INTERNATIONAL STANDARD

ISO 7176-14

Second edition
2008-02-15

Wheelchairs —

Part 14: Power and control systems for electrically powered wheelchairs and scooters — Requirements and test methods

Fauteuils roulants —

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

Reference number
ISO 7176-14:2008(E)

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Published in Switzerland

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Foreword

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

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

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

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

ISO 7176-14 was prepared by Technical Committee ISO/TC 173, *Assistive products for persons with disability*, Subcommittee SC 1, *Wheelchairs*.

This second edition cancels and replaces the first edition (ISO 7176-14:1997), all clauses of which have been technically revised.

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 electric wheelchairs*

— *Part 11: Test dummies*

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

— *Part 14: Power and control systems for electrically powered wheelchairs and scooters — Requirements and test methods*

— *Part 15: Requirements for information disclosure, documentation and labelling*

— *Part 16: Resistance to ignition of upholstered parts — Requirements and test methods*

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

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

— *Part 22: Set-up procedures*

— *Part 23: Requirements and test methods for attendant-operated stair-climbing devices*

— *Part 24: Requirements and test methods for user-operated stair-climbing devices*

— *Part 26: Vocabulary*

Introduction

This part of ISO 7176 specifies some wheelchair tests that are conducted on an inclined test plane. The intention of these tests is not to evaluate the performance of a wheelchair at the maximum gradient on which it is capable of operating. Instead, the objective is to reveal any changes in the wheelchair's behaviour that might occur under fault conditions, and these changes are more readily discovered when it is operated on a slope. For convenience, the inclined test plane has a fixed gradient, representative of those on which the wheelchair might be used.

The range of ambient temperatures under which testing is carried out is limited to allow comparison between the performance of a wheelchair in normal operation and performance when faults are introduced.

Wheelchairs —

Part 14: Power and control systems for electrically powered wheelchairs and scooters — 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 those carrying out or commissioning the tests from legal obligations relating to health and safety. For tests that could cause the wheelchair to exhibit dangerous behaviour, it is recommended that prior to carrying out those tests, the likely outcome is assessed to establish appropriate arrangements to minimize any risks.

1 Scope

This part of ISO 7176 specifies requirements and associated test methods for the power and control systems of electrically powered wheelchairs and scooters. It sets safety and performance requirements that apply during normal use and some conditions of abuse and failure. It also specifies methods of measurement of the forces necessary to operate controls and sets limits on the forces needed for some operations.

This part of ISO 7176 is applicable to electrically powered wheelchairs and scooters with a maximum speed no greater than 15 km/h intended to provide indoor and/or outdoor mobility for one disabled person whose mass lies in the range specified in ISO 7176-11.

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 3287, *Powered industrial trucks — Symbols for operator controls and other displays*

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

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

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

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

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

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

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

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

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60601-1, *Medical electrical equipment — Part 1: General requirements for basic safety and essential performance*

IEC 60601-1-2, *Medical electrical equipment — Part 1-2: General requirements for basic safety and essential performance — Collateral standard: Electromagnetic compatibility — Requirements and tests*

IEC 61032, *Protection of persons and equipment by enclosures — Probes for verification*

IEC 62262, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

EN 563, *Safety of machinery — Temperatures of touchable surfaces — Ergonomics data to establish temperature limit values for hot surfaces*

EN 12182, *Technical aids for disabled persons — General requirements and test methods*

EN 30993-1, *Biological evaluation of medical devices — Part 1: Guidance on selection of tests*

UL 94, *Tests for flammability of plastic materials for parts in devices and appliances*

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
nominal voltage
suitable approximate value of the voltage used to designate or identify a battery

[Adapted from IEV 482-03-31]

3.2
command signal
electrical signal from the control device

3.3
control device
device with which the operator indicates the desired speed and/or direction of movement of the wheelchair

NOTE A control device can be an integral part of a controller.

3.4
controller
electrical devices, circuits, and the case(s) in which they are housed that are used to convert the operator's indication of desired speed and/or direction of movement into the appropriate power to be supplied to the motor(s)

3.5
pinch point
location at which a moving part comes into contact with or close proximity to another part such that another object at that location would be cut or crushed

3.6
battery
one or more cells fitted with devices necessary for use, for example case, terminals, marking and protective devices

[IEV 482-01-04]

3.7
battery compartment
removable or non-removable enclosure for one or more batteries

3.8
battery pack
removable battery compartment that contains one or more batteries

NOTE If there are no removable battery compartments, a battery pack consists of a single battery.

3.9
battery set
set of interconnected batteries used to power a wheelchair

3.10
battery charger
device that is connected to supply mains and to a battery set for the purpose of charging the batteries

3.11
cut-off voltage
specified voltage at which the discharge of a battery is considered finished

3.12
hazardous situation
circumstance in which people, property or the environment are exposed to one or more hazard(s)

[IEC 60601-1]

3.13
hazard
potential source of harm

[IEC 60601-1]

3.14
harm
physical injury or damage to the health of people or animals, or damage to property or the environment

[IEC 60601-1]

3.15
enclosure
part providing protection of equipment against certain external influences and, in any direction, protection against contact

NOTE 1 Enclosures provide protection of equipment against harmful effects of mechanical impacts.

NOTE 2 Barriers, shapes of openings or any other means – whether attached to the enclosure or formed by the enclosed equipment – suitable to prevent or limit the penetration of the specified test probes, are considered as a part of the enclosure, except when they can be removed without the use of a key or tool.

3.16
capacity
⟨for cells or batteries⟩ electric charge which a cell or battery can deliver under specified discharge conditions

NOTE The SI unit for electric charge, or quantity of electricity, is the coulomb, C [1 C = 1 As (ampere second)] but in practice, capacity is usually expressed in ampere hours (Ah).

[IEV 482-03-14]

3.17
rated capacity
capacity value of a battery determined under specified conditions and declared by the manufacturer

[IEV 482-03-15]

3.18
discharge rate
electric current at which a battery is discharged

NOTE The discharge rate is calculated as the rated capacity divided by the corresponding discharge time, which results in an electric current.

[IEV 482-03-25]

3.19
charge rate
⟨relating to secondary cells and batteries⟩ electric current at which a secondary cell or battery is charged

NOTE The charge rate is expressed as the reference current $I_t = C_r/n$ where C_r is the rated capacity declared by the manufacturer and n is the time base in hours for which the rated capacity is declared.

[IEV 482-05-45]

3.20
theoretical state of charge
electric charge added to a fully discharged battery by charging at a known charge rate for a known time, or estimated to remain in a battery that has been fully charged and then discharged at a known discharge rate for a known time, and expressed as a percentage of the rated capacity

3.21
terminal
conductive part of a device, electric circuit or electric network, provided for connecting that device, electric circuit or electric network to one or more external conductors

[IEV 151-12-12]

NOTE Removable bolts, screws and fasteners are not considered part of a terminal.

3.22
analogue signal
signal in which the characteristic quantity representing information may at any instant assume any value within a continuous interval

NOTE For instance, an analogue signal may follow continuously the values of another physical quantity representing information.

[IEV 702-04-02]

3.23
leakage current
electric current in an unwanted conductive path other than a short circuit

[IEV 151-15-49]

4 Apparatus

4.1 Inclined test plane, with a surface of sufficient friction (as specified in ISO 7176-13) to cause minimal wheel slippage, of sufficient size to enable the applicable tests specified in this part of ISO 7176 to be performed and with a marker from which wheelchair stopping distance can be measured.

The inclined test plane shall be fixed at 3° or 6° to the horizontal. The steeper gradient shall be used unless the loaded wheelchair (see 5.2) is unable to climb it at a speed greater than 0,5 km/h.

NOTE An inclined test plane of size 6,0 m × 1,5 m will usually be suitable for testing a wheelchair with a maximum speed of 6 km/h.

4.2 Horizontal test plane, with the same high-friction surface as the inclined test plane (4.1), and of sufficient size to enable the applicable tests specified in this part of ISO 7176 to be performed.

NOTE A horizontal test plane of size 6,0 m × 1,5 m will usually be suitable for testing a wheelchair with a maximum speed of 6 km/h.

4.3 Acoustic test area, marked on a horizontal plane in a room with an ambient noise level not exceeding 55 dB(A-weighted) and of sufficient length for the wheelchair to attain its maximum speed before reaching the test area specified in 10.6 and to stop safely beyond the test area.

4.4 Speedometer, or other means for measuring the speed of a wheelchair within a range of 0 km/h to 20 km/h, to an accuracy of ± 0,5 km/h.

4.5 Means of measuring stopping distance of a wheelchair, to an accuracy of ± 100 mm.

NOTE It is important that the means for measuring the speed (4.4) and stopping 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.

4.6 Voltage source, with a voltage adjustable in the range 0,25 U_B to 1,5 U_B, where U_B is the nominal voltage of the battery set, expressed in volts.

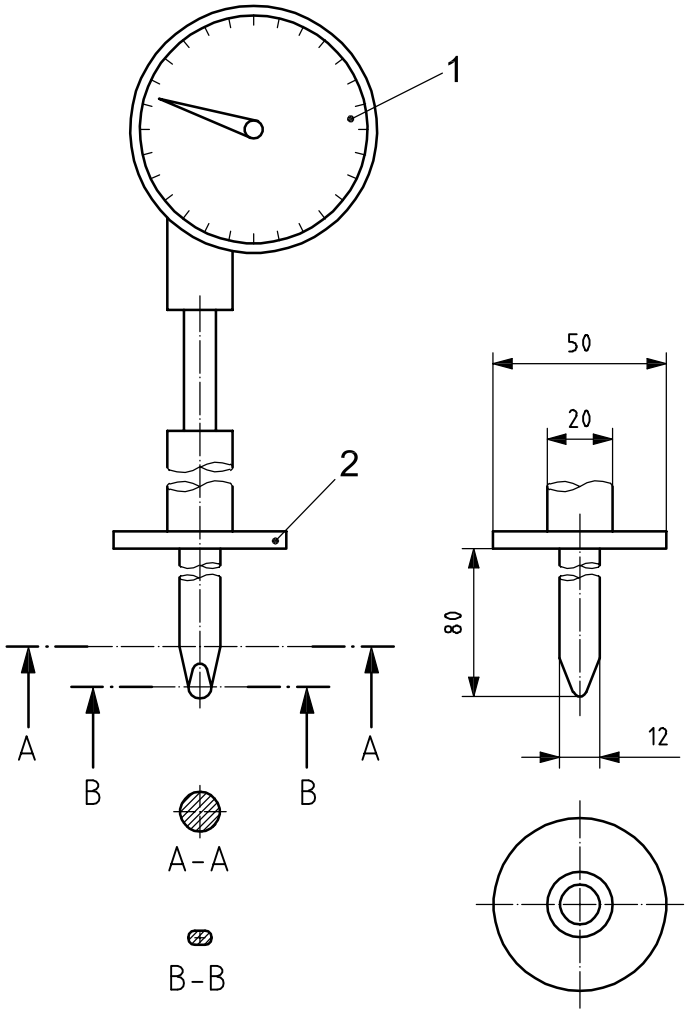
The voltage source shall be capable of supplying the peak current drawn from the battery set during wheelchair operation and shall be capable of sinking the peak current returned to the battery during wheelchair operation. Any change in the voltage shall be no greater than 5 % of U_B while the current is within this range.

4.7 Test probe B, as specified in IEC 61032.

4.8 Test probe 18, as specified in IEC 61032.

4.9 Test probe 11, as specified in IEC 61032, capable of attachment to a force measuring instrument (4.11). See Figure 1.

Dimensions in millimetres



Key

1 force measuring instrument
2 stop plate

Figure 1 — Test probe 11 (informative)

4.10 Small unjointed test probe, constructed as specified for test probe 18 (4.8), but without joints, and capable of attachment to a force measuring instrument (4.11) both with and without the handle extension.

4.11 Force measuring instrument, capable of measuring forces in the range of 0 N to 150 N in increments of 1 N with an accuracy of ± 1 N.

