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Wheelchairs —

Part 14:
Power and control systems for electric wheelchairs — Requirements and test methods

Fauteuils roulants —

Partie 14: Systèmes d'alimentation et de commande des fauteuils roulants électriques — Exigences et méthodes d'essai

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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 7176-14 was prepared by Technical Committee ISO/TC 173, *Technical systems and aids for disabled or handicapped persons,* Subcommittee SC 1, *Wheelchairs*.

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

- Part 1: Determination of static stability

- Part 2: Determination of dynamic stability of electric wheelchairs

- Part 3: Determination of efficiency of brakes

- Part 4: Determination of energy consumption of electric wheelchairs

- Part 5: Determination of overall dimensions, mass and turning space

- Part 6: Determination of maximum speed, acceleration and retardation of electric wheelchairs

- Part 7: Method of measurement of seating and wheel dimensions

- Part 8: Requirements and test methods for static, impact and fatigue strengths

- Part 9: Climatic tests for electric wheelchairs

- Part 10: Determination of obstacle-climbing ability of electric wheelchairs

- Part 11: Test dummies

- Part 13: Determination of coefficient of friction of test surfaces

- Part 14: Power and control systems for electric wheelchairs — Requirements and test methods

- Part 15: Requirements for information disclosure, documentation and labelling

- Part 16: Requirements and test methods for resistance to ignition of upholstered parts

The following parts are also on the programme of work

- *Part 17: Serial interface for electric wheelchair controllers*

- *Part 18: Stair traversing devices*

- *Part 19: Wheeled mobility devices for use in motor vehicles*

- *Part 20: Determination of the performance of stand-up type wheelchairs*

- *Part 21: Requirements and test methods for electromagnetic compatibility of powered wheelchairs and motorized scooters*

- *Part 22: Set up procedure*

Wheelchairs —

Part 14:
Power and control systems for electric wheelchairs — Requirements and test methods

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

1 Scope

This part of ISO 7176 specifies the requirements for the power and control systems of electrically powered wheelchairs, including battery chargers, and associated test methods. It sets minimum requirements for the protection of the wheelchair user during normal use and some conditions of abuse and failure. It also specifies methods of measurement of the forces necessary to operate the controls and sets limits on the forces needed for some operations.

This part of ISO 7176 is applicable to electrically powered vehicles intended to provide indoor and outdoor mobility for disabled persons whose mass at speeds up to 15 km/h does not exceed 100 kg.

It is not applicable to electrically powered vehicles which incorporate devices that need to be connected to a domestic or industrial power supply greater than 100 volts (e.g. those with built-in battery chargers).

It does not include requirements on electromagnetic susceptibility or emissions.

NOTE — Further work is in progress by CEN/TC 293 on electromagnetic compatibility requirements for wheelchairs related to the Medical Device Directive, whilst work in ISO/TC 173/SC 1 will provide specific electromagnetic compatibility requirements for wheelchairs.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 7176. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 7176 are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 6440:1985, *Wheelchairs — Nomenclature, terms and definitions*

ISO 7176-3:1988, *Wheelchairs — Part 3: Determination of efficiency of brakes*

ISO 7176-6:1988, *Wheelchairs — Part 6: Determination of maximum speed, acceleration and retardation of electric wheelchairs*

ISO 7176-8:—[1)], *Wheelchairs — Part 8: Requirements and test methods for static impact and fatigue strengths*

ISO 7176-11:1992, *Wheelchairs — Part 11: Test dummies*

ISO 7176-15:—[1)], *Wheelchairs — Part 15: Requirements for information disclosure, documentation and labelling*

IEC 335-2-29:1994, *Safety of household and similar electrical appliances — Part 2: Particular requirements for battery chargers*

IEC 529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 601-1:1988, *Safety of medical electrical equipment — Part 1: General requirements*

3 Definitions

For the purposes of this part of ISO 7176, the definitions given in ISO 6440 together with the following apply.

3.1 battery nominal voltage: Voltage by which a battery is designated.

NOTE — The actual voltage may be significantly different under operating conditions.

3.2 command signal: Electrical signal from the device with which the user indicates the desired speed and/or direction of movement.

3.3 controller: All electrical devices, circuits, and the case(s) in which they are housed that are used to convert the user's indication of desired speed and/or direction of movement into the appropriate power to be supplied to the motor(s).

3.4 pinch point: Location at which a moving part contacts or comes in close proximity to another part such that a third part at that location would be cut or crushed.

3.5 watchdog: Circuit dedicated to monitoring the operation of a microprocessor.

3.6 battery: Set of interconnected electric cells integrated into a physical package and designated as a battery by its manufacturer.

3.7 battery pack: Removable enclosure which contains one or more batteries.

NOTE — If there are no such enclosures, a battery pack consists of a single battery.

3.8 battery set: Set of interconnected batteries used to power a wheelchair.

3.9 battery charger: Device that is connected to supply mains and to a battery set for the purpose of charging the batteries.

NOTE — This part of ISO 7176 does not apply to battery chargers which are an integral part of the wheelchair.

[1)] To be published.

4 Apparatus

4.1 Inclined test plane, fixed at 5° to the horizontal, of sufficient size to enable the tests described in 6.13.3, 6.15.3 and 6.17.3 to be performed, and with a surface of sufficient friction to cause minimal wheel slippage during the performance of those tests.

NOTE — The recommended minimum size is 5 m x 1,5 m.

4.2 Horizontal test plane, with the same high-friction surface as the inclined test plane (4.1), of sufficient size to enable the tests described in 6.11.3, 6.12.3, 6.16.3 and 7.3 to be performed.

NOTE — The recommended minimum size is 5 m x 1,5 m.

4.3 Speedometer, or other means of measuring the speed of a wheelchair within a range of 0 km/h to 15 km/h, to an accuracy of ± 5 %.

4.4 Means of measuring braking distance of a wheelchair, to an accuracy of ± 100 mm.

4.5 Direct current source, comprising a battery set, which has a voltage 1,25 times the nominal voltage of the battery set of the wheelchair to be tested $^{+2}_{0}$ V, and which has a capacity not less than that of the battery set of the wheelchair.

NOTE — Other direct current power supplies are not suitable because the wheelchair can return energy during braking.

4.6 Standard jointed test finger, as specified in figure 7 of IEC 601-1:1988 (see also figure 1 of this part of ISO 7176).

4.7 Standard unjointed test finger, of the dimensions specified in figure 7 of IEC 601-1:1988, but without joints (see also figure 2 of this part of ISO 7176), capable of attachment to a force measuring instrument (4.8).

4.8 Force measuring instrument, capable of measuring forces in the range of 0 N to 100 N in increments of 1 N with an accuracy of ± 1 % of the rated capacity.

