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Wheelchairs

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

Fauteuils roulants —

Partie 28: Exigences et méthodes d'essai pour les dispositifs monte-escalier

Reference number
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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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 7176-28 was prepared by Technical Committee ISO/TC 173, *Assistive products for persons with disability*, Subcommittee SC 1, *Wheelchairs*.

This part of ISO 7176 becomes applicable as of the date of publication. It replaces ISO 7176-23 and ISO 7176-24. However, ISO 7176-23 and ISO 7176-24 remain valid for a transitional period of two years, to enable manufacturers and test houses to adapt their production lines and procedures for measuring and testing.

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 dimensions, mass and manoeuvring 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 electrically powered wheelchairs*

— *Part 11: Test dummies*

— *Part 13: Determination of coefficient of friction of test surfaces*

— *Part 14: Power and control systems for electrically powered wheelchairs and scooters — 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 as seats in motor vehicles*

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

— *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 25: Batteries and chargers for powered wheelchairs — Requirements and test methods*

— *Part 26: Vocabulary*

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

The following two Technical Reports are also available:

— ISO/TR 13570-1, *Wheelchairs — Part 1: Guidelines for the application of the ISO 7176 series on wheelchairs*

— ISO/TR 13570-2, *Wheelchairs — Part 2: Typical values and recommended limits of dimensions, mass and manoeuvring space as determined in ISO 7176-5*[1)]

1) Under preparation.

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.

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”.

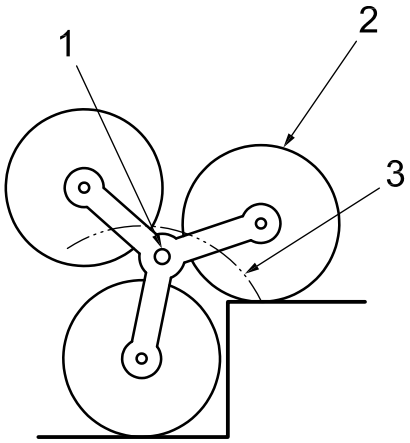
3.6
climbing
ascending or descending stairs

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

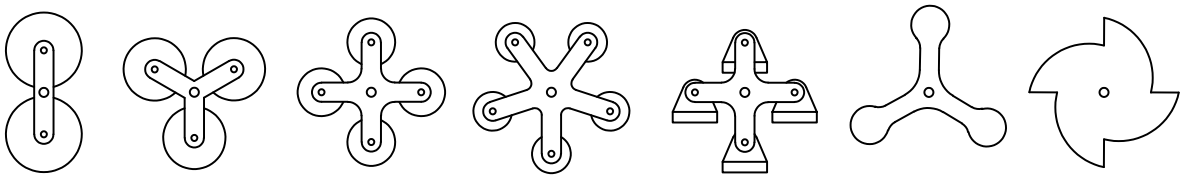
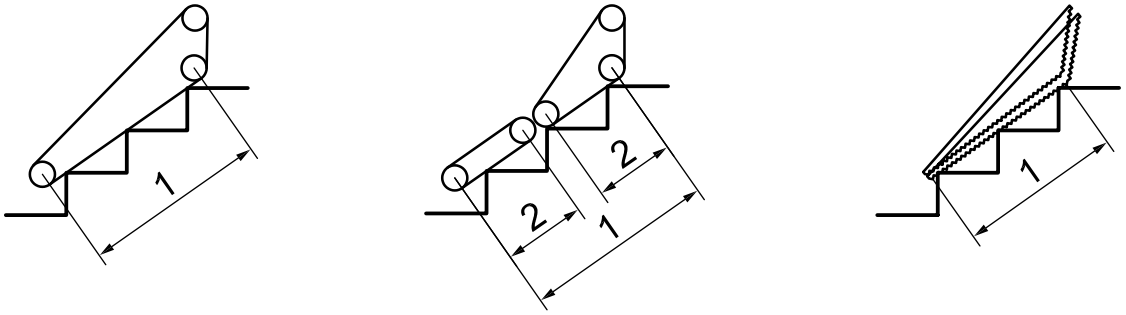


Figure 2 — Examples of clusters

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.



a) Undivided tracks **b) Divided tracks** **c) Stepping rails**

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 force**s (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

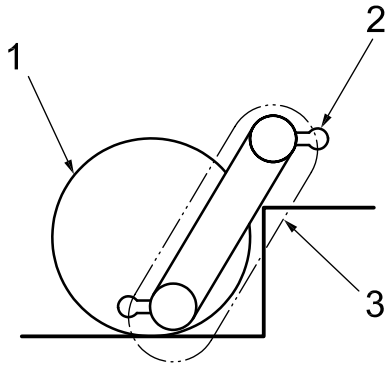
3.16
edge stop
device intended to stop forward movement of a stair-climbing device when it is on a landing above stairs and approaching the nosing of the top step

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.

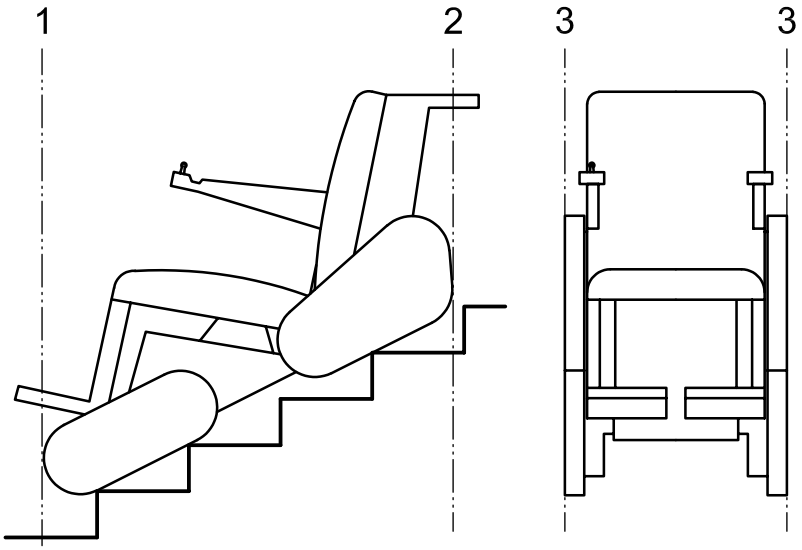


Key
1 lower actuator (wheel)
2 upper actuator (finger)
3 path of lowest point of finger relative to climbing mechanism

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 $(35 \pm 5)°$

See Figure 5.



Key

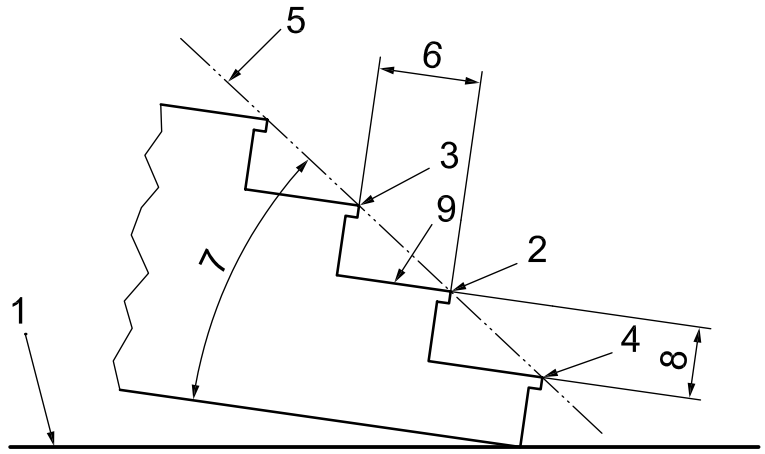
1 front vertical plane (3.19)
2 rear vertical plane (3.35)
3 side vertical plane (3.40)

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 force**s (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 ± 5)°

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.

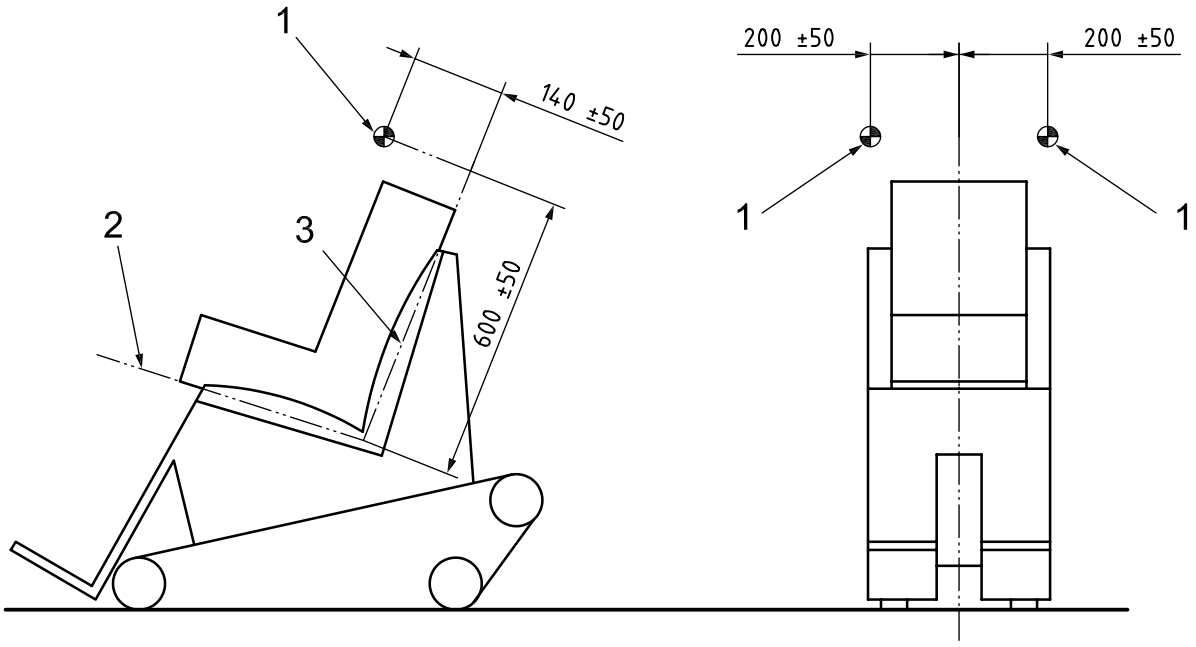
3.38
self-standing stair-climbing device
stair-climbing device that is statically stable while at rest on a horizontal surface, stairs or a landing when subjected only to the force of gravity

3.39
shoulder point
one of a pair of application points for **direct operating force**s (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.

Dimensions in millimetres



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 ± 5)°

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

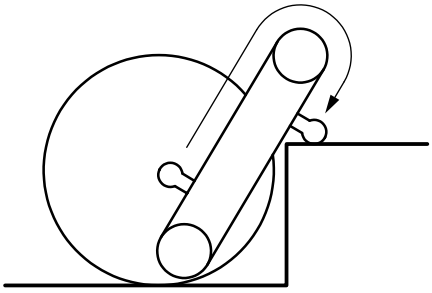
3.48
step
part of a stair including a tread on which the foot is placed to go upstairs or downstairs

NOTE Adapted from ISO 3880-1.

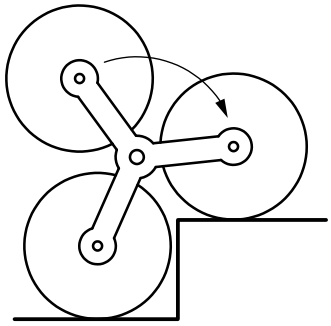
3.49
stepwise climbing mechanism
type of climbing mechanism which climbs using a cyclic action for each step

EXAMPLES **Finger drive**s (3.18), **cluster**s (3.8), **two-stroke stepping mechanism**s (3.52) or **three-stroke stepping mechanism**s (3.50).

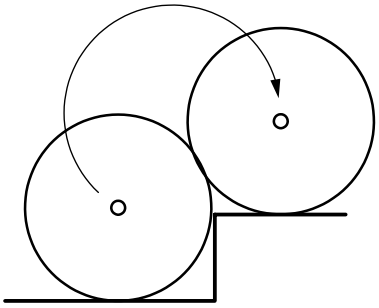
See Figure 8.



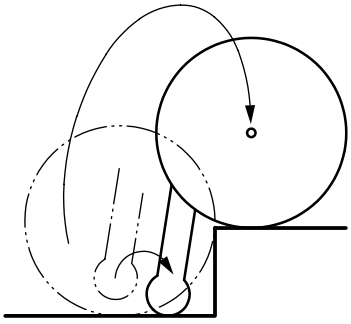
a) Finger drive (3.18)



b) Cluster (3.8)



c) Two-stroke stepping mechanism (3.52)



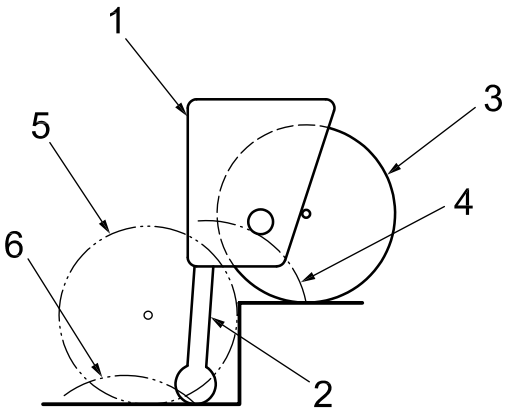
d) Three-stroke stepping mechanism (3.50)

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

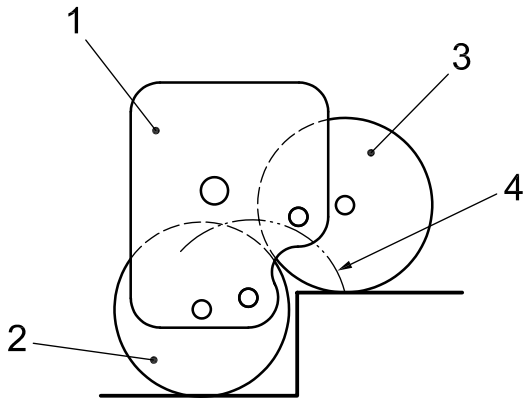
NOTE Adapted from ISO 3880-1.

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 $(4\ ^{+1}_{0})°$ 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 $(35\ ^{+1}_{0})°$ (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).

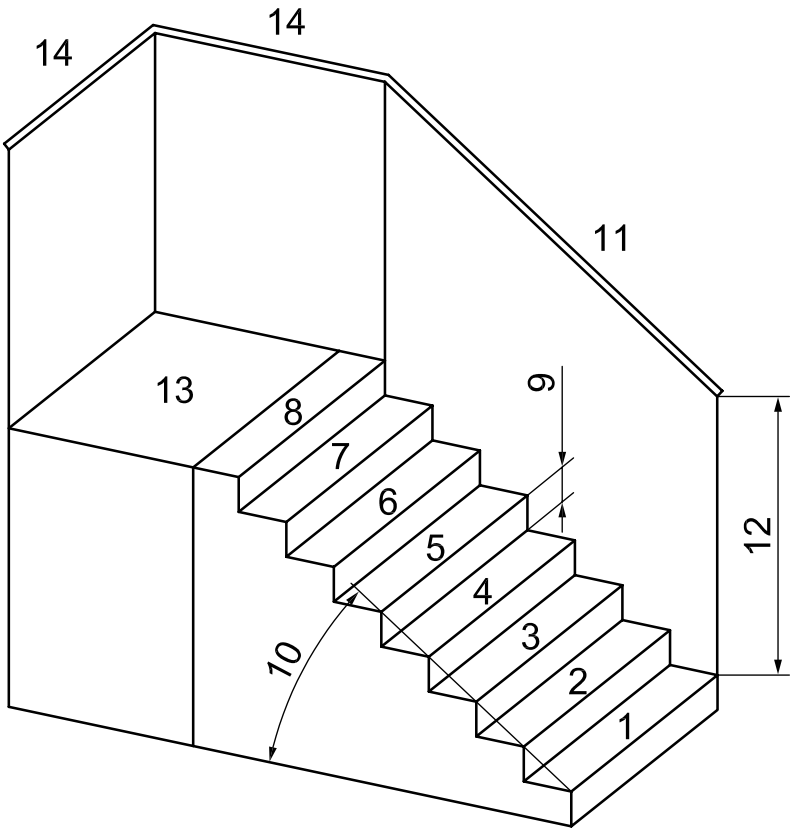
NOTE Stairs that are at least 500 mm wider than the stair-climbing device are recommended.

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 ± 0,5)°. 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).

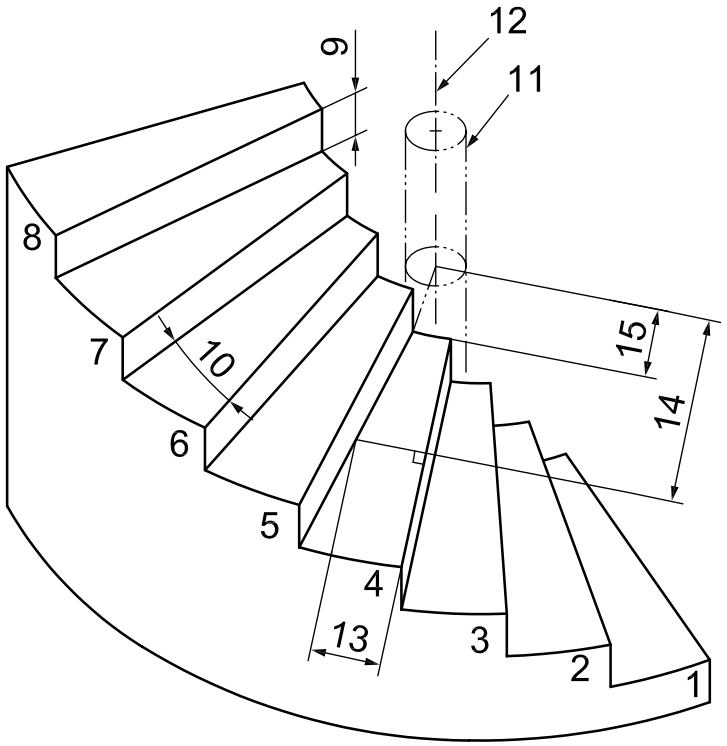
The step nosing shall be of a rigid material, smooth and rounded to a radius of (8 ± 1) mm. Each step shall be level when the winding test stairs rest on the horizontal test plane (6.4) and shall have a coefficient of friction that conforms to ISO 7176-13. The stairs shall be of sufficient width to accommodate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

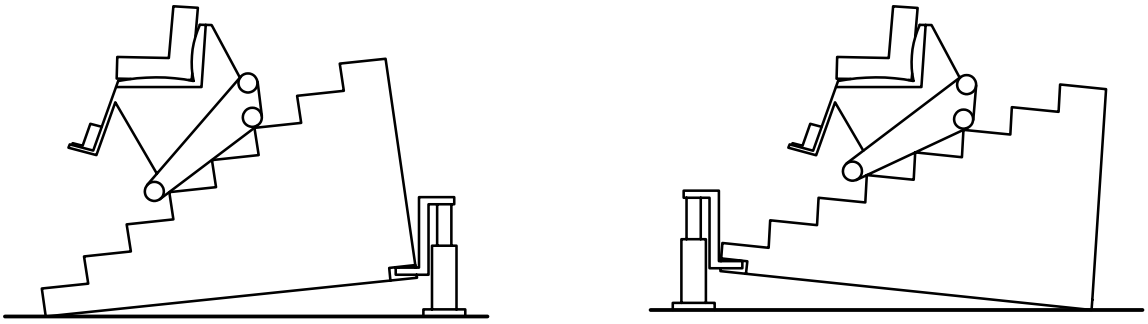
6.6 Test wheelchair, of the type or model recommended for transport in the stair-climbing wheelchair carrier by the manufacturer of the stair-climbing wheelchair carrier. If the manufacturer recommends several wheelchairs, the heaviest wheelchair shall be used. If no wheelchair is recommended, the surrogate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



a) Downwards **b) Upwards**

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 ± 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 ± 0,25) kg, and shall fit within a space measuring (35 × 20 × 42) cm.

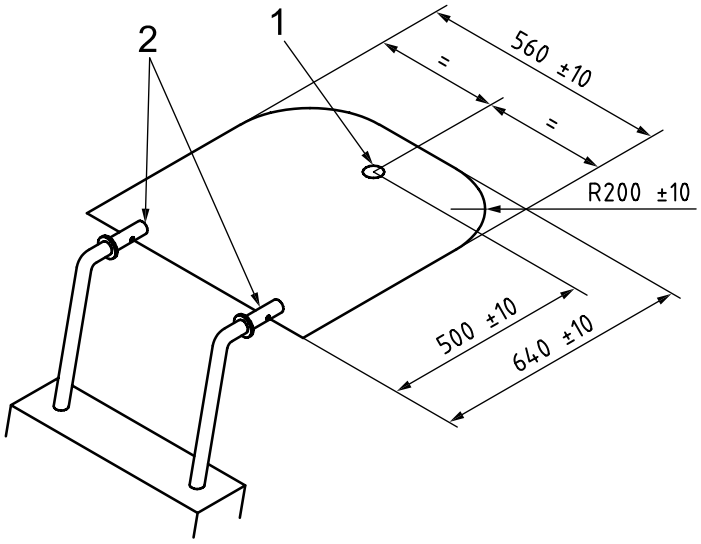
6.17 Assistant space gauge, a rigid frame or surface with a length of (640 ± 10) mm, and a width of (560 ± 10) mm or (200 ± 10) mm greater than the distance between the midpoints of the push handles of the tested stair-climbing device, whichever is the larger. Two corners have a radius of (200 ± 10)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

Dimensions in millimetres



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 ± 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:

a) 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

b) 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 $\pm$ 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.

7.9 Adaptation of the body support system

If the angle between the climbing mechanism and the body support system (of the stair-climbing device or the transported wheelchair) needs to be adapted manually when moving between driving surfaces and stairs (e.g. tilted to the rearward inclination on stairs and tilted to the forward inclination on driving surfaces or landings), perform the tests with the body support system tilted to the forward inclination while on driving surfaces or landings and tilted to the rearward inclination while on stairs.

If the body support system can be swivelled around a vertical axis to face in more than one direction, adjust it to the forward-facing position.

7.10 Exaggerated test set-up

7.10.1 General

Where a test method specifies that an exaggerated test set-up is used, follow the instructions below as applicable.

7.10.2 Forward

Place the surrogate bag (6.16) on top of the upper surface of the seat construction (i.e. the lap) of the test dummy. The centre of mass of the surrogate bag shall be placed not more than 10 mm from the plane of symmetry of the dummy (to ensure the overall centre of mass is not displaced to the right or left) and (280 $\pm$ 10) mm in front of the hinges of the dummy, measured parallel to its seat construction.

7.10.3 Rearward

If the manufacturer's instructions for use specify one or more positions for carrying a bag, place the surrogate bag (6.16) in the most rearward position in accordance with the instructions. Otherwise, hang the surrogate bag from the back support (of the stair-climbing chair or the transported wheelchair) at the most convenient location (e.g. the push handles or the top of the back support), so that its centre of mass is (300 $\pm$ 20) mm below the point of attachment and not more than 10 mm from the plane of symmetry of the test dummy.

8 Test conditions

The ambient temperature shall be (20 $\pm$ 5) °C and the relative humidity shall be from 30 % to 85 %RH.

9 Skew angle

9.1 Principle

The ability of a stair-climbing device to accommodate misalignment with stairs is evaluated by performing a series of functional tests with the stair-climbing device in climbing mode set at a skew angle to the straight test stairs.

9.2 Test method

WARNING These tests can be hazardous. It is essential that appropriate precautions (e.g. restraints that will catch the stair-climbing device in case of it falling) are taken to protect the test personnel.

NOTE This test is applicable to all stair-climbing devices.

Connect the straight test stairs to the upper landing and place them on the horizontal test plane.

Load the stair-climbing device with the test wheelchair (where applicable) and the appropriate test dummy or a human test occupant, as described in 7.8.

Set the stair-climbing device to climbing mode and configure it for climbing stairs in accordance with the manufacturer's instructions for use.

Perform the following tests at maximum test speed (7.7.3) and apply the full speed command throughout the test sequence, even when making the transition between stairs and landings. If the manufacturer's instructions for use give a clear warning not to use maximum speed when making the transition between stairs and landings, then follow the manufacturer's instructions for use.

