BS ISO 7176-3:2012

BSI Standards Publication

Wheelchairs

Part 3: Determination of effectiveness of brakes

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National foreword

This British Standard is the UK implementation of ISO 7176-3:2012. It supersedes BS ISO 7176-3:2003 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee CH/173/1, Wheelchairs.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Part 3: Determination of effectiveness of brakes

Fauteuils roulants —

Partie 3: Détermination de l'efficacité des freins

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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.

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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 7176-3 was prepared by Technical Committee ISO/TC 173, *Assistive products for persons with disability*, Subcommittee SC 1, *Wheelchairs*.

This third edition cancels and replaces the second edition (ISO 7176-3:2003), all clauses of which have been technically revised.

Significant technical changes from the second edition are under consideration.

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 postural support devices*

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

— *Part 26: Vocabulary*

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

Introduction

The performance of a wheelchair's brakes can be critical for safety. The tests specified in this part of ISO 7176 determine the ability of a wheelchair to stop in a safe manner on level ground and on a slope, and determine the ability of a wheelchair to remain stationary when parked on a slope.

INTERNATIONAL STANDARD **ISO 7176-3:2012(E)**

Wheelchairs —

Part 3: Determination of effectiveness of brakes

1 Scope

This part of ISO 7176 specifies test methods for the measurement of the effectiveness of brakes of manual wheelchairs and electrically powered wheelchairs, including scooters, intended to carry one person, with a maximum speed not exceeding 15 km/h. It also specifies disclosure requirements for the manufacturer.

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

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

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

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

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7176-26 and the following apply.

3.1
tipping
rotational movement of the wheelchair that occurs when the vertical projection of the centre of mass of the occupied wheelchair moves outside of a polygon connecting the ground contact points of all the running wheels

Note 1 to entry: The instant at which the wheelchair starts to tip is reached when the forces become zero under all uphill running wheels (i.e. there is only force through one side of the polygon). See ISO 7176-1 for more details.

3.2
sliding
movement of the wheelchair across the test surface where there is a difference in velocity between the test surface and the braked wheel rolling surface

4 Principle

A number of wheelchair braking operations are carried out and the resulting responses of the wheelchair are measured and observed.

5 Apparatus

5.1 Rigid, flat test planes and ramp

5.1.1 All test planes specified under this clause shall be rigid with a surface coefficient of friction as specified in ISO 7176-13 and of sufficient size to conduct the tests. The surface shall be flat such that any two points 1m apart on the plane shall be contained between two imaginary horizontal planes 5 mm apart, as an indication of flatness. Conformity with this requirement may be evaluated using a 1 m straight edge.

NOTE The imaginary planes are intended to provide a measure of control on the flatness of the test plane.

The planes and ramps in 5.1.2 to 5.1.4 may be combined into one or two units providing the plane/ramp requirements for each applicable type of plane/ramp are satisfied.

5.1.2 Rigid, flat, horizontal test plane, which shall meet the requirements of 5.1.1 and have no more than 0,5 degrees of variation in slope or cross slope from the horizontal throughout the test.

5.1.3 Rigid, flat, adjustable test plane, which shall meet the requirements of 5.1.1 and be of sufficient size to accommodate the wheelchair during parking brake testing, having a slope which can be adjusted from the horizontal about a single axis.

If the slope of the test plane is increased in a continuous fashion, the rate of increase should not exceed 1°/s as the angle of wheelchair instability is approached.

If the slope of the test plane is increased in a stepwise fashion, the size of the steps shall not exceed 0,5° and the movement between steps should be sufficiently smooth that it does not affect the test results.

NOTE A range of inclinations from horizontal to 25° is usually sufficient for most wheelchairs.

5.1.4 Rigid, flat, inclined test ramp, which shall meet the requirements of 5.1.1 and be of sufficient size to accommodate the wheelchair during running brake testing, having a slope which is adjustable to a specific inclination ($^{0}_{+0,5}$)° or which is fixed at that inclination. Conformity with the inclination requirement may be evaluated using the inclinometer specified in 5.5.

NOTE 1 If the angle is fixed, several different test ramps will have to be used.

NOTE 2 The recommended minimum size is 5 m × 1,5 m, but a size of 10 m × 1,5 m will often be necessary.