4.9 Force measuring instrument for control devices, capable of measuring forces in a range of 0 N to 10 N in 0,1 N increments with an accuracy of ± 1 % of the rated capacity.

4.10 Positive air pressure measuring device, capable of measuring positive air pressure, relative to local atmospheric pressure, in a range of 0 kPa to 20 kPa in 200 Pa increments with an accuracy of ± 1 % of the rated capacity.

4.11 Reduced air pressure measuring device, capable of measuring reduced air pressure, relative to local atmospheric pressure, in a range of 0 kPa to –20 kPa in 200 Pa increments with an accuracy of ± 1 % of the rated capacity.

4.12 Test circuit, arranged as shown in figures 3a) and 3b) and comprising the following:

a) direct current ammeter, capable of measuring current in the range 0 mA to 10 mA in 1 mA increments with an accuracy of not less than ± 1 mA, and capable of withstanding a current of 100 mA;

b) resistor of resistance R (in ohms), calculated from the following expression:

$$R = \frac{U}{0{,}1}$$

where U is the nominal voltage of the wheelchair's battery set (in volts).

EXAMPLE

At 12 V, R is 120 Ω; at 24 V, R is 240 Ω.

The minimum power rating P (in watts) of the resistor is calculated from the following expression:

$$P = 0{,}1\ U$$

where U is the nominal voltage of the wheelchair's battery set (in volts).

c) standard unjointed test finger (see 4.7).

4.13 Circuit breaker, manually operated, capable of interrupting the maximum possible current obtainable from the battery set or batteries.

NOTE — Testing personnel may add wiring to connect to the circuit breaker. It is important that any such additional wiring does not limit the current.

4.14 Means of supporting the wheelchair, such that it is secure, with all wheels lifted off the ground and free to revolve.

4.15 Means of detecting current flow with a timing function, capable of measuring the time for which current flows to an accuracy of ± 100 ms, and the time between the occurrence of an external event and the flow of current, described in 9.3.2, to an accuracy of ± 100 ms.

NOTE — This is used to detect currents up to the maximum current delivered by the battery set under fault conditions.

5 Preparation of test wheelchair

NOTE — A more precisely defined set-up procedure for the reference configuration of adjustable wheelchairs is under development in part 22 of ISO 7176. This work may influence the reference configuration.

5.1 Wheelchair set-up

Set up the wheelchair for normal use as specified by the manufacturer.

5.2 Inflation of pneumatic tyres

If the wheelchair has pneumatic tyres, inflate them to the pressure recommended by the manufacturer. If a pressure range is recommended, inflate the tyres to the highest pressure in that range.

5.3 Adjustments

Adjust the wheelchair in accordance with the methods specified for adjustment in ISO 7176-8.

Set any controls, except those that determine the speed and/or direction of movement of the wheelchair, to the manufacturer's recommended position for driving. If there is no recommended position for any such controls, set them to the mid-position.

5.4 Batteries

Fit batteries of the size and type recommended by the wheelchair manufacturer. Charge the batteries to not less than 75 % of their rated capacity.

5.5 Loading the wheelchair

Load the wheelchair using one of the following:

a) one of the dummies specified in ISO 7176-11 of mass equal to, or the next size greater than, the maximum mass of occupant recommended by the manufacturer; or

b) a human test occupant, combined with a mass evenly distributed over the seat of the wheelchair such that the total is within $^{+2}_{0}$ kg of the mass of the appropriate dummy specified in item a).

Where a human test occupant is used, it is essential that appropriate precautions be taken to ensure the person's safety.

5.6 Records

For each test record the following information:

a) the wheelchair equipment specified for the test;

b) the position of any adjustable parts of a body support system;

c) the battery manufacturer and battery type reference; and

d) the mass and configuration of the dummy or human load.

6 Electrical systems

NOTE — The tests used to verify the requirements given in this clause can be performed in any order unless otherwise stated in the test procedures. Any modifications made to the wheelchair while a test is being conducted should be reversed before beginning the next test. Any parts of the wheelchair damaged while a test is being conducted should be repaired or replaced before beginning the next test.

6.1 Battery connection and circuit protection diagram

A diagram shall be clearly visible when the batteries are uncovered. It shall be permanently attached to a surface as close as possible to the batteries.

NOTE — The diagram should be protected from deterioration from battery gases and acid.

The diagram shall show the following:

a) connections to the batteries with the identification of the wires and terminals;

b) the location and pictorial instructions for use of all circuit breakers and fuses intended to be serviced by the user or an attendant; and

c) the current rating and type of any fuses.

6.2 Colour and marking of wires connected to the batteries

All wires connected to the positive terminal of the most positive battery pack shall be red and permanently marked with a '+' symbol.

All wires connected to the negative terminal of the most negative battery pack shall not be red and be permanently marked with a '–' symbol.

Other wires connected to batteries shall not be red.

6.3 Electrical isolation of wheelchair

6.3.1 General

The chassis of an electric wheelchair should not be connected to the battery set or any other part of the electrical system of the wheelchair except by high d.c. impedance circuits. This will reduce the risk of fire that could be caused by a short circuit between parts in the electrical system and the chassis but will allow the use of the chassis for circuits which are intended to provide electromagnetic interference protection or electrostatic discharge protection.

6.3.2 Requirements

The wheelchair frames, motor cases, gearbox cases, battery cases and the controller cases shall not be connected to the battery set or any other part of the electrical system except by a circuit with a d.c. impedance of not less than 10 kΩ.

When tested in accordance with 6.3.3 the ammeter in the test circuit shall not indicate a current of more than 5 mA.

NOTE — This current limit indicates a d.c. impedance within the specified value.

6.3.3 Test procedure

6.3.3.1 General

Using the necessary means (see 4.14), support the wheelchair so that it is secure, with the drive wheels lifted off the ground and free to revolve.

6.3.3.2 Positive connection test

Identify all the electrically conducting parts of the chassis that can be touched by the test finger of the circuit described in 4.12 and shown in figure 3a).

Remove paint or other protective coating from part of the wheelchair frame and electrically connect the test finger of the circuit described in 4.12 as shown in figure 3a).

Operate control devices to drive each motor on the wheelchair, one at a time, at maximum speed, in each direction.

Apply the test finger in turn to all the electrically conductive parts of the chassis that it can touch and check that the ammeter in the test circuit does not indicate a current of more than 5 mA ± 1 mA.

6.3.3.3 Negative connection test

Repeat the test described in 6.3.3.2 except connect the test circuit described in 4.12 as shown in figure 3b).