Unless the manufacturer's instructions for use of an occupant-operated stair-climbing device declare that the operating occupant has to exert direct operating forces (3.11) when climbing on stairs or making the transition between stairs and landings, perform the test without applying a force to any handrail.

a) Position the stair-climbing device on the lower landing at a skew angle of $(4\ ^{+1}_{0})°$, unless the manufacturer's instructions for use declare that the stair-climbing device is capable of accommodating larger skew angles, in which case position the stair-climbing device on the lower landing at the largest skew angle with a tolerance of $(^{+1}_{0})°$ that is in accordance with the manufacturer's instructions for use.

b) Operate the stair-climbing device to climb the stairs from the lower landing to the upper landing in accordance with the manufacturer's instructions for use and score the performance in accordance with Table 3 (see 9.3).

c) Repeat a) to b) another two times.

d) Repeat a) to c) at the same skew angle, but with the stair-climbing device initially positioned on the upper landing and operated to climb down the stairs to the lower landing in accordance with the manufacturer's instructions for use.

e) Identify and record the lowest evaluated score of the entire test in the test report.

9.3 Evaluation of results

Evaluate the results of the skew angle test in accordance with Table 3.

Table 3 — Scoring system for quantifying the results of skew angle tests and dynamic stability tests

Observed response		Score
No tip, normal operation	All actuators remain in contact with the test surface[ab] AND Stair climbing is consistent with manufacturer's instructions for use Direct operating force needed is consistent with manufacturer's instructions for use	5
Minor tip, normal operation	One actuator lifts and returns to the test surface[ab] causing no visible tip of the stair-climbing device AND Stair climbing is consistent with manufacturer's instructions for use Direct operating force needed is consistent with manufacturer's instructions for use	4
Transient tip, moderately greater direct operating force needed	All actuators of one end[c] of the stair-climbing device lift and return to the test surface[ab]. No other part of the stair-climbing device makes contact with the test surface OR Stair climbing is consistent with manufacturer's instructions for use Direct operating force needed is moderately greater than for normal use Stair climbing is not interrupted	3

[a] The test surface can be the horizontal test plane, the straight test stairs or the lower or upper landing, as applicable.

[b] Excluding intentional lifting of actuators due to the climbing method used by the stair-climbing device.

[c] The front end, rear end, left side or right side of the stair-climbing device.

Table 3 *(continued)*

Observed response		Score
Transient tip with other contact, moderately greater direct operating force needed with other contact	All actuators of one end[c] of the stair-climbing device lift and return to the test surface[ab]. A part of the stair-climbing device other than an actuator makes contact with the test surface. OR Stair climbing is consistent with manufacturer's instructions for use, direct operating force needed is moderately greater than for normal use, a part of the stair-climbing device other than an actuator makes contact with the test surface, and stair climbing is not interrupted.	2
Partial tip, significant direct operating force needed	All actuators of one end[c] of the stair-climbing device lift off the test surface[ab], and the stair-climbing device comes to rest on a part of the stair-climbing device other than an actuator, not more than 10° from its original orientation OR Direct operating force needed is significantly greater than for normal use Stair climbing is interrupted	1
Full tip, unable to complete test	Stair-climbing device tips more than 10° from its original orientation (unless caught by a restraining device or test personnel) OR Test was unable to be completed	0

[a] The test surface can be the horizontal test plane, the straight test stairs or the lower or upper landing, as applicable.

[b] Excluding intentional lifting of actuators due to the climbing method used by the stair-climbing device.

[c] The front end, rear end, left side or right side of the stair-climbing device.

9.4 Test report

In addition to the information specified in Clause 20, the test report shall include the following information:

a) a statement as to whether the stair-climbing device met the requirements in 5.2;

b) the configuration of the stair-climbing device during the tests;

c) the skew angle used for the test;

d) the lowest score (see 9.2) evaluated in accordance with Table 3;

e) any hazardous situation that occurred during the tests;

f) any of the manufacturer's instructions for use that were disregarded, with reasons why;

g) any particular tests that could not be carried out, with reasons why;

h) any other observations relevant to the tests.

10 Effectiveness of brakes

10.1 Principle

The effectiveness of brakes is evaluated by subjecting the stair-climbing device to a series of braking tests and measuring braking distances, in addition to observing the behaviour of the stair-climbing device during each test.

NOTE This test is an extension and adaptation of ISO 7I76-3.

10.2 Test method

10.2.1 General

NOTE These tests are applicable to all stair-climbing devices.

Load the stair-climbing device with the test wheelchair (where applicable) and the appropriate test dummy or a human test occupant, as described in 7.8.

WARNING The tests can be hazardous. It is essential that appropriate precautions (e.g. restraints that will catch the stair-climbing device in case of falling) are taken to protect the test personnel.

10.2.2 Test on driving surfaces

Perform the brake effectiveness test for the parking brakes in accordance with ISO 7176-3 with the stair-climbing device in climbing mode. Test manually stabilized stair-climbing devices in the upright position.

If the stair-climbing device has a crawling mode that is separate from climbing mode and driving mode, repeat the parking brake test in the crawling mode. Where it is intended that the stair-climbing device can be pushed over driving surfaces, repeat the parking brake test with the stair climbing device configured for this activity.

10.2.3 Test on stairs

10.2.3.1 General

Perform the tests using the straight test stairs, with the stair-climbing device in climbing mode and configured for climbing stairs in accordance with the manufacturer's instructions for use.

10.2.3.2 Downward brake test

a) Position the stair-climbing device on the straight test stairs so that the lowermost point of the climbing mechanism intended to contact the stairs is in contact with step 2.

b) Mark the body of the stair-climbing device in a position corresponding to the nosing of step 3.

c) Operate the stair-climbing device to climb slowly up the stairs until it is located on step 7.

d) Operate the stair-climbing device to climb down the stairs at the maximum test speed.

e) Commence braking by the normal means in accordance with the manufacturer's instructions for use when the mark reaches the nosing of step 3.

NOTE 1 A string parallel to the stairs that becomes taut when the mark reaches the nosing can be used both to trigger the braking operation and facilitate measurement of the braking distance.

f) Operate the brake(s) to the maximum effect and maintain them in operation until the stair-climbing device is brought to a complete stop. Measure the braking distance, i.e. the distance between the position of the mark when braking commenced and its position after stopping, expressed in millimetres to a tolerance of $\pm$ 25 mm.

g) Without applying any operating force, other than the manual stabilizing force if needed, observe the stair-climbing device for one minute. Record whether the stair-climbing device remains stationary.

h) Repeat the test another two times.

i) Calculate and record the average downwards braking distance together with any other observations relevant to the test, such as tracking behaviour, loss of stability, sliding and brake failure and any other hazardous situation.

NOTE 2 The downwards braking distance is needed for the dynamic stability tests in 12.2.6.

10.2.3.3 Upward brake test

a) Position the stair-climbing device on the straight test stairs so that the uppermost point of the climbing mechanism intended to contact the stairs is in contact with step 7.

b) Mark the body of the stair-climbing device in a position corresponding to the nosing of step 6.

c) Operate the stair-climbing device to climb slowly down the stairs until it is located on step 2.

d) Operate the stair-climbing device to climb up the stairs at the maximum test speed.

e) Commence braking by the normal means in accordance with the manufacturer's instructions for use when the mark reaches the nosing of step 6.

NOTE 1 A string parallel to the stairs that becomes taut when the mark reaches the nosing can be used both to trigger the braking operation and facilitate measurement of the braking distance.

f) Operate the brake(s) to the maximum effect and maintain them in operation until the stair-climbing device is brought to a complete stop. Measure the braking distance, i.e. the distance between the position of the mark when braking commenced and its position after stopping, expressed in millimetres to a tolerance of $\pm$ 25 mm.

g) Without applying any operating force, other than the manual stabilizing force if needed, observe the stair-climbing device for one minute. Record whether the stair-climbing device remains stationary.

h) Repeat the test another two times.

i) Calculate and record the average upwards braking distance together with any other observations relevant to the test, such as tracking behaviour, loss of stability, sliding and brake failure and any other hazardous situation.

NOTE 2 The upwards braking distance is needed for the dynamic stability tests in 12.2.7.

10.2.3.4 Effect of repeated full application of brakes

Condition the brakes for the test by operating the stair-climbing device to climb up and down the straight test stairs as quickly as practicable in the following manner:

a) with the stair-climbing device located on step 7, operate it to climb down the stairs with maximum acceleration to the maximum test speed, and then operate the brake(s) to bring it to a full stop in the minimum distance so that it is located on step 2;

b) with the stair-climbing device located on step 2, operate it to climb up the stairs with maximum acceleration to the maximum test speed, and then operate the brake(s) to bring it to a full stop in the minimum distance so that it is located on step 7;

c) repeat a) and b) five times in succession and without pause.

Immediately following this conditioning, carry out the braking test specified in 10.2.3.2.

Calculate and record whether there is any difference between this test and the results obtained from the first downward braking test (10.2.3.2).

10.3 Test report

In addition to the information specified in Clause 20, the test report shall include the following information:

a) a statement as to whether the stair-climbing device met the requirements in 5.3;

b) the configuration of the stair-climbing device during the tests;

c) a description of the parking brake(s) tested, including the method of operation such as finger/hand/foot control and whether it is manual, electric, automatic, etc.;

d) if preparation of the wheelchair required measurement of the brake operating force as specified in ISO 7176-3, the force, expressed in newtons, required to operate the brakes during the tests;

e) the results of the parking brake tests as determined in 10.2.2;

f) the results of the running brake tests as determined in 10.2.3;

g) any hazardous situation that occurred during the tests;

h) any of the manufacturer's instructions for use that were disregarded, with reasons why;

i) any particular tests that could not be carried out, with reasons why;

j) any other observations relevant to the test.

11 Static stability

11.1 Principle

The static stability of a stair-climbing device is evaluated by subjecting it to a series of stability tests on driving surfaces and on stairs and observing its performance.

NOTE This test is an extension and adaptation of ISO 7176-1.

11.2 Test methods

11.2.1 General

Load the stair-climbing device with the test wheelchair (where applicable) and the appropriate test dummy, as described in 7.8, but do not use a human test occupant.

Perform the tests given in 11.2.2 and 11.2.3 with the stair-climbing device switched off, unless the manufacturer's instructions for use require the power to remain on when the stair-climbing device is in a static position. If this is the case, record it in the test report.

WARNING The tests can be hazardous. It is essential that appropriate precautions (e.g. restraints that will catch the stair-climbing device in case of falling) are taken to protect the test personnel.

11.2.2 Static stability on driving surfaces

11.2.2.1 General

Carry out the tests for static stability on driving surfaces in accordance with ISO 7176-1, with the modifications given in 11.2.2.2 and 11.2.2.3.

Test manually stabilized stair-climbing devices in the upright position.

If the angle between the climbing mechanism and the body support system (of the stair-climbing device or the transported wheelchair) needs to be adapted manually when moving between driving surfaces and stairs, perform the tests twice with the stair-climbing device set to both extreme angles.

If a manually stabilized stair-climbing device cannot be configured into either of these positions when it is in the applicable operational mode, the test for that particular combination of position and operational mode does not apply. Record this in the test report.

11.2.2.2 Climbing mode

NOTE 1 The test is applicable to all stair-climbing devices.

Perform the tests for static stability in the forward, rearward and sideways directions, as specified in ISO 7176-1, with the stair-climbing device in climbing mode. Place the stair-climbing device on the test plane in its least stable configuration with respect to the test direction for each test (see E.1) and least stable position with respect to the test direction for each test (see E.2). Use the exaggerated test set-up with respect to the test direction for each test, as described in 7.10.

NOTE 2 For testing in the sideways direction, the forward exaggerated test set-up is used.

11.2.2.3 Crawling mode

NOTE 1 The test is applicable to stair-climbing devices which have a crawling mode that is separate from the climbing mode and driving mode.

Perform the tests for static stability in the forward, rearward and sideways directions, as specified in ISO 7176-1, with the stair-climbing device in crawling mode. Place the stair-climbing device on the test plane in its least stable configuration with respect to the test direction for each test (see E.1) and least stable position with respect to the test direction for each test (see E.2). Use the exaggerated test set-up with respect to the test direction for each test, as described in 7.10.

NOTE 2 For testing in the sideways direction, the forward exaggerated test set-up is used.

11.2.3 Static stability on stairs

11.2.3.1 General

NOTE The tests given in 11.2.3 are applicable to self-standing stair-climbing devices.

Place the straight test stairs (6.1) on the horizontal test plane (6.4). Use the lifting gear (6.10) to tilt the straight test stairs.

Perform the tests for static stability given in 11.2.3.2 and 11.2.3.3 with the stair-climbing device in climbing mode.

11.2.3.2 Downward tipping on stairs

Set the stair-climbing device to the forward least stable configuration (see E.1.2) and use the forward exaggerated test set-up (see 7.10.2).

Set the stair-climbing device to the downward least stable position on step 4 in accordance with E.2.4.

Note the steps with which the stair-climbing device is initially in contact before the stairs are tilted.

Tilt the straight test stairs downwards to an angle of $(7\ ^{+1}_{0})°$ to the horizontal, or, if the manufacturer's instructions for use declare that the stair-climbing device is capable of climbing stairs with a pitch greater than 35°, tilt the straight test stairs to an angle that is $(7\ ^{+1}_{0})°$ greater than the declared pitch [(see Figure 15 a)].

Determine whether the requirements were met and record the test result in the test report.

11.2.3.3 Upward tipping on stairs

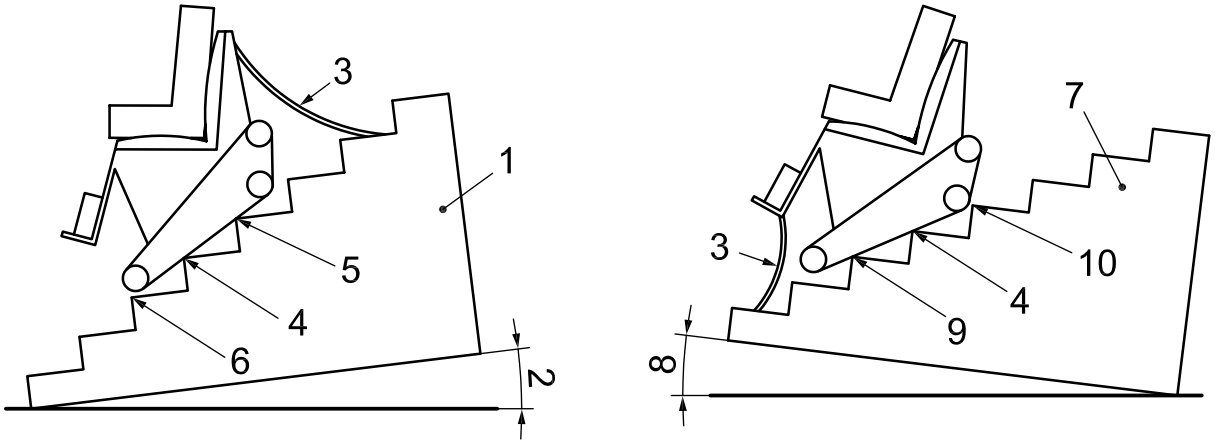
Set the stair-climbing device to the rearward least stable configuration (see E.1.3) and use the rearward exaggerated test set-up (see 7.10.3).

Set the stair-climbing device to the upward least stable position on step 4 in accordance with E.2.5.

Note the steps with which the stair-climbing device is initially in contact before the stairs are tilted.

Tilt the straight test stairs upwards to an angle of $(7\ ^{+1}_{0})°$ to the horizontal [(see Figure 15 b)].

Determine whether the requirements were met and record the test result in the test report.



a) Downward **b) Upward**

Key

1 test stairs tipped forward
2 angle of forward tip of the test stairs
3 slack tip-over restraint
4 step 4 acting as axis of tip
5 step above step 4 at which loss of contact is detected
6 step below step 4 at which contact is detected
7 test stairs tipped rearward
8 angle of rearward tip of the test stairs
9 step below step 4 at which loss of contact is detected
10 step above step 4 at which contact is detected

Figure 15 — Example of static stability tests on stairs

11.3 Test report

In addition to the information specified in Clause 20, the test report shall include the following information:

a) a statement as to whether the stair-climbing device met the requirements in 5.4;

b) the configuration of the stair-climbing device during the tests;

c) the tipping angles resulting from the tests in 11.2.2.2 and 11.2.2.3;

d) the angle at which the straight test stairs were tilted for the tests in 11.2.3.2 and 11.2.3.3;

e) any additional information required for the test report by ISO 7176-1;

f) any hazardous situation that occurred during the tests;

g) any of the manufacturer's instructions for use that were disregarded, with reasons why;

h) any particular tests that could not be carried out, with reasons why;

i) any other observations relevant to the test.

12 Dynamic stability

12.1 Principle

The dynamic stability of a stair-climbing device is evaluated by subjecting it to various tests of its stability for each of its movement functions and evaluating the results obtained.

NOTE 1 These tests are an extension and an adaptation of ISO 7176-2.

NOTE 2 Dynamic stability is tested under conditions that can reduce stability. Such conditions are often encountered during normal use of the stair-climbing device.

12.2 Test methods

12.2.1 General

NOTE 1 These tests are applicable only to self-standing stair-climbing devices.

Connect the straight test stairs to the upper landing and place them on the horizontal test plane.

Perform the tests with the stair-climbing device in the climbing mode.

Load the stair-climbing device with the test wheelchair (where applicable) and the appropriate test dummy or a human test occupant, as described in 7.8.

Perform the tests without the use of handrails unless the manufacturer's instructions for use state that an operating occupant has to exert direct operating forces when climbing on stairs or making the transition between stairs and landings.

NOTE 2 For some tests, the downstairs and upstairs braking distances (see 10.2.3.2 and 10.2.3.3) are needed.

Perform all tests on at maximum test speed (see 7.7.3). Maintain the full speed command throughout the test sequence, even when making the transition between stairs and landings, except as follows. If the manufacturer's instructions for use give a clear warning not to use maximum speed when making the transition between stairs and landings, then follow the manufacturer's instructions for use.

At each stage of the test, identify and record the points at which a hazardous situation occurs.

NOTE 3 A video recording can be useful for analysing results.

Evaluate the score for each test in accordance with Table 3 (see 9.3) immediately after each test run.

The tests given in 12.2 may be performed in any order.

WARNING The tests can be hazardous. It is essential that appropriate precautions (e.g. restraints that will catch the stair-climbing device in case of falling) are taken to protect the test personnel.

12.2.2 Upward test on upper transition

a) Set the stair-climbing device to the forward least stable configuration (see E.1.2) and use the forward exaggerated test set-up, as described in 7.10.2.

b) Locate the stair-climbing device on step 3.

c) Operate the stair-climbing device to climb up the stairs and over the upper transition until it is fully accommodated on the upper landing. Perform this procedure in one single movement without interruption.

d) Repeat the test procedure another two times and evaluate the results in accordance with Table 3 (see 9.3). Record the lowest evaluated score in the test report.

e) Set the stair-climbing device to the rearward least stable configuration (see E.1.3) and use the rearward exaggerated test set-up, as described in 7.10.3. Then repeat b) to d).

12.2.3 Downward test on upper transition

a) Set the stair-climbing device to the forward least stable configuration (see E.1.2) and use the forward exaggerated test set-up, as described in 7.10.2.

b) Position the stair-climbing device on the upper landing so that it is perpendicular to and facing toward the nosing of step 8.

c) Operate the stair-climbing device to climb over the upper transition and down the stairs until it is located on step 3. Perform this procedure in one single movement without interruption.

d) Repeat the test procedure another two times and evaluate the results in accordance with Table 3 (see 9.3). Record the lowest evaluated score in the test report.

e) Set the stair-climbing device to the rearward least stable configuration (see E.1.3) and use the rearward exaggerated test set-up, as described in 7.10.3. Then repeat b) to d).

12.2.4 Upward test on lower transition

a) Set the stair-climbing device to the forward least stable configuration (see E.1.2) and use the forward exaggerated test set-up, as described in 7.10.2.

b) Position the stair-climbing device on the horizontal test plane so that it is perpendicular to and facing away from the nosing of step 1.

c) Operate the stair-climbing device to climb over the lower transition and up the stairs until it is located on step 5. Perform this procedure in one single movement without interruption.

d) Repeat the test procedure another two times and evaluate the results in accordance with Table 3 (see 9.3). Record the lowest evaluated score in the test report.

e) Set the stair-climbing device to the rearward least stable configuration (see E.1.3) and use the rearward exaggerated test set-up, as described in 7.10.3. Then repeat b) to d).

12.2.5 Downward test on lower transition

a) Set the stair-climbing device to the forward least stable configuration (see E.1.2) and use the forward exaggerated test set-up, as described in 7.10.2.

b) Locate the stair-climbing device on step 5.

c) Operate the stair-climbing device to climb down the stairs and over the lower transition until it is fully accommodated on the horizontal test plane. Perform this procedure in one single movement without interruption.

d) Repeat the test procedure another two times and evaluate the results in accordance with Table 3 (see 9.3). Record the lowest evaluated score in the test report.

e) Set the stair-climbing device to the rearward least stable configuration (see E.1.3) and use the rearward exaggerated test set-up, as described in 7.10.3. Then repeat b) to d).

12.2.6 Dynamic stability — downwards braking on stairs

a) Set the stair-climbing device to the forward least stable configuration (see E.1.2) and use the forward exaggerated test set-up, as described in 7.10.2.

b) Set the stair-climbing device to the downward least stable position on step 4 in accordance with E.2.4.

c) Operate the stair-climbing device to climb slowly up the stairs until it has moved a distance equal to the downstairs braking distance ($^{+25}_{0}$) mm (see 10.2.3.2). Mark the body of the stair-climbing device in a position corresponding to the nosing of step 5.

d) Operate the stair-climbing device to climb slowly up the stairs until it is located on step 7.

e) Operate the stair-climbing device to climb down the stairs at the maximum test speed.

f) Commence braking by the normal means in accordance with the manufacturer's instructions for use when the mark reaches the nosing of step 5.

NOTE A string parallel to the stairs that becomes taut when the mark reaches the nosing can be used to trigger braking.

g) Operate the brake(s) to the maximum effect and maintain them in operation until the stair-climbing device is brought to a complete stop.

h) Repeat the test procedure another two times and evaluate the results in accordance with Table 3 (see 9.3). Record the lowest evaluated score in the test report.

i) Repeat b) to h) but when the mark reaches the nosing of step 5, commence braking by applying a command for maximum speed in the opposite direction.

j) Repeat b) to h) but, instead of operating the brakes, activate the emergency system when the mark reaches the nosing of step 5.

k) Repeat b) to h) but, instead of operating the brakes, switch off the stair-climbing device when the mark reaches the nosing of step 5.

l) Set the stair-climbing device to the rearward least stable configuration (see E.1.3) and, using the rearward exaggerated test set-up (see 7.10.3), repeat b) to k).

m) Identify and record the braking procedure that gives the least dynamic stability.

12.2.7 Dynamic stability when upwards braking on stairs

a) Set the stair-climbing device to the rearward least stable configuration (see E.1.3) and use the rearward exaggerated test set-up (see 7.10.3).

b) Set the stair-climbing device to the upward least stable position on step 4 in accordance with E.2.5.

c) Operate the stair-climbing device to climb slowly down the stairs until it has moved a distance equal to the upstairs braking distance ($^{+25}_{0}$) mm (see 10.2.3.3). Mark the body of the stair-climbing device in a position corresponding to the nosing of step 3.

d) Operate the stair-climbing device to climb slowly down the stairs until it is located on step 2.

e) Operate the stair-climbing device to climb up the stairs at the maximum test speed.

f) Commence braking by the normal means in accordance with the manufacturer's instructions for use when the mark reaches the nosing of step 3.

NOTE A string parallel to the stairs that becomes taut when the mark reaches the nosing can be used to trigger braking.

g) Operate the brake(s) to the maximum effect and maintain them in operation until the stair-climbing device is brought to a complete stop.

h) Repeat the test procedure another two times and evaluate the results in accordance with Table 3 (see 9.3). Record the lowest evaluated score in the test report.

i) Repeat b) to h) but when the mark reaches the nosing of step 3, commence braking by applying a command for maximum speed in the opposite direction.

j) Repeat b) to h) but, instead of operating the brakes, activate the emergency system when the mark reaches the nosing of step 3.

k) Repeat b) to h) but, instead of operating the brakes, switch off the stair-climbing device when the mark reaches the nosing of step 3.

l) Set the stair-climbing device to the forward least stable configuration (see E.1.2) and, using the forward exaggerated test set-up (see 7.10.2), repeat b) to k).

m) Identify and record the braking procedure that gives the least dynamic stability.