4.12 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 ± 0,1 N, and that can be fitted with a rigid spherical tip of radius 5,0 mm ± 0,2 mm.

4.13 Positive differential air pressure measuring device, capable of measuring positive differential air pressure, relative to local atmospheric pressure, in a range of 0 kPa to 20 kPa in 200 Pa increments with an accuracy of ± 200 Pa.

4.14 Negative differential air pressure measuring device, capable of measuring negative differential air pressure, relative to local atmospheric pressure, in a range of 0 kPa to −20 kPa in 200 Pa increments with an accuracy of ± 200 Pa.

4.15 Test circuit, that can be arranged as shown in Figure 2 and Figure 3, 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 ± 1 mA, and capable of withstanding a current of 100 mA;

b) a resistor of resistance R ± 5 %, where R (in ohms) is calculated from the following expression:

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

where U_B is the nominal voltage of the battery set.

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:

$$P = 0,1 \times U_B$$

c) test probe 11 (4.9).

Key

1 test probe
2 wheelchair battery set

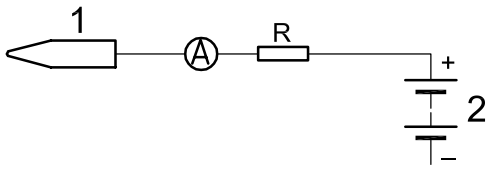


Figure 2 — Test circuit in positive configuration

Key

1 test probe
2 wheelchair battery set

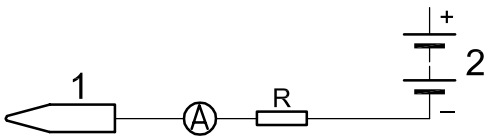


Figure 3 — Test circuit in negative configuration

4.16 Circuit breaker, manually operated, capable of interrupting the maximum possible current obtainable from the battery set or batteries, such that the voltage drop across the circuit breaker and its associated wiring at that current does not exceed 10 % of the nominal voltage of the battery set.

NOTE Typical wheelchair batteries have maximum short-circuit currents of several hundred amperes.

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

4.18 Means for measuring sound pressure level, to an accuracy of ± 3 dB(A-weighted).

4.19 Fine wire thermocouples, with suitable means for indicating temperature to an accuracy of ± 2 °C.

4.20 Means for measuring motor current, to an accuracy of $\pm$ 5 % of the maximum stall current of the wheelchair motors.

4.21 Test track, as specified in ISO 7176-4.

4.22 Voltmeter, capable of measuring the voltage of the battery set to an accuracy of $\pm$ 1 %.

4.23 Variable resistance, capable of being set within the range 20 kΩ to 1 MΩ.

5 Preparation of test wheelchair

5.1 Wheelchair set-up

Set up the wheelchair in accordance with ISO 7176-22.

NOTE The battery set-up is changed for some tests.

5.2 Loading the wheelchair

If required for a particular test, load the wheelchair using one of the following:

a) a dummy as specified in ISO 7176-22, selected and fitted as specified in that part of ISO 7176;

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 dummy specified in a).

Where a dummy is fitted to a wheelchair that has an anterior pelvic support, the support should be used to restrain the dummy.

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

NOTE Use of anterior pelvic support by a human test occupant may be hazardous, for example in the event that the test occupant needs to get out of the chair quickly.

5.3 Wheelchair attributes

Measure and record the maximum speed, v, of the wheelchair on a horizontal surface by the method specified in ISO 7176-6.

Measure and record the maximum stopping distance, L_I, at speed $(0{,}5 \pm 0{,}05) \times v$, of the wheelchair moving down the inclined test plane (4.1) by the method specified in ISO 7176-3 for normal operation.

5.4 Wheelchair documentation

Obtain circuit diagrams for the wheelchair from the wheelchair manufacturer.

5.5 Preparation records

Record the following information for each test:

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;

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

6 Guidance for tests

6.1 Test order

The tests used to verify the requirements given in Clauses 7 to 14 may be performed in any order, unless otherwise stated in the test methods. Reverse any modifications made to the wheelchair for a test before beginning another test. Repair or replace any parts of the wheelchair damaged during testing before beginning another test. Record the nature of any such repairs in the test report. Repeat the applicable procedures specified in Clause 5 after any such repairs.

6.2 Batteries

The manufacturer shall declare the nominal voltage and the cut-off voltage of the battery set.

6.3 Test conditions

Carry out the tests at an ambient temperature of 20 °C ± 5 °C.

7 Single fault safety

7.1 Single fault conditions

7.1.1 General

In the event of a single fault condition arising in a wheelchair, appropriate means should be adopted to eliminate or reduce as far as possible consequent risks. However, wheelchair control systems are complex and diverse, making it impractical to write specific requirements. Furthermore, because of the increasing integration of electronic devices that are commonly used in control systems, it is possible that test personnel have no direct access to many of the functional elements.

NOTE Software testing is not addressed in this edition of this part of ISO 7176, due to its impracticability.

7.1.2 Requirements

The manufacturer shall adopt appropriate means to eliminate or reduce as far as possible the probability of a hazardous situation developing in the event of a single fault condition.

NOTE Single fault conditions that have been observed in wheelchairs include:

— short and open circuits of conductors and wiring;

— exposure of electronic components to liquids, such as rainwater and urine;

— component failure, such as leakage, internal short circuit, latched logic state.

The manufacturer shall declare to test personnel the means by which the wheelchair is made safe against single fault conditions.

7.2 Controller command signal processing failure

7.2.1 General

It is important that a single command signal error due to an open-circuit, short-circuit or leakage current does not result in a hazardous situation.

7.2.2 Requirements

7.2.2.1 Provision shall be made to ensure that an open-circuit or short-circuit command signal failure

a) does not result in loss of control of the wheelchair other than to stop,

b) does not prevent the wheelchair from stopping when the control device is put in its stop position,

c) does not result in a hazardous situation.

When the wheelchair is tested in accordance with 7.2.3.2 and 7.2.3.3, it shall stop without tipping over within a distance not exceeding $5 \times L_1$.

7.2.2.2 Testing the wheelchair in accordance with 7.2.3.4 shall not

a) result in any drive wheel turning with a circumferential speed that is greater than 0,1 m/s,

b) result in movement greater than 10 mm of any part of the wheelchair that usually comes into contact with the occupant,

c) result in a hazardous situation (e.g. fire).

7.2.3 Test method

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.

7.2.3.1 Preparation

7.2.3.1.1 Examine the wheelchair and its circuit diagram to locate

— control device conductors that carry signals involved in the speed and/or direction control of the wheelchair,

— conductors that supply power and/or reference signals to the control device,

— conductors that carry signals involved in controlling the motion of parts of the wheelchair that usually come into contact with the occupant,

and which are suitable for introducing disturbances into those signals that could affect the control of the wheelchair.

NOTE Suitable conductors can include discrete wires, component leads, connector terminals and printed circuit tracks.

7.2.3.1.2 Identify one point on each of the conductors identified in 7.2.3.1.1 which may be used for introducing open circuits in them.

7.2.3.1.3 For each of the conductors identified in 7.2.3.1.1, identify all other conductors where it is reasonably foreseeable that a short circuit could occur between them.

7.2.3.1.4 Among the conductors identified in 7.2.3.1.1, identify each conductor that is used to carry an analogue signal.

7.2.3.1.5 For each of the conductors identified in 7.2.3.1.4, identify all other conductors where it is reasonably foreseeable that a current leakage path due to contamination from liquids could occur between them.

NOTE 1 Examples include: conductors in a cable connecting the control device enclosure to another component or enclosure; adjacent connector terminals in exposed connectors on the control device enclosure; adjacent conductors inside the control device enclosure that could get wet if the enclosure were damaged and liquid were to leak into it.

NOTE 2 Examples of conductors not included: conductors in an encapsulated subassembly within the control device enclosure; tracks or components on a printed circuit card assembly that are conformally coated.

NOTE 3 Enclosures that do not allow ingress of water when subjected to the test specified in 13.1 after being subjected to the impact test specified in 14.2 may be considered unlikely to allow contamination by liquids, except where such enclosures have fragile flexible components as part of their environmental protection, such as typical joystick gaiters.

7.2.3.2 Open-circuit test

Make provision for the wheelchair to be driven on the inclined test plane (4.1).

Switch off the controller and disconnect it from the battery set. For one of the points identified in 7.2.3.1.2, 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 forwards in a straight line down the inclined test plane towards it until a speed of $(0{,}5 \pm 0{,}05) \times v$ 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 $\pm$ 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 forwards in a straight line down the inclined test plane towards it until a speed of $(0{,}5 \pm 0{,}05) \times v$ 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 $\pm$ 100 mm.

Reset and/or replace any circuit protection devices.

Repeat the test for each of the conductors identified in 7.2.3.1.2.

7.2.3.3 Short-circuit test

Make provision for the wheelchair to be driven on the inclined test plane (4.1).

Switch off the controller and disconnect the battery set.

From those conductor pairs identified in 7.2.3.1.3, make provision for connecting the two conductors 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 forwards in a straight line down the inclined test plane towards it until a speed of $(0{,}5 \pm 0{,}05) \times v$ 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 $\pm$ 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 forwards in a straight line down the inclined test plane towards it until a speed of $(0{,}5 \pm 0{,}05) \times v$ 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 $\pm$ 100 mm.

Reset and/or replace any circuit protection devices.

Repeat the test for every combination of two conductors from those identified in 7.2.3.1.3.

7.2.3.4 Leakage current test

Support the wheelchair by suitable means (4.17) so that it is secure with the drive wheels lifted off the ground and free to revolve.

Switch off the controller and disconnect the battery set.

From those conductor pairs identified in 7.2.3.1.5, make provision for connecting the two conductors via a variable resistance (4.23) without changing the original connections (to simulate a leakage current). Set the variable resistance to its maximum value.

Reconnect the battery set and switch on the controller.

Adjust the variable resistance at a rate of change not exceeding 10 % of the present value of the variable resistance per second.

While varying the resistance, observe whether any drive wheel turns with a circumferential speed greater than 0,1 m/s or any part of the wheelchair that usually comes into contact with the occupant moves more than 10 mm.

Reset and/or replace any circuit protection devices.

Repeat the test for every combination of two conductors from those identified in 7.2.3.1.5.

7.3 Controller output device failure

7.3.1 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.

NOTE A power transistor is a common output device.

7.3.2 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 7.3.3.2 and 7.3.3.3, the wheelchair shall

a) not create a hazardous situation,

b) stop within a distance of $5 \times L_1$ (see 5.3), 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 1), when the switch is operated and the control device is put to its stop position at the marker.

7.3.3 Test method

7.3.3.1 Preparation

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.

Make provision for the wheelchair to be driven down the inclined test plane (4.1) at a speed of $(0{,}5 \pm 0{,}05) \times v$.

Connect the circuit breaker (4.16) 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, test the devices that carry and regulate current for either or both driving motors.

NOTE 1 In the procedures given in 7.3.3.2 and 7.3.3.3, 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 causes the device to 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. If necessary, refer to the manufacturer for advice.

NOTE 2 If necessary, 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.

7.3.3.2 Open-circuit test

Repeat the following procedure for each of the output devices identified in item a) of 7.3.3.1.

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. (See Figure 4 for typical circuits.)