6.4 Fuses

When changing fuses that do not need a tool for access, it shall not be possible to touch electrically live leads or terminals exposed during this procedure to any other part of any electrical circuit.

6.5 Interchangeability of connectors

Connectors provided for use by the wheelchair occupant or attendant shall be impossible to connect in a manner that will cause operation different from that specified by the manufacturer.

NOTE — Suitable methods include:

- plug and socket shapes that only permit correct assembly;

- length of wire to plugs and sockets that only permits correct assembly.

Connectors shall not simply be colour coded to identify correct assembly.

It shall not be possible to connect any connector intended for operation at or below the battery set nominal voltage to any socket intended for domestic or industrial electrical power distribution.

6.6 Attachment and positioning of wiring

6.6.1 General

Protruding wires from the wheelchair can be damaged by moving parts or snag objects that the wheelchair passes. This could cause malfunction of the wheelchair or damage the objects.

6.6.2 Requirements

All wires shall be routed and secured in such a manner that they cannot be snagged on furniture or any other protrusion or be damaged by, or interfere with, any moving part of the wheelchair.

When examined and tested in accordance with 6.6.3 it shall be demonstrable that no wires could

a) be snagged on furniture or any other protrusion;

b) be damaged by parts that move; or

c) be trapped in any pinch points.

6.6.3 Test procedure

Examine all wires to see if they can be damaged by, or interfere with, any moving parts of the wheelchair.

Pull all wires towards parts that move and any pinch points with a force of 10 N ± 1 N.

If the wheelchair is of variable configuration (e.g. adjustable back rest), repeat the procedure for all possible configurations.

6.7 Protection from non-insulated electrical parts

6.7.1 General

A wheelchair occupant or attendant shall not be burned or given an electrical shock, or the wheelchair caused to malfunction by contacting non-insulated electrical parts.

Battery terminals should be insulated when connected.

6.7.2 Requirement

When tested in accordance with 6.7.3, it shall not be possible for a test finger to touch non-insulated electrical parts except those protected by a circuit with a d.c. impedance of not less than 10 kΩ (see 6.3.2).

6.7.3 Test procedure

Apply the standard unjointed test finger (4.7) to all openings from every possible position with a force of 30 N ± 1 N.

If the finger enters any opening, use the standard jointed test finger (4.6) in every possible position, with all joints bent and then with all joints straight to determine if any non-insulated electrical part can be touched.

6.8 Short-circuit protection

6.8.1 General

Wheelchair batteries contain a large amount of energy which can cause fires if they are short circuited. Protection shall be provided as close as possible to the batteries to protect the wheelchair occupant.

6.8.2 Requirements

Short-circuit protection shall be provided as close as possible to each battery pack. When tested in accordance with 6.8.3, a circuit protection device shall disconnect all wheelchair circuits from each battery pack under short circuit conditions.

Circuit protection devices shall not be of the automatic resetting type.

6.8.3 Test procedure

WARNING: This test can be hazardous. It is essential that appropriate safety precautions be taken to protect test personnel.

Check that the circuit protection devices are of the type that need to be reset or replaced manually.

Disconnect the controller and any other electrical device(s) from each battery pack but leave the main leads from the battery packs in place.

Repeat the following test procedure for each battery pack on the wheelchair, one at a time.

a) Determine the point closest to the battery pack where the positive and negative wires from the battery pack, or their insulation, can be pulled into contact with a force less than 10 N ± 1 N. At this point connect the positive and negative wires to the circuit breaker (4.13) so that the wires will be connected together when the circuit breaker is closed. Ensure that the circuit breaker is positioned so that the tester can operate it without personal hazard.

WARNING: It is essential that the tester be prepared to open the circuit breaker quickly if circuit protection devices do not operate.

b) Close the contacts of the circuit breaker.

c) Observe and record if the circuit protection device fails to operate.

d) Open the contacts of the circuit breaker.

e) Observe and record if the circuit protection device resets automatically.

6.9 Safety when charging batteries

6.9.1 General

Battery chargers are connected to supply mains and explosive gas can be generated when charging the battery set. Electrical fires from short circuits, explosions caused by sparks igniting the gas, and mechanical damage or injury might occur if the wheelchair moves while the battery charger is connected to the battery set.

6.9.2 Requirement

When tested in accordance with 6.9.3, it shall not be possible to drive the wheelchair.

6.9.3 Test procedure

Connect the battery charger to the battery set and supply mains in accordance with the manufacturer's instructions and switch it on.

Switch on the wheelchair controller and attempt to drive the wheelchair. Record any movement of the wheelchair.

Repeat the procedure with the battery charger disconnected from supply mains.

6.10 Reversed polarity at the battery

6.10.1 General

During maintenance and new battery installation there is a possibility of connecting batteries with reversed polarity. This could cause damage to the wheelchair controller and possibly cause a fire.

6.10.2 Requirements

When tested in accordance with 6.10.3:

a) with the battery set connections reversed, there shall be no damage to the controller or any part of the drive system other than blown fuses and if the wheelchair operates, it shall be in accordance with the manufacturer's specification with no uncontrolled or unwanted movements;

b) after reconnection of the battery set to the original configuration the wheelchair shall operate in accordance with the manufacturer's specification.

NOTE — Circuit protection devices may need to be reset or replaced before the wheelchair can be operated after reverse polarity battery set connection.

6.10.3 Test procedure

WARNING: This test can be hazardous. It is essential that appropriate safety precautions be taken to protect test personnel.

Disconnect the battery set and connect the circuit breaker (4.13) into the wires from the battery set. Position the circuit breaker so that it can disconnect the battery set without hazard to test personnel.

Ensure that the wheelchair main power is off and that all control devices are in the neutral position.

Make any necessary modifications to the wires, and connect them in reversed polarity to the battery set.

Switch on the wheelchair main power and operate all the control devices. Record any uncontrolled or unwanted movements.

Disconnect the battery set, examine the electrical system and record any damage other than blown fuses.

Reconnect the battery set in the original configuration. Replace or reset any circuit protection devices that have operated.

Check and record if the wheelchair operates in accordance with the manufacturer's specification.

6.11 Controller overvoltage protection

6.11.1 General

At the conclusion of a charging cycle, batteries can exceed their nominal voltage. Wheelchairs should not malfunction under these overvoltage conditions.

6.11.2 Requirements

When tested in accordance with 6.11.3.2:

a) the controller shall not fail or operate in a manner that results in uncontrolled movement of the wheelchair; and

b) there shall be no abnormal movement of the wheels, other than to stop, or any damage to the controller, other than blown fuses.

6.11.3 Test procedure

6.11.3.1 Preparation

WARNING: This test is carried out in order to ensure the safety of the test personnel by detecting if the wheels turn and therefore if the wheelchair is likely to move.