12.3 Test report

In addition to the information specified in Clause 20, the test report shall include the following information:

a) a statement as to whether the stair-climbing device met the requirements in 5.5;

b) the configuration of the stair-climbing device during the tests;

c) the results of testing in accordance with 12.2;

d) the lowest score (see 12.2) evaluated in accordance with Table 3 (see 9.3);

e) any hazardous situation that occurred during the testing;

f) any of the manufacturer's instructions for use that were disregarded, with reasons why;

g) any particular tests that could not be carried out, with reasons why;

h) any other observations relevant to the test.

13 Direct operating forces

13.1 Principle

The direct operating forces required during operation of a stair-climbing device are evaluated by subjecting it to various tests on driving surfaces and on stairs and determining the direct operating forces that the operator has to apply.

These tests are applicable to stair-climbing devices where the operator applies 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.

13.2 Preparation

13.2.1 General

Load the stair-climbing device with the test wheelchair (where applicable) and the appropriate test dummy or a human test occupant, as described in 7.8.

Do not use the exaggerated test set-up.

Unless otherwise specified in a particular test, perform tests where the stair-climbing device is in motion at nominal test speed (see 7.7.2).

13.2.2 Preparation for testing assistant-operated stair-climbing devices

If the stair-climbing device does not have a horizontal handlebar, attach a handlebar (see 6.19) between the push handles. Make provision for application of a force to the midpoint of the handlebar and a means for measuring the applied force (see 6.20).

Where direct operating forces for changing the angle between the body support system (of the stair-climbing device or the transported wheelchair) and the climbing mechanism are not applied to the push handles or handlebar, make provision for application of force and means for measurement as necessary.

13.2.3 Preparation for testing occupant-operated stair-climbing devices

Make provision to measure a force applied to a shoulder point.

WARNING The tests can be hazardous. It is essential that appropriate precautions (e.g. restraints that will catch the stair-climbing device in case of falling) are taken to protect the test personnel.

13.3 Test methods for assistant-operated stair-climbing devices

13.3.1 Self-standing stair-climbing devices

13.3.1.1 Lifting

If the manufacturer's instructions for use recommend that, in order to manoeuvre the stair-climbing device on driving surfaces, the assistant applies a force to the push handles to lift one end of the stair-climbing device, perform the following test.

If the angle between the climbing mechanism and the body support system (of the stair-climbing device or the transported wheelchair) needs to be adapted manually when moving between driving surfaces and stairs, perform the test twice with the stair-climbing device set to both extreme angles.

a) Set the loaded stair-climbing device to its forward least stable configuration (see E.1.2).

b) Place the loaded stair-climbing device on the horizontal test plane.

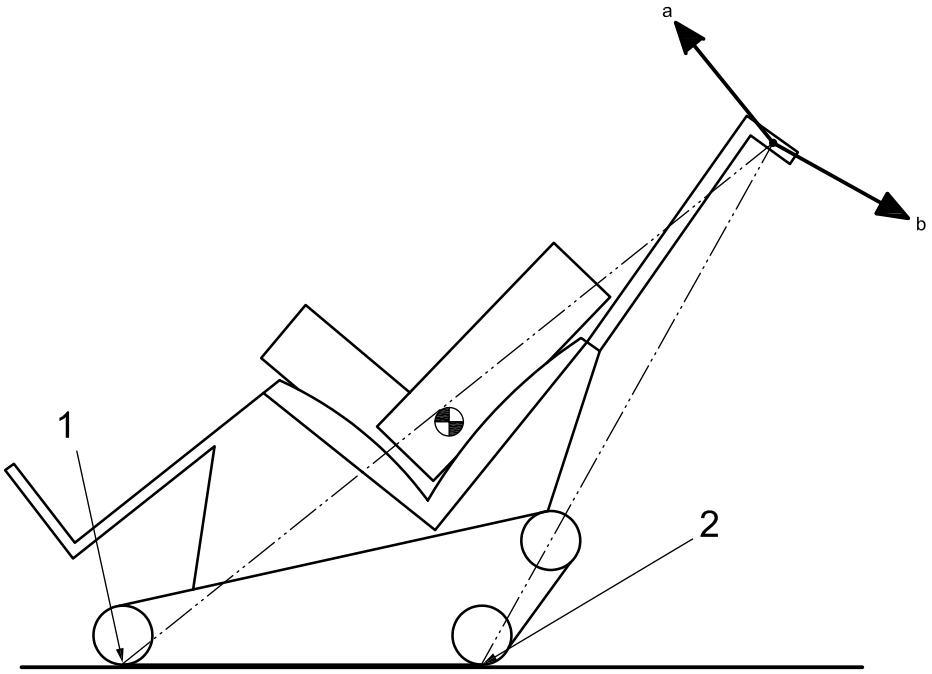
c) Apply force to the handlebar, in accordance with the manufacturer's instructions for use, to tilt the stair-climbing device.

d) Measure and record, to an accuracy of $\pm$ 10 N, the minimum force required to perform the manoeuvre (see Figure 16).

e) Repeat c) and d) for each method of tilting specified in the manufacturer's instructions for use.

f) Set the loaded stair-climbing device to its rearward least stable configuration (see E.1.3) and repeat c) to e).

g) Record the largest of the forces recorded during the tests.



Key

1 front support point

2 rear support point

a Direct operating force applied to lift the rear end of the climbing mechanism.

b Direct operating force applied to lift the front end of the climbing mechanism.

Figure 16 — Direct operating forces for lifting

13.3.1.2 Steering

If the manufacturer's instructions for use recommend that, in order to steer the stair-climbing device when crawling, the assistant applies a lateral force to the push handles, perform the following test.

If the angle between the climbing mechanism and the body support system (of the stair-climbing device or the transported wheelchair) needs to be adapted manually when moving between driving surfaces and stairs, perform the tests twice with the stair-climbing device set to both extreme angles.

a) Set the loaded stair-climbing device to its forward least stable configuration (see E.1.2).

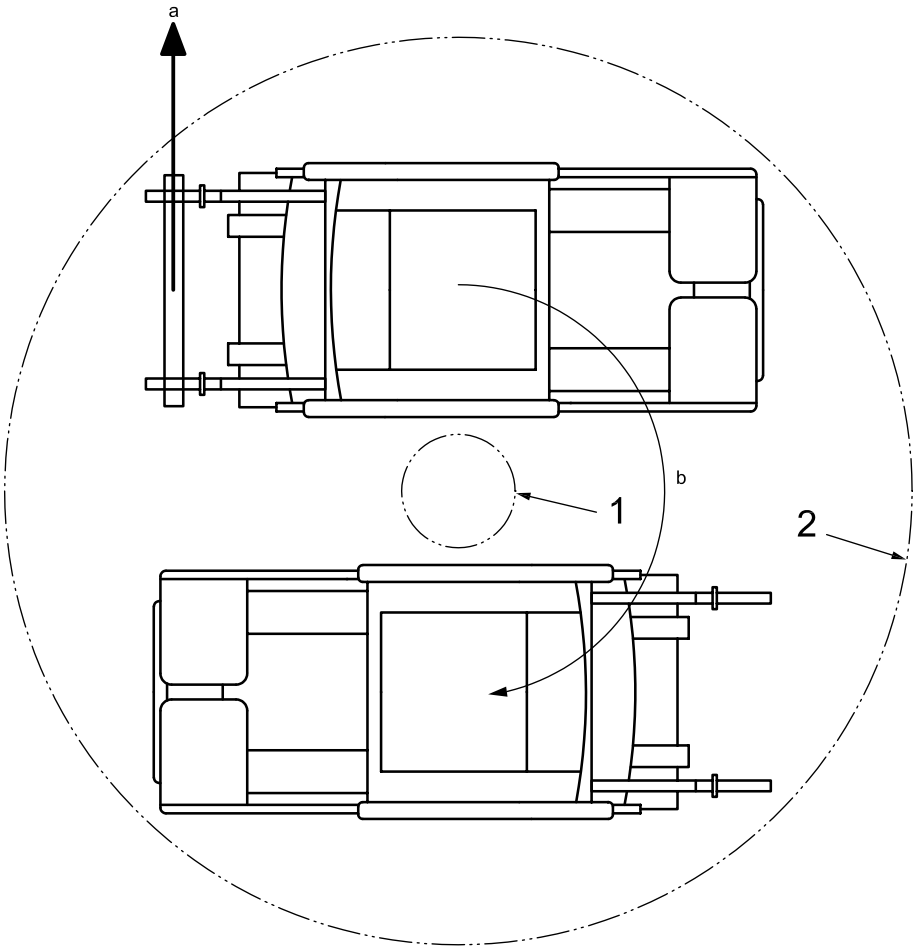
b) Place the loaded stair-climbing device on the horizontal test plane.

c) Operate the loaded stair-climbing device to crawl forward. Apply force to the handlebar, in accordance with the manufacturer's instructions for use, to turn the stair-climbing device through an angle of 180° in the space between two concentric circles of radius 150 mm and 1200 mm (see Figure 17).

d) Measure and record, to an accuracy of ± 10 N, the minimum lateral force required perform the manoeuvre.

e) Set the loaded stair-climbing device to its rearward least stable configuration (see E.1.3) and repeat c) and d).

f) Record the largest of the forces recorded during the tests.



Key

1 circle of radius 150 mm

2 circle of radius 1 200 mm

a Direct operating force for steering the stair-climbing device.

b Direction of travel.

Figure 17 — Direct operating force for steering (top view)

13.3.1.3 Adapting the angle of the body support system

If the manufacturer's instructions for use recommend that direct operating forces be applied by the assistant in order to change the angle between the body support system (of the stair-climbing device or the transported wheelchair) and the climbing mechanism, perform the following test.

a) Set the loaded stair-climbing device to its forward least stable configuration (see E.1.2).

b) Place the loaded stair-climbing device on the horizontal test plane.

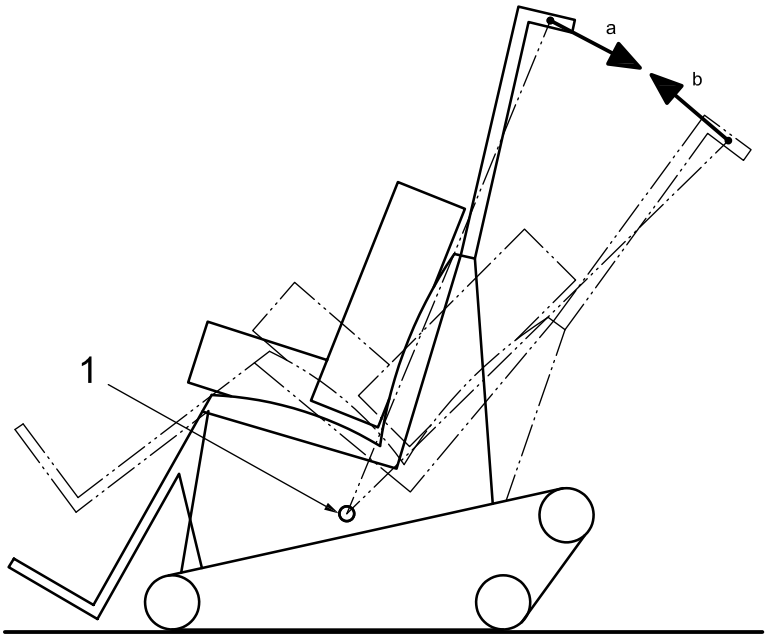
c) Apply force, in accordance with the manufacturer's instructions for use, to tilt the loaded body support system from the forward inclination to the rearward inclination.

d) Measure and record, to an accuracy of ± 10 N, the minimum force required to perform the manoeuvre (see Figure 18).

e) Repeat c) and d), but tilt the loaded body support system from the rearward inclination to the forward inclination (see Figure 18).

f) Set the loaded stair-climbing device to its rearward least stable configuration (see E.1.3) and repeat c) to e).

g) Record the largest of the forces recorded during the tests.



Key

1 fulcrum

a Direct operating force applied to tilt from the forward inclination to the rearward inclination.

b Direct operating force applied to tilt from the rearward inclination to the forward inclination.

Figure 18 — Direct operating forces to adapt the angle of the body support system

13.3.1.4 Transitions between stairs and upper landings

If the manufacturer's instructions for use recommend that direct operating forces be applied by the assistant in order to make the transition between stairs and upper landings, perform the following test.

a) Set the loaded stair-climbing device to its forward least stable configuration (see E.1.2).

b) Connect the straight test stairs to the upper landing and place them on the horizontal test plane.

c) Place the loaded stair-climbing device on the straight test stairs, in accordance with the manufacturer's instructions for use.

d) Operate the stair-climbing device to climb up the stairs until it reaches the point of transition (see Figure 19).

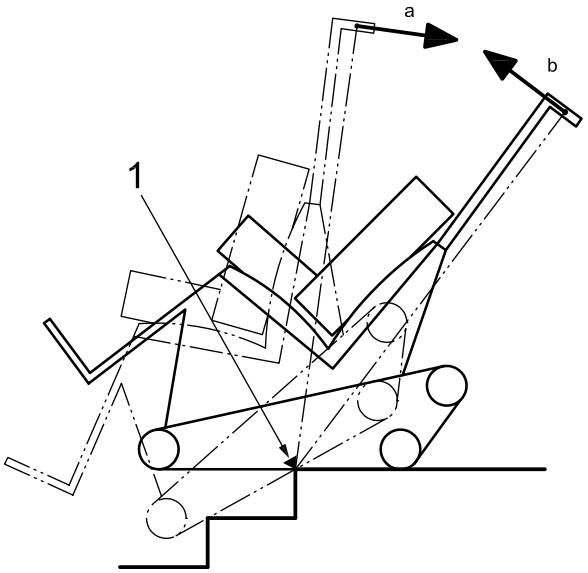
e) Determine the direction of application that will minimize the direct operating force required to cause the stair-climbing device to make the transition onto the upper landing, and then apply the minimum force in the established direction to make the transition.

f) Measure and record, to an accuracy of ± 10 N, the minimum force required to make the transition.

g) Set the loaded stair-climbing device to its rearward least stable configuration (see E.1.3) and repeat c) to f).

h) Repeat c) to g) but making the transition from the upper landing to the stairs.

i) Record the largest of the forces recorded during the tests.



Key

1 tipping point

a Direct operating force applied to make the transition from the stairs to the upper landing.

b Direct operating force applied to make the transition from the upper landing to the stairs.

Figure 19 — Direct operating forces on transitions between stairs and upper landing

13.3.1.5 Evaluation of test results

Identify and record the greatest of the direct operating forces recorded in 13.3.1.1 to 13.3.1.4.

13.3.2 Manually stabilized stair-climbing devices

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

13.4 Test methods for occupant-operated stair-climbing devices

13.4.1 Transitions between stairs and upper landings

If the manufacturer's instructions for use recommend that direct operating forces be applied by the occupant in order to make the transition between stairs and upper landings, perform the following test.

a) Set the loaded stair-climbing device to its forward least stable configuration (see E.1.2).

b) Connect the straight test stairs to the upper landing and place them on the horizontal test plane.

c) Place the loaded stair-climbing device on the straight test stairs, in accordance with the manufacturer's instructions for use.

d) Operate the stair-climbing device to climb up the stairs until it reaches the point of transition (see Figure 20).

e) Apply a force to the shoulder point, parallel to the pitch line, to cause the stair-climbing device to make the transition onto the upper landing.

f) Measure and record, to an accuracy of ± 10 N, the minimum force required to make the transition.

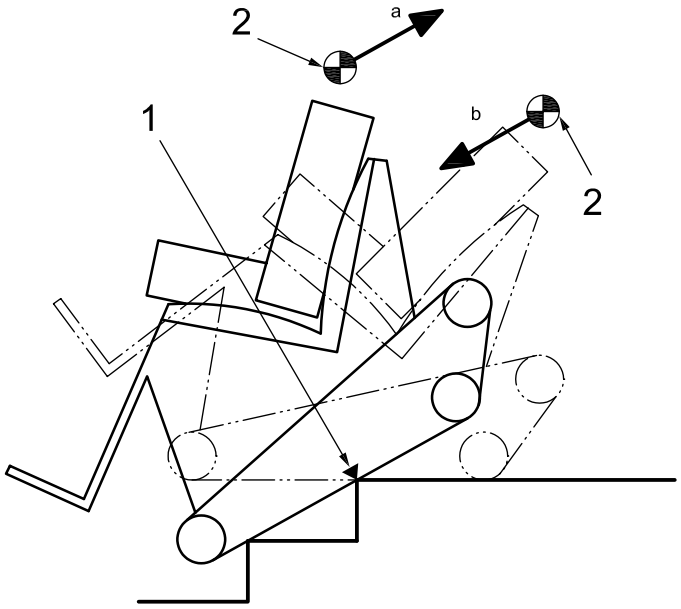
g) Set the loaded stair-climbing device to its rearward least stable configuration (see E.1.3) and repeat c) to f).

h) Repeat c) to g) but making the transition from the upper landing to the stairs.

i) Record the largest of the forces recorded during the tests.

j) Calculate the theoretical direct operating force by multiplying the force identified in i) by 1,2. Record, to the nearest multiple of 10 N, the theoretical direct operating force.

NOTE The multiplication factor corresponds to an angle of 34° between the pitch line and a representative direction of application of force to a handrail by the operating occupant.



Key

1 tipping point

2 shoulder point

a Direct operating force applied to make the transition from the stairs to the upper landing.

b Direct operating force applied to make the transition from the upper landing to the stairs.

Figure 20 — Forces causing transitions between stairs and upper landings

13.5 Test evaluation

After completing all tests in 13.3 and 13.4 that apply to the stair-climbing device, examine the test records to determine whether the stair-climbing device met the requirements of 5.6.

13.6 Test report

In addition to the information specified in Clause 20, the test report shall include the following information:

a) a statement as to whether the stair-climbing device met the requirements in 5.6;

b) the configuration of the stair-climbing device during the tests;

c) the maximum direct operating force for the stair-climbing device;

d) any hazardous situation that occurred during the tests;

e) any of the manufacturer's instructions for use that were disregarded, with reasons why;

f) any particular tests that could not be carried out, with reasons why;

g) any other observations relevant to the test.

14 Step transition safety

14.1 Principle

The step transition safety of a stair-climbing device is evaluated by a test that simulates its approach to the uppermost step of a flight of stairs as if to descend, and observing its response.

14.2 General

NOTE 1 This test is applicable to all stair-climbing devices.

Connect the straight test stairs to the upper landing and place them on the horizontal test plane.

NOTE 2 Since the whole flight of test stairs is not needed for this test, test personnel might find it easier and safer to perform the test using an upper landing connected to a flight of at least two steps with dimensions as specified for the straight test stairs.

Load the stair-climbing device with the test wheelchair (where applicable) and the appropriate test dummy, as described in 7.8, but do not use a human test occupant.

Do not use the exaggerated test set-up.

If the angle between the climbing mechanism and the body support system (of the stair-climbing device or the transported wheelchair) needs to be adapted manually when moving between driving surfaces and stairs, perform the tests twice with the stair-climbing device set to both extreme angles.

WARNING The tests can be hazardous. It is essential that appropriate precautions (e.g. restraints that will catch the stair-climbing device in case of falling) are taken to protect the test personnel.

14.3 Test method

a) Set the loaded stair-climbing device into its rearward least stable configuration (see E.1.3).

b) Place the loaded stair-climbing device on the upper landing.

c) Switch on the stair-climbing device. Do not operate the control device.

d) Set the stair-climbing device to climbing mode.

e) If the stair-climbing device has an edge stop that can be deactivated, ensure it is not deactivated.

NOTE When the stair-climbing device is in its rearward least stable configuration, it is in a more stable configuration for testing in the forward direction.

f) Where possible, arrange the climbing mechanism so that only actuators that allow free forward rolling (e.g. unlocked wheels) are in contact with the upper landing and no actuators that prevent free forward rolling (e.g. locked wheels or posts) obstruct or hinder forward movement of the stair-climbing device.

If the climbing mechanism has no actuators that allow free forward rolling (e.g. it has tracks), set the stair-climbing device to a configuration that is most likely to minimize the resistance of the stair-climbing device to being moved forward. Record the configuration of the stair-climbing device.

g) If the stair-climbing device is manually stabilized, hold it in its reclined working position for climbing stairs in accordance with the manufacturer's instructions for use. Take care to minimize the effect of the manual stabilizing force on the test result.

h) Position the stair-climbing device on the upper landing so that it is perpendicular to and facing toward the nosing of the uppermost step with a distance of (100 $\pm$ 10) mm between the nosing and the most forward contact point of the climbing mechanism with the upper landing. Disregard any contact points for parts that do not carry a load. Do not apply the normal brakes for driving, climbing or crawling on driving surfaces, stairs or landings. Instead use suitable means (e.g. rope) to retain the stair-climbing device in position.

i) Attach the acceleration rig (see 6.13) to a suitable point on the stair-climbing device as close as possible to the surface of the landing, such that the stair-climbing device will be pulled or pushed horizontally forward by a force of (100 ± 10) N with smooth acceleration (see Figure 21 and Figure 22).

j) Release the means holding the stair-climbing device in its initial position. In the case of a manually stabilized stair-climbing device, continue to maintain its reclined working position without opposing or assisting any forward movement.

k) Observe the behaviour of the stair-climbing device during the test and record whether:

- the behaviour of the stair-climbing device is in accordance with the manufacturer's instructions for use;
- any hazardous situation occurs;
- the stair-climbing device moves forward on the landing;
- any actuator lifts from the upper landing;
- any edge stop retains the stair-climbing device on the upper landing;
- the stair-climbing device crosses the step nosing;
- the stair-climbing device tilts by more than 3°, due to the lifting of an actuator from the test surface, and then recovers immediately;
- any part of the stair-climbing device not originally in contact with the test surface makes contact with it;
- the stair-climbing device climbs down with its own climbing mechanism;
- the stair-climbing device climbs down at more than the nominal test speed;
- the stair-climbing device slides down without operation of its climbing mechanism;
- the stair-climbing device comes to rest on the first step below the landing;
- the stair-climbing device tips in any direction, coming to rest at least 10° from its original orientation;
- the test cannot be completed as intended.

l) Evaluate the score in accordance with Table 4 (see 14.4) immediately after each test.

m) Repeat a) to l) with the stair-climbing device in its freewheel mode or pushing mode (if applicable).

n) Repeat a) to l) with the stair-climbing device in its crawling mode (if applicable).

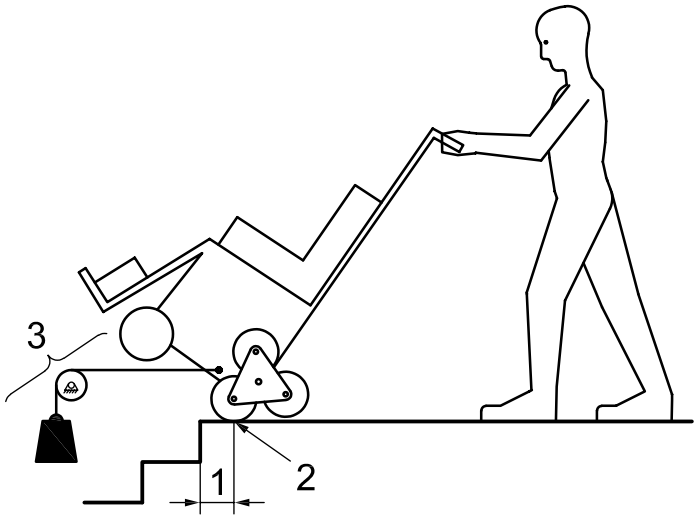
o) Repeat a) to l) with the stair-climbing device in its driving mode (if applicable).

p) If the stair-climbing device has an edge stop that can be deactivated, repeat a) to o) with the edge stop deactivated.

q) Repeat a) to p) but with the emergency system activated.

r) Repeat a) to p) but with the stair-climbing device switched off.

