-climbing device or the test wheelchair.

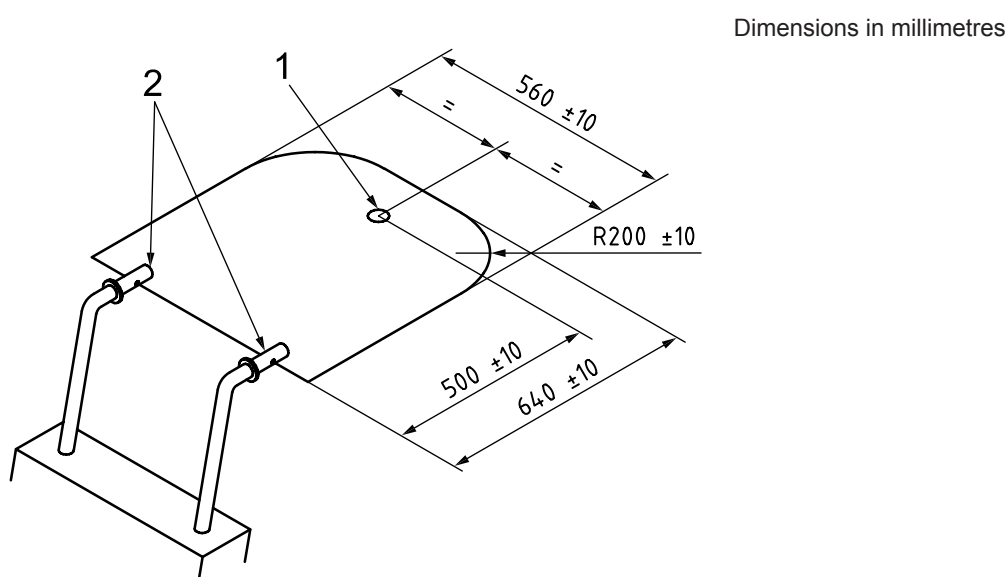
6.16 Surrogate bag, (e.g. backpack) attached to the test stair-climbing device to achieve the exaggerated test set-up. The surrogate bag shall have the largest mass and dimensions recommended for items to be carried on the stair-climbing device in the manufacturer's instructions for use. Where there is no recommendation, the surrogate bag shall have a mass of $(7 \pm 0,25)$ kg, and shall fit within a space measuring $(35 \times 20 \times 42)$ cm.

6.17 Assistant space gauge, a rigid frame or surface with a length of (640 ± 10) mm, and a width of (560 ± 10) mm or (200 ± 10) mm greater than the distance between the midpoints of the push handles of the tested stair-climbing device, whichever is the larger. Two corners have a radius of (200 ± 10) mm as shown in Figure 14.

The space gauge shall be capable of being attached to the push handles of the stair-climbing device so that the edge opposite the rounded corners passes through the midpoints of the push handles.

EXAMPLE A frame made of wood or steel wire.

NOTE The assistant space gauge is intended to simulate the space an assistant occupies when performing the tests in Annex J.



Key

- 1 datum point (see Annex J)
- 2 push handles of stair-climbing device

Figure 14 — Example of assistant space gauge

6.18 Escalator test machine, if needed for conducting the alternative test method, specified in Annex F, for fatigue testing of the stair-climbing device in climbing mode.

6.19 Handlebar, rigid rod or bar for attachment between the push handles of a stair-climbing device in order to apply a test force to its midpoint.

6.20 Means for measuring force, capable of measuring up to 200 N with an accuracy of $\pm 3 \%$.

7 Preparation of the stair-climbing device for testing

7.1 General

Before carrying out any of the tests specified in this part of ISO 7176, prepare the stair-climbing device as described in 7.2 to 7.10 unless otherwise specified for a particular test. Record any deviations from the provisions of this clause and the reasons for deviation.

7.2 Equipment

Equip and configure the stair-climbing device for climbing in accordance with the manufacturer's instructions for use.

If the stair-climbing device can be delivered with anti-tip devices and/or kerb-climbing devices, these devices shall be used.

Remove any loose cushions.

Record the equipment fitted to the stair-climbing device under test.

7.3 Adjustments

Set any adjustable dimensions of the stair-climbing device to the reference set-up values specified in ISO 7176-22.