Disconnect the wheelchair's battery set and connect the d.c. source (4.5) in its place via the circuit breaker (4.13).

Support the wheelchair by suitable means (4.14) so that it is secure with the drive wheels lifted off the ground and free to revolve.

Switch on the d.c. source and operate all the control functions and note if there is any movement of the drive wheels which might cause dangerous movement of the wheelchair if the wheels were in contact with the ground.

Switch off the d.c. source. Replace or reset any circuit protection devices that have operated.

6.11.3.2 Test

Position the wheelchair on the horizontal test plane (4.2).

WARNING: Take any necessary precautions to protect the tester and wheelchair occupant from any movement noted during the procedure in 6.11.3.1.

Switch on the d.c. source and record details of any unwanted or uncontrolled movement of the wheelchair.

Operate all the control functions and record any malfunction. Restrict all movements to less than 2 m.

Record if any circuit protection devices operate.

Remove the d.c. source and reconnect the wheelchair's battery set.

Reset or replace any circuit protection devices that have operated.

Operate all the control functions including brake operation and record any malfunction.

Examine the controller and record any damage.

6.12 Controller command signal processing failures

6.12.1 General

It is important that an open-circuit or short-circuit command signal failure does not result in loss of control of the wheelchair other than to bring it to a stop.

6.12.2 Requirements

Provision shall be made to ensure that an open-circuit or short-circuit command signal failure does not:

a) result in loss of control of the wheelchair other than to stop;

b) prevent the wheelchair from stopping when the control device is put in its stop position.

When tested in accordance with 6.12.3.2 and 6.12.3.3, the wheelchair shall not tip over, and shall stop within a distance not exceeding

$$D = 1{,}3\ L_H$$

where

D is the braking distance (in metres);

L_H is the braking distance at maximum speed on a horizontal plane as measured by the method described in ISO 7176-3 (in metres).

6.12.3 Test procedure

WARNING: This test can be hazardous. It is essential that appropriate safety precautions to protect test personnel be taken. A wide test area is needed as the wheelchair may start moving at maximum speed in an uncontrolled way.

6.12.3.1 Preparation

If not previously determined, measure the maximum speed, v, of the wheelchair on a horizontal surface by the method specified in ISO 7176-6.

If not previously determined, measure the braking distance L_H, at speed v of the wheelchair on the horizontal test plane (4.2) by the method specified in ISO 7176-3.

Connect the circuit breaker (4.13) between the battery set and the wheelchair controller.

Make provision for the wheelchair to be driven on the horizontal test plane at a speed of 0,5 v to an accuracy of ± 5 %.

NOTE — This may be achieved by means of stops on the joystick control.

Examine the circuit diagram of the wheelchair to determine which conductors from the control device are involved in the speed and/or direction control of the wheelchair and which conductors supply power and/or reference signals to the control device.

Position a marker on the test plane from which the braking distance can be measured.

6.12.3.2 Open-circuit test

Repeat the following procedure for each of the conductors identified in 6.12.3.1.

Switch off the controller and disconnect it from the battery set. Disconnect the conductor to be tested and connect it via a switch back to its original connection. Close the switch and reconnect the battery set.

Switch on the controller. Note the position of the marker on the test plane and drive the wheelchair in a straight line towards it until a speed of 0,5 v is achieved. When the marker is reached open the switch.

NOTE — It is important that the means for measuring the speed and braking distance give the required accuracy. Suitable methods include:

a) a photocell operated interrupting switch capable of detecting reflective tape or a light source on the test plane;

b) a 'fifth wheel' capable of recording the distance travelled where the recording device can be started by the interrupting switch.

Measure along the centreline of the track of the driving wheels the distance taken to stop to an accuracy of ± 100 mm.

Switch off the controller and close the switch.

Reset and/or replace any circuit protection devices.

Switch on the controller. Note the position of the marker on the test plane and drive the wheelchair towards it in a straight line until a speed of 0,5 *v* is achieved. When the marker is reached, open the switch and put the control device to its stop position.

Measure along the centre line of the track of the driving wheels the distance taken to stop to an accuracy of ± 100 mm.

Examine the controller and record any damage.

Reset and/or replace any circuit protection devices.

6.12.3.3 Short-circuit test

Switch off the controller and disconnect the battery set.

From those conductors identified in 6.12.3.1, make provision for connecting two conductors together via a switch without changing the original connections (to simulate a short circuit).

Open the switch and reconnect the battery set.

Switch on the controller. Note the position of the marker on the test plane and drive the wheelchair in a straight line towards it until a speed of 0,5 *V* is achieved. When the marker is reached close the switch.

Measure along the centreline of the track of the driving wheels the distance taken to stop to an accuracy of ± 100 mm.

Switch off the controller and open the switch.

Reset and/or replace any circuit protection devices.

Switch on the controller. Note the position of the marker on the test plane and drive the wheelchair towards it in a straight line until a speed of 0,5 *v* is achieved. When the marker is reached, close the switch and put the control device to its stop position.

Measure along the centreline of the track of the driving wheels the distance taken to stop to an accuracy of ± 100 mm.

Examine the controller and record any damage.

Reset and/or replace any circuit protection devices.

Repeat the test for every combination of two conductors from those identified in 6.12.3.1.

6.13 Controller output device failure

6.13.1 General

It is important that the failure of any output device does not result in loss of control of the wheelchair other than to stop.

6.13.2 Requirements

Provision shall be made to ensure that the failure of any output device will not result in loss of control of the wheelchair other than to stop.

When tested in accordance with 6.13.3.2 and 6.13.3.3, the wheelchair shall

a) not tip over;

b) stop within a distance of 1,3 L_i, either

1) when the switch is operated (either opened or closed, depending on whether the short-circuit or open-circuit test is being conducted) at the marker, or

2) where it fails to stop under the conditions in item 1), when the switch is operated and the control device is put to its stop position at the marker,

where L_i is the braking distance, at speed v as defined in 6.12.2, on the inclined test plane, as measured by the method described in ISO 7176-3 (in metres).

6.13.3 Test procedure

WARNING: This test can be hazardous. It is essential that appropriate safety precautions be taken to protect test personnel. A wide test area is needed since the wheelchair may start moving at maximum speed in an uncontrolled way.

6.13.3.1 Preparation

If not previously determined, measure the maximum speed, v, of the wheelchair on a horizontal surface by the method specified in ISO 7176-6.

If not previously determined, measure the maximum braking distance, L_i, at speed v, of the wheelchair on the inclined test plane (4.1) by the method specified in 7.2.3 of ISO 7176-3:1988.

Position a marker on the test plane from which the braking distance can be measured.