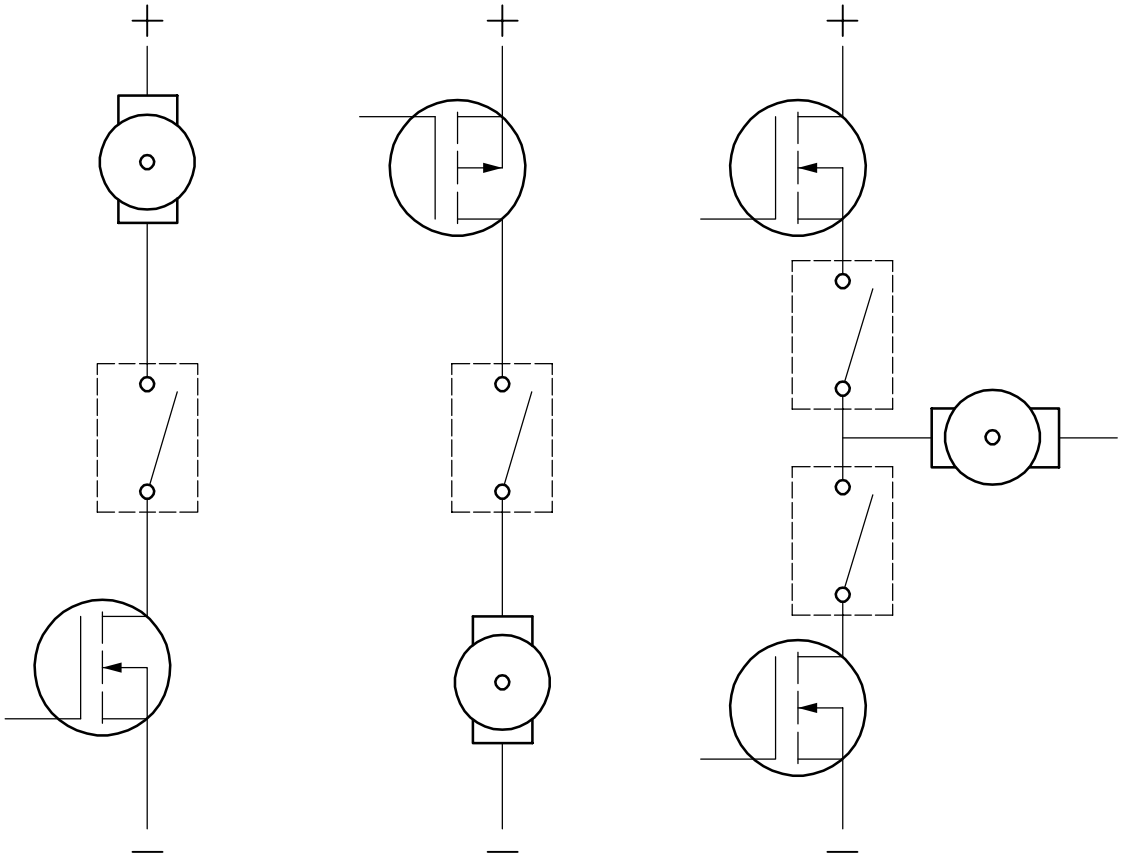


Figure 4 — Open circuit testing switches installed

Switch on the controller. Note the position of the marker on the inclined test plane and drive the wheelchair in a straight line towards it until a speed of $(0{,}5 \pm 0{,}05) \times v$ 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.

If the wheelchair does not stop within a distance of $5 \times L_1$, repair any damage and reset and/or replace any circuit protection devices that have operated, then repeat the test method, except open the switch before the marker is reached. When the marker is reached, put the control device to its stop position.

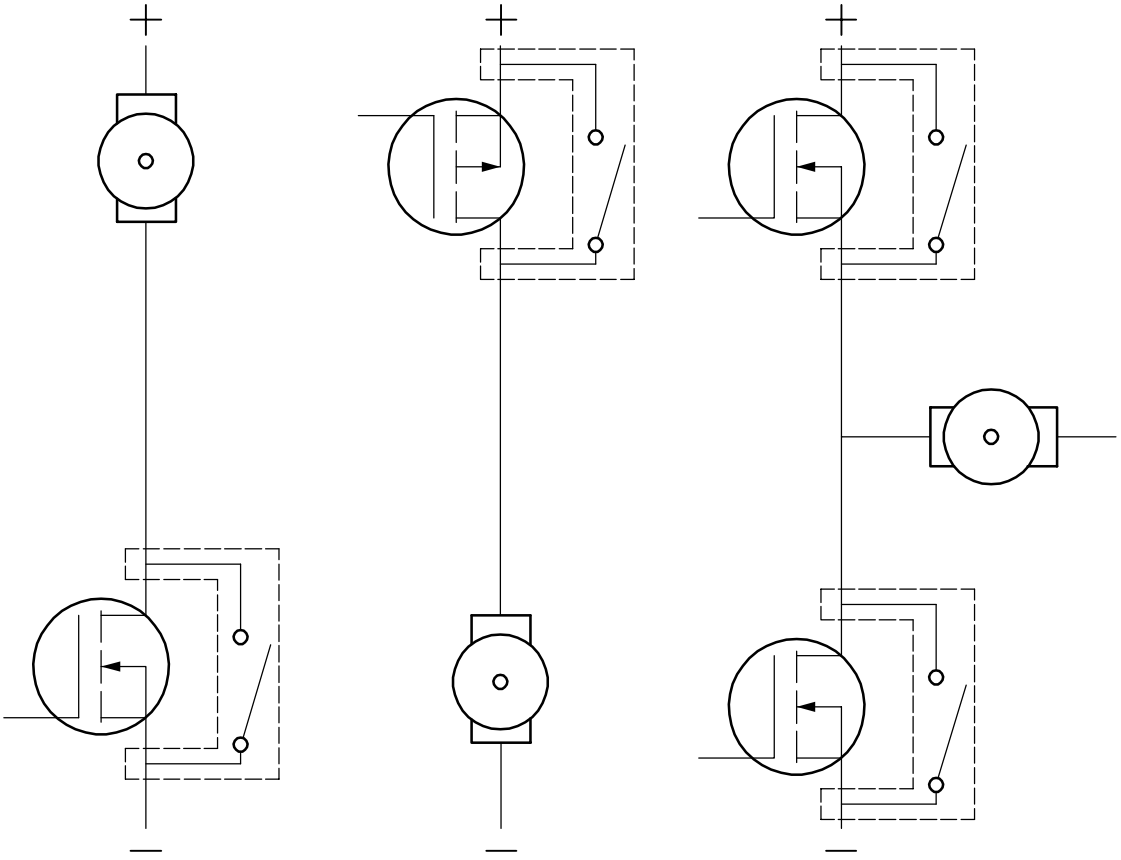
Measure along the centreline of the track of the driving wheels the distance taken to stop to an accuracy of ± 100 mm.

Switch off the controller. Reset and/or replace any circuit protection devices.

7.3.3.3 Short-circuit test

Repeat the following procedure for each of the devices identified in item a) of 7.3.3.1.

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. (See Figure 5 for typical circuits.)



NOTE When carrying out a test, only one of the two switches in the sub-figure on the right would be closed at any time.

Figure 5 — Short circuit testing switches installed

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 $(0{,}5 \pm 0{,}05) \times v$ 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.

If the wheelchair does not stop within a distance of $5 \times L_1$, repair any damage and reset and/or replace any circuit protection devices that have operated, then repeat the test method, 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.

Reset and/or replace any circuit protection devices.

7.4 Ability to stop when power is removed

7.4.1 General

The power to a wheelchair can be unintentionally lost while the wheelchair is being driven. If this happens on a slope, there is a risk that the wheelchair could 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 react unpredictably in this situation.

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

7.4.2 Requirements

When the wheelchair is tested in accordance with 7.4.3, it shall

a) steer normally or

b) stop in a distance not exceeding $5 \times L_1$ (see 5.3) from the point at which it ceases to steer normally.

In addition to a) or b), the wheelchair shall stop in a distance not exceeding $5 \times L_1$ when the control device is put to the stop position.

7.4.3 Test method

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 fail to stop when moving at maximum speed.

a) Make provision for the wheelchair to be driven down the inclined test plane (4.1).

b) Connect the circuit breaker (4.16) between the battery set and the wheelchair controller.

c) 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 a speed of $(0{,}5 \pm 0{,}05) \times v$ is achieved. When the marker is reached, open the circuit breaker.

d) 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 $\pm$ 100 mm.

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

e) If the wheelchair does not stop, or does not stop within a distance of $5 \times L_1$, repeat c) and d), except open the circuit breaker before the marker is reached, then, when the marker is reached, steer the wheelchair to one side. Note the steering response.

f) If the wheelchair stops, measure along the centreline of the track of the driving wheels the distance taken to stop to an accuracy of $\pm$ 100 mm.

g) If the wheelchair does not stop, or does not stop within a distance of $5 \times L_1$, but the steering response is normal, repeat c) to f), except steer the wheelchair to the other side. If the wheelchair does not stop, note if the steering response is normal.

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

i) Calculate and record the arithmetic mean stopping distance from the three measurements.

j) Repeat c) to d), except before the marker is reached open the circuit breaker, then when the marker is reached, return the control device to its stop position.

k) If the wheelchair stops, measure and record the distance to an accuracy of $\pm$ 100 mm.

l) Repeat j) and k) twice.

m) Calculate and record the arithmetic mean stopping distance from the three measurements.

8 Design

8.1 On/off switch

8.1.1 Requirements

There shall be available at least one means to

— switch on the wheelchair,

— switch off the wheelchair.

Each means shall be clearly marked with a symbol, either on the means or adjacent to it.

NOTE 1 These means may be combined into a single device.

NOTE 2 If the wheelchair is intended for operation by the occupant, at least one means for switching on the wheelchair and at least one means for switching off the wheelchair should be provided for the occupant.

When the wheelchair is switched off, the controller shall not cause the drive wheels to revolve.

8.1.2 Test method

Position the wheelchair on the inclined test plane, facing down the slope. Switch off the wheelchair and attempt to drive the wheelchair without switching it on. Record any movement of the wheelchair.

8.2 Current consumption while switched off

8.2.1 General

When the wheelchair is switched off, circuits or leakage paths in the wheelchair should not drain the battery set.

8.2.2 Requirement

With the wheelchair switched off, it shall not draw from the battery set a current greater than that which would remove, in a period of four months, the rated capacity at the 20 h discharge rate of the smallest capacity battery specified for the wheelchair.

8.2.3 Test method

Disconnect the wheelchair's battery set.

Connect a voltage source (4.6) adjusted to the nominal voltage of the battery set $^{+10}_{0}$ % in place via the circuit breaker (4.16) and an ammeter with an accuracy not less than 5 % of $I_{2\,900}$, calculated from the following expression:

$$I_{2\,900} = \frac{C_{20}}{2\,900}$$

where

$I_{2\,900}$ is the numerical value of the current, expressed in amperes (A), drawn from the battery set corresponding to a four month discharge period (2 900 h);

C_{20} is the rated capacity at the 20 h discharge rate, expressed in ampere hours (Ah), of the smallest capacity battery specified for the wheelchair by the wheelchair manufacturer.

Record the mean current drawn by the wheelchair when it is switched off and compare it to the maximum limit, $I_{2\,900}$.

NOTE When the voltage source is first connected, some wheelchairs can draw transient currents that are much greater than the mean current. During this test, such transient currents could overload the ammeter. The ammeter may be bypassed until the current reaches a steady state.

8.3 Control signal at switch on

8.3.1 Requirement

If the wheelchair is switched on with any control device not in its neutral position, the wheelchair shall not move and automatic brakes shall not release. In this situation, it shall not be possible to drive the wheelchair unless the control device is returned to the neutral position and then operated again.

8.3.2 Test method

a) Support the wheelchair by suitable means (4.17) so that it is secure with the drive wheels lifted off the ground and free to revolve.

b) Select a control device.

c) Determine the control device setting that is required to give a forward speed of 0,1 m/s $^{+0,1}_{0}$ m/s.

d) Switch off the wheelchair.

e) Set the control device to the setting determined in c).

f) Switch on the wheelchair.

g) Record whether any drive wheels rotate or any automatic brake is released.

h) Switch off the wheelchair.

i) Set the control device for maximum forward speed.

j) Switch on the wheelchair.

k) Record whether any drive wheels rotate or any automatic brake is released.

l) Repeat b) to k) for each control device.

m) The wheelchair fails the test if it is recorded in g) or k) that any drive wheels move or any automatic brake is released.

8.4 Safe operation as the battery set becomes depleted

8.4.1 General

The wheelchair should not create a hazardous situation when the battery set nears depletion.