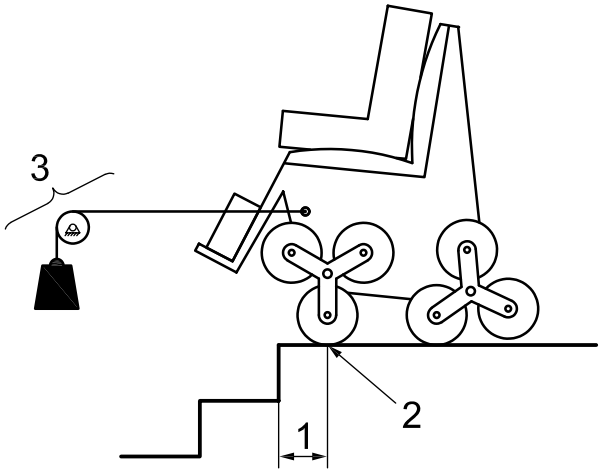
s) Identify and record the lowest evaluated score from all tests in a) to r).



Key

1 starting distance of (100 ± 10) mm
2 most forward contact point
3 acceleration rig (example)

Figure 21 — Step transition safety test of a manually stabilized stair-climbing device



Key

1 starting distance of (100 ± 10) mm
2 most forward contact point
3 acceleration rig (example)

Figure 22 — Step transition safety test of self-standing stair-climbing devices

14.4 Evaluation of results

The results of the step transition safety test shall be evaluated in accordance with Table 4.

Table 4 — Scoring system for quantifying the results of the step transition safety test

Observed response		Score
No movement	The behaviour of the stair-climbing device is in accordance with the manufacturer's instructions for use without the occurrence of any hazardous situation. AND The stair-climbing device does not move forward and does not tilt.	5
Stops before step nosing	The behaviour of the stair-climbing device is in accordance with the manufacturer's instructions for use without the occurrence of any hazardous situation. AND The stair-climbing device comes to rest on the upper landing before crossing the step nosing. AND The stair-climbing device does not tilt by more than 3° due to the lifting of an actuator from the test surface without recovering immediately. AND No part of the stair-climbing device not originally in contact with the test surface makes contact with it.	4
One safe step	The behaviour of the stair-climbing device is in accordance with the manufacturer's instructions for use without the occurrence of any hazardous situation. AND The stair-climbing device climbs down with its own climbing mechanism and comes to rest on the first step below the landing.	3
Under control	The stair-climbing device climbs down with its own climbing mechanism, does not stop and continues to climb down: — without exceeding the nominal test speed, and — without the occurrence of any hazardous situation. OR The stair-climbing device slides down without operation of its climbing mechanism, coming to rest on the first step below the landing without the occurrence of any hazardous situation.	2
Out of control	The stair-climbing device crosses the step nosing, does not stop and continues to move down, either: — exceeding the nominal test speed, or — with the occurrence of a hazardous situation.	1
Tip or incomplete	The stair-climbing device tips in any direction, coming to rest at least 10° from its original orientation. OR The test could not be completed.	0

14.5 Test report

In addition to the information specified in Clause 20, the test report shall include the following information:

a) a statement as to whether the stair-climbing device met the requirements in 5.7;

b) the configuration of the stair-climbing device during the tests;

c) the results of testing in accordance with 14.3;

d) the lowest score (see 14.3) evaluated in accordance with Table 4 (see 14.4);

e) any hazardous situation that occurred during the testing;

f) any of the manufacturer's instructions for use that were disregarded, with reasons why;

g) any particular tests that could not be carried out, with reasons why;

h) any other observations relevant to the test.

15 Static, impact and fatigue strength

15.1 Principle

The stair-climbing device is subjected to a series of tests of its static, impact and fatigue strengths and its performance is evaluated.

15.2 General

Depending on the construction of the stair-climbing device, it may not be possible to perform all tests in this clause, in which case the omission and reason(s) shall be noted in the test report.

Do not use the exaggerated test set-up.

Perform the strength tests in the following sequence:

a) static strength tests in accordance with ISO 7176-8;

b) additional static strength tests in accordance with 15.3;

c) impact strength tests in accordance with ISO 7176-8;

d) fatigue strength — driving, in accordance with ISO 7176-8 and the modifications as specified in Table 1;

e) fatigue strength — climbing, in accordance with 15.4;

f) parking brake fatigue tests in accordance with ISO 7176-3.

WARNING The tests can be hazardous. It is essential that appropriate precautions (e.g. restraints that will catch the stair-climbing device in case of falling) are taken to protect the test personnel.

15.3 Additional static strength tests

15.3.1 Static strength test for docking systems

This test applies only to stair-climbing wheelchair carriers.

Use the horizontal test plane.

Dock the stair-climbing device together with the test wheelchair in accordance with the manufacturer's instructions for use.

NOTE The test wheelchair may be docked to the stair-climbing device or vice versa.

Set the stair-climbing device to climbing mode and in the configuration for climbing stairs in accordance with the manufacturer's instructions for use.

Set the speed setting to zero.

If either the manufacturer's instructions for use of the stair-climbing device or the test wheelchair declare that the seat or back support of the test wheelchair can be tilted or that the test wheelchair can be placed in more

than one position or angle on the stair-climbing device (e.g. tilted to the forward or rearward inclination), select a position or angle that gives the minimum seat plane angle and/or back support angle.

Load the test wheelchair with the appropriate test dummy, as described in 7.8, but do not use a human test occupant.

Place the loaded stair-climbing device on the horizontal test plane in the position it would be in when on a landing prior to or following climbing in accordance with the manufacturer's instructions for use.

Set up a means for restraining the stair-climbing device from moving or tipping during the test. Fix the restraints to the stair-climbing wheelchair carrier as close as possible to but not at the docking points. Take care to prevent any additional loads that assist or oppose the test load described below.

Set up a means for applying a test load so that:

— the test force acts vertically downwards ± 10° (at initiation of the test);

— the test force acts on the upper surface of the seat construction (lap) of the dummy, at half width of the dummy (±25 mm) and (280 ± 25) mm in front of the hinges of the dummy when measured parallel to the seat construction of the dummy.

Slowly increase the load until a force, F, expressed in newtons (N) is applied, as given by the formula

$$F = 0{,}5 \times g \times \left(m_{\mathrm{D}} + m_{\mathrm{TW}} \right)$$

where:

g is the gravitational constant equal to 9,81 m/s^2;

m_{D} is the mass of the appropriate dummy, expressed in kilograms (kg);

m_{TW} is the mass of the test wheelchair, expressed in kilograms (kg).

If the manufacturer's instructions for use declare that the stair-climbing device is capable of withstanding a force that exceeds F, apply the force declared.

Maintain the load for a period of 5 s to 10 s and then remove the load.

Record any cracks, breaks or gross deformations and any components that needed to be tightened, adjusted or replaced.

15.3.2 Static strength test for assistant push handles

15.3.2.1 General

NOTE The tests in 15.3.2 are applicable to assistant-operated stair-climbing devices.

Load the stair-climbing device with the test wheelchair (where applicable) and the appropriate test dummy, as described in 7.8, but do not use a human test occupant. Set the speed setting to zero.

Apply loads to each push handle in turn. Do not test parts which are not part of the stair-climbing device (such as the handles, etc.) of the test wheelchair.

Record any cracks, breaks or gross deformations and any components that needed to be tightened, adjusted or replaced as a result of testing.

15.3.2.2 Upward forces

15.3.2.2.1 Self-standing stair-climbing devices

a) If the angle between the climbing mechanism and the body support system (of the stair-climbing device or the transported wheelchair) needs to be adapted manually when moving between driving surfaces and stairs, perform the tests with the body support system tilted to the rearward inclination.

b) Position the loaded stair-climbing device on the test plane.

c) Set the stair-climbing device to its rearward least stable configuration (see E.1.3).

d) If the position of the climbing mechanism can be adjusted by the operator, adjust it so that the ground contact points are in their most forward position.

e) Set up means to prevent the stair-climbing device from moving forwards or backwards.

f) Set up means to prevent any part of the stair-climbing device from being lifted above the test plane by more than 25 mm when the test force is applied.

g) Attach these restraints to the stair-climbing device in places that will not affect the results of the test (e.g. away from push handles).

h) Apply the test force:

— at the middle of the handgrip;

— vertically upwards $\pm$ 5°.

NOTE Figure 23 shows a recommended test arrangement.

i) Slowly increase the test force until the stair-climbing device just starts to lift from the test plane.

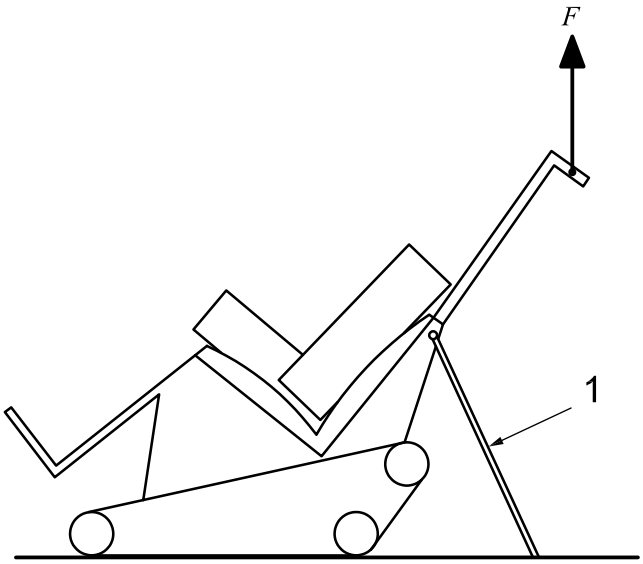
j) Measure and record the force as F_0.

k) Continue to increase the force until a value F is reached, where $F = (1{,}5 \pm 0{,}1) \times F_0$.

l) Maintain the force F for a period of between 5 and 10 s.

m) Remove the force.

n) Repeat h) to m) for each push handle (if applicable).



Key

1 restraints

F force

Figure 23 — Application of upward loads to handles of self-standing stair-climbing devices

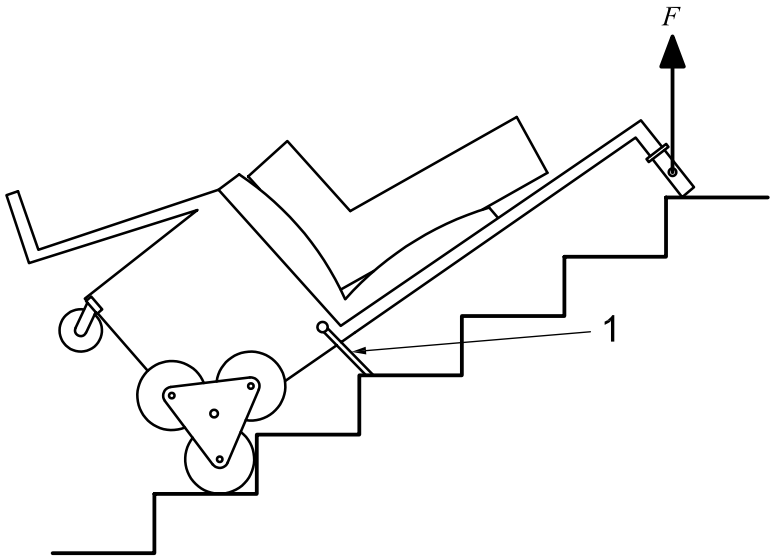
15.3.2.2.2 Manually stabilized stair-climbing devices

a) Position the loaded stair-climbing device on the straight test stairs in the configuration it would have when laid down rearward on the stairs should the assistant need to leave the stair-climbing device in an emergency, in accordance with the manufacturer's instructions for use.

NOTE 1 Under normal circumstances, the assistant should never leave the stair-climbing device unattended on stairs. However, in an emergency there could be the need to do so. It is important that push handles are capable of withstanding the loads generated in these situations.

NOTE 2 Figure 24 shows a recommended test arrangement.

b) Repeat 15.3.2.2.1 c) to n).



Key

1 restraints

F force

Figure 24 — Application of upward loads to handles of manually stabilized stair-climbing devices

15.3.2.3 Rearward forces

a) Place the loaded stair-climbing device on the horizontal test plane in its upright position.

b) Set the stair-climbing device to its forward least stable configuration (see E.1.2).

c) If the position of the climbing mechanism can be adjusted by the operator, adjust it so that the ground contact points are in their most rearward position.

d) Repeat 15.3.2.2.1 e) to g).

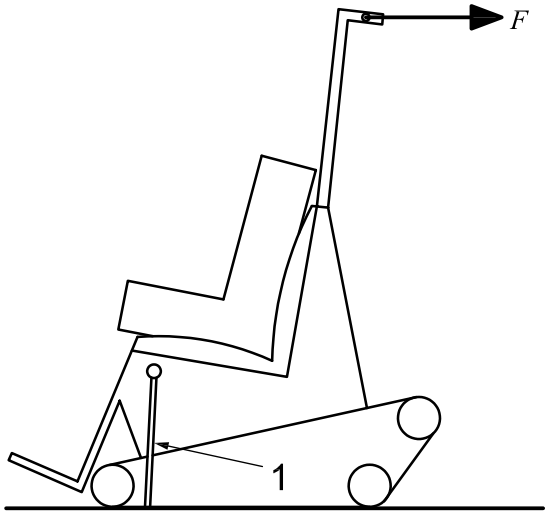
e) Apply the test force:

— at the middle of the handgrip;

— horizontally rearwards ± 5°.

f) Repeat 15.3.2.2.1 i) to n)

NOTE Figures 25 and 26 show recommended test arrangements for testing self-standing stair-climbing devices and for manually stabilized stair-climbing devices respectively.

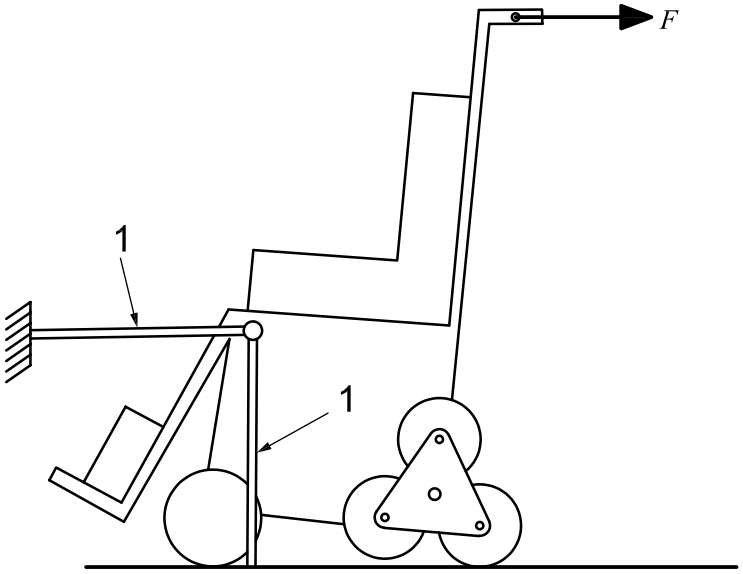


Key

1 restraints

F force

Figure 25 — Application of rearward loads to handles of self-standing stair-climbing devices



Key

1 restraints

F force

Figure 26 — Application of rearward loads to handles of manually stabilized stair-climbing devices

15.3.2.4 Lateral forces

a) Place the loaded stair-climbing device on the horizontal test plane in its upright position.

b) Set the stair-climbing device to its forward least stable configuration (see E.1.2).

c) Repeat 15.3.2.2.1 e) to g).

d) Apply the test force:

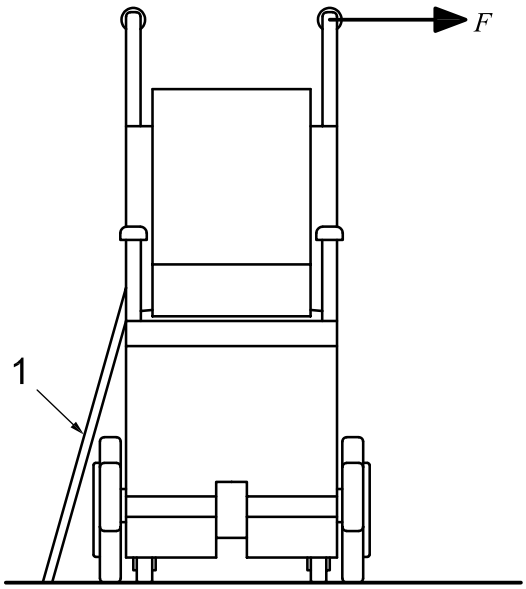
— in the middle of the handgrip;

— horizontally to the left ± 5°.

NOTE Figure 27 shows a recommended test arrangement.

e) Repeat 15.3.2.2.1 i) to n).

f) Repeat a) to e) with the test force applied to the right.



Key

1 restraints

F force

Figure 27 — Application of lateral loads to handles of stair-climbing devices

15.4 Fatigue strength — climbing

15.4.1 General

NOTE This test is applicable to all stair-climbing devices.

Load the stair-climbing device with the test wheelchair (where applicable) and the appropriate test dummy or a human test occupant, as described in 7.8.

If the manufacturer does not specify the climbing speed, perform the test at a speed as close as possible to 20 steps per minute.

15.4.2 Test arrangements

15.4.2.1 General

Perform the fatigue tests in a manner that will not cause overheating, as agreed between the test laboratory and the manufacturer of the stair-climbing device. If such agreement is not practicable, operate within the following limits.

Maximum climbing time before stopping to allow cooling: 10 min.

Maximum duty cycle: 15 %.

Perform the fatigue tests using one of the two alternative test arrangements: using stairs in a building (15.4.2.2) or using a test machine (15.4.2.3).

NOTE Climbing may be performed up and/or down stairs.

15.4.2.2 Test arrangement using building stairs

Set the stair-climbing device to climbing mode.

Operate the stair-climbing device to climb up and/or down stairs in accordance with the manufacturer's instructions for use.

The building stairs shall be straight and have a rise of (180 ± 5) mm. The overall pitch shall be (35 ± 5)°. The number of steps shall be sufficient to conduct the test and to allow each circulating, rotating or reciprocating part of the climbing mechanism to complete at least one operating cycle.

An auxiliary power source for the stair-climbing device may be used for this test or, alternatively, provision may be made to charge or replace the batteries during the test.

Periodically check the position of the test wheelchair (if used) and the test dummy or human test occupant and correct them if necessary.

Perform the test until the stair-climbing device fails or the required number of cycles specified in Table 2 is completed.

Record any cracks, breaks or gross deformations and components that needed to be tightened, adjusted or replaced.

15.4.2.3 Test arrangement using a test machine

Test the stair-climbing device using a test machine that reproduces the kinematics of operation during normal use and does not apply forces that are substantially different from those applied during normal use.

NOTE 1 The trajectory of the point of application of operating forces can undulate.

NOTE 2 An elastic link might be suitable to control operating forces.

NOTE 3 An example test machine is described in Annex F.

15.5 Test evaluation

After completing each test in 15.2 a) to f), examine the stair-climbing device to determine whether it meets the requirements of 5.8.

Check the test records to establish whether any parts were adjusted, tightened or replaced more than once.

Test all power-operated systems of the stair-climbing device to establish whether they operate in accordance with the manufacturer's instructions for use.

Test all attachable parts to establish whether they can be attached and detached in accordance with the manufacturer's instructions for use.

If any of the requirements of 5.8 is not met, the stair-climbing device fails the test.

15.6 Test report

In addition to the information specified in Clause 20, the test report shall include the following information:

a) a statement as to whether the stair-climbing device met the requirements in 5.8;

b) a statement as to whether the stair-climbing device met any claims made by the manufacturer exceeding the requirements in 5.8;

c) the configuration of the stair-climbing device during the tests;

d) a description of any failures identified by the test evaluation in 15.5 and the configuration of the stair-climbing device during the tests;

e) any hazardous situation that occurred during the testing;

f) any of the manufacturer's instructions for use that were disregarded, with reasons why;

g) any particular tests that could not be carried out, with reasons why;

h) any other observations relevant to the test.

16 Climatic tests

16.1 Principle

The climatic immunity of the stair-climbing device is evaluated by subjecting it to the climatic tests specified in ISO 7176-9 and then assessing its function by means of functional checks appropriate for stair-climbing devices.

16.2 Test methods

16.2.1 General

When exposing the stair-climbing device to the environmental test conditions, do not load the stair-climbing device with the test wheelchair, test dummy or human test occupant. Do not use the exaggerated test set-up. Set the speed setting to zero.

For the functional checks, load the stair-climbing device with the test wheelchair (where applicable) and the appropriate test dummy or a human test occupant, as described in 7.8.

Perform the functional checks before the stair-climbing device is subjected to the environmental test conditions and at the end of each particular test.

WARNING The tests can be hazardous. It is essential that appropriate precautions (e.g. restraints that will catch the stair-climbing device in case of falling) are taken to protect the test personnel.

16.2.2 Climatic test on driving surfaces

If the stair-climbing device has a crawling mode that is separate from climbing mode and driving mode, test the stair-climbing device in its crawling mode in accordance with ISO 7176-9.

16.2.3 Climatic test on stairs

NOTE The test is applicable to all stair-climbing devices.

Test the stair-climbing device in accordance with ISO 7176-9 with the following modifications and additions.

16.2.3.1 Exposure to test conditions

Expose the stair-climbing device to the environmental conditions as specified in ISO 7176-9.

During the exposure, switch the stair-climbing device off.

16.2.3.2 Functional check

Connect the straight test stairs to the upper landing and place them on the horizontal test plane.

Perform the functional check at nominal test speed (see 7.7.2).

Set the stair-climbing device to the operational mode for approaching and climbing stairs in accordance with the manufacturer's instructions for use.

Position the loaded stair-climbing device on the lower landing, not less than 200 mm in front of the first step.

Operate the stair-climbing device to crawl toward the stairs, climb up at least four steps, come to a full stop, then continue to climb up onto the upper landing, crawl at least a further 200 mm and stop.

Operate the stair-climbing device to crawl back to the stairs, climb down at least four steps, come to a full stop, then continue to climb down to the lower landing, crawl at least a further 200 mm and stop.

16.3 Test report

In addition to the information specified in Clause 20, the test report shall include the following information:

a) a statement as to whether the stair-climbing device met the requirements in 5.9;

b) the configuration of the stair-climbing device during the tests;

c) any functional changes in the stair-climbing device after testing;

d) any evidence of damage to the stair-climbing device after testing;

e) any hazardous situation that occurred during the testing;

f) any of the manufacturer's instructions for use that were disregarded, with reasons why;

g) any particular tests that could not be carried out, with reasons why;

h) any other observations relevant to the test.

17 Electromagnetic compatibility

17.1 Principle

The electromagnetic compatibility (EMC) of a stair-climbing device is evaluated by subjecting it to the electromagnetic compatibility tests given in ISO 7176-21, with certain modifications and additions, and observing its performance in relation to the requirements of ISO 7176-21.

17.2 Test method

17.2.1 General

NOTE These tests are applicable to all stair-climbing devices.

Do not use the exaggerated test set-up.

WARNING The tests can be hazardous. It is essential that appropriate precautions (e.g. restraints that will catch the stair-climbing device in case of falling) are taken to protect the test personnel.

17.2.2 EMC on driving surfaces and landings

Test the stair-climbing device in accordance with ISO 7176-21, with the stair-climbing device set in each electrically powered operational mode that is not a driving mode but is intended for operation on driving surfaces and/or landings. For the purpose of this test, the mechanism that propels the stair-climbing device is considered analogous to drive wheels in ISO 7176-21.

17.2.3 EMC on stairs

Test the stair-climbing device in accordance with ISO 7176-21 with the following modifications.

a) Set the stair-climbing device to climbing mode and configure it for stair climbing in accordance with the manufacturer's instructions for use.

b) Replace the definitions of the reference planes given in ISO 7176-21 with the definitions given in 3.19, 3.35 and 3.40.

c) Verify the functional requirement in accordance with the functional check as specified in 16.2.3.2 of this part of ISO 7176, rather than ISO 7176-9.

d) Construct a support system so that the stair-climbing device is supported as if on stairs that have a pitch of (30 ± 5)°.