Make provision for the wheelchair to be readily driven on the inclined test plane at a speed of 0,5 v to an accuracy of ± 5 %; e.g. by means of stops on the joystick control.

Connect the circuit breaker (4.13) between the battery set and the wheelchair controller.

Examine the circuit diagram of the wheelchair and determine:

a) which devices carry and regulate the current to the driving motors and any steering motors;

b) which, if any, circuit protection devices protect the respective devices and the recommended current ratings for these circuit protection devices.

c) whether the wheelchair has two driving motors, one for the left side of the wheelchair and one for the right side, and whether the circuits that regulate the power for the left and the right motor are identical.

If item c) is applicable, the devices which carry and regulate current for only one driving motor need be tested.

In the procedures given in 6.13.3.2 and 6.13.3.3, it is assumed that a switch can be connected to the device that carries the current to a driving or steering motor. This is often impractical. In such cases, the switch may be connected to one of the conductors in the control circuit that determines whether the device will be in its on or off state. In these cases, the switch has only to be able to carry the controlling current for the device. Refer to the manufacturer for advice.

Refer to the manufacturer for advice on the maximum current that could flow when any output device becomes a short circuit or an open circuit.

6.13.3.2 Short-circuit test

Repeat the following procedure for each of the devices identified in item a) of 6.13.3.1.

Switch off the controller and disconnect it from the battery set. Connect a suitably rated switch to simulate a short circuit in the device. Open the switch and reconnect the battery set.

Figures 4a) and 4b) illustrate typical circuits.

Switch on the controller. Note the position of the marker on the test plane and drive the wheelchair in a straight line towards it until a speed of 0,5 v is achieved. When the marker is reached close the switch.

Measure along the centreline of the track of the driving wheels the distance taken to stop to an accuracy of ± 100 mm.

Switch off the controller and open the switch.

Reset and/or replace any circuit protection devices.

If the wheelchair does not stop within a distance of 1,3 L_1, repeat the test procedure except close the switch before the marker is reached. When the marker is reached, put the control device to its stop position.

Measure along the centreline of the track of the driving wheels the distance taken to stop to an accuracy of ± 100 mm.

Examine the controller and record any damage.

Reset and/or replace any circuit protection devices.

6.13.3.3 Open-circuit test

Repeat the following procedure for each of the devices identified in item a) of 6.13.3.1.

Switch off the controller and disconnect it from the battery set. Connect a suitably rated switch to simulate an open circuit in the device. Close the switch and reconnect the battery set.

Figures 4a) and 4c) illustrate typical circuits.

Switch on the controller. Note the position of the marker on the test plane and drive the wheelchair in a straight line towards it until a speed of 0,5 *v* is achieved. When the marker is reached, open the switch.

Measure along the centreline of the track of the driving wheels the distance taken to stop to an accuracy of ± 100 mm.

Switch off the controller and close the switch.

Reset and/or replace any circuit protection devices.

If the wheelchair does not stop within a distance of 1,3 L_i, repeat the test procedure except open the switch before the marker is reached. When the marker is reached, put the control device to its stop position.

Measure along the centreline of the track of the driving wheels the distance taken to stop to an accuracy of ± 100 mm.

Examine the controller and record any damage.

Reset and/or replace any circuit protection devices.

6.14 Stalled condition protection

6.14.1 General

When a wheelchair is driven against an obstacle like a high curb, the motor or motors may be stalled. If the driver tries to continue to drive when a motor is stalled, high currents will flow and the motor(s) could overheat and be damaged permanently. The wheelchair is to be protected against such damage.

6.14.2 Requirements

Circuit protection devices that immobilize the wheelchair shall not operate in less than 15 s after the wheelchair is stalled with a maximum speed command signal applied.

After being stalled for a period of 3 min with a maximum speed command signal applied, the wheelchair shall operate in accordance with the manufacturer's specification.

When tested in accordance with 6.14.3:

a) current shall flow in the motor windings for at least 15 s before the initial break in current;

NOTE — The period during which current flows in subsequent cycles may be less than 15 s.

b) no fuse shall blow that immobilizes the wheelchair; and

c) any resettable circuit protection devices shall be capable of being operated not less than five times consecutively without damage.

On completion of the test in accordance with 6.14.3:

d) the wheelchair shall operate in accordance with the manufacturer's specification; and

e) no part of the drive system shall be damaged.

6.14.3 Test procedure

Condition the wheelchair in an ambient temperature of 20 °C ± 2 °C for 24 h prior to testing.

If the test area is at a temperature other than 20 °C ± 2 °C commence the test within 15 min of removal of the wheelchair from the conditioning atmosphere.

Mechanically lock the position of the wheelchair so that movement of the drive wheels is prevented when full drive power is applied in the forward direction.

Fit a means of detecting whether current is flowing in the motor windings and measuring the time for which that current flows (4.15).

Put the control device to the position for maximum forward speed and hold it in that position for 3 min or until the current to the motors is cut off. If the current is cut off, record the time for which it flowed.

If the wheelchair is fitted with manually reset protective devices, reset them in accordance with the manufacturer's instructions and repeat the test as many times as possible, up to a maximum of five test cycles, during a total period of 3 min from the time the current first flows.

If the wheelchair is fitted with automatically reset protective devices, take such steps as necessary to permit the devices to reset (e.g. returning the control device to neutral; see manufacturer's instructions), and repeat the test as many times as possible, up to a maximum of five test cycles, during a total period of 3 min from the time current first flows.

Complete any test cycle started within the 3 min test period.

Remove the means of locking the position of the wheelchair. Reset or replace any circuit protection devices that have operated.

Operate all the control functions and examine all parts of the drive system and record any damage or abnormal operation.

Record if any fuse blew during the test which would leave the wheelchair immobilized.

6.15 Ability to stop when power is switched off or lost

6.15.1 General

The power to a wheelchair can be unintentionally switched off or lost while the wheelchair is being driven. If this happens on a slope, the wheelchair can start rolling in an uncontrolled way.

Controllers with regenerative braking may generate enough power on a downhill slope to keep the controller operating even if the battery set is disconnected. A wheelchair could therefore react in this situation just as if power is not disconnected.

If power to the wheelchair is lost it should stop automatically or otherwise react in a safe way.

6.15.2 Requirements

With the wheelchair travelling at its maximum speed down a slope, when the power supply is interrupted it shall either:

a) stop in a distance not exceeding 1,3 L_{lmax}; or

b) stop in a distance not exceeding 1,3 L_{lmax} as soon as any steering control device is changed from the straight ahead position; or

c) be capable of being steered normally until the control device is put to the stop position, after which it shall stop in a distance not exceeding 1,3 L_{lmax};

where L_{lmax} is the braking distance at maximum speed on the inclined test plane, as measured by the method described in ISO 7176-3 (in metres).