8.4.2 Requirements

When the wheelchair is tested in accordance with 8.4.3:

a) no supporting wheel of the wheelchair shall touch any part the slope outside the slope test outline;

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

8.4.3 Test method

8.4.3.1 Preparation

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

Fit the lowest capacity battery specified by the wheelchair manufacturer.

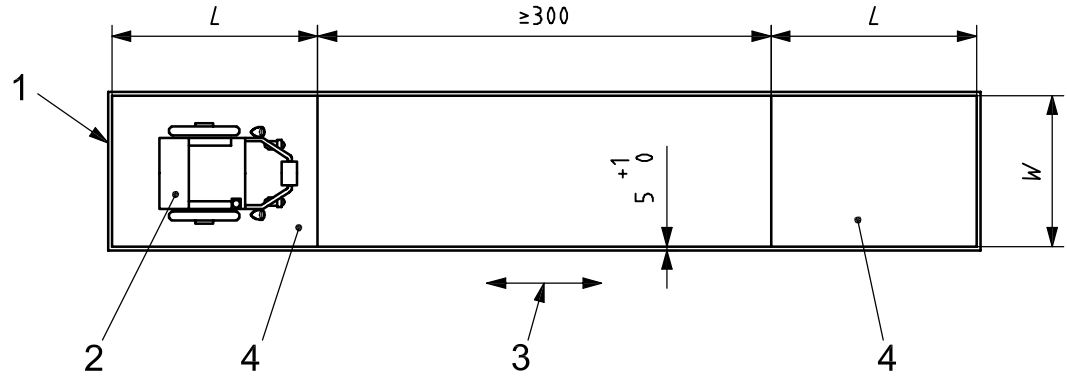
Discharge the battery set by driving the wheelchair until it stops, or alternatively by connecting an external load adjusted to draw a current not exceeding the 5 h rate until the voltage of the battery set falls to the cut-off voltage specified for the 5 h rate. Charge the battery set with sufficient charge to complete at least one full ascent and descent as specified in 8.4.3.2.

EXAMPLE If charging the wheelchair for 5 min allows it to complete more than one full ascent and descent as specified in 8.4.3.2, this is sufficient charge.

Mark out the slope test outline shown in Figure 6 on the inclined test plane (4.1). The slope test outline has internal width W, equal to 1,5 × the overall width of the wheelchair, ± 50 mm, and the two end boxes have internal length L, equal to 1,5 × the overall length of the wheelchair, ± 50 mm.

NOTE The slope test outline has a specified thickness to allow for minor errors in manual control of the wheelchair.

Dimensions in centimetres



Key

1 slope test outline
2 wheelchair
3 up-down direction of inclined test plane
4 end box

Figure 6 — Slope test outline

8.4.3.2 Upslope test

Position the wheelchair in the lower box of the slope test outline, facing up the slope.

Drive the wheelchair up the slope, using the control device to keep the wheelchair within the slope test outline, and stop the wheelchair within the upper box.

NOTE It is not necessary to drive the wheelchair at the maximum speed that can be attained on the slope.

Reverse the wheelchair down the slope, using the control device to keep the wheelchair within the slope test outline, and stop the wheelchair within the lower box.

Repeat driving up and down the slope within the slope test outline until the wheelchair is unable to move. Record whether any supporting wheel of the wheelchair touched any part of the slope outside the slope test outline.

Switch off the controller. Wait for three minutes, then switch on the controller.

Repeat driving up and down the slope within the slope test outline until the wheelchair is unable to move after the waiting time.

8.4.3.3 Downslope test

Recharge the battery set in accordance with 8.4.3.1.

Repeat the procedure given in 8.4.3.2, except with the wheelchair facing down the slope.

8.5 Over-discharge protection

8.5.1 Requirement

The wheelchair shall

— avoid over-discharge of the battery set by stopping if the battery voltage falls below the cut-off voltage or

— provide a visual and auditory indication that the battery has fallen below the cut-off voltage.

NOTE This is to avoid damage to the battery set.

8.5.2 Test method

8.5.2.1 General

Use either of the test methods specified in 8.5.2.2 and 8.5.2.3.

8.5.2.2 Battery set test method

Prepare the wheelchair as specified in 8.4.3.1.

Support the wheelchair by suitable means (4.17) so that it is secure with the drive wheels lifted off the ground and free to revolve. Monitor the voltage of the battery set using the voltmeter (4.22).

Set the control device for maximum forward speed. Wait until either the drive wheels stop or the voltage reaches 0,90 × the cut-off voltage of the battery set.

Record whether the drive wheels stop before the voltage reaches the cut-off voltage or, if they do not stop, whether the wheelchair provides a visual and auditory indication that the voltage has fallen below the cut-off voltage.

8.5.2.3 Voltage source test method

Disconnect the battery set and connect the voltage source (4.6) in place via the circuit breaker (4.16).

Support the wheelchair by suitable means (4.17) so that it is secure with the drive wheels lifted off the ground and free to revolve.

Switch on the voltage source and set its voltage so that it is equal to the nominal voltage of the battery set $^{+5}_{0}$ %. Set the control device for maximum forward speed. Reduce the voltage of the voltage source, at a rate not exceeding 1 % of the nominal voltage of the battery set per second, until either the drive wheels stop or the voltage reaches 0,90 $\times$ the cut-off voltage of the battery set.

Record whether the drive wheels stop before the voltage reaches the cut-off voltage or, if they do not stop, whether the wheelchair provides a visual and auditory indication that the voltage has fallen below the cut-off voltage.

8.6 Controller over-voltage protection

8.6.1 General

During charging and regeneration, batteries can exceed their nominal voltage. Wheelchairs should not malfunction under these higher voltage conditions.

8.6.2 Requirements

When tested in accordance with 8.6.3,

a) the wheelchair shall operate in accordance with the manufacturer's specification,

b) the wheelchair shall not create a hazardous situation,

c) no damage shall occur, other than blown fuses.

8.6.3 Test method

Set the voltage of the voltage source (4.6) to $(1{,}33 \pm 0{,}05) \times U_B$, where U_B is the nominal voltage of the battery set. Disconnect the wheelchair's battery set and connect the voltage source in its place via the circuit breaker (4.16).

Support the wheelchair by suitable means (4.17) so that it is secure with the drive wheels lifted off the ground and free to revolve.

Switch on the voltage source. Operate sufficient control functions to cause all driven parts of the wheelchair to operate. Note any movement of any part of the wheelchair that would produce a hazardous situation if the wheels were in contact with the ground.

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

8.7 Switch-off while driving

8.7.1 General

It is important that the wheelchair does not create a hazardous situation if any means to switch it off is operated while driving.

8.7.2 Requirements

The wheelchair shall not create a hazardous situation when any means to switch it off is operated while driving at maximum forward speed or maximum reverse speed.

8.7.3 Test method

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

a) Identify a means to switch off the wheelchair that is accessible to an operator. Make provision to operate this means while the wheelchair is driven.

b) Drive the wheelchair forward on the horizontal test plane (4.2) at full speed.

c) Operate the means to switch off the wheelchair identified in a).

d) Record whether the wheelchair creates a hazardous situation.

EXAMPLE In this test a hazardous situation could be tipping of the wheelchair, a sudden stop that creates the risk of the occupant falling from the wheelchair or loss of control of the wheelchair other than to stop.

e) Repeat b) to d) with the wheelchair driving in reverse.

f) Repeat a) to e) for each means to switch off the wheelchair which is accessible to an operator.

8.8 Measuring devices

8.8.1 General

Wheelchair devices that provide a measuring and indication function should be designed and manufactured in such a way as to provide sufficient accuracy and stability within appropriate limits of accuracy and taking account of the intended purpose. The limits of accuracy should be indicated by the manufacturer.

The measurement, monitoring and display scale should be designed in line with ergonomic principles, taking account of the intended purpose.

Where practicable, the measurements made by devices with a measuring function should be expressed in SI units.

8.8.2 Battery gauge

8.8.2.1 General

The wheelchair should be equipped with a means of indicating to the operator, the state of the battery set while it is in normal use, in order to assist the operator in estimating the remaining range available.

8.8.2.2 Requirements

The wheelchair shall provide an indication that the battery set is nearing depletion.

The indication should represent a remaining distance range.

The manufacturer shall disclose information describing the conditions affecting the accuracy of the indication.

8.8.2.3 Test method — Indication

Verify that the wheelchair has a means of indicating that the battery set is nearing depletion.

8.8.2.4 Test method — Remaining distance range (informative)

Ensure that the battery set is at a state of charge greater than the state that activates the indicator.

Discharge the battery set by driving the wheelchair on the test track (4.21) until the indicator is activated.

Drive the wheelchair on the test track (4.21) while recording the distance travelled, until the wheelchair stops due to a depleted battery set.

Record the distance travelled after activation of the indicator.

8.9 Drive inhibit during charging

8.9.1 General

Mechanical damage or injury might occur, or electrical hazards exposed, if the wheelchair moves while it is connected for charging.

8.9.2 Requirement

When tested in accordance with 8.9.3, it shall not be possible to drive the wheelchair.

8.9.3 Test method

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.

Switch off the supply mains. Attempt to drive the wheelchair and record any movement of the wheelchair.

8.10 Charging connection voltage drop

8.10.1 General

Charging efficiency can be affected by the voltage difference between the terminals of the battery charger and the terminals of the battery set. This voltage difference depends on the electrical characteristics of the wiring, fuses, connectors or other circuitry used to connect them.

8.10.2 Requirements

Where a battery charger is not supplied with the wheelchair or where the wheelchair manufacturer does not specify the make and model of suitable battery chargers, the voltage difference, dU, between the voltage at

the entry point of the charger, U_{ep}, and the total of the terminal voltages of the batteries in the battery set, $U_{batt,tot}$, shall not exceed 3,5 % of the nominal voltage of the battery set when tested in accordance with 8.10.3.

NOTE The entry point is defined to be the output terminals of the charger for on-board, off-board and carry-on chargers.

8.10.3 Test method

Charge or discharge the battery set to a theoretical state of charge between 30 % and 50 % of the rated capacity of the battery set at the 5 h discharge rate.

Select a battery charger with a charging current, I_{chg} within the range 80 % to 100 % of $I_{chg,max}$, where $I_{chg,max}$ is the maximum rated charging current specified by the wheelchair manufacturer. Prepare for measuring the mean value of the charging current, I_{chg}, with an accuracy of $\pm$ 5 % of I_{chg}, using an ammeter that does not cause a voltage drop greater than 0,1 % of the nominal voltage of the battery set.

NOTE 1 A non-contacting ammeter is a suitable device.

Prepare for measuring the mean value of the entry point voltage, U_{ep} and the terminal voltage of every battery in the battery set, U_{batt1}, U_{batt2}, ..., U_{battn} with an accuracy of $\pm$ 0,5 %.

NOTE 2 The mean values of current and voltage should be measured over a period no greater than 1 s.

Commence charging.

Charge for 5 min $\pm$ 1 min.

Measure and record I_{chg}, U_{ep}, U_{batt1}, U_{batt2}, ..., U_{battn} within 1 min.

Calculate the total battery voltage $U_{batt,tot}$:

$$U_{batt,tot} = U_{batt1} + U_{batt2} + ... + U_{battn}$$

Calculate dU at $I_{chg,max}$:

$$dU = \left(U_{ep} - U_{batt,tot}\right) \times \left(\frac{I_{chg,max}}{I_{chg}}\right)$$

8.11 Non-powered mobility

8.11.1 General

In the event that the wheelchair loses electric power, it is essential that an assistant be able to move the wheelchair without difficulty.

8.11.2 Requirements

The force required to start the loaded wheelchair (5.2) moving in a straight line on the horizontal without electrical power shall not exceed f, calculated from the following expression:

$$f = 65 + \left(0{,}6 \times M\right)$$

where

f is the maximum pushing force, expressed in newtons (N);

M is the maximum occupant mass specified for the wheelchair, expressed in kilograms (kg).

Where there is provision for the drive or automatic braking system to be disengaged, the disengagement 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 for combined hand and arm operation;
- 13,5 N for operation by one hand;
- 5 N for operation by one finger;
- 100 N for operation by pushing with a foot;
- 60 N for operation by pulling with a foot.