5.2 Test dummy, as specified in ISO 7176-11, with appropriate restraints, or a human test occupant.

NOTE 1 If a dummy is used, remote control devices may be used to operate the wheelchair controls.

NOTE 2 A human test occupant should take care to minimize any movement during testing as it can affect the results.

5.3 Supplementary weights, with appropriate restraints, to add to the human test driver to give the mass and mass distribution equivalent to the applicable dummy.

5.4 Braking distance measurement equipment to measure the braking distance of a wheelchair with an accuracy of ± 50 mm.

5.5 Inclinometer to measure the angle of the slope of a test plane with respect to the horizontal to an accuracy of ± 0,2°.

5.6 Force measurement equipment to measure force with an accuracy of 5 % over a range of 10 N to 250 N.

6 Preparation of test wheelchair

Prepare the test wheelchair as follows before commencing the sequence of tests.

a) Set up the wheelchair as specified in ISO 7176-22. If a test dummy is used, select and fit the dummy as specified in ISO 7176-22 and add restraints to minimize movement of the dummy. If a human test occupant is used, position and secure the supplementary weights (see 5.3) to give substantially the same mass distribution as the test dummy when the human test occupant is seated in the wheelchair.

b) Adjust the brakes so that:

— where the manufacturer's instructions for use specify the method for adjustment of the brakes, the brakes are adjusted in accordance with those instructions;

— if there are no specifications, the brakes are adjusted so that the operating forces lie within the ranges specified in Table 1;

— where brakes cannot be adjusted to give operating forces as specified in Table 1, the brakes are adjusted so that the operating forces are as close as possible to those in Table 1.

Table 1 — Operating forces

Means of operation	Operating force
	N
hand/arm operation[a]	60 ± 5
foot, push	100 ± 10
foot, pull	60 ± 5
finger	5 ± 1
hand[b]	13,5 ± 2

[a] An operation where the strength of the combined hand and arm can be used.

[b] An operation where only the strength of a single hand can be used; this may include two or more fingers.

The operating forces are derived from ISO 9355-3 where maximum recommended force for a normal adult is given, considering the direction of force applied.

If an operating force exceeds the value specified in Table 1, the operating force shall be disclosed as specified in Clause 9.

c) Immediately before testing, condition the wheelchair by maintaining it at an ambient temperature of 20 °C ± 10 °C for at least 3 h.

d) If a human test occupant is used, seat the occupant in the wheelchair.

7 Brake performance

WARNING — These tests are potentially hazardous to test personnel. Take appropriate precautions.

7.1 General

Perform the tests specified in 7.2 to 7.5 in any order.

7.2 Parking brakes

This test applies to parking brakes, if fitted, for all types of wheelchair. If a wheelchair is fitted with more than one parking brake system, where each system can be operated independently both systems should be evaluated separately.

EXAMPLE An electrically powered wheelchair with an automatic parking brake that is part of the propulsion system and a manual parking brake that acts directly on the wheels would be considered separate independent parking brakes.

a) Set the adjustable test plane to an inclination of less than 2°.

b) Ensure that any propulsion systems and any braking systems are at working temperature.

NOTE 1 This may be done by driving the wheelchair in a typical pattern of usage involving stopping and starting for approximately 10 min.

c) Complete d) to h) within 5 min of completing b).

d) Place the wheelchair on the adjustable test plane facing downhill with any castors in the trailing position. Select a pair of wheels for aligning the wheelchair that are perpendicular to the direction of travel and share the same axis. Align the wheelchair so that the axis of the pair of wheels is parallel to the axis of tip of the plane with a tolerance of ± 3°.

NOTE 2 It is preferable that the pair of wheels furthest downhill be used for the alignment.

e) Switch off any controller.

f) Fully apply one parking brake and disengage all other parking brakes that can be operated independently.

NOTE 3 If two or more brakes are supposed to be used in parallel according to manufacturer's instructions, apply them simultaneously; an example is left and right manual wheel brakes.

g) Increase the angle of the plane until the chair starts to move down the slope. If the wheelchair starts to tip (see 3.1) before sliding (see 3.2) or rolling down the slope, apply the minimum force necessary to prevent the wheelchair from tipping. Apply the force to the uphill wheels in a direction perpendicular to the test plane. Ensure that the force is applied in a manner which has a minimal effect on sliding or rolling.

h) Measure and record to the nearest degree the angle of the plane when movement commences and the type of movement.