When tested in accordance with 6.15.3, the average braking distance of the wheelchair shall not exceed 1,3 L_{lmax} and the steering response throughout the test shall be in accordance with the manufacturer's specification.

6.15.3 Test procedure

WARNING: This test can be hazardous. It is essential that appropriate safety precautions are taken to protect test personnel. A wide test area is needed since the wheelchair may fail to stop when moving at maximum speed.

Conduct this test within 10 min of completion of the test in described in 6.14.3.

NOTE — This is to ensure that the test is performed while the drive system is still warm.

Make provision for the wheelchair to be readily driven down the inclined test plane (4.1) at the maximum speed the wheelchair can achieve.

Position a marker on the inclined test plane from which the braking distance can be measured.

If not previously determined, measure the maximum braking distance, L_{lmax}, of the wheelchair on the inclined test plane, at the maximum speed the wheelchair can achieve, by the method specified in ISO 7176-3.

Connect the circuit breaker (4.13) between the battery set and the wheelchair controller.

Switch on the controller. Note the position of the marker on the test plane and drive the wheelchair in a straight line down the plane towards it until maximum speed is achieved. When the marker is reached, open the circuit breaker with the speed control still in its maximum position.

If the wheelchair stops, measure along the centreline of the track of the driving wheels the distance taken for the wheelchair to stop to an accuracy of ± 100 mm.

WARNING: Some controllers permit regenerated power from the motors to hold the brakes in the 'off' position.

If the wheelchair does not stop, or does not stop within a distance of 1,3 L_{lmax}, repeat the test procedure except before the marker is reached open the circuit breaker, then when the marker is reached, steer the wheelchair to one side while maintaining the speed control in its maximum position. Note the steering response.

If the wheelchair stops, measure along the centreline of the track of the driving wheels the distance taken to stop to an accuracy of ± 100 mm.

If the wheelchair does not stop, or does not stop within a distance of 1,3 L_{lmax}, but the steering response is normal, repeat the test except steer the wheelchair to the other side. If the wheelchair does not stop, note if the steering response is normal.

If the wheelchair stops, measure along the centreline of the track of the driving wheels the distance taken to stop to an accuracy of ± 100 mm.

If the wheelchair still does not stop within a distance of 1,3 L_{lmax} but the steering response is normal, repeat the test procedure except before the marker is reached open the circuit breaker, then when the marker is reached, return the speed control to its stop position.

If the wheelchair stops, measure and record the distance to an accuracy of ± 100 mm.

Examine the controller and record any damage (e.g. fused relay contacts, welded contacts on power switch, etc.).

Repeat the procedure twice for the method which yields an effective means of stopping.

Calculate and record the average braking distance from the three measurements.

6.16 Controller microprocessor watchdog

6.16.1 General

Modern controllers often include a microprocessor. Usually a processor receives information from the wheelchair's control devices such as switches and/or the joystick. Then, according to its program, activates motors and other equipment in the wheelchair. If the processor fails, it could activate any device in the wheelchair at random. Because such a fault situation could be very dangerous, the system should have a "watchdog" that will detect a failure of the processor and take appropriate action to prevent injury to the driver and damage to the wheelchair.

6.16.2 Requirements

If the controller of the wheelchair uses a microprocessor, provision shall be made to ensure that failure of the microprocessor or its associated components does not result in uncontrolled movement of the wheelchair and its actuators that could injure the driver or damage the wheelchair. The brakes shall automatically be applied if the microprocessor fails.

When tested in accordance with 6.16.3.2, the wheelchair shall stop within a distance of 1,3 L_H (see 6.12.2). When tested in accordance with 6.16.3.3, the motor(s) shall stop within 1,5 s.

6.16.3 Test procedure

WARNING: This test can be hazardous. It is essential that appropriate safety precautions be taken to protect test personnel. A wide test area is needed since the wheelchair may start moving at maximum speed in an uncontrolled way.

6.16.3.1 Preparation

If not previously determined, measure the maximum speed, *v*, of the wheelchair on a horizontal surface by the method specified in ISO 7176-6.

If not previously determined, measure the braking distance L_H, at speed v of the wheelchair on the horizontal test plane (4.2) by the method specified in ISO 7176-3.

Connect the circuit breaker (4.13) between the battery set and the wheelchair controller.

Make provision for the wheelchair to be readily driven on the horizontal test plane at a speed of 0,5 v to an accuracy of ± 5 %; e.g. by means of stops on the joystick control.

Identify the clock input to the microprocessor and the microprocessor ground.

Switch off the controller and disconnect it from the battery set. Make provision for connecting the clock input to the microprocessor to the microprocessor ground via a switch. Open the switch and reconnect the battery set.

Position a marker on the test plane from which the braking distance can be measured.

6.16.3.2 Watchdog: drive motors

Switch on the controller. Note the position of the marker on the test plane and drive the wheelchair in a straight line towards it until a speed of 0,5 v is achieved. When the marker is reached, close the switch and put the control device to its stop position.

Measure along the centreline of the track of the driving wheels the distance taken to stop to an accuracy of ± 100 mm.

Switch off the controller and open the switch.

Repeat this test for each microprocessor.

6.16.3.3 Watchdog: actuator motors

Determine whether the wheelchair has any motor controlled by the microprocessor other than the drive motors where the unexpected operation of this motor could injure the operator. If it does, repeat the tests for each such motor, one at a time.

Place the wheelchair on the horizontal test plane.

Switch on the controller and set the control device to drive the motor.

Close the switch to connect the clock input previously identified to the microprocessor ground. Immediately after the connection is made put the control device to its stop position.

Note whether the motor stops within 1,5 s.

Switch off the controller and open the switch.

Repeat this test for each microprocessor.

6.17 Safety with discharged battery

6.17.1 General

The wheelchair should not exhibit unsafe responses when the battery set nears depletion.

6.17.2 Requirements

The wheelchair shall not deviate from its intended path, when fitted with batteries recommended by the manufacturer, until the chair stops due to lack of battery capacity.

When tested in accordance with 6.17.3:

a) the wheelchair shall not deviate from the intended path by more than 1 m in any direction;

b) no motor, other than a drive motor, shall exhibit any unintended movement.

6.17.3 Test procedure

WARNING: This test can be hazardous. It is essential that appropriate safety precautions be taken to protect test personnel.

6.17.3.1 Preparation

Fit the highest internal resistance batteries specified by the wheelchair manufacturer (usually these will be the lowest capacity gel-type cells).

Charge the battery set to between 10 % and 30 % of its rated capacity.