NOTE 1 If it is not obvious how to operate the means, the operation should be shown in the user manual and/or marking on the wheelchair.

It shall not be possible for the drive or automatic braking system to be partially engaged. If the wheelchair is fitted with means of disengaging each drive wheel independently, it shall not be possible to partially engage any of those means.

NOTE 2 The term “partial engagement” indicates a condition of neither full engagement nor full disengagement. The term is applied only to each individual means of disengagement, not to a collection of such means. For example, it does not apply to a wheelchair with one drive wheel fully engaged and one drive wheel fully disengaged, but it does apply to a friction clutch where the force between the clutch plates would allow them to slip.

If any automatic brake is disengaged, and electrical power is restored, it shall not be possible to drive the wheelchair.

8.11.3 Test method

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

Load the wheelchair with the dummy or human load.

Disconnect the battery set from the wheelchair controller.

Use the force measuring instrument (4.11) to measure the maximum force required to operate any means for disengaging the drive or braking system as the means moves through its range of movement. In this way, take three measurements for each device and record the arithmetic mean of the measurements. See Figure 7 and 10.2.3 for examples of methods for applying forces to knobs and levers.

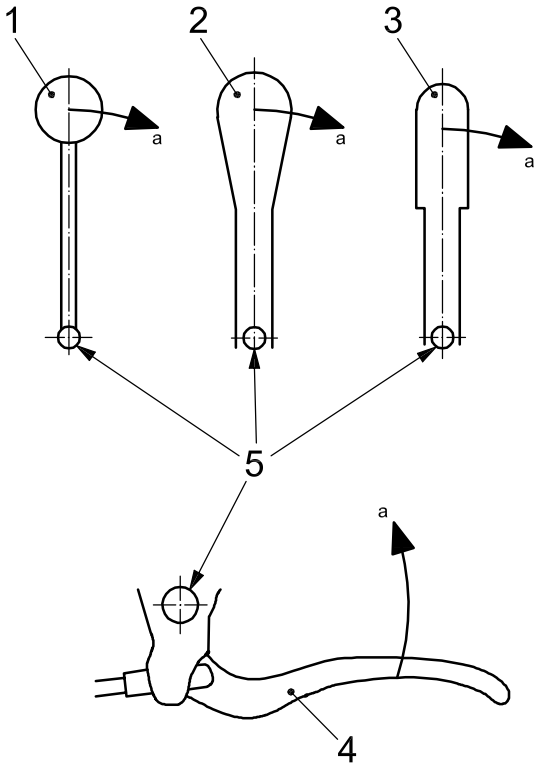
Operate each means to disengage the drive and braking system that can be operated without the use of a tool.

Place castor wheels in a trailing position and steered wheels in the straight ahead position. Use the force measuring instrument to apply equal horizontal forces to the push handles or back of the loaded wheelchair (see 5.2) in a way that simulates pushing straight ahead by an assistant.

Slowly increase the pushing force until the wheelchair starts to move and note the maximum force indicated by the force measuring instrument. Take three measurements in this way and record the arithmetic mean of the measurements.

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

Where possible with the automatic brakes still disengaged, operate all drive controls and observe if the wheelchair drives.



Key

1 lever with spherical knob
2 tapered lever
3 parallel lever
4 bicycle brake style lever
5 fulcrum

[a] Path of the point of application of the operating force.

Figure 7 — Application of forces to levers

8.12 Brakes

8.12.1 General

The basic requirement for safety with single component failure also applies to wheelchair braking systems. For example, vehicles with a single brake can lose the ability to brake in the event of a single failure of a transmission component, which could lead directly to a safety hazard.

8.12.2 Requirements

When the wheelchair is tested in accordance with 8.12.3, there shall be no single component failure that can:

— lead to complete loss of braking or

— lead to partial loss of braking such that the wheelchair will not stop when another brake available to the operator is used.

NOTE Components can include, but are not limited to, mechanical, electrical and electro-mechanical parts.

8.12.3 Test method

a) Trace the brake activation command path of the wheelchair from the operator command signal to the wheel or wheels that are braked. Identify the components in the braking system, using any necessary design drawings, wiring diagrams and schematics. Exclude mechanical components used in the transmission, such as the rotors of the drive motors, shafts, gears and belts.

b) Identify each potential single failure of the components identified in a) which can lead to a complete or partial loss of braking when the control device is in the stop position.

c) Place the loaded wheelchair (see 5.2) on the inclined test plane (4.1) facing up the slope. Switch on the wheelchair. Introduce a single failure identified in b) and then immediately operate any other brake available to the intended operator (the occupant or assistant).

d) The wheelchair fails the test if it travels more than two metres down the slope.

e) Repeat c) and d) for each brake provided on the wheelchair.

f) Repeat c) to e) with the wheelchair facing down the slope.

g) Repeat c) to f) for each potential failure identified in b).

8.13 Battery enclosures

8.13.1 Requirements

Battery compartments shall be designed such that the batteries used for wheelchair propulsion are accessible for inspection and service operations as recommended by the manufacturer.

Any compartment for lead-acid batteries shall be ventilated by an opening or some openings with a minimum total area calculated from the following expression:

$$A = 0{,}005 \times n \times C_5$$

where

A is the cross-sectional area of the openings, expressed in square centimetres (cm^2);

n is the number of cells contained in the compartment;

C_5 is the rated capacity at the 5 h discharge rate, expressed in ampere hours (Ah).

NOTE The openings are intended to permit escape of gases.

Battery compartments shall be used unless the batteries are designated non-spillable. Such compartments shall not leak when tested in accordance with 8.13.2.

Battery compartments should be resistant to corrosion caused by battery spillage.

8.13.2 Test method

Place the battery or batteries in the compartment.

Fill the compartment with water to a depth of half of the total battery height ± 3 mm.

Tilt the compartment through (20 ± 3)° from the horizontal in all directions.

Examine the compartment for visible evidence of leakage.

8.14 Symbols

Symbols used for marking on the wheelchair shall conform to IEC 60601-1.

NOTE See also 10.1.

8.15 Safety of moving parts

8.15.1 General

It is important that, as far as is practicable, electrically powered moving parts of a wheelchair do not present a hazard.

Where practicable, the occupant's hands should be protected from injury due to collisions with other objects such as furniture. Particular attention should be paid to preventing unintended operation of the control device due to such collisions.

8.15.2 Requirements

Electrically powered moving parts of wheelchairs shall meet the requirements of EN 12182 concerning:

— safety of moving parts;

— prevention of traps for parts of the human body;

— folding and adjusting mechanisms.

8.16 Use in combination with other devices

If the wheelchair is intended by the manufacturer for use in combination with other devices or equipment that would be electrically connected to the battery set, the whole combination, including the connection system, shall conform to this part of ISO 7176.

9 Protection against electric shock, burns, fire and explosion

9.1 Electrical isolation

9.1.1 General

The chassis of an electrically powered wheelchair should not be connected to the battery set or any other part of the electrical system of the wheelchair except by circuits with a high d.c. impedance. 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 that might have a low a.c. impedance, which are intended to provide electromagnetic interference protection or electrostatic discharge protection.

9.1.2 Requirements

The wheelchair frames, motor cases, gearbox cases, battery cases and the controller cases shall not be connected to the battery set or to any other part of the electrical system except by a circuit that will not allow a direct current greater than 5 mA to flow.

When tested in accordance with 9.1.3, the ammeter in the test circuit shall not indicate a current greater than 5 mA.

9.1.3 Test method

9.1.3.1 General

Using the necessary means (4.17), support the wheelchair so that it is secure, with the drive wheels lifted off the ground and free to revolve.

9.1.3.2 Positive connection test

Identify all the electrically conducting parts of the chassis that can be touched by the tip of the test probe 11 (4.9).

Remove paint or other protective coating from part of the wheelchair frame. Connect the test circuit (4.15) to the positive terminal of the battery set as shown in Figure 2.

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

Apply the test probe in turn to all the electrically conductive parts of the chassis that can be touched and check that the ammeter in the test circuit does not indicate a current greater than 5 mA.

9.1.3.3 Negative connection test

Repeat the test described in 9.1.3.2, with the test circuit connected to the negative terminal of the battery set as shown in Figure 3.

9.2 Protection from non-insulated electrical parts

9.2.1 General

It is essential that a wheelchair occupant or assistant is not burned or given an electric shock, or the wheelchair caused to malfunction, by contact with non-insulated electrical parts.

9.2.2 Requirement

When tested in accordance with 9.2.3, it shall not be possible for a test probe to touch non-insulated electrical parts except those protected by a circuit which will not allow a direct current greater than 5 mA to flow (see 9.1.2).

Battery terminals shall be insulated when connected.

9.2.3 Test method

Apply the test probe 11 (4.9) and the small unjointed test probe (4.10) to all openings that give access to electrical parts from every practicable position, with a force no greater than 30 N.

If either test probe enters any opening, use the test probe B (4.7) and test probe 18 (4.8) 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.

9.3 Circuit protection

9.3.1 General

Wheelchair batteries store considerable energy and are capable of supplying that energy quickly with power levels sufficient to burn unprotected or inadequate wiring in fault situations. Burning wiring is a significant hazard for wheelchair occupants.

It is important that all wiring has adequate protection for its conductor size. It is also important that the protective devices are placed as close as practicable to the energy source to minimize the amount of unprotected wiring.

Wiring that carries traction power, and wiring that is used to change the position of body support components, is subjected to short-term/intermittent peak current but under normal conditions is not subjected to high current for long periods. This contrasts with control wiring, particularly that which carries charging current, which carries significant current for lengthy periods of time. This fact makes the protection requirements for control wiring different from that of wiring that carries traction power.

Short circuit tests are used to test wiring carrying traction current.

A combination of short circuit tests and load current tests is used to test control wiring that carries charging current.

Annex A is provided to assist in the selection of combinations of wire sizes and protection which might conform to the requirements of 9.3 and 9.4. Recognizing that there are many acceptable variations and combinations of wire ratings and protection ratings for a particular system, Annex A is provided only as informative guidance for a particular circuit design. Since all systems are not identical and because of technology advancements, there might be combinations different than those outlined in Annex A which, when supported by risk analysis and additional component-level testing, would conform to the requirements of 9.3 and 9.4.

NOTE Further related requirements and tests are included in 9.4.

9.3.2 Requirements

All wiring and connections in a wheelchair shall be suitably protected against excessive current flow from energy sources within the wheelchair or external energy sources connected to it.

When the wheelchair is tested in accordance with 9.3.3, there shall be no visible damage to any current-carrying conductor, insulation or connector, and wire insulators and connectors shall not exceed their dry rated temperature.

NOTE Examples of visible damage include melting, colour change, smoke, copper migration and oxidation.

Circuit protection devices shall not be of the type that can self-reset while a fault is still present.

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

9.3.3 Test methods

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

9.3.3.1 General

Fit the maximum capacity batteries specified by the wheelchair manufacturer. Ensure that the theoretical state of charge of the battery set is not less than 75 % of its rated capacity C_5. Make provision for monitoring the highest temperatures of wire insulation and connectors using thermocouples (4.19).

NOTE Often the inner wires of a bundle will reach a higher temperature than the outer ones.

9.3.3.2 Short-circuit test for wiring that predominantly carries power from the batteries to the drive motors

Identify the wiring that predominantly carries traction current and complete the following tests.

Repeat the following tests for each battery on the wheelchair, one at a time (see Figures 8, 9 and 10 for examples of recommended test points).

a) Determine the location of the point closest to the battery terminals where the positive and negative wires from the battery, or their insulation, can be pulled into contact with each other or with any other wire with a force that is less than 10 N (test points A in Figures 8, 9 and 10). The wheelchair fails the test if there is no circuit protection device within the circuit loop containing this contact point and the battery.

b) If there is a circuit protection device present in the circuit loop containing the contact point described in a) and the battery, strip the insulation from the wires at the contact point and connect the positive and negative wires to the circuit breaker (4.16) so that the wires will be connected 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.

c) Close the contacts of the circuit breaker.

d) Observe and record if the circuit protection device fails to operate, or if the wire insulation shows visible damage due to heating, or if any wire insulation or connector exceeds its rated temperature.

e) Leave the contacts closed for at least 2 min and observe and record if the circuit protection device resets automatically. Use a measuring instrument if necessary.

f) Open the contacts of the circuit breaker.