NOTE 4 Typical types of movement are wheels turning, wheels sliding and tyres rolling off.

i) Repeat a) to h) with the wheelchair facing uphill when the plane is inclined.

j) Repeat a) to h) for each parking brake that can be operated independently.

7.3 Running brakes, normal operation

This test applies to running brakes on electrically powered wheelchairs only.

NOTE 1 Annex B provides a recommended test method for determining the performance of manual running brakes fitted to wheelchairs.

NOTE 2 If the complete test cycle cannot be performed on the test ramp, see Annex C.

a) Engage the motor drive system.

b) Ensure that any electrical propulsion and braking systems are at working temperature.

NOTE 3 This may be done by driving the wheelchair in a typical pattern of usage involving stopping and starting for approximately 10 min.

c) Complete d) to g) within 5 min of completing b).

d) Drive the wheelchair forwards at maximum speed along the horizontal test plane. Measure and record the maximum value of speed achieved as specified in ISO 7176-6.

NOTE 4 Driving at maximum speed means that the maximum speed command is applied. It is essential that the wheelchair has reached its maximum speed at the point of measurement.

e) Stop the wheelchair by operating the control device as rapidly as practicable to command zero speed.

NOTE 5 In most wheelchairs, this can be done simply by releasing the joystick. For manually operated running brakes, see Annex B.

f) Determine and record the linear distance to the nearest 100 mm travelled by the wheelchair between operation of the brakes in e) and the wheelchair finally coming to rest.

g) Record any abnormal behaviour of the wheelchair during braking, such as tipping (see 3.1), sliding (see 3.2), brake failure, or veering to one side.

h) Repeat a) to g) a further two times and determine the arithmetic mean value of the braking distance from the three runs. Record this value in the test report as specified in Table 2.

i) Repeat a) to h) with the wheelchair travelling in reverse on the horizontal test plane.

j) Repeat a) to h) using the inclined test ramp at 3°, 6° and then 10° to the horizontal, with the wheelchair travelling forwards downhill and then in reverse downhill. If the manufacturer specifies a maximum slope on which the wheelchair should be used, do not test at an inclination steeper than that specified, but repeat a) to h) using the specified inclination.

k) If test results are requested for other inclinations, repeat a) to h) using the specified inclinations.

NOTE 6 If a wheelchair fails to stop at a particular inclination of the ramp, there is no need to continue testing at steeper inclinations.

7.4 Running brakes, operation by reverse command

This test applies to running brakes on electrically powered wheelchairs only.

Repeat 7.3, bringing the wheelchair to a halt by operating the control device to command maximum speed in the direction opposite to that of travel.

7.5 Running brakes, emergency operation

This test applies to running brakes on electrically powered wheelchairs only.

Repeat 7.3, bringing the wheelchair to a halt using the method specified by the user manual for stopping in an emergency or, if no instruction is provided, by switching off the wheelchair.

8 Test report

The test report shall contain the following information:

a) a reference to this edition of ISO 7176-3 used for testing;

b) the name and address of the testing institution;

c) the name and address of the manufacturer of the wheelchair;

d) the date of issue of the test report;

e) the wheelchair type and any serial and batch numbers;

f) the mass of the dummy used or, if a human test occupant is used, the mass of the person and weights;

g) details of the set-up of the wheelchair as specified in ISO 7176-22, including equipment and adjustments;

h) a photograph of the wheelchair equipped as during the test;

i) a description of the parking brake(s) tested including method of operation such as finger/hand/foot control, manual, electrical, automatic, and direction of force application;

j) if preparation of the wheelchair requires measurement of the preadjusted brake operating force as specified in 6 b), the force, in Newtons, required to operate the brakes during these tests;

NOTE 1 This may include actuators.

k) the results of the parking brake tests specified in 7.2;

l) the results of the running brake tests specified in 7.3 to 7.5, including each mean minimum braking distance along with each associated maximum test speed;

NOTE 2 Table 2 shows how these results may be presented.

m) any abnormal behaviour of the wheelchair during braking noted as defined in 7.3 g).

n) a list of the equipment used for testing.

o) if a force was applied to prevent tipping.