Position the wheelchair on the inclined test plane (4.1) facing up the slope.

6.17.3.2 Upslope test

Drive the wheelchair up the slope in a straight line for a distance of not less than 4 m.

Without pausing, move the control device to reverse down the slope.

Reverse in a straight line down the slope to the starting point $^{+1}_{0}$ m.

Without pausing, move the control device to drive up the slope.

Repeat the procedure until the wheelchair does not move.

Switch off the controller. Wait for 3 min, then switch on the controller.

Repeat the procedure until the wheelchair does not move after the 3 min wait.

6.17.3.2 Downslope test

Recharge the battery set to between 10 % and 30 % of its rated capacity.

Repeat the procedure given in 6.17.3.1 except with the wheelchair facing down the slope.

7 Non-powered mobility test

7.1 General

In the event of the loss of electrical power, an attendant should be able to move the wheelchair easily.

7.2 Requirements

The force required to move the wheelchair in a straight line on the horizontal without electrical power shall not exceed 100 N.

Where there is provision for the drive or automatic braking system to be disengaged, for disengagement it shall not:

a) require any component to be detached;

b) affect any adjustment of the transmission;

c) require the use of tools;

d) require the use of force exceeding 60 N.

It shall not be possible for the drive or automatic braking system to be partially engaged.

If the automatic braking system is disengaged, and electrical power is restored, it shall not be possible to drive the wheelchair unless a visual and/or auditory alarm is activated.

When tested in accordance with 7.3:

a) the average force necessary to operate the means for drive or brake disengagement shall not exceed 60 N;

b) the average force necessary to move the loaded wheelchair shall not exceed 100 N;

c) when electrical power is restored and any automatic brakes are still disengaged, the wheelchair shall not drive unless a visual and/or auditory alarm is activated.

7.3 Test procedure

Place the wheelchair on the horizontal test plane (4.2).

Disconnect the battery set from the wheelchair controller.

Use a force measuring instrument (4.8) to measure the force required to operate any means for disengaging the drive or braking system.

Figure 5 illustrates methods of applying force gauges to knobs and levers.

Take three measurements in this way for each device and record the average of the three.

Operate any devices that disengage the drive and braking system.

With any castor wheels placed in a trailing position and any steered wheels in the straight ahead position use a force measuring instrument (4.8) to apply equal horizontal forces to the push handles or back of the loaded wheelchair in a way that simulates pushing straight ahead by an attendant.

Slowly increase the pushing force until the wheelchair starts to move and note the force indicated by the force measuring instrument.

Take three measurements in this way and record the average of the three.

WARNING: This test can be hazardous. It is essential that appropriate safety precautions be taken to protect test personnel. A wide test area is needed since the wheelchair may start moving without any means of braking.

Reconnect the battery set to the wheelchair controller and re-engage the drive.

Where possible with the automatic brakes still disengaged, operate all drive controls and observe if the wheelchair drives and whether a visual and/or auditory alarm is activated.

8 Safety guard test

8.1 General

It is important that any moving parts that can injure the user be guarded. However, it is not possible to totally avoid pinch points on devices such as power adjusted seat positioners and so such devices should stop as soon as the control is released.

8.2 Requirements

When tested in accordance with 8.3, it shall not be possible to touch the following:

a) any power driven parts of the propulsion system, except the wheels and up to 50 mm of their axles;

b) any gears, drive belts, pulleys, chains or other drive mechanisms which create a pinch point or could injure a user or trap loose clothing;

c) any shaft which rotates more than two revolutions during its total cycle of operation.

NOTE 1 It is usual for moving parts associated with changing the configuration of the wheelchair to stop automatically when the control input is removed.

NOTE 2 For wheelchairs with such moving parts which do not stop automatically when the control input is removed, information should be provided which will explain the possible hazards to the user, prescriber and/or attendant.

8.3 Test procedure

Apply the unjointed standard test finger (4.7), with a force of 30 N ± 1 N, to all openings and places where an occupant or attendant may contact or be pinched by a moving part. Note these openings and places.

Apply the jointed standard test finger (4.6) to all noted openings and places, in every possible position with all joints bent and then with all joints straight to determine if any of the parts listed in items a) to c) of 8.2 can be touched.

9 Battery chargers

9.1 General

Battery chargers need to be provided with a means to prevent accidental change of output voltage or battery type in cases of poor vision or manipulative skills of the user.

Expensive batteries are easily damaged by incorrect charging so it should be clear for which type of battery the charger is set.

Both the battery set and charger can be damaged by reverse polarity connection if protection is not provided. Even with polarized plug-socket combinations, mistakes can be made when fitting replacement batteries.

It is important to users that they know that their battery set can be recharged overnight so this information should be given on the battery charger.

If a charger is connected to a battery set that gives off flammable gas, and current flows immediately, sparks may ignite the gas. It is therefore essential that a delay <SNP> occurs between the connection of the battery set to the charger, and the flow of current, to prevent such sparks.

9.2 Requirements

9.2.1 General

Battery chargers that are not mounted on the wheelchair and that are intended for wheelchair batteries shall meet the requirements of Class 2 of IEC 335-2-29 and shall be moisture resistant to IEC 529-IPX1 (drip proof).

In addition, battery chargers shall conform to the requirements given in 9.2.2 to 9.2.7.

9.2.2 **Battery chargers having more than one rated output voltage** (manual selection only)

NOTE — This subclause does not apply to battery chargers which have an automatic output voltage selection device.

It shall not be possible to change the voltage setting of the battery charger without the aid of a tool, key entry combination or similar means of restricting access. If the means of restricting access is other than a tool, it shall not consist of operations which are performed in normal use of the charger.

9.2.3 **Battery chargers which are suitable for more than one type of battery** (manual selection device only)

NOTE — This subclause does not apply to battery chargers which have an automatic battery type selection device.

The selected battery type shall be conspicuously marked on the outside of the case. It shall not be possible to change the charging characteristics without a tool, key entry combination or similar means of restricting access. If the means of restricting access is other than a tool, it shall not consist of operations which are performed in normal use of the charger.

9.2.4 Indication of correct connection

The charger shall clearly indicate when it is correctly connected to a battery set.

9.2.5 Reverse polarity connection

Reverse polarity connection of the charger to a battery set shall not damage the charger and excessive current shall not flow from the battery set under this condition.

NOTE — Circuit protection devices may need to be reset or replaced before the charger will operate normally after reverse polarity connection.

When tested in accordance with 9.3.1:

a) the current that flows to discharge the battery set shall be no greater than 100 mA;

b) there shall be no damage to the battery set after reverse polarity connection and following resetting and/or replacement of any circuit protection devices the battery charger shall operate as specified by the manufacturer.