NOTE 1 If it is not possible to support the stair-climbing device at its bottom, it may be suspended from above.

e) Replace the wheel speed monitor with a climbing mechanism speed monitor that:

1) is capable of monitoring the speed of each of the climbing mechanisms to an accuracy of 5 %;

2) is capable of calculating the average speed change, and the differential speed change if the climbing mechanisms can be driven differentially, from the measured speed of the climbing mechanisms, in accordance with the formulas in ISO 7176-21 for average wheel speed change and differential wheel speed change;

3) has a time constant not exceeding 0,1 s;

4) does not introduce any conductive path between the stair-climbing device and the ground plane;

5) does not perturb nor is susceptible to the electromagnetic fields measured or generated during the test.

f) Instead of equipping the stair-climbing device in accordance with ISO 7176-21:2009, 7.1, prepare it as specified in Clause 7 of this part of ISO 7176 but do not fit the test wheelchair and the test dummy. For the functional checks, load the stair-climbing device with the test wheelchair (where applicable) and the appropriate test dummy or a human test occupant, as described in 7.8. Fit non-spillable batteries if the stair-climbing device is to be tipped during testing.

NOTE 2 If it is not possible to operate the climbing mechanism while it is not in contact with the stairs, the climbing mechanism of the stair-climbing device may be supported on a support system (suitable for EMC tests) as if on stairs and tested in climbing mode while stationary. If the manufacturer's instructions for use specify a weight requirement in the body support system, load it with a mass that has minimum influence on the test results.

17.3 Test report

In addition to the information specified in Clause 20, the test report shall include the following information:

a) a statement as to whether the stair-climbing device met the requirements in 5.11;

b) the configuration of the stair-climbing device during the tests;

c) any hazardous situation that occurred during the testing;

d) any of the manufacturer's instructions for use that were disregarded, with reasons why;

e) any particular tests that could not be carried out, with reasons why;

f) any other observations relevant to the test.

18 Safe operation as the battery becomes depleted

18.1 General

Discharge the battery set by driving the stair-climbing device until it stops, or alternatively by connecting an external load adjusted to draw a current not exceeding the 5 h rate until the voltage of the battery set falls to the cut-off voltage specified for the 5 h rate. Charge the battery set with sufficient charge to complete at least one full ascent and descent as specified in 18.2.

EXAMPLE If charging the stair-climbing device for 5 min allows it to complete more than one full ascent and descent as specified in 18.2, this is sufficient charge.

18.2 Test method

Set the stair-climbing device to the operational mode for approaching and climbing stairs in accordance with the manufacturer's instructions for use.

Connect the straight test stairs to the upper landing and place them on the horizontal test plane.

Perform the functional check at nominal test speed (see 7.7.2).

Position the stair-climbing device in front of the test stairs.

Drive the stair-climbing device up the stairs and onto the upper landing.

Drive the stair-climbing device down the stairs and onto the lower landing.

Repeat driving up and down the stairs until the stair-climbing device is unable to move.

Switch off the stair-climbing device. Wait for three minutes and then switch it on again.

Repeat driving up and down the stairs until the stair-climbing device is unable to move after the waiting time.

Record whether any hazardous situation occurred.

18.3 Test report

In addition to the information specified in Clause 20, the test report shall include the following information:

a) a statement as to whether the stair-climbing device met the requirements in 5.12;

b) the configuration of the stair-climbing device during the tests;

c) any hazardous situation that occurred during the testing;

d) any of the manufacturer's instructions for use that were disregarded, with reasons why;

e) any particular tests that could not be carried out, with reasons why;

f) any other observations relevant to the test.

19 Safety equipment

19.1 Principle

The effectiveness of safety equipment fitted to the stair-climbing device is evaluated by subjecting the stair-climbing device to functional tests on test stairs and evaluating its performance.

19.2 Test methods

19.2.1 Emergency system

WARNING The tests can be hazardous. It is essential that appropriate precautions (e.g. restraints that will catch the stair-climbing device in case of falling) are taken to protect the test personnel.

NOTE This test is applicable to all stair-climbing devices.

Confirm that the manufacturer's instructions for use include instructions for using the emergency system, and that they specify at least two separate operator actions for its deactivation.

Connect the straight test stairs to the upper landing and position them on the horizontal test plane.

Load the stair-climbing device with the test wheelchair (where applicable) and the test dummy or a human test occupant, as described in 7.8. Do not use the exaggerated test set-up.

Set the stair-climbing device to climbing mode.

Position the stair-climbing device on the upper landing and set it into its rearward least stable configuration (see E.1.3).

NOTE 1 When the stair-climbing device is in its rearward least stable configuration, it is in a more stable configuration for testing in the forward direction.

Operate the stair-climbing device to climb down the stairs at nominal test speed, as described in 7.7.2.

Activate the emergency system when the climbing mechanism comes into contact with step 4. Observe whether the stair-climbing device stops.

If the stair-climbing device does not stop, terminate the test and record the results and observations from the test.

If the stair-climbing device stops, attempt to operate it to climb both up and down the stairs under its own power after no operator actions, after any single operator action and after any combination of operator actions, excluding the combination of separate operator actions that the manufacturer's instructions for use specify are to be used to deactivate the emergency system (see 21.4 g). Observe whether the stair-climbing device remains in position.

If the stair-climbing device moves, terminate the test and record the results and observations from the test.

If the stair-climbing device does not move, switch off the stair-climbing device and wait for at least 10 seconds. Switch on again and attempt to operate the stair-climbing device to climb both up and down the stairs under its own power after any single operator action and after any combination of operator actions, excluding the combination of separate operator actions that the manufacturer's instructions for use specify are to be used to deactivate the emergency system (see 21.4 g). Observe whether the stair-climbing device remains in its position.

If the stair-climbing device moves, terminate the test and record the results and observations from the test.

If the stair-climbing device does not move, deactivate the emergency system in accordance with the manufacturer's instructions for use. Then operate the stair-climbing device to climb both up and down at least three steps. Observe any abnormal behaviour of the stair-climbing device.

Repeat these tests after setting the stair-climbing device into its forward least stable configuration (see E.1.2) and operate the stair-climbing device to climb up the stairs after a start from the lower landing.

NOTE 2 When the stair-climbing device is in its forward least stable configuration, it is in a more stable configuration for testing in the rearward direction.

19.2.2 Climbing mode exit restriction

WARNING The tests can be hazardous. It is essential that appropriate precautions (e.g. restraints that will catch the stair-climbing device in case of falling) are taken to protect the test personnel.

NOTE This test is applicable to stair-climbing devices that have operational modes in addition to a climbing mode, unless it is declared in the manufacturer's instructions for use that exiting the climbing mode or changing to an operational mode other than climbing mode while on stairs is intended or permitted.

Connect the straight test stairs to the upper landing and position them on the horizontal test plane. Do not use the exaggerated test set-up.

Load the stair-climbing device with the test wheelchair (where applicable) and the appropriate test dummy or a human test occupant, as described in 7.8.

Set the stair-climbing device to climbing mode and configure it for climbing stairs in accordance with the manufacturer's instructions for use.

Perform the test at nominal test speed, as described in 7.7.2, as follows.

a) Place the stair-climbing device on the upper landing, operate it to climb down the straight test stairs to step 4 and stop. Attempt to exit the climbing mode. If it is possible to exit the climbing mode, attempt to operate the stair-climbing device to climb both up and down the stairs in any operational mode other than climbing mode.

b) Repeat a) but, after the stair-climbing device has stopped on the stairs, attempt to directly enter an operational mode other than the climbing mode, without first exiting climbing mode. If it is possible to enter any operational mode other than the climbing mode, attempt to operate the stair-climbing device to climb both up and down the stairs in the new mode.

c) Repeat a) but, after the stair-climbing device has stopped on the stairs, activate the emergency system. Deactivate the emergency system and attempt to enter any operational mode other than climbing mode. If it is possible to enter any operational mode other than the climbing mode, attempt to operate the stair-climbing device to climb both up and down the stairs in the new mode.

d) Repeat a) but, after the stair-climbing device has stopped on the stairs, switch off the stair-climbing device. Wait for at least 10 s and switch on again. If the stair-climbing device is no longer in climbing mode, or if it is possible to enter any operational mode other than the climbing mode, attempt to operate the stair-climbing device to climb both up and down the stairs in the new mode.

e) Repeat a), but continue operating the stair-climbing device to climb down the straight test stairs without stopping at step 4. When the stair-climbing device reaches step 4, while maintaining the nominal test speed command of the control device, attempt to exit the climbing mode. If it is possible to exit the stair-climbing mode, attempt to operate the stair-climbing device to climb both up and down the stairs in any operational mode other than climbing mode.

f) Repeat a), but continue operating the stair-climbing device to climb down the straight test stairs without stopping at step 4. When the stair-climbing device reaches step 4, while maintaining the nominal test speed command of the control device, attempt to directly enter an operational mode other than the climbing mode, without first exiting climbing mode. If it is possible to enter any operational mode other than the climbing mode, attempt to operate the stair-climbing device to climb both up and down the stairs in the new mode.

g) If the emergency system can be activated by the occupant while being transported in the stair-climbing device or by the assistant while operating the stair-climbing device, repeat a) but continue operating the stair-climbing device to climb down the straight test stairs without stopping at step 4. When the stair-climbing device reaches step 4, while maintaining the nominal test speed command of the control device, activate the emergency system. Attempt to operate the stair-climbing device to climb both up and down the stairs in any operational mode. Deactivate the emergency system and attempt to enter any operational mode other than climbing mode. Attempt to operate the stair-climbing device to climb both up and down the stairs in any operational mode other than climbing mode.

h) Repeat a), but continue operating the stair-climbing device to climb down the straight test stairs without stopping at step 4. When the stair-climbing device reaches step 4, while maintaining the nominal test speed command of the control device, switch off the stair-climbing device. Wait for at least 10 s and switch on again. Attempt to operate the stair-climbing device to climb both up and down the stairs in any operational mode other than climbing mode.

i) Repeat a) to h) but operating the stair-climbing device to climb up the straight test stairs after starting from the lower landing.

19.3 Test report

In addition to the information specified in Clause 20, the test report shall include the following information:

a) a statement as to whether the stair-climbing device met the requirements in 5.13;

b) the configuration of the stair-climbing device during the tests;

c) the results from each test;

d) any hazardous situation that occurred during the testing;

e) any of the manufacturer's instructions for use that were disregarded, with reasons why;

f) any particular tests that could not be carried out, with reasons why;

g) any other observations relevant to the test.

20 Test report

In addition to the specific data recorded in each test (Clauses 4, 9 to 19, Annexes H to J) the test report shall contain the following information:

a) a statement that the tests have been carried out in accordance with ISO 7176-28;

b) the name and address of the testing institution;

c) the name and address of the manufacturer of the stair-climbing device;

d) the date of issue of the test report;

e) the type of the stair-climbing device and any serial and batch numbers (including its classification in accordance with Annex A);

f) the classification of the stair-climbing device as specified in ISO 7176-21;

g) the effective seat width of the stair-climbing device used for the tests (see 7.3);

h) the equipment and adjustments of the stair-climbing device under test (see 7.2 and 7.3);

i) the brand name, model and mass of the test wheelchair (if used);

j) the mass of the test dummy or, if a human test occupant is used, the mass of the human test occupant with any additional weights;

k) details of the preparation of the stair-climbing device as specified in Clause 7, including equipment and adjustments and any deviation from the instructions therein, with reasons why;

l) the nominal capacity, the manufacturer's name, and the product name, code or other type of identification of the batteries fitted to the stair-climbing device during the test;

m) the test conditions (see Clause 8);

n) a photograph of the stair-climbing device under test.

21 Labelling and documentation

21.1 General

The manufacturer's documentation and labelling shall conform to the requirements in ISO 7176-15.

21.2 Labels

The stair-climbing device shall have permanent and easily visible labels. The labels shall include the following:

a) the maximum rated load, expressed in kilograms, as follows:

   — for stair-climbing chairs, the maximum occupant mass;

   — for stair-climbing wheelchair carriers, the maximum total load mass (mass of transported wheelchair plus occupant mass);

b) a statement to the effect that before using the stair-climbing device, it is essential that the operator is trained by a qualified instructor.

21.3 Specification sheets

The manufacturer's specification sheets shall provide the following information:

a) the model name of the stair-climbing device, including its classification as specified in Annex A;

b) a statement of conformity to this part of ISO 7176 based on the intended use of the product disclosed in the manufacturer's instructions for use and other manufacturer's documentation;

c) the overall length, overall width, pivot width (if applicable) and the reversing width (if applicable) obtained from ISO 7176-5 (see Clause 4);

d) the minimum stair width for straight stairs (see Annex J);

e) the minimum landing length and width for U-shaped stairs (see Annex J);

f) the minimum outer stair radius on winding stairs, if applicable (see Annex J);

g) the minimum inner stair radius on winding stairs, if applicable (see Annex J);

h) the total mass of the empty stair-climbing device, expressed in kilograms;

i) the mass of the heaviest part of the stair-climbing device, when it is taken apart without the use of tools for the purpose of transportation or stowage, expressed in kilograms;

j) for stair-climbing wheelchair carriers, the recommended wheelchair type(s) or model(s) intended to be carried;

k) the maximum rated load, expressed in kilograms, as follows:

   — for stair-climbing chairs, the maximum occupant mass,

   — for stair-climbing wheelchair carriers, the maximum total load mass (mass of transported wheelchair plus occupant mass);

l) a statement as to whether the stair-climbing device is intended for use on winding stairs;

m) the maximum pitch of the stairs, expressed in degrees, that can be negotiated safely;

n) any limitations on the permissible dimensions of rise and/or going of stairs and any limitations on stair surfaces e.g. deep pile carpets;

o) the maximum permissible slope of upper and lower landings;

p) the maximum speed for climbing on stairs, expressed in steps per minute, for ascending and descending respectively, as determined in accordance with Annex H;

q) where applicable, the maximum speed for driving on driving surfaces, expressed in metres per second, as determined in accordance with ISO 7176-6 (see Clause 4);

r) the theoretical number of steps up and steps down that the stair-climbing device is capable of climbing with one battery charge, as determined in accordance with Annex I;

s) the theoretical distance range of the stair-climbing device on driving surfaces, as determined in accordance with ISO 7176-4 (see Clause 4);

t) the greatest of the direct operating forces measured as specified in 13.3.1.5 or 13.4.1 as applicable for the type of stair-climbing device, expressed in newtons.

Where applicable, in addition manufacturers shall disclose in their specification sheet, in the manner and sequence specified in ISO 7176-15, the information obtained from tests in driving mode (see 4.1), and any other operational mode (see 4.2).

21.4 Instructions for use

The instructions for use shall provide the information contained in 20.3 and the following:

a) the serial and batch numbers of the individual stair-climbing device;

b) an instruction that it is essential that the operator is trained by a qualified instructor before using the stair-climbing device;

c) a statement to the effect that the use of a stair-climbing device can entail a higher degree of risk and require greater ability of the operator than using a wheelchair;

d) a warning that any use of the stair-climbing device is dangerous if the operator is not aware of, or does not follow, the manufacturer's instructions for use;

e) a statement to the effect that stability tests have been performed using test dummies and (where applicable) standard test wheelchairs, and stability performance might vary in real life situations;

f) if the stair-climbing device is intended to be dismantled for ease of carrying, and components with a mass greater than 10 kg are not provided with suitable handling devices, the instructions for use shall indicate the points where the components can be lifted safely and/or give a method for handling during assembly;

g) an explanation for the use of the emergency system and the set of at least two separate operator actions needed for its deactivation;

h) a description of the operation of user accessible control features, and the safety implications of altering their settings;

i) instructions necessary for maintenance and repair;

j) instructions for installation, charging and replacement of the battery;

k) the battery type, nominal voltage and rated capacity;

l) if the stair-climbing device is equipped with an anterior trunk support, an instruction to use the anterior trunk support (see Annex C);

m) if the stair-climbing device is available with a head support and the back support angle is more than 25° when the stair-climbing device is in use, an instruction to use the a head support.

Annex A
(normative)

Types of stair-climbing devices with typical representations

Table A.1 shows the system that is used to classify stair-climbing devices. A stair-climbing device may fall into one or more classes.

Table A.1 — Classification of stair-climbing devices

Assistant-operated stair-climbing device				**Occupant-operated stair-climbing device**			
Self-standing		Manually stabilized		Self-standing		Manually stabilized	
Stair-climbing chair	Stair-climbing wheelchair carrier	Stair-climbing chair	Stair-climbing wheelchair carrier	Stair-climbing chair	Stair-climbing wheelchair carrier	Stair-climbing chair	Stair-climbing wheelchair carrier
Type A	Type B	Type C	Type D	Type E	Type F	Type G	Type H
See Figure A.1	See Figure A.2	See Figure A.3	See Figure A.4	See Figure A.5	See Figure A.6	See Figure A.7	At present no known specimen

An important issue when describing a stair-climbing device is whether it is capable of climbing straight stairs only or both straight stairs and winding stairs.

Another important issue is whether or not a driving mode is incorporated (at the time of publication, some models of stair-climbing devices of types A, C, E and G have a driving mode).

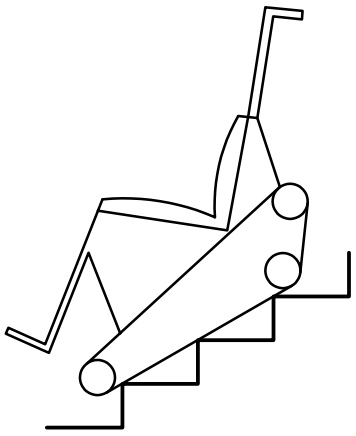


Figure A.1 — Representation of a typical assistant-operated, self-standing stair-climbing chair (Type A)

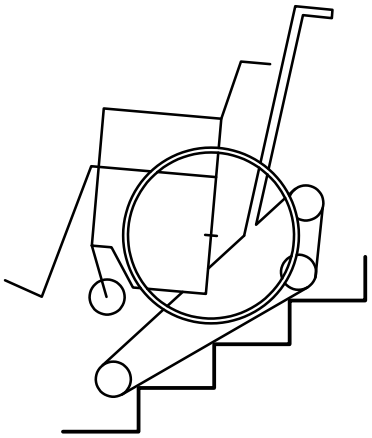


Figure A.2 — Representation of a typical assistant-operated, self-standing stair-climbing wheelchair carrier (Type B)

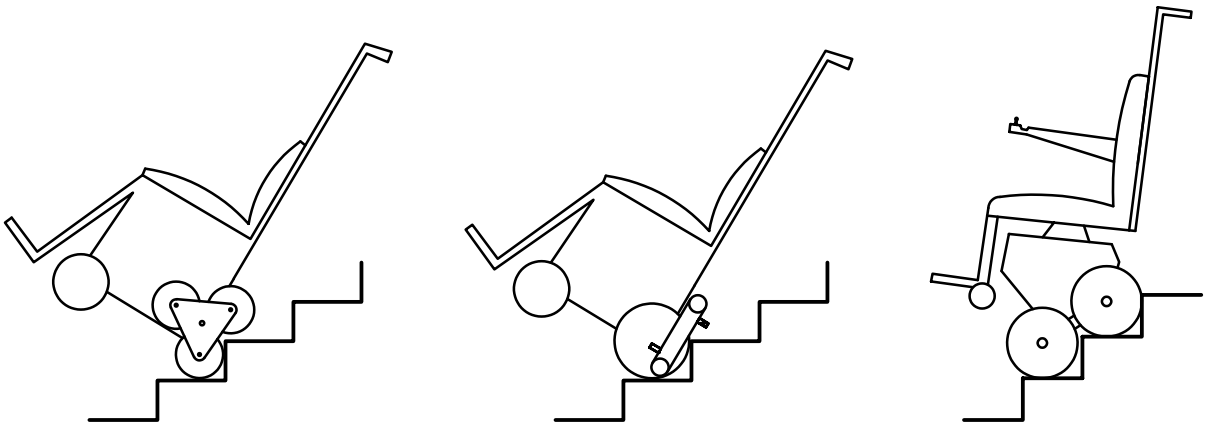


Figure A.3 — Representations of typical assistant-operated, manually stabilized stair-climbing chairs (Type C)

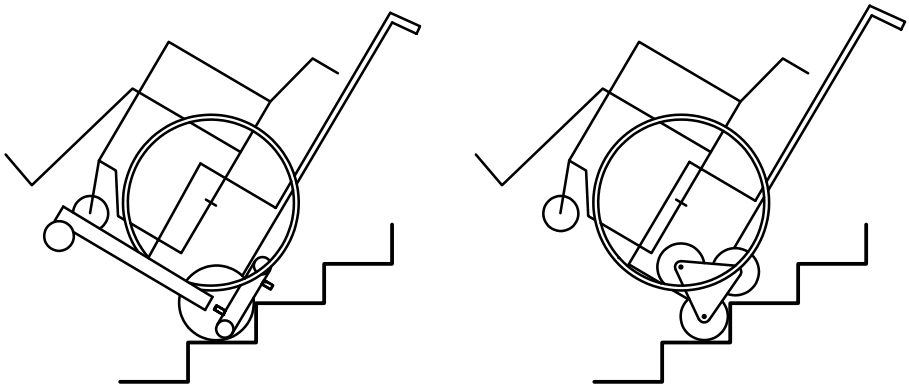


Figure A.4 — Representations of typical assistant-operated, manually stabilized stair-climbing wheelchair carriers (Type D)

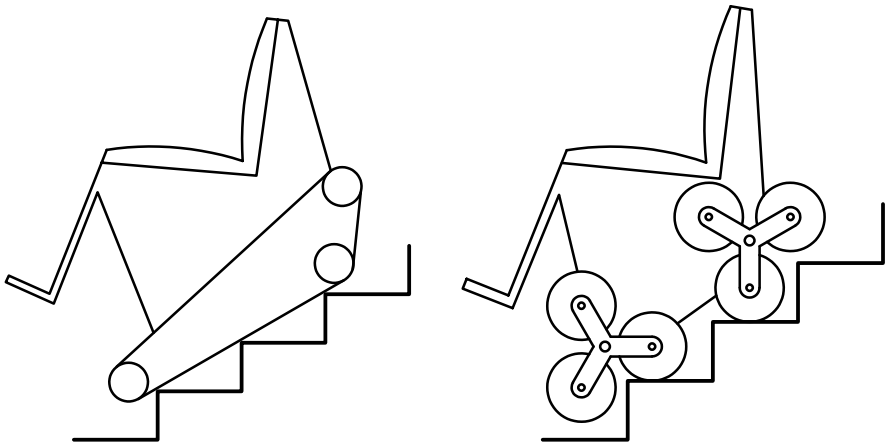


Figure A.5 — Representations of typical occupant-operated, self-standing stair-climbing chairs (Type E)

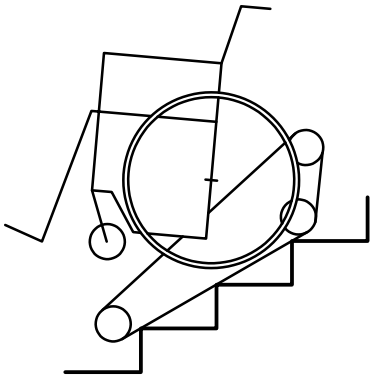


Figure A.6 — Representation of a typical occupant-operated, self-standing stair-climbing wheelchair carrier (Type F)

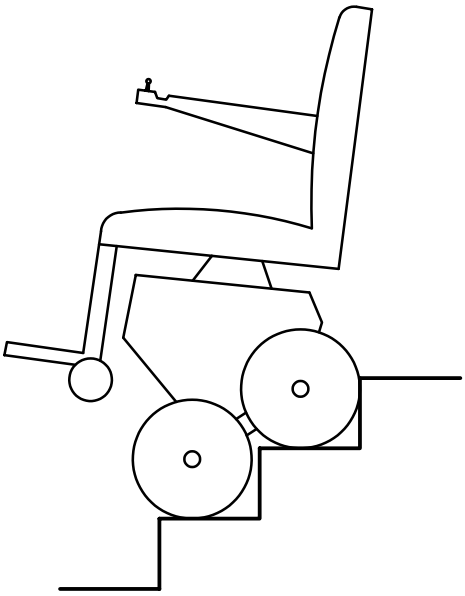


Figure A.7 — Representation of a typical occupant-operated, manually stabilized stair-climbing chair (Type G)

Annex B
(normative)

Space of easy reach of the operator

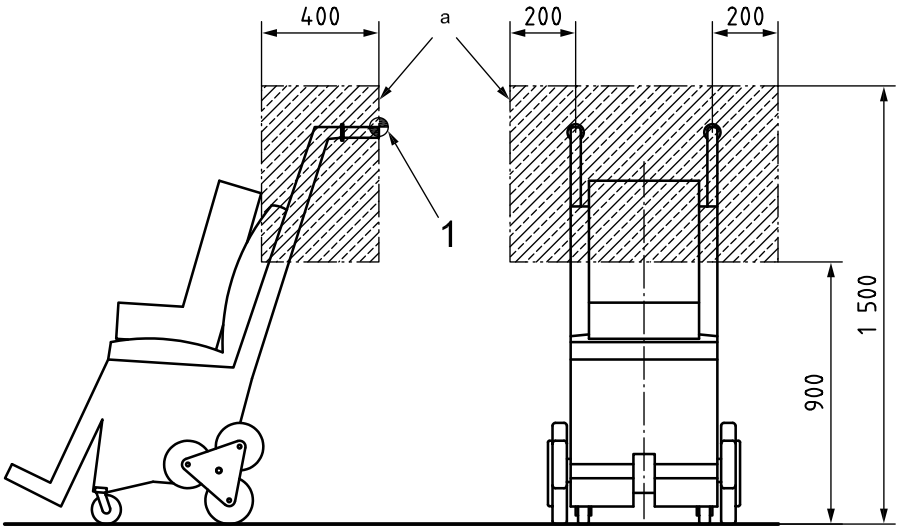
The means for operation should be within easy reach of the operator, in accordance with the following limits:

— for an assistant on driving surfaces, as shown in Figure B.1;

— for an assistant on stairs, as shown in Figure B.2;

— for an operating occupant, as shown in Figure B.3.