9 Disclosure

The following results shall be disclosed in the manufacturer's specification sheets in the format specified in ISO 7176-15:

a) parking brakes, if fitted:

— maximum slope uphill;

— maximum slope downhill;

— brake operating force, if it exceeds the value specified in Table 1;

b) running brakes, if fitted, minimum braking distance from maximum speed forward on horizontal surface:

— normal operation;

— reverse command;

— emergency operation;

— brake operating force, if it exceeds the value specified in Table 1.

Table 2 — Results of running brake tests

Test plane inclination	Direction of travel	Maximum Speed	Normal operation	Reverse command	Emergency operation	Comments
		(m/s)	(m)	(m)	(m)	
Horizontal	Forwards					
Horizontal	Reverse					
3°	Forwards downhill					
3°	Reverse downhill					
6°	Forwards downhill					
6°	Reverse downhill					
10°	Forwards downhill					
10°	Reverse downhill					
Maximum slope specified by the manufacturer	Forwards downhill					
Maximum slope specified by the manufacturer	Reverse downhill					

The wheelchair shall stop in a safe way according to Annex C if the tests cannot be carried out as above.

Annex A
(normative)

Brake levers — Determination of operating force

A.1 Test method

a) Select the part of the lever through which the force is to be applied from the following (see Figure A.1) with precedence for selection given to the earliest in the sequence below:

   1) if the lever is fitted with a generally spherical knob, apply the force through the centre of the knob;

   2) if the lever is tapered, apply the force through the point where the largest cross section intersects the centreline of the lever;

   3) if the form of the lever is such that the lever is gripped by the whole hand, apply the force through the centreline of the lever, 15 mm from the end;

   4) if the brake is operated by pushing or pulling a bar or pad, apply the force to the centroid of the bar or pad;

   5) if the lever is parallel or any shape other than those above, apply the force through a point on the centreline of the lever, 15 mm below the top;

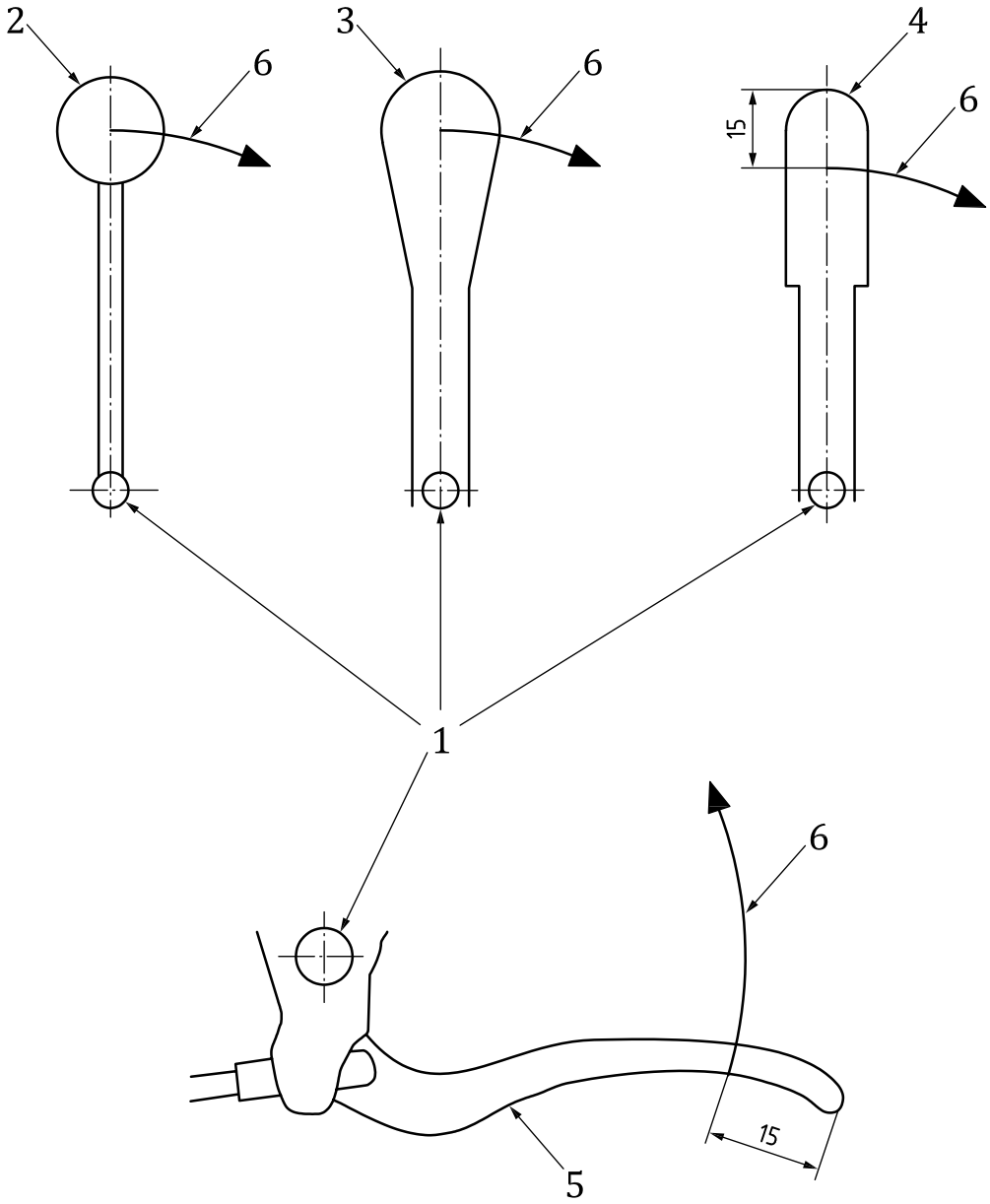
   6) if the lever is telescoping or is supplied with an extension handle, apply the force 15 mm from the end when fully extended.