9.2.6 Charging

The charger shall charge the battery set to 80 % of the rated capacity in a period not exceeding 8 h.

The charger shall be labelled to indicate the rated capacity of the battery set that it is capable of charging to 80 % of the rated capacity in a period not exceeding 8 h.

When tested in accordance with 9.3.3, the measured charge of the battery set after charging for 8 h shall not be less than 80 % of the rated capacity of the battery set.

9.2.7 Chargers for batteries that give off flammable gas

For chargers for batteries that give off flammable gas, there shall be a delay of not less than 0,5 s before charging commences when connection to the battery set is made after the charger has been switched on.

When tested in accordance with 9.3.2 the delay between the connection of the battery set and the flow of current shall be at least 0,5 s.

9.3 Test procedures

WARNING: These tests can be hazardous. It is essential that appropriate safety precautions be taken to protect test personnel.

9.3.1 Protection against reverse polarity connection

Make provision for connecting the battery set to the battery charger with reverse polarity.

Connect into the battery charger output circuit a device that will detect a flow of current (4.15) between the charger and the battery set.

With the battery charger not connected to supply mains, connect the battery set to the battery charger with reverse polarity. Note if any current greater than 100 mA flows in the battery charger output circuit, discharging the battery set.

Connect the battery charger to supply mains, switch it on, and note if any current greater than 100 mA flows in the battery charger output circuit, discharging the battery set.

Disconnect the battery charger from supply mains and from the battery set, examine it and record any damage.

If the battery charger is undamaged, reset or replace any circuit protection devices. Reconnect the battery charger to the supply mains and battery set in accordance with the manufacturer's instructions and check and record if it operates correctly.

9.3.2 Delay before the output circuit is energized

Connect into the battery charger output circuit a device (4.15) that will detect the flow of current between the battery charger and the battery set. Set up the timing device to measuring the time taken for the charging current to flow after the battery charger is connected to the battery set.

Connect the battery charger to supply mains.

Switch on the charger.

Connect the charger to the battery set.

Measure and record the time taken before the output current flows.

9.3.3 Charging capability

Select a battery of the type and size indicated by the battery charger manufacturer as being capable of being charged to 80 % of the rated capacity in a period not exceeding 8 h and recommended by the wheelchair manufacturer for use in the wheelchair and for which its actual capacity is not less than its rated capacity.

NOTE — Some types of new battery need to be cycled up to ten times before they are capable of reaching their full capacity.

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

Condition the battery set and battery charger in an ambient temperature of 20 °C ± 2 °C for a period of 24 h.

Discharge the battery set for 5 h ± 5 min at the current I (in amperes) calculated from the following:

$$I = 0{,}2\ Q_5$$

where Q_5 is the rated capacity of the battery set declared by the battery manufacturer at the 5 h rate (in ampere-hours).

Charge the battery set in accordance with the battery charger manufacturer's instructions for a period of 8 h ± 5 min at an ambient temperature of 20 °C ± 2 °C.

Disconnect the battery charger.

Discharge the battery set at current I and measure its charge using a method appropriate to the battery type.

NOTE — For wet lead-acid batteries, the method given in clause 11 of IEC 254-1:1983 [2] is suitable.

10 Forces needed to operate control devices

10.1 General

Some wheelchair users need to know the forces required to operate control devices when purchasing a wheelchair.

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[2] IEC 254-1:1983, *Lead-acid traction batteries — Part 1: General requirements and methods of test — Additional requirements for valve regulated lead-acid traction batteries*

10.2 Requirements

The manufacturer shall disclose the forces necessary to operate all control devices on the wheelchair. If the pressures for operating pneumatic switches are adjustable, the maximum and minimum operating pressures shall be disclosed.

The forces or pressures required to operate the control devices shall be measured in accordance with 10.3.1 to 10.3.4.

10.3 Test procedure

10.3.1 Lever to control speed and/or direction

Select the part of the lever (see figure 5) through which the force is to be applied from the following:

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

b) if the lever is tapered, apply the force through the point where the largest cross section intersects the centre line of the lever;

c) if the lever is parallel, or of any shape other than those listed in items a) and b), apply the force through a point on the centre line of the lever 15 mm below the top.

Use a force measuring instrument for control devices (4.9) to move the lever to the limit of its travel in all directions, keeping the line of application of the force normal to the centreline of the lever in its neutral position.

Measure and record the force needed to move the lever to the maximum extent of its travel.

Take three measurements in this way and record the average of the three.

10.3.2 Push button, rocker, and keypad switches

Use a force measuring instrument for control devices (4.9) to apply a force to the centre of the button in line with its axis of operation. Slowly increase the force until the button operates.

Measure and record the force needed to operate the switch.

Take three measurements in this way and record the average of the three.

10.3.3 Toggle switches

Make provision for attaching a force measuring instrument for control devices (4.9) to the end of the toggle switch so that a force can be applied to the switch in the direction of its operation and parallel to the surface on which it is mounted.

NOTE — This may be achieved by use of tape, string or similar material.

Slowly increase the force applied to the switch until it operates.

Measure and record the force needed to operate the switch.

Take three measurements in this way and record the average of the three.

10.3.4 Pneumatic switches (sip and puff)

10.3.4.1 Positive pressure switches (puff)

If the operating pressure of the positive air pressure switch is adjustable, select the minimum operating pressure.

Connect the positive air pressure measuring device (4.10) to the pneumatic switch inlet without obstructing the ability to operate the switch in the usual way.

Switch on the controller.

Slowly increase the air pressure in the inlet until the switch operates.

Measure and record the air pressure, expressed in pascals, above atmospheric pressure at which the switch operates.

Allow the inlet to return to atmospheric pressure.

Take three measurements in this way and record the average of the three.

If the operating pressure is adjustable, select the maximum operating pressure and repeat this test.

Repeat this test for each of the positive pressure pneumatic switch inlets.

10.3.4.2 Reduced pressure switches (sip)

If the operating pressure of the reduced air pressure switch is adjustable, select the minimum operating pressure.

Connect the reduced air pressure measuring device (4.11) to the pneumatic switch inlet without obstructing the ability to operate the switch in the usual way.

Switch on the controller.

Slowly decrease the air pressure in the inlet until the switch operates.

Measure and record the air pressure, expressed in pascals, below atmospheric pressure at which the switch operates.

Allow the inlet to return to atmospheric pressure.

Take three measurements in this way and record the average of the three.

If the operating pressure is adjustable, select the maximum operating pressure and repeat this test.

Repeat this test for each of the reduced pressure pneumatic switch inlets.

11 Test report

The test report shall contain the following information:

a) the name and address of the testing organization;

b) the date of the test;