Dimensions in millimetres



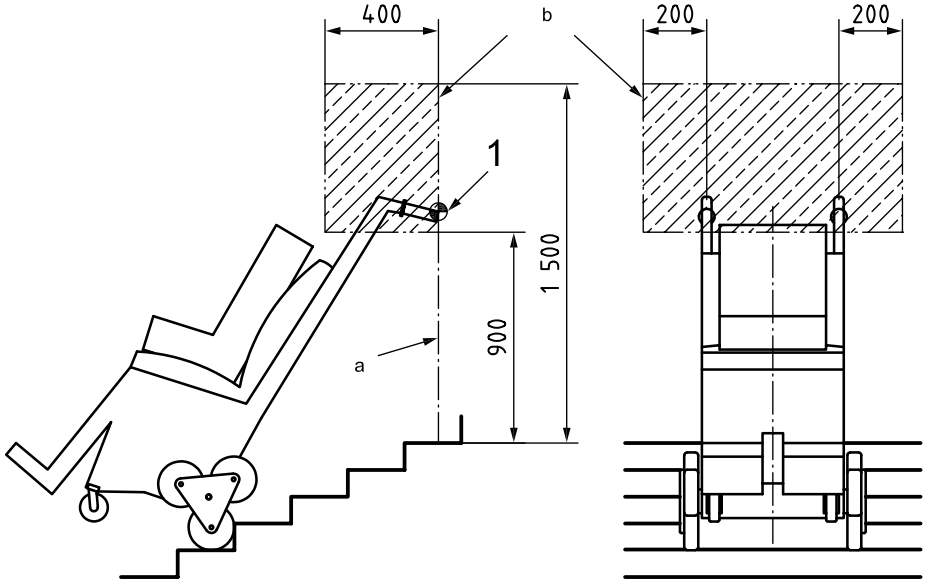
Key

1 rearmost upper point of push handle

[a] Space of reach of an assistant, on driving surfaces.

Figure B.1 — Space of reach of an assistant, on driving surfaces

Dimensions in millimetres



Key

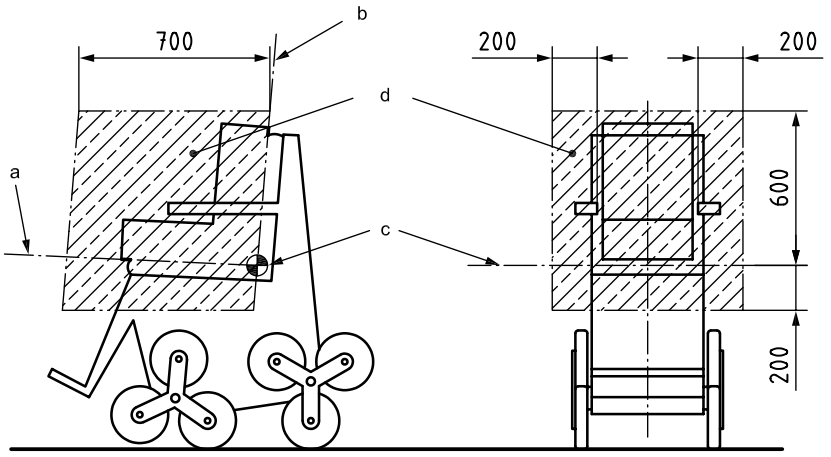
1 rearmost upper point of push handle

a Vertical.

b Space of reach of an assistant, on stairs.

Figure B.2 — Space of reach of an assistant, on stairs

Dimensions in millimetres



Key

a Seat reference plane.

b Back support reference plane.

c Line of intersection between seat reference plane and back support reference plane.

d Space of reach of an operating occupant.

Figure B.3 — Space of reach of an operating occupant

Annex C
(normative)

Recommended safety equipment

C.1 General

Manufacturers of stair-climbing devices should incorporate appropriate safety equipment into stair-climbing devices. This annex gives recommendations for the most common types of safety equipment for stair-climbing devices and their functions and features.

C.2 Anterior trunk support

The stair-climbing device should be equipped with an anterior trunk support capable of restricting excessive movement of the occupant during stair-climbing.

NOTE The anterior trunk support need not be a crash restraint for use, for example, in motor vehicles.

C.3 Head support

If the back support angle is more than 25° when the stair-climbing device is in use, the stair-climbing device should have provision to attach a head support.

Where the stair-climbing device has provision to attach a head support, compatible head supports appropriate for the body sizes of various occupants should be available from the manufacturer. The “head support height above seat” dimension (see ISO 7176-7) should cover the range 600 mm to 860 mm for adult stair-climbing devices and the range 420 mm to 760 mm for paediatric stair-climbing devices.

C.4 Stair indicator

The stair-climbing device should be provided with a stair indicator.

The stair indicator may either be a device fixed to the stair-climbing device or a hand-held accessory that is used by the operator when approaching stairs with unknown pitch and/or unusual step dimensions.

Annex D
(normative)

Surrogate wheelchair

The surrogate wheelchair is used only if the manufacturer's instructions for use do not specify a particular type or model of wheelchair for use with the stair-climbing device.

The overall dimensions of the surrogate wheelchair are determined in accordance with ISO 7176-5; the seat and wheel dimensions in this annex are named and measured as specified in ISO 7176-7.

The surrogate wheelchair[2)] shall:

a) be a durable four-wheel, handrim propelled, rear-wheel driven wheelchair;

b) have a total mass of 15 kg ± 5 kg;

c) have a centre of mass located (450 ± 50) mm above the ground and (150 ± 50) mm in front of the rear axle;

d) have a frame which provides suitable docking or attachment points for the stair-climbing device;

e) have an overall width of (580 ± 40) mm;

f) have an overall length of (1120 ± 60) mm;

g) have an effective seat width of (450 ± 50) mm, an effective seat depth of (450 ± 50) mm and a seat plane angle of (4 ± 2)°;

h) have a seat surface height at the front edge of (520 ± 40) mm;

i) have a back support width of (430 ± 50) mm, a back support height of (420 ± 50) mm and a back support angle of (10 ± 2)°;

j) have a foot support-to-seat dimension of (450 ± 40) mm;

k) have a foot support length of (150 ± 40) mm;

l) have a foot support-to-leg angle of (90 ± 5)°;

m) have a leg-to-seat surface angle of (97 ± 5)°;

n) have arm support height of (200 ± 40) mm;

o) have a handrim diameter of (530 ± 40) mm;

p) have a manoeuvring wheel diameter of (610 ± 25) mm;

q) have a horizontal location of wheel axle of (20 ± 25) mm;

NOTE The horizontal location of wheel axle and the vertical location of wheel axle are defined in ISO 7176-7. These dimensions specify the position of the manoeuvring wheels with respect to the body support system.

r) have a vertical location of wheel axle of (184 ± 25) mm;

s) have a castor wheel diameter of (175 ± 75) mm.

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2) Meyra *Service 3.600*, Ortopedia *Universal 9083*, Otto Bock *Start Basic*, Sunrise Medical *Breezy 200* and Vermeiren *Standard 28TII* may be used as the surrogate wheelchair, provided the dimensions, mass and location of centre of mass are selected, set or adjusted in accordance with the specifications given in this annex. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named.

Annex E
(normative)

Least stable configuration and least stable position

E.1 Least stable configuration

E.1.1 General

Set the stair-climbing device to the least stable configuration for the direction in which the test is to be conducted, in accordance with the following instructions.

NOTE The forward least stable configuration can be used to provide a sideways least stable configuration.

E.1.2 Forward

Set adjustable parts, wheels and climbing mechanisms in the least stable configuration for forward stability in accordance with Table E.1.

Table E.1 — Adjustments for least forward stability

Adjustable component	Adjustment for least forward stability
Wheelchair (if used) docking position, fore-aft	Forward
Wheelchair (if used) docking position, tilting angle	Tilted to the forward inclination
Seat position, fore-aft	Forward
Seat position, vertical	High
Seat position, tilting angle	Tilted to the forward inclination
Back support position, fore-aft shift	Forward
Back support position, tilting angle	Tilted to the forward inclination
Elevating leg support	Up
Angle of recline	Recommended minimum

E.1.3 Rearward

Set adjustable parts, wheels and climbing mechanisms in the least stable configuration for rearward stability in accordance with Table E.2.

Table E.2 — Adjustments for least rearward stability

Adjustable component	Adjustment for least rearward stability
Wheelchair (if used) docking position, fore-aft	Rearward
Wheelchair (if used) docking position, tilting angle	Tilted to the rearward inclination
Seat position, fore-aft	Back
Seat position, vertical	High
Seat position, tilting angle	Tilted to the rearward inclination
Back support position, fore-aft shift	Back
Back support position, tilting angle	Tilted to the rearward inclination
Elevating leg support	Down
Angle of recline	Recommended maximum

E.2 Least stable position

E.2.1 General

Set the stair-climbing device to the least stable position in the direction required for the test to be conducted, in accordance with the following examples.

E.2.2 On driving surfaces — Forward

Figure E.1 shows examples of stair-climbing devices placed on the test surface in a manner likely to produce the forward least stable position. In these examples:

a) the centre of mass is as high as possible above the most forward contact point;

b) the centre of mass is as forward as possible while remaining behind the most forward contact point;

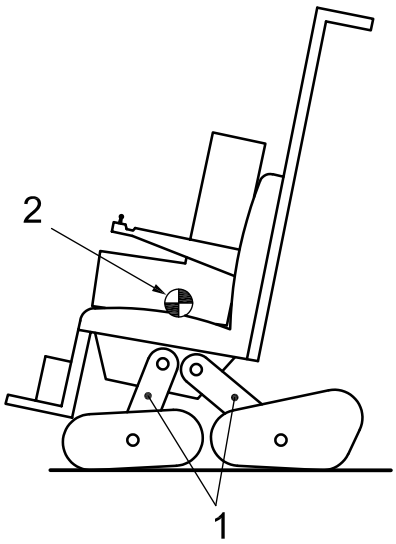
c) the climbing mechanism is arranged so that the most forward contact point is as rearward as possible with respect to the stair-climbing device while still allowing the stair-climbing device to tip forward $(3 \pm 1)°$;

NOTE 1 When the stair-climbing device is set into the least stable position, some parts of the climbing mechanism might be very close to the test surface but not in contact with it. For some tests it is important to observe whether or not these parts make contact with the test surface.

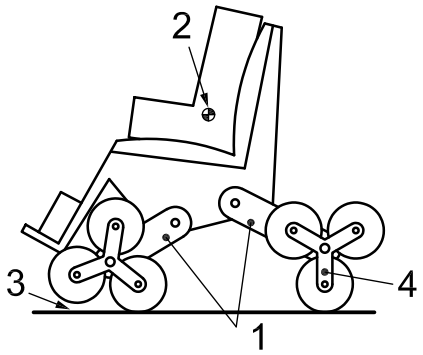
d) where a front wheel is a castor wheel or pivot wheel, it is swivelled to the rear;

e) the climbing mechanism is arranged so that the rearward end of the stair-climbing device is as high as possible.

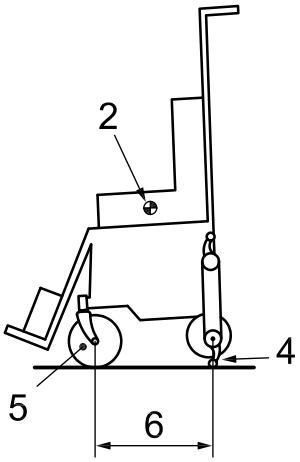
NOTE 2 Other practical details are shown in Figure E.1.



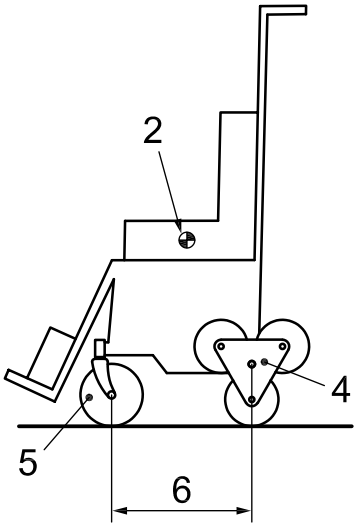
a) Tracks on arms



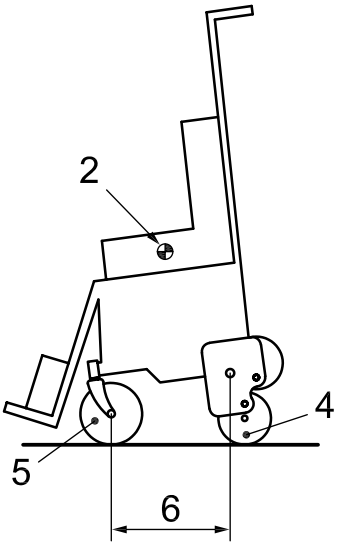
b) Clusters on arms



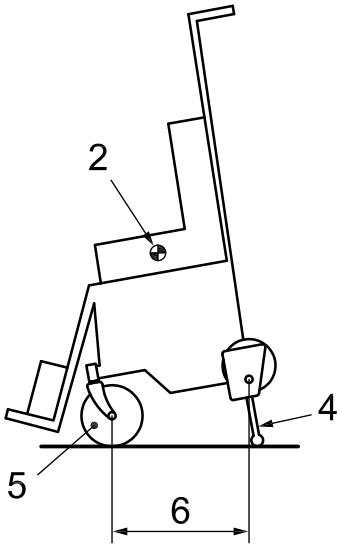
c) Finger drive



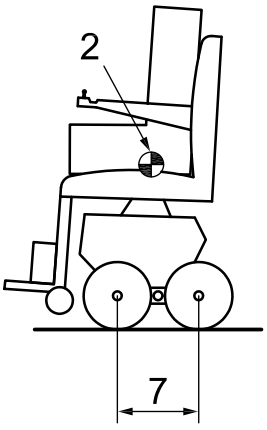
d) Rear cluster



e) Two-stroke climbing mechanism



f) Three-stroke climbing mechanism



g) Dynamically controlled stair-climbing device

Key

1 position and configuration of climbing mechanism adjusted, if possible, to ensure the most forward and upward position of the centre of mass
2 centre of mass
3 space between forward climbing mechanism and test surface, allowing the stair-climbing device to tip forward (3 ± 1)°
4 rearward climbing mechanism arranged so that the stair-climbing device is as high as possible
5 forward castor wheel or pivot wheel swivelled to the rear
6 distance between wheel and climbing mechanism adjusted, if possible, to ensure the most forward and upward position of the centre of mass
7 distance between the cams adjusted, if possible, to ensure the most forward and upward position of the centre of mass

Figure E.1 — Examples of forward least stable position on driving surfaces

E.2.3 On driving surfaces — Rearward

Figure E.2 shows examples of stair-climbing devices placed on the test surface in a manner likely to produce the rearward least stable position. In these examples:

a) the centre of mass is as high as possible above the most rearward contact point;

b) the centre of mass is as rearward as possible while remaining in front of the most rearward contact point;

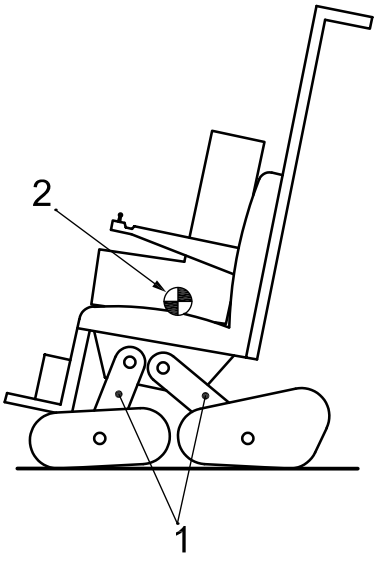
c) the climbing mechanism is arranged so that the most rearward contact point is as forward as possible with respect to the stair-climbing device while still allowing the stair-climbing device to tip rearward (3 ± 1)°;

NOTE 1 When the stair-climbing device is set into the least stable position, some parts of the climbing mechanism might be very close to the test surface but not in contact with it. For some tests it is important to observe whether or not these parts make contact with the test surface.

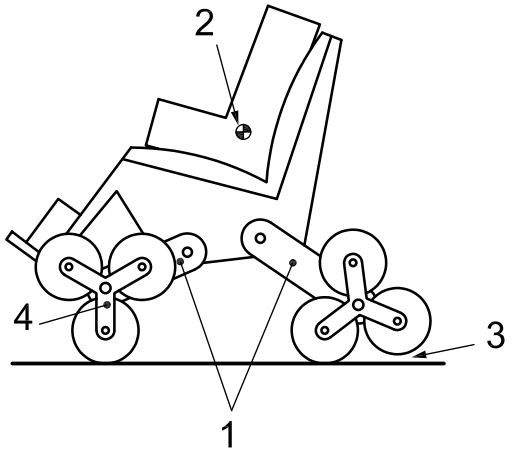
d) where a front wheel is a castor wheel or pivot wheel, it is swivelled to the rear;

e) the climbing mechanism is arranged so that the forward end of the stair-climbing device is as high as possible.

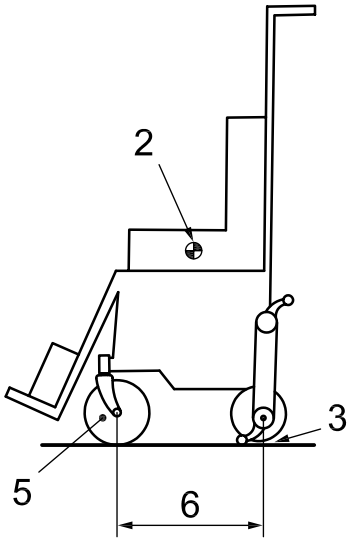
NOTE 2 Other practical details are shown in Figure E.2.



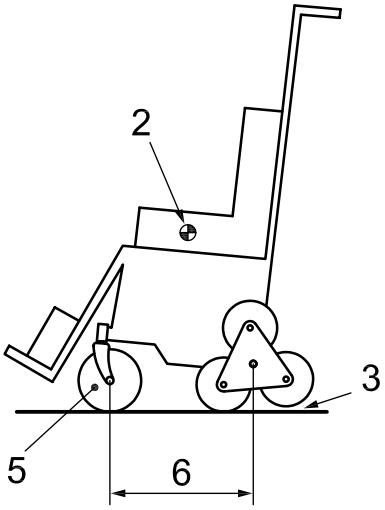
a) Tracks on arms



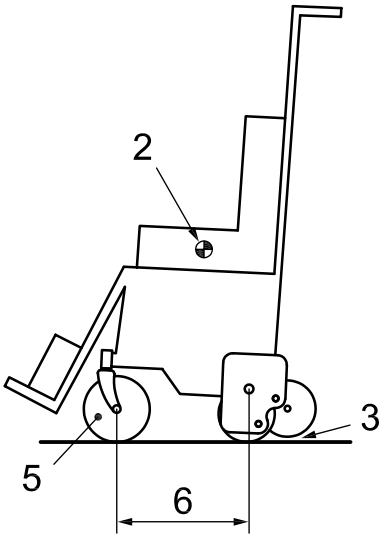
b) Clusters on arms



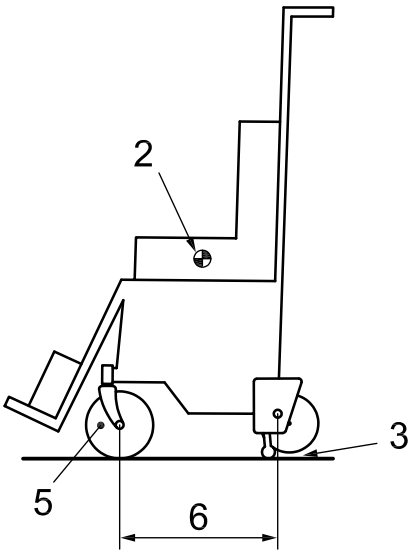
c) Finger drive



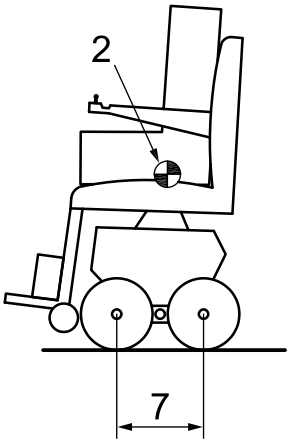
d) Rear cluster



e) Two-stroke climbing mechanism



f) Three-stroke climbing mechanism



g) Dynamically controlled stair-climbing device

Key

1 position and configuration of climbing mechanisms adjusted, if possible, to ensure the most rearward and upward position of the centre of mass
2 centre of mass
3 space between rearward climbing mechanism and test surface, allowing the stair-climbing device to tip rearward $(3 \pm 1)°$
4 forward climbing mechanism arranged so that the stair-climbing device is as high as possible
5 forward castor wheel or pivot wheel swivelled to the rear
6 distance between wheel and climbing mechanism adjusted, if possible, to ensure the most rearward and upward position of the centre of mass
7 distance between the cams adjusted, if possible, to ensure the most rearward and upward position of the centre of mass

Figure E.2 — Examples of rearward least stable position on driving surfaces

E.2.4 On stairs — Downward

Place the loaded stair-climbing device on the straight test stairs so that the lowermost point of the climbing mechanism intended to contact the stairs is in contact with the designated step.

If the stair-climbing device has a continuous climbing mechanism with teeth that contact the stairs (e.g. tracks) make sure that the nosing of the designated step lies within the gap between two teeth where the upper tooth is in contact with the tread.

NOTE 1 Usually some rocking, shaking, lifting or twisting of the stair-climbing device can help in positioning the teeth.