9.3.3.3 Short circuit test for wiring other than that which predominantly carries traction current

Repeat 9.3.3.2 for the following test points (see Figures 8, 9 and 10 for clarification of test positions):

a) immediately adjacent to the battery side of any circuit protection device (test points B);

b) each charging connector (test points C), using a matching connector to carry the connections to the circuit breaker;

c) the extreme end of any control wiring or points at the end of all branches (test points D).

9.3.3.4 Load current test for wiring that carries battery charging current

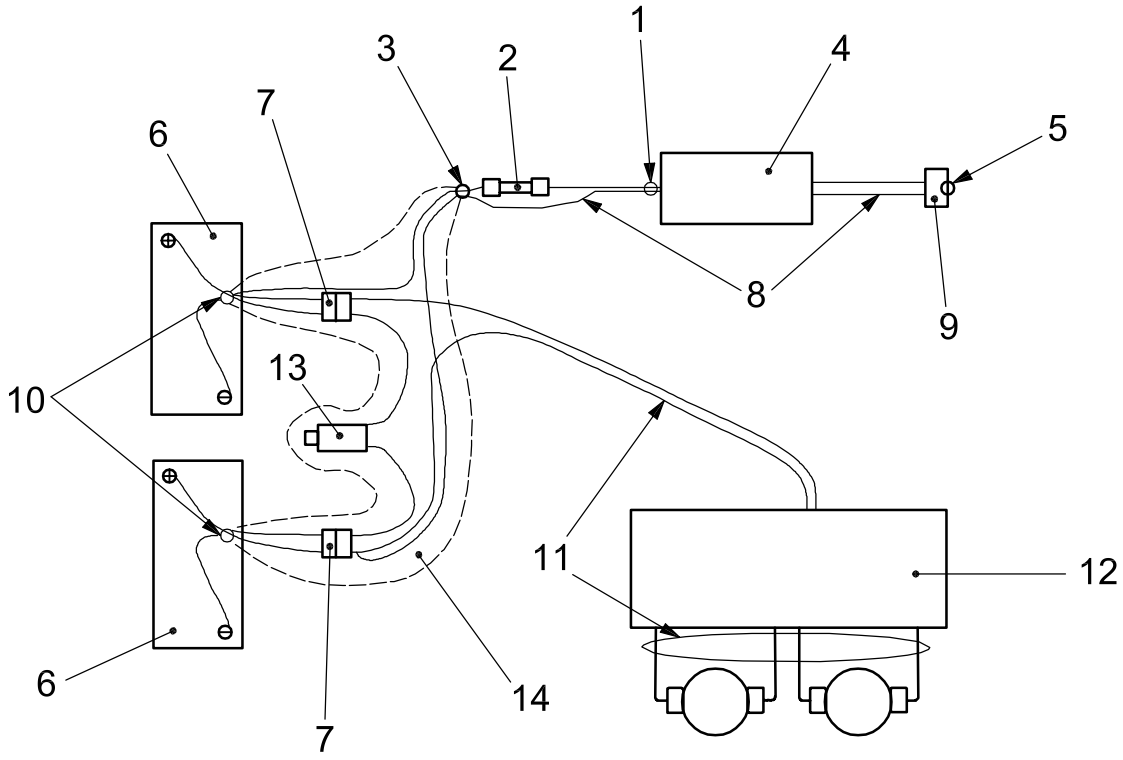
Identify the current-carrying capacity of the circuit protection device that is installed to protect the wheelchair wiring that carries battery charging current. The wheelchair fails the test if there is no circuit protection device suitably installed to protect the wiring.

Ensure that the theoretical state of charge of the wheelchair battery set is not less than 75 % of its rated capacity C_5.

Select an adjustable resistive load or constant current load that is rated to carry the capacity of the protection device. Use the load in combination with a recommended connector that matches the wheelchair's charging connector, a switch and an ammeter that has a range not less than the capacity of the protection device and an accuracy no greater than $\pm$ 2 % of the capacity of the protection device.

Ensure that the switch is off and connect the combined test apparatus to the wheelchair's charging connector via the recommended connector. Connect a voltmeter (4.22) to the battery terminals.

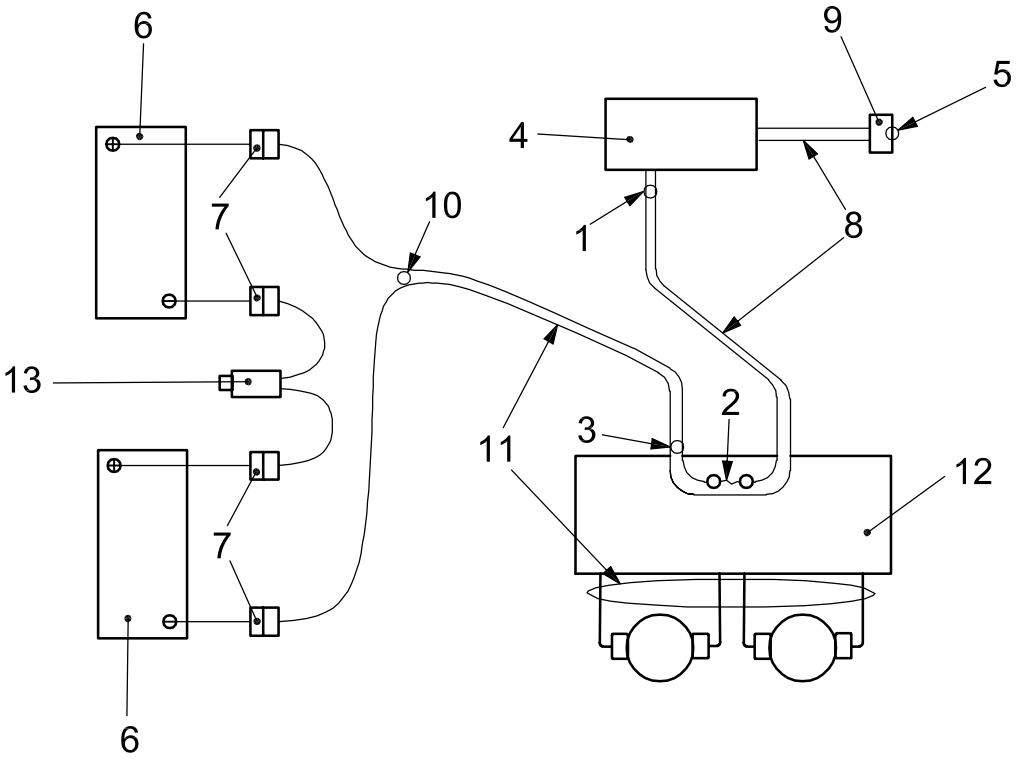
Turn the switch on. Adjust the current if necessary and ensure that it stays within 5 % of the desired level for the duration of the test. Leave the current flowing until the battery voltage falls below 85 % of the nominal battery voltage or visible damage appears on any wiring or connector. The wheelchair passes the test if no visible damage occurs and no wire insulation or connector exceeds its rated temperature.



Key

1	test point D	8	charger and/or control wiring
2	control wiring fuse	9	charger socket
3	test point B	10	test point A
4	low power controls	11	traction wiring
5	test point C	12	wheelchair drive controller
6	battery	13	circuit protection device
7	connector	14	unprotected wiring

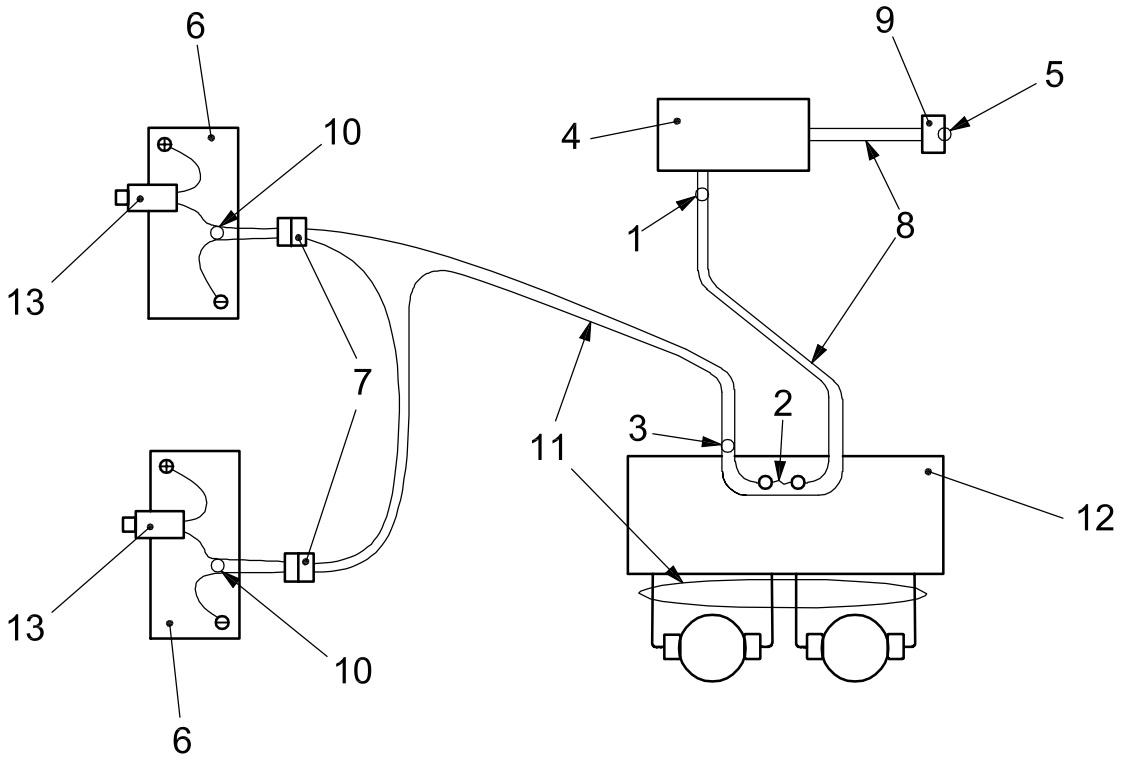
Figure 8 — Example of poor protection



Key

1	test point D	8	charger and/or control wiring
2	control wiring fuse	9	charger socket
3	test point B	10	test point A
4	low power controls	11	traction wiring
5	test point C	12	wheelchair drive controller
6	battery	13	circuit protection device
7	connector		

Figure 9 — Example of good protection with protection device between batteries



Key

1 test point D
2 control wiring fuse
3 test point B
4 low power controls
5 test point C
6 battery
7 connector
8 charger and/or control wiring
9 charger socket
10 test point A
11 traction wiring
12 wheelchair drive controller
13 circuit protection device

Figure 10 — Example of good protection with protection device for each battery

9.4 Stalled condition protection

9.4.1 General

When a wheelchair is driven against an obstacle such as a high kerb, the drive motor or motors can be stalled. If the operator continues to drive when a motor is stalled, high currents could flow and the motor(s) could overheat and be damaged permanently. The wheelchair should be protected against such damage yet supply sufficient power for reasonable kerb climbing and heavily loaded situations.

9.4.2 Requirements

Circuit protection devices that immobilize the wheelchair shall not operate during a period of 15 s after the wheelchair is stalled, with a maximum speed command signal continuously applied.

After being locked in position with a maximum speed command signal applied for a period of 3 min, and for a further period of 30 min, the wheelchair shall pass the functional check specified in ISO 7176-9.

When tested in accordance with 9.4.3.1:

a) current shall flow in the motor windings for not less than 15 s before any break in current,

NOTE 1 The period during which current flows in subsequent cycles may be less than 15 s.

NOTE 2 The current may vary during the three minutes.

b) no non-resettable circuit protection device shall operate that immobilizes the wheelchair.