b) Set up a means to operate the brake by applying a force via the force measuring device specified in 5.8 and aligned as shown in Figure A.1.

c) Fully apply the brake via the force measuring device and record, the maximum operating force. The force shall be applied at right angles ± 5° to the lever at the point where the brakes are beginning to engage. Although the angle of the lever may change due to its movements, the direction of force shall be constant.

d) Perform c) three times, rotating the relevant wheel between applications, and calculate, to the nearest newton, the arithmetic mean value of the forces measured.

Dimensions in millimetres



Key

1 fulcrum
2 lever with spherical knob
3 tapered lever
4 parallel lever
5 bicycle brake style lever
6 path of the point of application of the operating force

Figure A.1 — Application of force on hand-operated brakes

Annex B
(informative)

Manual running brakes — Determination of performance

B.1 General

WARNING — These tests are potentially hazardous to test personnel. Take appropriate precautions.

This test applies to all wheelchairs fitted with manual running brakes.

NOTE This test method is still under development and consequently is included as an informative annex.

B.2 Recommendation

When they are tested as specified in B.3, the running brakes of a wheelchair should be capable of bringing the wheelchair to a halt without any abnormal behaviour such as tipping (see 3.1), sliding (see 3.2), brake failure, or veering to one side.

B.3 Test method

a) Prepare the wheelchair as specified in Clause 6.

b) Set the wheelchair so that it can be driven.

c) Ensure that the braking system is at working temperature.

NOTE 1 This may be done by driving the wheelchair in a typical pattern of usage involving stopping and starting for approximately 10 min.

d) Complete e) to i) within 5 min of completing c).

e) Carry out one of the following:

— 1) If the wheelchair is electrically powered, drive it forwards at maximum speed across the horizontal test plane. Measure and record the maximum value of speed achieved as specified in ISO 7176-6.

NOTE 2 Driving at maximum speed means that the maximum speed command is applied. It is essential that the wheelchair has reached its maximum speed at the point of measurement.

— 2) If the wheelchair is a manual wheelchair, propel it forwards across the horizontal test plane, measuring the speed in accordance with ISO 7176-6. When the speed exceeds 7 km/h, cease propelling the wheelchair and allow the wheelchair to decelerate naturally. Proceed to f) once the speed reaches (6 ± 0,5) km/h.

f) Stop the wheelchair by operating the running brakes as rapidly as practicable, using operating forces not exceeding those specified in Table 1 determined as specified in Annex A.

g) Determine and record to the nearest 100 mm, the linear distance travelled by the wheelchair between initiating the operation of the brakes and the wheelchair finally coming to rest.

h) Record any abnormal behaviour of the wheelchair during braking, such as tipping (see 3.1), sliding (see 3.2), brake failure or veering to one side.

i) Repeat a) to h) a further two times and determine from the three runs the arithmetic mean values of the braking distances.

j) Repeat a) to i) using the test ramp inclined at 3°, 6° and 10° to the horizontal, except that in e) 2) cease propelling the wheelchair before the wheelchair reaches (6 ± 0,5) km/h and allow it to accelerate or decelerate naturally.

k) If test results are requested for other slope inclinations, repeat a) to i) on the specified slope inclinations.