Figure E.3 shows examples of stair-climbing devices placed on the straight test stairs in a manner likely to produce the downward least stable position. In these examples:

a) the centre of mass is as high as possible above the most forward contact point;

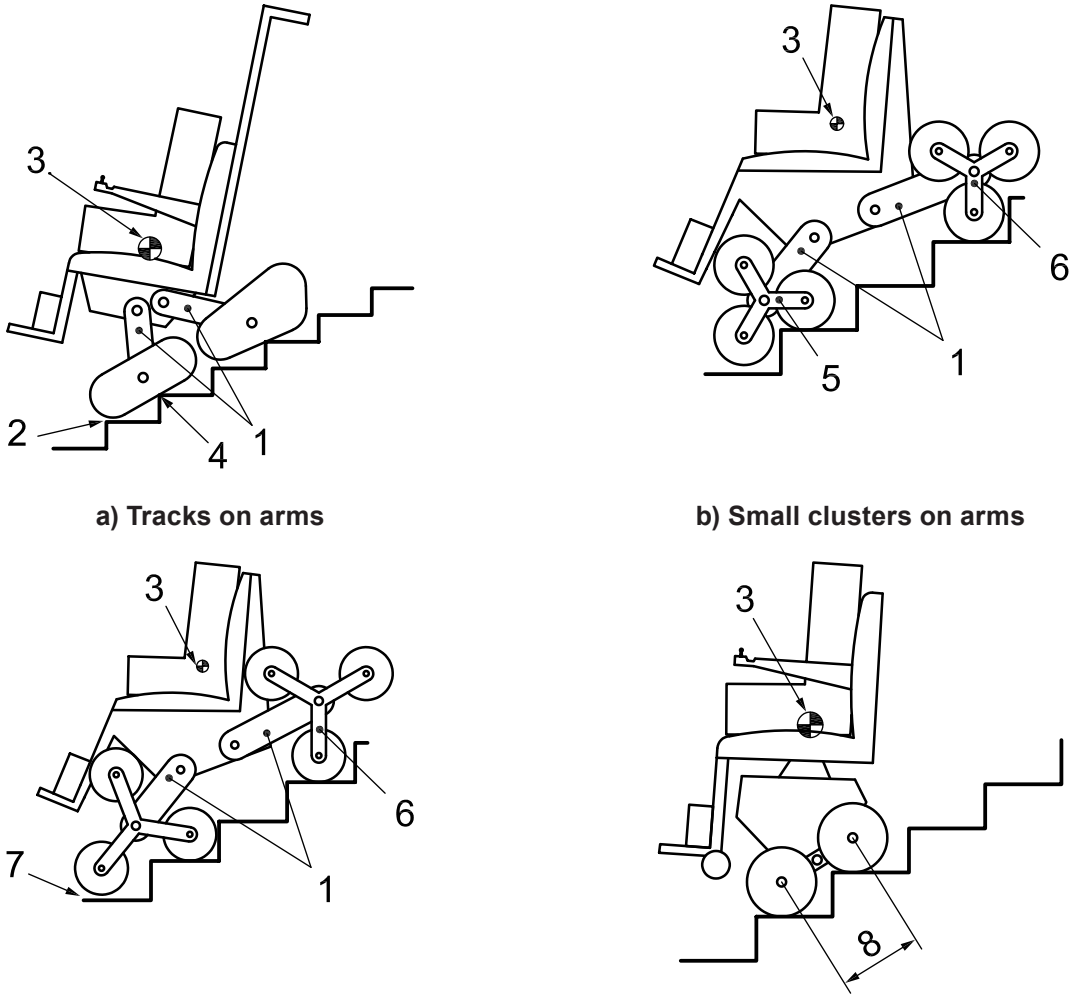
b) the centre of mass is as forward as possible while remaining behind the most forward contact point;

c) the climbing mechanism is arranged so that the most forward contact point is as rearward as possible with respect to the stair-climbing device while still allowing the stair-climbing device to tip downward $(3 \pm 1)°$;

NOTE 2 When the stair-climbing device is set into the least stable position, some parts of the climbing mechanism might be very close to the treads of some steps but not in contact with them. For some tests it is important to observe whether or not these parts make contact with those treads.

d) the climbing mechanism is arranged so that the rear end of the stair-climbing device is as high as possible.

NOTE 3 Other practical details are shown in Figure E.3.



a) Tracks on arms

b) Small clusters on arms

c) Large clusters on arms

d) Dynamically controlled stair-climbing device

Key

1 position and configuration of climbing mechanisms adjusted, if possible, to ensure the most forward and upward position of the centre of mass

2 space between forward climbing mechanism and step, allowing the stair-climbing device to tip downward (3 ± 1)°

3 centre of mass

4 most forward contact point

5 small forward cluster arranged so that the cam which contacts the step is as far as possible to the rear of the centre of the cluster

6 rear cluster arranged so that the stair-climbing device is as high as possible

7 space between large forward cluster and step, allowing the stair-climbing device to tip downward (3 ± 1)°

8 distance between the cams adjusted, if possible, to ensure the most forward and upward position of the centre of mass

Figure E.3 — Examples of downward least stable position on stairs

E.2.5 On stairs — Upward

Place the loaded stair-climbing device on the straight test stairs so that the lowermost point of the climbing mechanism intended to contact the stairs is in contact with the designated step.

If the stair-climbing device has a continuous climbing mechanism with teeth that contact the stairs (e.g. tracks) make sure that the nosing of the designated step lies within the gap between two teeth where the upper tooth is in contact with the tread.

NOTE 1 Usually some rocking, shaking, lifting or twisting of the stair-climbing device can help in positioning the teeth.

Figure E.4 shows examples of stair-climbing devices placed on the straight test stairs in a manner likely to produce the upward least stable position. In these examples:

a) the centre of mass is as high as possible above the most rearward contact point;

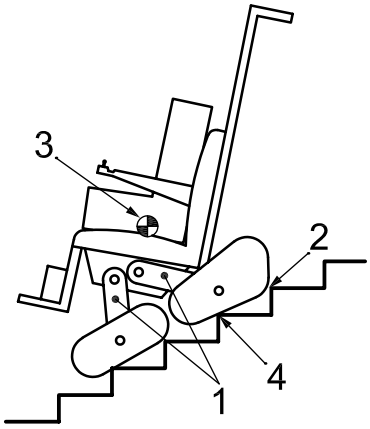
b) the centre of mass is as rearward as possible while remaining in front of the most rearward contact point;

c) the climbing mechanism is arranged so that the most rearward contact point is as forward as possible with respect to the stair-climbing device while still allowing the stair-climbing device to tip upward (3 ± 1)°;

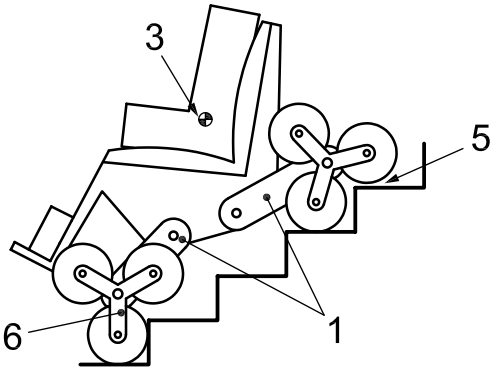
NOTE 2 When the stair-climbing device is set into the least stable position, some parts of the climbing mechanism might be very close to the treads of some steps but not in contact with them. For some tests it is important to observe whether or not these parts make contact with those treads.

d) the climbing mechanism is arranged so that the front end of the stair-climbing device is as high as possible.

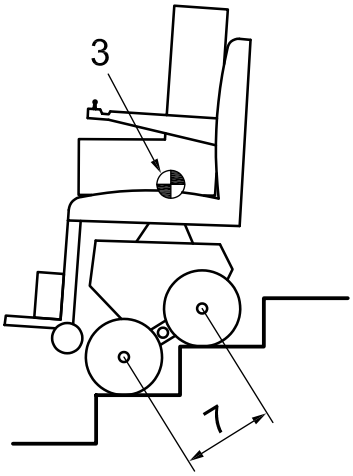
NOTE 3 Other practical details are shown in Figure E.4.



a) Tracks on arms



b) Clusters on arms



c) Dynamically controlled stair-climbing device

Key

1 position and configuration of climbing mechanisms adjusted, if possible, to ensure the most rearward and upward position of the centre of mass

2 space between rearward climbing mechanism and step, allowing the stair-climbing device to tip upward (3 ± 1)°

3 centre of mass

4 most rearward contact point

5 space between rearward cluster and step, allowing the stair-climbing device to tip upward (3 ± 1)°

6 forward cluster arranged so that the stair-climbing device is as high as possible

7 distance between the cams adjusted, if possible, to ensure the most rearward and upward position of the centre of mass

Figure E.4 — Examples of upward least stable position on stairs

Annex F
(informative)

Fatigue tests with test machine

F.1 Escalator test machine

The proposed test machine is similar to an escalator but is not equipped with a motor. It consists of the following:

a) a continuous belt of moving stairs, having at least five steps, lying on a flat plane inclined at (35 ± 5)° to the horizontal;

b) stair width at least 100 mm greater than the width of the stair-climbing device under test;

c) steps with going and rise appropriate for the climbing mechanism of the stair-climbing device;

NOTE 1 For most stair-climbing devices, a going and rise of (146 ± 20) mm is suitable.

d) step nosings with a radius of (4 ± 2) mm;

e) a structure supporting the moving stairs that is capable of bearing the weight of the loaded stair-climbing device while in operation;

f) provision to mount the stair-climbing device on the moving stairs and maintain it in the orientation for climbing in accordance with the manufacturer's instructions for use, without interfering with the action of the climbing mechanism;

NOTE 2 In order to achieve this, restraints are fixed to the frame of the stair-climbing device.

g) means of measuring the tension forces in longitudinal restraints in the range of 10 N to 400 N with an accuracy of 5 %;

h) restraints that restrict lateral movement of the stair-climbing device to ± 50 mm;

i) provision for the moving stairs to be set in motion by the weight of the loaded stair-climbing device and the action of the climbing mechanism;

j) provision for adjusting the resistance of the moving stairs so that the stair-climbing device, when being operated to climb up the stairs, is not moving substantially upwards or downwards relative to the ground while the stairs are in motion;

k) means of counting the number of steps climbed by the stair-climbing device.

F.2 Method

Position the stair-climbing device on the escalator test machine so that all parts of the climbing mechanism are on the straight flight of steps (see Figure F.1 and Figure F.2).

Set the stair-climbing device to climbing mode.

Restrain the stair-climbing device by longitudinal restraints and lateral restraints attached to the frame. If the stair-climbing device is manually stabilized, hold it in its normal working position by handle restraints.

NOTE 1 If necessary, non-structural covers that restrict access to an attachment point may be removed.

Arrange the longitudinal restraints so that they are parallel to the pitch line ± 10°, such that the stair-climbing device has free movement along the pitch line of (30 ± 5) mm.

If applicable, arrange handle restraints so that they are perpendicular to a line that connects the centre of the climbing mechanism with the handle, ± 15°, such that they do not interfere with climbing.

NOTE 2 The trajectory of the point of application of operating forces can undulate.

Ensure that restraints do not generate any forces that offset or twist the stair-climbing device.

Arrange the restraints so that it is not possible for the stair-climbing device to move laterally more than 50 mm.

Set the resistance of the moving stairs to substantially maintain the position of the stair-climbing device when the climbing mechanism is in operation, and so that the tension forces in the longitudinal restraints do not exceed 5 % of the total weight of the loaded stair-climbing device.

NOTE 3 Small variations of the speed of the moving stairs resulting from any complicated kinematics of the climbing mechanism can be disregarded.

NOTE 4 An auxiliary power source for the stair-climbing device may be used for this test or, alternatively, provision may be made to charge or replace the batteries during the test.

Identify the number of steps to be climbed.

If the stair-climbing device has a continuous climbing mechanism, and the distance between consecutive step nosings of the moving stairs is greater than 339 mm or less than 289 mm, adjust the number of steps to climb by multiplying by the compensation factor determined as specified in Annex G.

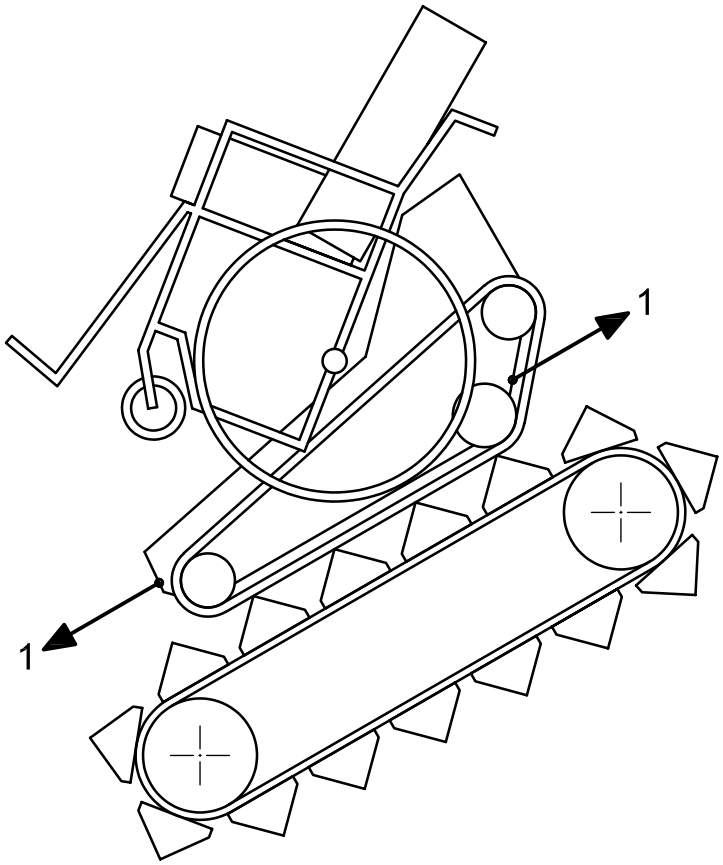
NOTE 5 The nominal distance between nosings of 314 mm corresponds to that of the straight test stairs.

Operate the stair-climbing device to climb in accordance with the manufacturer's instructions for use.

Periodically check the position of the test wheelchair (if used) and the test dummy or human test occupant and correct them if necessary.

Continue testing until the stair-climbing device has climbed the required number of steps or until it has failed.

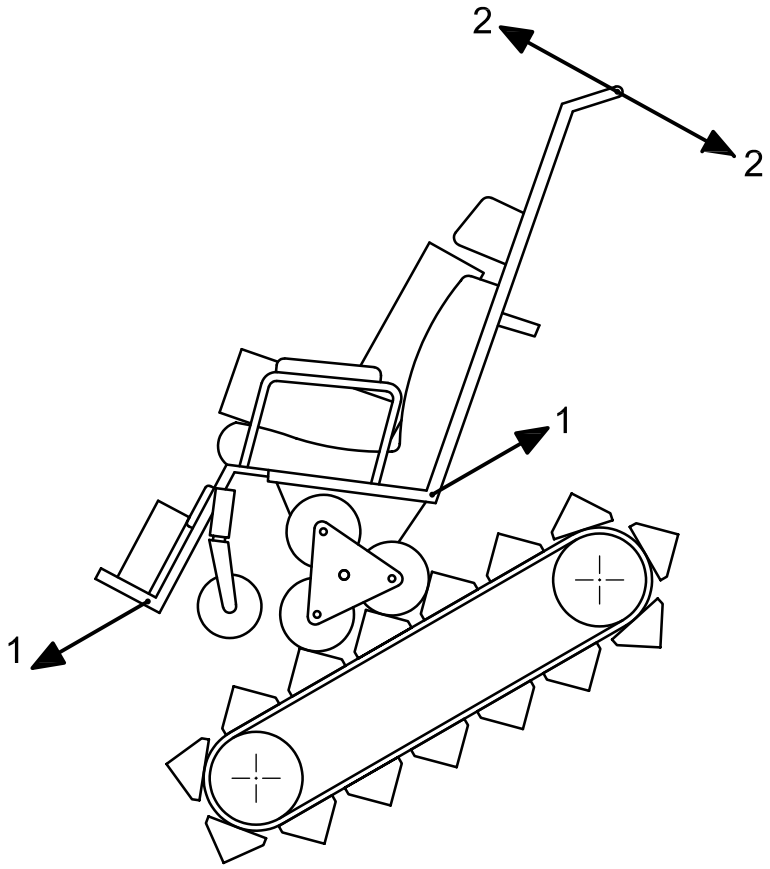
Record any cracks, breaks or gross deformations and components that needed to be tightened, adjusted or replaced.



Key

1 longitudinal restraints

Figure F.1 — Self-standing stair-climbing device on the escalator test machine



Key

1 longitudinal restraints

2 handle restraints

Figure F.2 — Manually stabilized stair-climbing device on the escalator test machine

Annex G
(informative)

Compensation factor

In order to gain comparable results, tests are performed on straight test stairs which have a pitch of 35° and a rise of 180 mm, and a nominal distance between nosings of consecutive steps of 314 mm.

For climbing fatigue strength testing, two alternative test arrangements are specified. In the first, the stair-climbing device is operated to climb up and down stairs. In the second, an escalator test machine is used (see 6.18 and Annex F).

In order for the escalator test machine to accommodate most known types of stair-climbing devices, it might be constructed with a nosing distance between consecutive steps which differs from that of the straight test stairs.

Stair-climbing devices with continuous climbing mechanisms (e.g. tracks) crawl steadily along the pitch line of the stairs. They work independent of rise and going and therefore the size of the steps is not important for their progress as long as the steps provide sufficient grip. The total time taken for climbing stairs is approximately proportional to the distance to climb along the pitch line.

Stair-climbing devices with stepwise climbing mechanisms (e.g. clusters) climb step by step. They work following the rule “one action per step”. The total time taken for climbing stairs is approximately proportional to the number of steps.

Hence, when the nosing distance of the escalator test machine differs significantly from that of the straight test stairs, the test results need to be corrected for stair-climbing devices with continuous climbing mechanisms but not for those with stepwise climbing mechanisms.

NOTE 1 It is considered necessary to correct for differences of 25 mm or more.

A compensation factor is introduced to provide comparability of test results for stair-climbing devices with different methods of climbing.

This compensation factor is given by the following formula:

$$f = \frac{S_T}{D}$$

where:

f is the compensation factor;

S_T is the distance between consecutive step nosings of the straight test stairs (equal to 314 mm);

D is the measured distance between consecutive step nosings of the escalator test machine.

NOTE 2 For purposes of investigation, the escalator test machine might be used for the determination of maximum speed (Annex H) or for the determination of energy consumption (Annex I), in which case the compensation factor ensures that results between stair-climbing devices with various climbing mechanisms are comparable.

Annex H
(normative)

Determination of maximum speed

H.1 Principle

The maximum speed of the stair-climbing device is determined by operating it on stairs and measuring the time taken to cover certain distances.

NOTE This test is used to verify the manufacturer's information concerning the maximum speed on straight test stairs and is an extension and adaptation of ISO 7176-6.

H.2 Test method

NOTE This test is applicable to all stair-climbing devices.

WARNING The tests can be hazardous. It is essential that appropriate precautions (e.g. restraints that will catch the stair-climbing device in case of falling) are taken to protect the test personnel.

Fully charge the battery set in accordance with the manufacturer's instructions for use.

Load the stair-climbing device with the test wheelchair (where applicable) and the appropriate test dummy or a human test occupant (see 7.8). Do not use the exaggerated test set-up.

Connect the straight test stairs to the upper landing and place them on the horizontal test plane.

Perform tests at nominal test speed, in accordance with 7.7.2.

Set the stair-climbing device to climbing mode. Configure it for climbing stairs in accordance with the manufacturer's instructions for use. Place it on the straight test stairs.

Operate the loaded stair-climbing device to climb up the entire straight test stairs, with the control device set to maintain nominal test speed throughout.

Measure the time, with a relative accuracy of 3 %, taken to ascend a whole number of steps while the stair-climbing device remains completely on the stairs. The number of steps shall be not less than four. Perform the test three times and calculate the mean time for ascending the number of steps.

Operate the loaded stair-climbing device to climb down the entire straight test stairs, with the control device set to maintain nominal test speed throughout.

Measure the time, with a relative accuracy of 3 %, taken to descend a whole number of steps while the stair-climbing device remains completely on the stairs. The number of steps shall be not less than four. Perform the test three times and calculate the mean time for descending the number of steps.

Calculate the average speeds, expressed in steps per minute, for ascending and descending respectively, and record them with a precision of two significant figures.

H.3 Test report

In addition to the information specified in Clause 20, the test report shall include the maximum speed for climbing on stairs, expressed in steps per minute, for ascending and descending respectively, as determined in accordance with H.2.

Annex I
(normative)

Determination of theoretical energy consumption

I.1 Principle

The theoretical energy consumption of a stair-climbing device is estimated by operating the stair-climbing device to climb up and down the test stairs while measuring the electric energy consumed and then calculating the theoretical number of flights of stairs that the stair-climbing device is able to climb before the battery is discharged.

I.2 Test method

NOTE 1 This test is applicable to all stair-climbing devices.

WARNING This test can be hazardous. It is essential that appropriate precautions (e.g. restraints that will catch the stair-climbing device in case of falling) are taken to protect the test personnel.

a) Fully charge the battery set in accordance with the manufacturer's instructions for use.

b) Connect the straight test stairs to the upper landing and place them on the horizontal test plane.

c) Load the stair-climbing device as described in 7.8. Do not use the exaggerated test set-up.

NOTE 2 It is not normal for this test to completely discharge the battery of the stair-climbing device but care should be taken not to discharge the battery below the level recommended by the manufacturer's instructions for use.

d) Immediately after completing the preparation specified in ISO 7176-4, set the stair-climbing device to climbing mode and configure it for climbing stairs in accordance with the manufacturer's instructions for use.

e) Perform tests at nominal test speed, as described in 7.7.2.

f) Position the stair-climbing device on the lower landing adjacent to step 1 of the straight test stairs. Operate the stair-climbing device to climb upwards until it is fully accommodated on the upper landing adjacent to step 8 and then operate it to climb back downwards to the starting position. Perform this procedure a total of five times.

NOTE 3 In f), the stair-climbing device makes a total of 10 transitions from a landing to the stairs (five up and five down), 10 transitions from the stairs to a landing (five up and five down), and climbs 40 steps up and 40 steps down.

g) Use the energy consumption instrumentation (6.8) to measure the electric energy consumed by the stair-climbing device. Record the electric energy consumed by the stair-climbing device during f), expressed in watt hours.

h) Position the stair-climbing device on the straight test stairs so that it is in contact with step 1, but making sure it is not in contact with the lower landing. Operate the stair-climbing device to climb upwards until it has climbed six entire steps up and operate it to climb down to the starting position. Perform this procedure a total of 10 times.

NOTE 4 In h), the stair-climbing device does not make transitions to or from landings. Ten cycles is equivalent to 60 steps up and 60 steps down. If the length of the stair-climbing device is such that fewer than six steps can be climbed in this manner, change the number of steps per cycle and the number of cycles to complete 60 steps up and 60 steps down.

NOTE 5 If the stair-climbing device does not climb normally when approaching landings (e.g. reduces speed or activates an auxiliary device like a sledge), start at the lowest point where the stair-climbing device does climb normally but observe NOTE 4.

i) Use the energy consumption instrumentation (6.8) to measure the electric energy consumed by the stair-climbing device. Record the total electric energy consumed by the stair-climbing device in h) plus the energy recorded in g), expressed in watt hours.

NOTE 6 Items f) to i) may be combined in any way that results in the same total number of transitions of each type (up and down), steps climbed up, and steps climbed down.

NOTE 7 Items f) to i) represent a climb up and down five flights of 20 stairs each, including transitions between stairs and landings at each end of each flight.

NOTE 8 Care should be taken not to cause the stair-climbing device to overheat. Allow appropriate cooling time between cycles if necessary. Do not include energy consumed by the stair-climbing device while cooling in the values recorded.

j) Calculate the theoretical number of flights of stairs R_S that the stair-climbing device can climb both up and down from the following formula:

$$R_S = \frac{5 \times E_{BAT}}{E_S}$$

where

R_S is the theoretical number of flights of stairs that the stair-climbing device can climb both up and down;

E_{BAT} is the nominal energy capacity of the stair-climbing device's battery set, expressed in watt hours;

E_S is the electric energy consumed during the test, expressed in watt hours.

If the battery manufacturer declares the nominal energy capacity, E_{BAT} is the nominal energy capacity of each battery, declared for a discharge time of five hours, multiplied by the number of batteries in the battery set used to climb stairs. If the energy capacity is declared for a discharge time different from five hours, use the energy capacity declared for the nearest shorter period. Otherwise, calculate E_{BAT} from the following formula:

$$E_{BAT} = V_{NOM} \times C_5$$

where

V_{NOM} is the nominal voltage of the battery set, expressed in volts;

C_5 is the charge capacity of the battery for a discharge time of five hours, as declared by the battery manufacturer, expressed in ampere hours.

NOTE 9 This formula is an estimate of the relationship between nominal energy capacity and nominal charge capacity for typical batteries of stair-climbing devices. It is preferable that the battery manufacturer declares the nominal energy capacity.

If the battery manufacturer does not declare the charge capacity of the battery for a discharge time of five hours, calculate C_5 from the following formula:

$$C_5 = 0{,}80 \times C_{20}$$

where

C_{20} is the charge capacity of the battery for a discharge time of 20 h, as declared by the battery manufacturer, expressed in ampere hours.

NOTE 10 This formula is an estimate of the relationship between C_5 and C_{20} for typical batteries of stair-climbing devices.

I.3 Test report

In addition to the information specified in Clause 20, the test report shall include:

a) the theoretical number of flights of stairs, R_S, that the stair-climbing device can climb both up and down with one battery charge, determined as described in I.2, rounded to the nearest whole number;

b) the type of battery and capacity of the battery set, as declared by the battery manufacturer, that was used for the calculation in I.2.