On completion of the test in accordance with 9.4.3.1 and 9.4.3.2:

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

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

Self-resetting over-current releases that operate when the wheelchair is tested in accordance with 9.4.3 shall be capable of operation not less than 200 times. Non-self-resetting over-current releases that operate when the wheelchair is tested in accordance with 9.4.3 shall be capable of operation not less than 10 times.

9.4.3 Test method

9.4.3.1 Initial stall test

Condition the wheelchair in an ambient temperature of 20 °C ± 5 °C for 24 h prior to testing.

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 measure the time for which the current flows (4.20).

Set the control device 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 resettable circuit protection devices, immediately 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 three minutes from the time the current first flows.

If the wheelchair is fitted with self-resetting circuit protection devices, take such steps as necessary to permit the devices to reset (e.g. returning the control device to neutral; see manufacturer's instructions). Repeat the test as many times as practicable, 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 three-minute test period.

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

Within one minute of removing the means of locking, begin the functional check specified in ISO 7176-9. If the wheelchair will not drive because a self-resetting protection device has not yet reset, wait no more than one minute and attempt the functional check again, repeating until the device resets, up to a maximum of 15 min after the end of the test.

After performing the functional check, examine the drive system and wiring.

Record if any non-resettable circuit protection device operated that would immobilize the wheelchair, whether the functional check was successfully completed and whether any damage to the controller or wiring was observed.

9.4.3.2 Extended stall test

Within 10 min of completing 9.4.3.1, mechanically lock the position of the wheelchair again.

Set the control device for maximum forward speed and hold it in that position for 30 min $^{+10\,\text{min}}_{0}$.

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

Within 3 h of removing the means of locking, begin the functional check specified in ISO 7176-9. If the wheelchair will not drive because a self-resetting protection device has not yet reset, wait no more than 15 min and attempt the functional check again, repeating until the device resets, up to a maximum of 4 h after the end of the test.

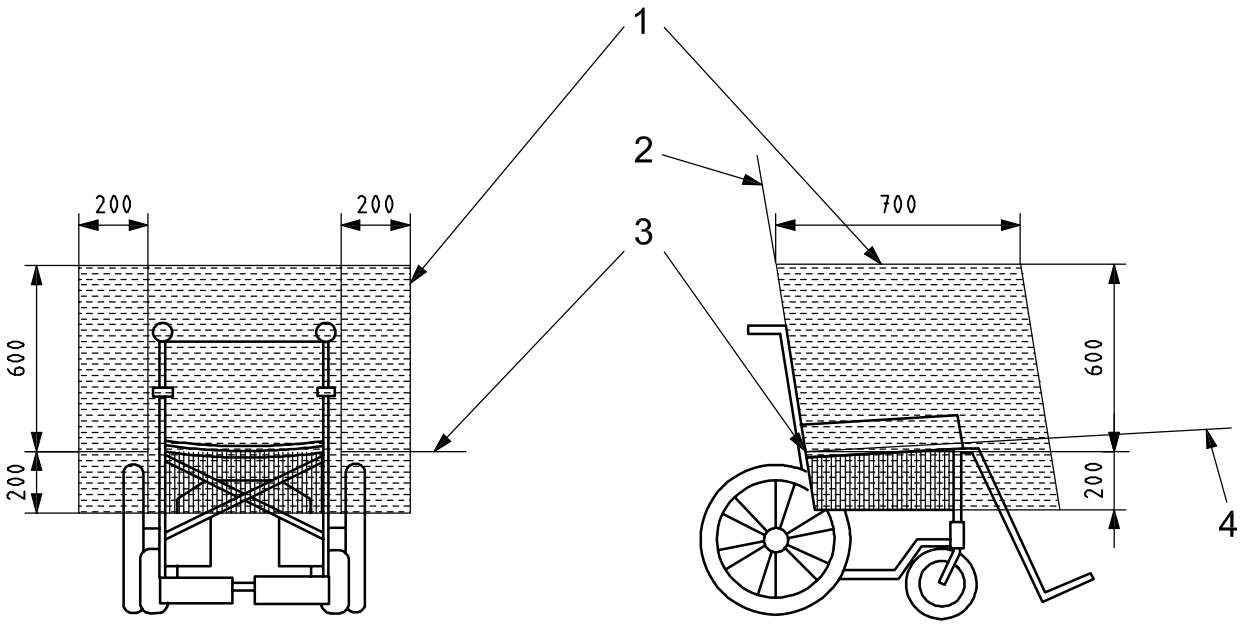
After performing the functional check, examine the drive system and wiring.

Record whether the functional check was successfully completed and whether any damage to the controller or wiring was observed.

9.5 Surface temperatures

Surfaces which can come into constant direct contact with the occupant's skin during normal use and including at least those within the occupant reach space illustrated in Figure 11 shall not exceed 41 °C as measured by the test method specified in EN 563.

Dimensions in millimetres



Key

1 occupant reach space
2 backrest reference plane
3 intersection line between backrest reference plane and seat reference plane
4 seat reference plane

NOTE The darker shaded region below the seat is excluded from the occupant reach space.

Figure 11 — Occupant reach space

9.6 Disconnection of battery system

9.6.1 General

It is important for transportation, storage and safety to be able to electrically disconnect the battery set or remove the battery set without dismantling the wheelchair. Many airlines require disconnection of the battery set for transport.

9.6.2 Requirement

The wheelchair shall be equipped with a means of electrically disconnecting the battery set or removing the battery set without the use of a tool. The means shall be clearly marked.

NOTE Removal of battery packs from the wheelchair, without removal of batteries from battery packs, is considered to be removal of the battery set from the wheelchair.

9.6.3 Test method

Check that there is a means of electrically disconnecting the battery set or removing the battery set without the use of a tool. Confirm by inspection that the battery set can be isolated without use of a tool.

9.7 Resistance to ignition

9.7.1 General

It is essential that safety risks due to flammability of materials in the wheelchair are minimized.

9.7.2 Requirement

Where the following parts are made of polymeric material, the material shall be classified V-0 when subjected to the 20 mm vertical burning test specified in UL 94:

— components within 25 mm of any connected battery terminal;

— components within 50 mm of any connected battery terminal, unless there is a barrier of non-flammable material, or material with UL 94 classification V-0, between the components and the battery terminal, excluding any material in contact with the battery terminal;

— electrical enclosures including controller cases;

— lamp housings;

— connector housings for conductors that carry battery charging current, motor current, or lamp current, and that are outside or part of any controller case.

NOTE This requirement does not apply to the cases and handles of lead-acid batteries.

10 Ergonomics

10.1 User interface

Where the wheelchair bears marking, visual indicators and/or visual displays, they shall be understandable to the operator.

Where appropriate, this information should take the form of symbols. Symbols and colours used for markings, controls, visual indicators and/or visual displays shall conform to IEC 60601-1 and ISO 3287 where applicable, except that the colour red may be used for indicator warnings that require a prompt response by the operator,

rather than an immediate response. All symbols used for markings, visual indicators and/or visual displays, and the sounds made by auditory indicators, shall be described in the user manual.

The size and style of font used for text should be appropriate for the viewing distance and should contrast in colour and luminance with its background. All information conveyed with colour shall be available without the perception of colour.

10.2 Operating forces

10.2.1 General

Some wheelchair operators need to know the forces required for operating control devices when purchasing a wheelchair.

10.2.2 Requirements

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

The operating force for switches intended for operation by a single finger shall not exceed 5 N.

The forces or pressures required to operate the control devices shall be measured in accordance with 10.2.3.

10.2.3 Test method

10.2.3.1 Lever to control speed and/or direction

Select the part of the lever (see Figure 7) 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 from the end.

Use a force-measuring instrument for control devices (4.12) aligned in the direction of travel of the point of application of the force $\pm$ 15°, to move the lever to the limit of its travel in all directions, keeping the line of application of the force through the centreline of the lever $\pm$ 2 mm.

Measure and record the maximum force needed to operate the lever, to an accuracy of 0,1 N.

Take three measurements in this way and record the arithmetic mean of the three measurements.

10.2.3.2 Push-button, rocker and keypad switches

Where the control device is a push-button, fit the spherical tip to the force-measuring instrument for control devices (4.12).

Use the force-measuring instrument for control devices (4.12) to apply a force to the centre of the switch in line with its axis of operation. Increase the force until the switch operates.

Measure and record the maximum force needed to operate the switch to an accuracy of 0,1 N.

Take three measurements in this way and record the arithmetic mean of the three measurements.

10.2.3.3 Toggle switches

Make provision for attaching the force-measuring instrument for control devices (4.12) 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 ± 15°.

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

Increase the force applied to the switch until it operates.

Measure and record the maximum force needed to operate the switch to an accuracy of 0,1 N.

Take three measurements in this way and record the arithmetic mean of the three measurements.

10.2.3.4 Pneumatic switches (sip and puff)

10.2.3.4.1 Positive differential air pressure switches (puff)

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

Connect the positive differential air pressure measuring device (4.13) to the pneumatic switch inlet without obstructing the ability to operate the switch in the usual way.

Switch on the controller.

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, to a resolution of 200 Pa.

Allow the inlet to return to atmospheric pressure.

Take three measurements in this way and record the arithmetic mean of the three measurements.

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

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

10.2.3.4.2 Negative differential air pressure switches (sip)

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

Connect the negative differential air pressure measuring device (4.14) 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, to a resolution of 200 Pa.

Allow the inlet to return to atmospheric pressure.

Take three measurements in this way and record the arithmetic mean of the three measurements.

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

Repeat this test for each of the negative differential air pressure switch inlets.

10.3 Display position

Devices that present visual information to the occupant shall be positioned so that they are clearly visible by the occupant when seated in the wheelchair. All information conveyed with colour shall be available without the perception of colour.

Displays should be designed in line with ergonomic principles, taking account of the intended purpose of the wheelchair.

10.4 On/off indicator

The wheelchair shall be equipped with a device that indicates whether the wheelchair is switched on and ready for operation.

10.5 Connectors

It shall be possible for electrical connectors intended for use by the occupant or assistant to be connected and disconnected without the use of tools.

10.6 Audible noise

10.6.1 General

Wheelchairs might be used in environments where the ambient noise level is low. It is important that they are not intrusive in such environments.

10.6.2 Requirement

When the wheelchair and ancillary equipment (apart from the audible warning device) are tested as specified in 10.6.3 and 10.6.4, the sound pressure level shall not exceed

— 65 dB(A-weighted) for wheelchairs not intended primarily for outdoor operation or

— 75 dB(A-weighted) for wheelchairs intended primarily for outdoor operation.

10.6.3 Test method

Carry out the tests for audible noise using the following method.

a) Position the sound pressure level measurement device (4.18) level with the mid-point of the acoustic test area (4.3) 1 m ± 0,05 m above the test plane and 1 m ± 0,1 m from the centre line of the acoustic test area as illustrated in Figure 12.

b) Drive the wheelchair forward at its maximum speed, as measured by the method specified in ISO 7176-6, along the centre line of the acoustic test area, ± 100 mm, such that it reaches its maximum speed before it enters the measuring distance shown in Figure 12 and maintains its maximum speed within it.

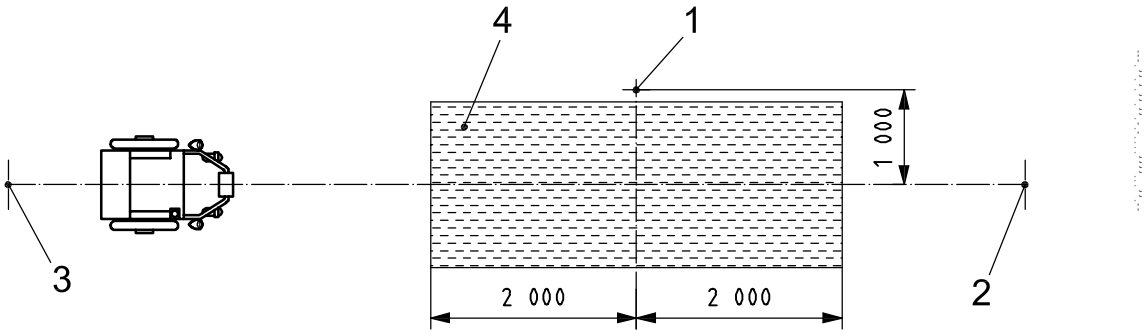
c) Measure and record the maximum time-weighted sound level to an accuracy of ± 3 dB(A-weighted), using frequency weighting (A), time weighting (F), with the hold facility activated.

d) Repeat b) and c) a further two times with the wheelchair travelling in the same direction.

e) Calculate the arithmetic mean of the three recorded values. If the arithmetic mean exceeds the applicable requirement of 10.6.2, the wheelchair fails the test.

f) Repeat items b) to e) with the wheelchair travelling forward in the opposite direction.