In the case of a manually stabilized stair-climbing device, adjust the angle of recline in accordance with the manufacturer's instructions for use.

Record the adjusted dimensions of the stair-climbing device under test.

7.4 Batteries

Batteries at risk of spillage during testing may be replaced by equivalent non-spillable batteries, or other objects having the same mass, size and centre of mass, as needed to conduct each test.

When batteries are used, charge them to at least 75 % of their rated nominal capacity.

7.5 Tyre inflation

If the stair-climbing device has pneumatic tyres, inflate them to the pressure recommended by the manufacturer of the stair-climbing device. If a pressure range is given, inflate the tyres to the highest pressure in the range. If there is no recommendation, inflate the tyres to the maximum pressure recommended by the tyre manufacturer.

7.6 Power switch

Switch on the stair-climbing device.

7.7 Speed setting

7.7.1 General

The speed setting depends on the type of test. Select the speed setting as specified in 7.7.2 or 7.7.3.

7.7.2 Nominal test speed

Where a test method specifies that nominal test speed is used, set the stair-climbing device to the highest speed for the required operational mode that is in accordance with the manufacturer's instructions for use.

7.7.3 Maximum test speed

Where a test method specifies that maximum test speed is used:

- when the speed is independent of direct operating forces, set the stair-climbing device to the maximum speed for the required operational mode that the stair-climbing device can attain; or
- when the speed is dependent on direct operating forces, operate the stair-climbing device at a speed that is 20 % above the nominal test speed of the required operational mode (see 7.7.2).

NOTE The 20 % increase constitutes a margin for foreseeable variations in speed when it is governed manually.

7.8 Loading of stair-climbing devices

7.8.1 Loading of stair-climbing chairs

- a) Where a test dummy (6.7) is specified for use in a particular test, select a test dummy of appropriate mass and place it in the stair-climbing device in accordance with ISO 7176-22. If the range of dummy masses specified in ISO 7176-11 does not include a dummy with the specified mass, select the nearest lower mass.
- b) Where a particular test method requires the dummy to be secured to the body support system, use the dummy securement (6.15).
- c) Where a particular test method allows a human test occupant to be used instead of a test dummy, seat the test occupant in the stair-climbing device in accordance with ISO 7176-22. If the mass of the human test occupant is less than that of the applicable test dummy, add mass so that the total mass and location of centre of mass are as close as possible to those of the dummy.
- d) Record the mass of the test dummy or human test occupant in the test report.

WARNING Performing tests with a human test occupant can be hazardous. It is essential that appropriate precautions are taken to protect the test personnel.

7.8.2 Loading of stair-climbing wheelchair carriers

Select the combination of wheelchair and test dummy (6.7) that satisfies the following:

- a) the wheelchair is one of those specified for use with the stair-climbing device, or, where no wheelchair is specified, it is the surrogate wheelchair as specified in Annex D;
- b) the combination of dummy mass and wheelchair mass is equal to the maximum rated load of the stair-climbing device ± 5 kg;
- c) the ratio of dummy mass to wheelchair mass is the greatest within those combinations that can be selected;
- d) the dummy is within the range of occupant masses specified for the wheelchair.

If the range of dummy masses specified in ISO 7176-11 does not include a test dummy that allows the combination of dummy mass and wheelchair mass to be within the tolerance specified in 2) above, select the nearest lower combined mass.

Follow the instructions given in ISO 7176-22 for fitting the test dummy in the wheelchair.

If a given test requires the test dummy to be secured to the body support system, use the dummy securement (6.15).

Where a particular test method allows a human test occupant to be used instead of a test dummy, seat the test occupant in the wheelchair in accordance with ISO 7176-22. If the mass of the human test occupant is less than that of the applicable test dummy, add mass so that the total mass and location of centre of mass are as close as possible to those of the dummy.

Record the type and mass of the test wheelchair and the mass of the test dummy or human test occupant in the test report.

Dock the loaded test wheelchair in the stair-climbing wheelchair carrier and configure the stair-climbing device for the appropriate operational mode in accordance with the manufacturer's instructions for use.

Where convenient for the purposes of the test, the test wheelchair may be docked in the stair-climbing wheelchair carrier before the test dummy is loaded into the wheelchair.

WARNING Performing tests with a human test occupant can be hazardous. It is essential that appropriate precautions are taken to protect the test personnel.