Annex J
(normative)

Determination of occupied dimensions and manoeuvring space

J.1 Principle

The manoeuvring space of a stair-climbing device is evaluated by measuring the envelope in which the loaded stair-climbing device can perform various manoeuvres associated with climbing stairs that are frequently encountered during real use.

NOTE This test is an adaptation and extension of ISO 7176-5.

J.2 Test methods

J.2.1 General

Load the stair-climbing device with the test wheelchair (where applicable) and the appropriate test dummy or a human test occupant, as described in 7.8. Do not use the exaggerated test set-up.

Test assistant-operated stair-climbing devices as follows using the assistant space gauge (see 6.17). Attach the assistant space gauge to the push handles and maintain it horizontal ± 10° throughout the tests. If the stair-climbing device is both occupant-operated and assistant-operated, use the assistant space gauge only when simulating operation by an assistant.

Test occupant-operated stair-climbing devices as follows using hand space gauges (see ISO 7176-5) or any suitable substitute that adds (50 ± 1) mm in the lateral direction to any lever, handle or handrim that is operated by the occupant during climbing. If the stair-climbing device is both occupant-operated and assistant-operated, use hand space gauges only when simulating operation by the occupant.

Where applicable, perform tests at nominal test speed, as described in 7.7.2.

WARNING The tests can be hazardous. It is essential that appropriate precautions (e.g. restraints that will catch the stair-climbing device in case of falling) are taken to protect the test personnel.

J.2.2 Determination of minimum stair width for straight stairs

NOTE This test is applicable to all stair-climbing devices.

a) Connect the straight test stairs to the upper landing and position them on the horizontal test plane. Position the adjustable barriers (6.5) at both sides of each step.

b) Set the stair-climbing device to climbing mode and position it on the lower landing for ascending the stairs, in accordance with the manufacturer's instructions for use.

c) Operate the stair-climbing device to climb upstairs until the stair-climbing device is fully accommodated on the upper landing.

d) Repeating b) and c) as necessary, gradually move the barriers to reduce the effective width of the stairs and determine the minimum stair width that can be ascended without the stair-climbing device, the test wheelchair (if used), the test dummy or any space gauge making contact with the barriers. Take care to keep the adjustable barriers perpendicular to the step nosings during the test. Measure, parallel to the step nosings, the distance between the barriers to an accuracy of ± 25 mm.

e) Position the stair-climbing device on the upper landing for descending the stairs in accordance with the manufacturer's instructions for use.

f) Operate the stair-climbing device to climb downstairs so that the whole stair-climbing device is on the lower landing.

g) Repeating e) and f) as necessary, gradually move the barriers to reduce the effective width of the stairs and determine the minimum stair width that can be descended without the stair-climbing device, the test wheelchair (if used), the test dummy or any space gauge making contact with the barriers. Take care to keep the adjustable barriers perpendicular to the step nosings during the test. Measure, parallel to the step nosings, the distance between the barriers to an accuracy of ± 25 mm.

h) Record the greater of the two test results obtained for ascending and descending as the minimum stair width for straight stairs.

J.2.3 Determination of minimum intermediate landing size for U-shaped stairs

NOTE This test is applicable to all stair-climbing devices.

J.2.3.1 Upwards

This test consists of two parts, in which the straight test stairs and landings are used to simulate two flights and an intermediate landing of some U-shaped stairs. In the first part of the test, the straight test stairs and upper landing represent the lower flight and the intermediate landing of the U-shaped stairs; in the second part of the test, the horizontal test plane and straight test stairs represent the intermediate landing and upper flight of the U-shaped stairs.

Perform the first part of the test as follows:

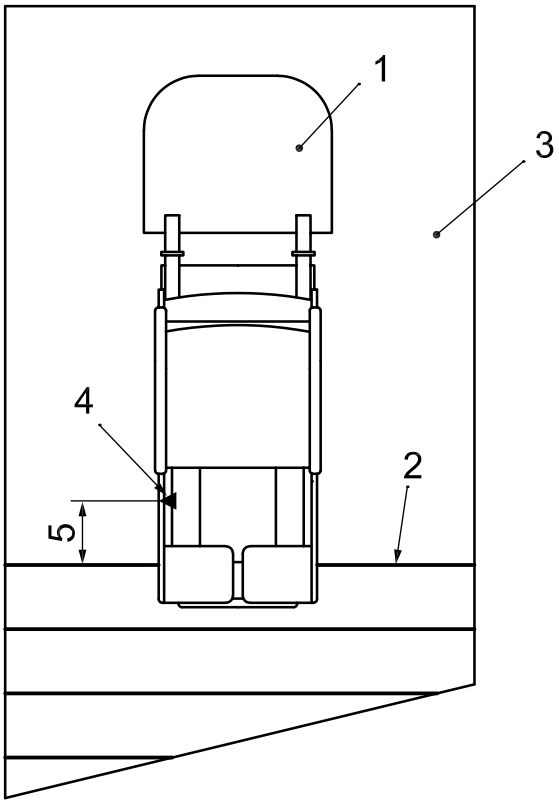
a) Connect the straight test stairs to the upper landing and position them on the horizontal test plane.

b) Set the stair-climbing device to climbing mode.

c) Operate the stair-climbing device to climb straight upwards onto the upper landing and stop as soon as it is fully accommodated on the upper landing. If necessary, change to the crawling mode. Operate the stair-climbing device to crawl straight onward a further (200 ± 25) mm.

d) Make a datum mark in a suitable location on the stair-climbing device. Measure, perpendicular to the nosing of step 8, the horizontal distance between the nosing and the datum mark, to an accuracy of ± 25 mm, as shown in Figure J.1.

e) Operate the stair-climbing device to climb down to the horizontal test plane.



Key

1 attendant space gauge
2 nosing of step 8
3 upper landing
4 datum mark
5 distance between the nosing of step 8 and the datum mark

Figure J.1 — Distance between the nosing of step 8 and the datum mark

Perform the second part of the test as follows:

a) Mark a line on the horizontal test plane to the side of the straight test stairs, so that it is in line with the nosing of step 1, as shown in Figure J.2 a).

NOTE 1 The line represents the nosing of the top step of the lower flight of the U-shaped stairs.

b) Position the handrail barrier next to the straight test stairs, in line with the nosing of step 1. Position two adjustable barriers as lateral barriers perpendicular to step 1. Position a third adjustable barrier as the rear barrier, parallel to step 1. See Figure J.2 a).

c) Position the stair-climbing device on the horizontal test plane, so that it is perpendicular to the marked line with the datum mark at the same distance from the marked line as was established in d), and so that the lateral distance from the stair-climbing device to the handrail barrier is in accordance with the manufacturer's instructions for use. If the manufacturer's instructions do not contain this information, position the stair-climbing device so that the lateral distance is (200 ± 25) mm.

d) Operate the stair-climbing device to crawl around the handrail barrier as if to prepare for climbing up the stairs. Perform the turn in accordance with the manufacturer's instructions for use. If there are no such instructions, perform the turn in the most suitable manner, smoothly, with a minimum of stopping, without reversing direction and without causing any hazardous situation.

e) Complete the turn before the stair-climbing device starts to climb the straight test stairs.

f) Repeating h) to j) as necessary, gradually reduce the size of the landing and determine the minimum landing size in which the stair-climbing device can manoeuvre without the stair-climbing device, the test wheelchair (if used), the test dummy or any space gauge making contact with the barriers. Take care to keep the barriers parallel or perpendicular to step 1, as applicable, during the test.

g) Measure, parallel to the step nosings, the distance between the middle of the handrail barrier and the more remote lateral barrier to an accuracy of ± 25 mm. Multiply by two and record the result as the minimum landing length for ascending U-shaped stairs.

h) Measure, horizontally and perpendicular to the marked line, the distance between the marked line and the rear barrier to an accuracy of ± 25 mm. Record the result as the minimum landing width for ascending U-shaped stairs.

NOTE 2 Some experimentation might be necessary to determine the minimum dimensions.

J.2.3.2 Downwards

a) Position the stair-climbing device on the straight test stairs so that it is perpendicular to the step nosings, and so that the lateral distance from the stair-climbing device to the handrail barrier is in accordance with the manufacturer's instructions for use. If the manufacturer's instructions do not contain this information, position the stair-climbing device so that the lateral distance is (200 ± 25) mm.

b) Operate the stair-climbing device to climb straight downwards onto the lower landing until it is fully accommodated on the horizontal test plane. If necessary, change to the crawling mode.

c) Operate the stair-climbing device to crawl around the handrail barrier as if to prepare for climbing down the lower stairs (represented by the area beyond the marked line). Perform the turn in accordance with the manufacturer's instructions for use. If there are no such instructions, perform the turn in the most suitable manner, smoothly and with as little stopping as possible, without reversing and without causing any hazardous situation.

d) Complete the turn before the horizontal distance between the datum mark and the marked line is less than the distance measured in J.2.3.1 d).

e) Repeating a) to d) as necessary, gradually reduce the size of the landing and determine the minimum landing size in which the stair-climbing device can manoeuvre without the stair-climbing device, the test wheelchair (if used), the test dummy or any space gauge making contact with the barriers. Take care to keep the barriers parallel or perpendicular to step 1, as applicable, during the test.

f) Measure, parallel to the step nosings, the distance between the middle of the handrail barrier and the more remote lateral barrier to an accuracy of ± 25 mm. Multiply by 2 and record the result as the minimum landing length for descending U-shaped stairs.

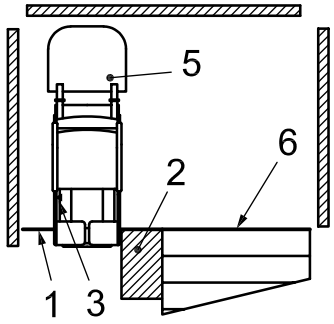
g) Measure, horizontally and perpendicular to the marked line, the distance between the marked line and the rear barrier to an accuracy of ± 25 mm. Record the result as the minimum landing width for descending U-shaped stairs.

NOTE Some experimentation might be necessary to determine the minimum dimensions.

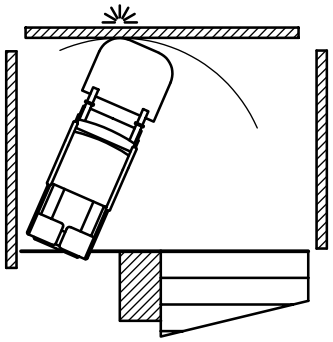
J.2.3.3 Evaluation of results

a) Identify the greatest of the landing lengths from all single tests (i.e. the maximum for ascending or descending) and record it as the minimum landing length for U-shaped stairs.

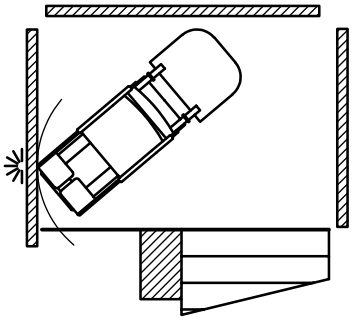
b) Identify the greatest of the landing widths from all single tests (i.e. the maximum for ascending or descending) and record it as the minimum landing width for U-shaped stairs.



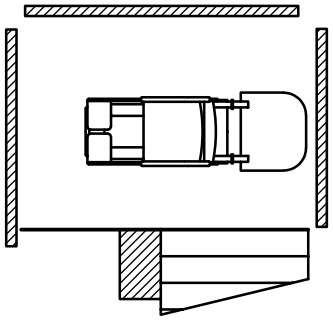
a) Starting position for first 90° turn



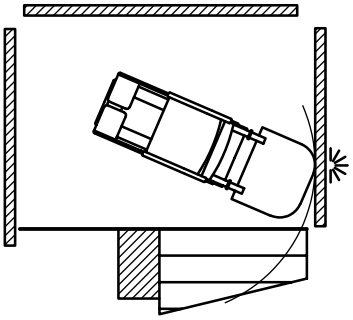
b) Contact with rear barrier



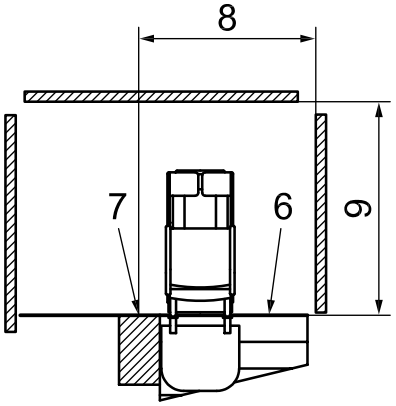
c) Contact with lateral barrier



d) Starting position for second 90° turn



e) Contact with other lateral barrier



f) Ending position

Key

1 marked line on horizontal test plane
2 handrail barrier
3 datum mark
4 distance between the datum mark and the nosing of the line
5 assistant space gauge
6 step 1 of the straight test stairs, representing the first step of the upper flight of stairs
7 middle of the handrail barrier
8 distance between the middle of the handrail barrier and the more remote lateral barrier
9 minimum landing width for U-shaped stairs

Figure J.2 — Determination of minimum size for an intermediate landing — ascending

J.2.4 Determination of minimum outer radius for winding stairs

NOTE 1 This test is applicable to stair-climbing devices intended for use on winding stairs.

a) Connect the winding test stairs to the upper landing and position them on the horizontal test plane. Position adjustable barriers on each step. Set the adjustable barriers at a distance from the central axis of the stairs in order to detect the outer radius of the space needed to climb the winding test stairs.

b) Set the stair-climbing device to climbing mode.

NOTE 2 This test may be performed in conjunction with the test given in J.2.5.

c) Position the loaded stair-climbing device on the lower landing in front of step 1 in a position corresponding to the shortest going or the minimum stair radius that is in accordance with the manufacturer's instructions for use. If the instructions for use do not contain this information, position the stair-climbing device at a point where the going is as calculated using the following formula:

$$G = \frac{D}{2} + M$$

where

G is the going for testing, expressed in millimetres;

D is the largest horizontal distance between the contact point of an actuator intended to be accommodated on a step and any part of the actuator that could come into contact with the riser or nosing of the next higher step, expressed in millimetres;

M is the safety margin, equal to 50 mm.

d) Operate the stair-climbing device to climb upwards to the upper landing in accordance with the manufacturer's instructions for use.

e) If, during the test, a hazardous situation occurs, recommence the test using a starting position that is (50 $\pm$ 2) mm further away from the central axis of the winding test stairs. Repeat this procedure as necessary until the test can be completed without the occurrence of a hazardous situation.

f) Repeating c) to e) as necessary, while the stair-climbing device is climbing the stairs, gradually move the barriers to reduce the effective outer radius of the stairs and determine the minimum outer radius of winding stairs that can be ascended without the stair-climbing device, the test wheelchair (if used), the test dummy or any space gauge touching the barriers.

g) Measure the greatest horizontal distance between the central axis of the stairs and the barriers, to an accuracy of $\pm$ 25 mm.

h) Position the loaded stair-climbing device on the upper landing facing the nosing of step 8 in a position corresponding to the shortest going or the minimum stair radius that is in accordance with the manufacturer's instructions for use. If the instructions for use do not contain this information, position the stair-climbing device at a point where the going is calculated using the formula in c).

i) Operate the stair-climbing device to climb downstairs to the lower landing in accordance with the manufacturer's instructions for use.

j) If, during the test, a hazardous situation occurs, recommence the test using a starting position that is (50 $\pm$ 2) mm further away from the central axis of the winding test stairs. Repeat this procedure as necessary until the test can be completed without the occurrence of a hazardous situation.

k) Repeating h) to j) as necessary, while the stair-climbing device is climbing the stairs, gradually move the barriers to reduce the effective outer radius of the stairs and determine the minimum outer radius of winding stairs that can be descended without the stair-climbing device, the test wheelchair (if used), the test dummy or any space gauge touching the barriers.

l) Measure the greatest horizontal distance between the central axis of the stairs and the barriers, to an accuracy of $\pm$ 25 mm.

m) Record the greater of the test results obtained for ascending and descending as the minimum outer stair radius on winding stairs.

J.2.5 Determination of minimum inner radius for winding stairs

NOTE 1 This test is applicable to stair-climbing devices intended for use on winding stairs.

a) Connect the winding test stairs to the upper landing and position them on the horizontal test plane. Position adjustable barriers on each step. Set the adjustable barriers at a distance from the central axis of the stairs in order to detect the inner radius of the space needed to climb the winding test stairs.

b) Set the stair-climbing device to climbing mode.

NOTE 2 This test may be performed in conjunction with the test given in J.2.4.

c) Position the loaded stair-climbing device on the lower landing in front of step 1 in a position corresponding to the shortest going or the minimum stair radius that is in accordance with the manufacturer's instructions for use. If the instructions for use do not contain this information, position the stair-climbing device at a point where the going is calculated using the formula in J.2.4 c).

d) Operate the stair-climbing device to climb upwards to the upper landing in accordance with the manufacturer's instructions for use.

e) If, during the test, a hazardous situation occurs, recommence the test using a starting position that is (50 ± 2) mm further away from the central axis of the winding test stairs. Repeat this procedure as necessary until the test can be completed without the occurrence of a hazardous situation.

f) Repeating c) to e) as necessary, while the stair-climbing device is climbing the stairs, gradually move the barriers to increase the effective inner radius of the stairs and determine the minimum inner radius of winding stairs that can be ascended without the stair-climbing device, the test wheelchair (if used), the test dummy or any space gauge touching the barriers.

g) Measure the greatest horizontal distance between the central axis of the stairs and the barriers, to an accuracy of ± 25 mm.

h) Position the loaded stair-climbing device on the upper landing facing the nosing of step 8 in a position corresponding to the shortest going or the minimum stair radius that is in accordance with the manufacturer's instructions for use. If the instructions for use do not contain this information, position the stair-climbing device at a point where the going is calculated using the formula in J.2.4 c).

i) Operate the stair-climbing device to climb downstairs to the lower landing in accordance with the manufacturer's instructions for use.

j) If, during the test, a hazardous situation occurs, recommence the test using a starting position that is (50 ± 2) mm further away from the central axis of the winding test stairs. Repeat this procedure as necessary until the test can be completed without the occurrence of a hazardous situation.

k) Repeating h) to j) as necessary, while the stair-climbing device is climbing the stairs, gradually move the barriers to increase the effective inner radius of the stairs and determine the minimum inner radius of winding stairs that can be descended without the stair-climbing device, the test wheelchair (if used), the test dummy or any space gauge touching the barriers.

l) Measure the greatest horizontal distance between the central axis of the stairs and the barriers, to an accuracy of ± 25 mm.

m) Record the greater of the test results obtained in the tests for ascending and descending as the minimum inner stair radius on winding stairs.

J.3 Test report

In addition to the information specified in Clause 20, the test report shall include the dimensions determined in accordance with J.2.2 to J.2.5.

Annex K
(normative)

Distinction between small and large clusters

This annex explains and identifies the boundary, b, between small and large clusters.

Small clusters are those where the distance between the common axis of the cluster and the centres of its cams is smaller than the respective value of b, given in Table K.1. This will result in a tipping angle that is greater than 3° on the straight test stairs when the common axis of the cluster is horizontally in front of the centre of the load-bearing cam.

Large clusters are those where the distance between the common axis of the cluster and the centre of its cams is greater than the respective value of b, given in Table K.1. This will result in a tipping angle that is smaller than 3° on the straight test stairs when the common axis of the cluster is horizontally in front of the centre of the load-bearing cam.

Table K.1 — Boundary, b, between small and large clusters

Number of cams per cluster, n	α °	β °	d mm	**Boundary,** b mm
3	60	57	330,5	190,8
4	45	42	242,2	171,3
5	36	33	214,6	182,6
NOTE These values are derived from the nominal rise of the test stairs of 180 mm.				

For stair-climbing devices with clusters, the downward least stable position on stairs depends on the size of the cluster (see the Figures in Annex E for examples). The determination of whether it is a small or large cluster depends on the distance between the common axis of the cluster and the centres of its cams, the number of cams per cluster, n, which usually ranges between 2 and 5, and the rise of the step, r, which is nominally 180 mm for the straight test stairs.

If a cluster is positioned on stairs (see Figure K.1) so that its common axis is horizontally in line with the centre of the load-bearing cam, the angle α, between the vertical and a line connecting the contact point of this cam with the contact point of the cam that will come into contact with the next lower tread, is calculated in accordance with the following formula:

$$\alpha = \frac{360}{2n}$$

where

α is the angle, expressed in degrees.

Dimensions in millimetres

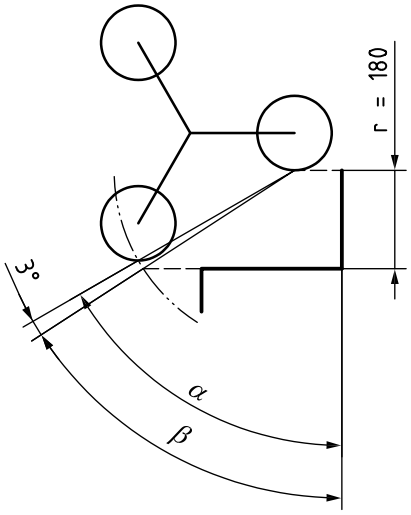


Figure K.1 — Angles α and β (example for $n = 3$)

The boundary for the cluster is where the length of the connecting line is such that, after a tip of 3°, the next cam will come into contact with the next lower tread.

Hence the angle β between a line connecting the contact points of the two consecutive cams and the vertical is given as follows (and as shown in Figure K.1):

$$\beta = \alpha - 3$$

where α and β are expressed in degrees.

The length of the line, d, connecting the contact points of the cams is then given by the following formula:

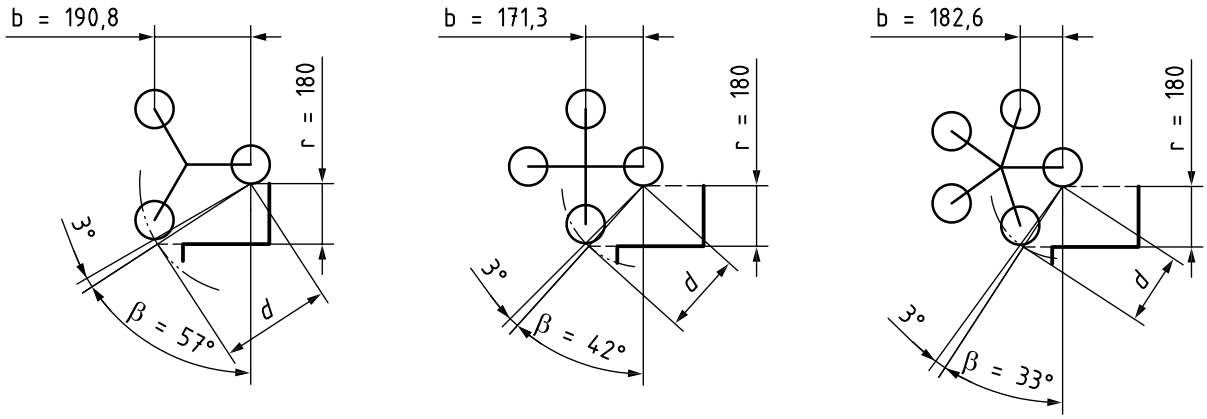
$$d = \frac{r}{\cos(\beta)}$$

where

d is the length of the connecting line;

r is the rise of the step, equal to 180 mm for the test stairs (see Figure K.2).

Dimensions in millimetres



a) Three cams **b) Four cams** **c) Five cams**

Figure K.2 — Lengths of d and b (examples for $n = 3$, 4 and 5)

Finally the boundary, b, which is the distance between the common axis of the cluster and the centres of its cams, can be calculated from the relation between the radius and side length of a polygon in accordance with the following formula (and as shown in Figure K.2):

$$b = \frac{d}{2 \times \sin\left(\frac{180°}{n}\right)}$$

The whole set of calculations compiled into one formula in common notation is given as follows:

$$b = \frac{r}{\cos\left(\frac{360°}{2n} - 3°\right)} \Big/ 2 \times \sin\left(\frac{180°}{n}\right)$$

Together with this formula and the given values of n and r, the distance, b, has been calculated for clusters with 3, 4 and 5 cams as expressed in Table K.1. The formula may be used for clusters with any number of cams.

According to this formula, for $n = 2$ a boundary b of 1719,7 mm is derived. Since this is far too large to be encountered in practice, all clusters with $n = 2$ are small clusters.

ICS 11.180.10

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