B.4 Test report

The results of the tests should be presented in the test report as specified in Table 2 for normal operation.

B.5 Disclosure

The results should be disclosed as specified in 9 b) for normal operation. If the wheelchair is a manual wheelchair, instead of the text “normal operation” use “normal operation (from 6 km/h)”.

Annex C
(informative)

Running brakes — Alternative test method

C.1 General

Most of the test slopes used today are approximately 10 m long and can be set to an angle of 10°. If a wheelchair has a nominal speed greater than 10 km/h, it is unlikely to be able to accelerate to its maximum speed and stop on the test slope.

A wheelchair with a nominal speed of 15 km/h will commonly reach a speed of about 19 km/h on a 10° slope. In order to test such a wheelchair the test slope would have to be at least 15 m in length. A slope of this size is not feasible for most test facilities.

Testing a wheelchair's running brakes on a slope that does not have the specified coefficient of friction, or which is not subject to the specified environmental conditions, is preferable to not performing the test at all.

The test method specified in this Annex will give information on whether the wheelchair comes to a safe stop, but does not give comparable braking distance measurements. It also provides for testing on slopes greater than 10° in accordance with the claims made by the manufacturer.

C.2 Test method

This test method applies only to electrically powered wheelchairs.

a) Conduct the test on an inclined test ramp, which may be indoors or outdoors. The test ramp shall have a region inclined to the horizontal at the required inclination ± 1° of sufficient length that the wheelchair, travelling down the slope at its maximum speed, can stop within it. The term "measurement area" is used to refer to this region. The coefficient of friction of the test ramp need not conform to ISO 7176-13, but it should be dry, free from ice and loose material (such as gravel), and sufficiently flat.

   EXAMPLE 1 An inclined asphalt path.

b) Engage the motor drive system.

c) Ensure that any electrical propulsion and braking systems are at working temperature.

   NOTE 1 This may be done by driving the wheelchair in a typical pattern of usage involving stopping and starting for approximately 10 min.

d) Complete e) to h) within 5 min of completing c).

e) Drive the wheelchair forwards at maximum speed down the inclined test ramp towards the measurement area. Measure and record the maximum value of speed achieved within the measurement area as specified in ISO 7176-6.

   NOTE 2 Driving at maximum speed means that the maximum speed command is applied. It is essential that the wheelchair has reached its maximum speed at the point of measurement.

f) Stop the wheelchair within the measurement area by operating the control device as rapidly as practicable to command zero speed.

   NOTE 3 In most wheelchairs, this can be done simply by releasing the joystick. For manually operated running brakes see Annex B.

g) Determine and record whether the wheelchair comes to a stop in a safe way.

h) Record any abnormal behaviour of the wheelchair during braking, such as tipping (see 3.1), sliding (see 3.2), brake failure, or veering to one side.

i) Repeat a) to h) with the wheelchair travelling in reverse down the inclined test ramp.

j) If test results are requested for other slope inclinations, repeat a) to i) on the specified slope inclinations.

EXAMPLE 2 If the manufacturer claims a maximum operating slope greater than 10°, test at the claimed inclination.

NOTE 4 If the wheelchair fails to stop at a particular inclination of ramp, there is no need to continue testing at steeper inclinations.

C.3 Running brakes, operation by reverse command

Repeat C.2, bringing the wheelchair to a halt by operating the control device to command maximum speed in the direction opposite to that of travel.

C.4 Running brakes, emergency operation

Repeat C.2, bringing the wheelchair to a halt using the method specified by the user manual for stopping in an emergency or, if no instruction is provided, by switching off the wheelchair.

Bibliography

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

[2] ISO 9355-3, *Ergonomic requirements for the design of displays and control actuators — Part 3: Control actuators*

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