Dimensions in millimetres



Key

1 measuring device
2 stop position
3 start position
4 measuring distance

Figure 12 — Audible noise drive test

10.6.4 Ancillary equipment test

Perform the following test sequence on each set of electrically adjustable body support components (such as seat, back support or leg support mechanisms) that can be operated at any one time by the occupant or assistant.

a) Position the wheelchair in the acoustic test area.

b) Place the sound pressure level measurement device (4.18) at one of the positions shown in Figure 13, 1 m ± 0,05 m above the test plane and 1 m ± 0,05 m from the perimeter of the wheelchair.

c) Operate the set of electrically adjustable body support components throughout its range of operation.

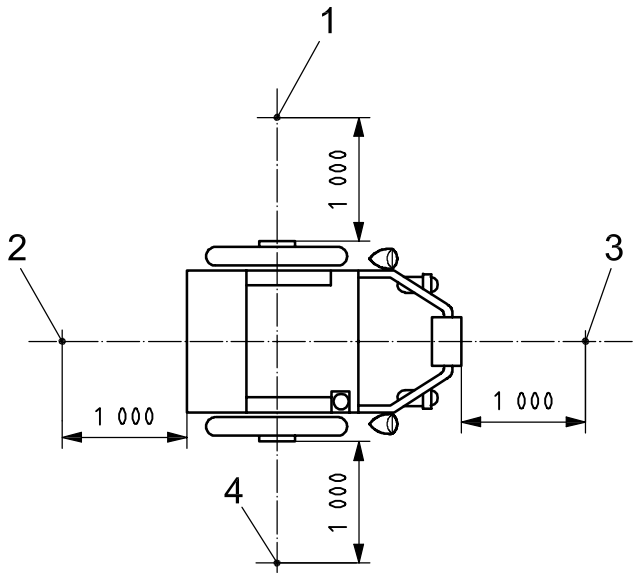
d) Measure and record the maximum time-weighted sound level to an accuracy of ± 3 dB(A-weighted), using frequency weighting (A), time weighting (F), with the hold facility activated.

e) Repeat c) and d) a further two times.

f) Calculate the arithmetic mean of the three recorded values. If the arithmetic mean exceeds the applicable requirement of 10.6.2, the wheelchair fails the test.

g) Repeat the test for each of the remaining positions shown in Figure 13.

Dimensions in millimetres



Key

1 measuring point 1
2 measuring point 2
3 measuring point 3
4 measuring point 4

Figure 13 — Audible noise ancillary equipment test

10.7 Acoustic warning device

10.7.1 General

Wheelchairs shall be equipped with an acoustic warning device to allow the operator to warn others.

10.7.2 Requirements

The wheelchair shall be equipped with an occupant-operable acoustic warning device (e.g. a horn).

The sound of the warning device shall be a single continuous tone with a fundamental frequency between 500 Hz and 3 kHz.

When tested as specified in 10.7.3, the sound pressure level of an acoustic warning device in at least one of the test points shall not be less than

— 65 dB(A-weighted) for wheelchairs not intended primarily for outdoor operation or

— 75 dB(A-weighted) for wheelchairs intended primarily for outdoor operation.

10.7.3 Test method

Perform the following test sequence on each acoustic warning device.

a) Position the wheelchair in the acoustic test area.

b) Place the sound pressure level measurement device (4.18) at one of the positions shown in Figure 13, 1 m ± 0,05 m above the test plane and 1 m ± 0,05 m from the perimeter of the wheelchair.

c) Operate the acoustic warning device.

d) Measure and record the maximum time-weighted sound level to an accuracy of ± 3 dB(A-weighted), using frequency weighting (A), time weighting (F), with the hold facility activated.

e) If the maximum time-weighted sound level is less than the applicable requirement of 10.7.2, the wheelchair fails the test.

f) Repeat the test for each of the remaining positions shown in Figure 13.

11 Durability

11.1 Control devices

11.1.1 General

Control devices shall be of robust design.

11.1.2 Requirement

11.1.2.1 General

When tested as specified in 11.1.2.2, there shall be no change in performance of control devices.

NOTE This requirement applies to switches when they are used as control devices.

11.1.2.2 Test method for fatigue strength of control devices

a) Carry out the test on three control device specimens.

b) Check that the control device operates the wheelchair as specified by the manufacturer by performing the functional check specified in ISO 7176-9.

c) Using the method specified in 10.2.3, determine the magnitude of the operating force, F, and its point of application, or the magnitude of the operating pressure, P.

d) If the control device is operated by a force, measure the distance, d, moved by the point of application of the force, F.

e) If the control device is operated by a force, and the distance, d, moved by the point of application of the force is greater than 5 mm, follow the procedure given in h).

f) If the control device is operated by a force and the distance, d, moved by the point of application of the force is less than or equal to 5 mm, follow the procedure given in i).

g) If the control device is operated by pressure, follow the procedure given in j).

h) Move the control device from its neutral position through a displacement, x, and back to its neutral position. This action constitutes one cycle, where:

$$0{,}90 \times d < x < 0{,}99 \times d$$

Ensure that no load greater than the operating force is applied to the control device at the extremes of travel.

NOTE An eccentric driving motor, lifting magnet or similar device can be used to move the control device.

i) Apply a force normal to the centre line of the control device. Gradually increase the force from zero to $F \pm 5$ %, and then gradually reduce the force to zero. This action constitutes one cycle.

NOTE An eccentric motor and a spring or a similar arrangement may be used to provide the force.

j) Apply a pressure to the control device, gradually increasing from atmospheric pressure to $P \pm 5$ %, and then gradually reducing the pressure to atmospheric pressure. This action constitutes one cycle.

Repeat the operation for 1,5 million cycles $\pm$ 1 %, at a frequency of between 1 Hz and 2 Hz.

Check whether the control device operates the wheelchair as specified by the manufacturer by performing the functional check specified in ISO 7176-9.

11.2 Switches

11.2.1 General

It is essential that switches provided for use by the occupant and/or assistant are sufficiently robust.

11.2.2 Requirements

Switches that are intended for operation by the occupant and/or assistant, other than those used as control devices, shall be rated for not less than 100 000 electrical cycles and not less than 100 000 mechanical cycles.

11.3 Connectors

11.3.1 General

Connectors shall be of robust design.

11.3.2 Requirements

Connectors intended by the wheelchair manufacturer for daily use, including charging connectors, and connectors uncoupled for transfer and/or transport, shall be rated for not less than 4 000 coupling/uncoupling cycles if no inspection and replacement instructions are included for those connectors in the service manual. Where inspection and replacement instructions are included for such connectors in the service manual, the connectors shall be rated for not less than one coupling/uncoupling cycle for each day of the specified interval between inspections.

12 Electrical connections

12.1 Interchangeability

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

Colour coding shall not be the only means used to prevent incorrect 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 supply mains.

12.2 Wire routing

12.2.1 General

Wires protruding 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.

12.2.2 Requirements

All wires shall be routed and secured in such a manner that they cannot be snagged on objects encountered in the wheelchair's intended environment, or be damaged by, or interfere with, any moving part of the wheelchair.

When the wheelchair is tested in accordance with 12.2.3, no wires shall

a) be damaged by parts that move or

b) be trapped in any pinch points.

12.2.3 Test method

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 $\pm$ 1 N.

If the wheelchair has adjustable components or assemblies (e.g. adjustable back rest), repeat the procedure for the positions least favourable to each cable.

Examine all wires to determine whether they can be snagged on objects encountered in the wheelchair's intended environment.

12.3 Wire colours

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

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

Other wires connected to batteries shall not be red.

NOTE Batteries with built-in connectors that cannot be misconnected are exempt from these requirements.

12.4 Intermediate battery connection power drains

12.4.1 General

Drawing power from intermediate battery connections can shorten the service life of the battery set.

12.4.2 Requirements

No power shall be drawn from the battery set other than via the positive and negative terminals of the battery set.

Circuits used for monitoring or maintaining the state of the batteries are exempt from this requirement.

12.4.3 Test method

Check by inspection.

13 Environmental

13.1 Substance/liquid ingress (in)

The wheelchair shall meet the requirements concerning rain conditions specified in ISO 7176-9, when tested using the spray nozzle specified in IEC 60529 for the second characteristic numeral 4 (IPX4).

13.2 Leakage of substances (out)

Substances that can leak from the wheelchair shall either

a) be found to be biocompatible in accordance with the guidance given in EN 30993-1, where the assessment shall take into account the intended use and contact by those involved in occupant care, wheelchair transport and storage, or

b) be provided with protection that minimizes the possibility of such substances becoming a hazard.

NOTE 1 Substances that can leak include battery electrolytes, lubricants and hydraulic fluids.

NOTE 2 An example of a method of protection from a hazardous substance is where lead-acid batteries are placed in a compartment made from acid resistant material.

13.3 Electromagnetic compatibility

Wheelchairs shall conform to ISO 7176-21.

Electrical parts of wheelchairs which are not addressed by the requirements of ISO 7176-21 and which could give rise to a safety hazard if they malfunctioned, shall conform to IEC 60601-1-2 using the test levels specified in ISO 7176-21.

14 Misuse and abuse

14.1 Reversed polarity at the battery set

14.1.1 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.

14.1.2 Requirements

When tested in accordance with 14.1.3:

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;

b) if the wheelchair operates, it shall be in accordance with the manufacturer's specification with no uncontrolled or unwanted movements;

c) 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.

Wheelchairs that have battery connectors that cannot be misconnected are exempt from these requirements.

14.1.3 Test method

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 (4.16) to 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.

Carry out the functional check specified in ISO 7176-9.

14.2 Integrity of enclosures

14.2.1 General

It is essential that exposed enclosures for electrical circuitry be able to withstand impacts with objects in the wheelchair's intended operating environment without mechanical failure that could lead to a safety hazard.

14.2.2 Requirements

When tested in accordance with 14.2.3, enclosures for electrical circuitry that are at risk of impact with static external structures during normal operation

— shall not be fractured or have visible cracks,

— shall have no nut, bolt, screw, locking pin, adjustable component or similar item that has become detached,

— shall have no electrical connector that has become displaced or disconnected,

— shall have all parts intended to be removable or folding or adjustable, operable in accordance with the manufacturer's instructions,

— shall have no hand-grips that have become displaced,

— shall have no component or assembly of parts that exhibits deformation, free play or loss of adjustment that adversely affects the function of the wheelchair.

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

Following the test, the enclosures shall meet the requirements of 9.2.2.

Following the test, the wheelchair shall pass the functional check specified in ISO 7176-9.

14.2.3 Test method

Test each enclosure using the test method specified in IEC 62262 for IK10, with the following provisions:

a) test a single sample;

b) use a pendulum hammer;

c) test each enclosure fitted to the wheelchair on a horizontal test surface;

d) conduct the test with the wheelchair switched on.

Carry out the functional check specified in ISO 7176-9.

15 Information provided with the wheelchair related to control systems

15.1 General

It is essential that each wheelchair be accompanied by the information needed to use it safely, taking account of the training and knowledge of the potential operators. As far as is practicable and appropriate, it is important that the information needed to use the wheelchair safely be set out on the wheelchair itself and/or in the user manual.

15.2 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.

The diagram shall show the following:

a) connections to the batteries with identification of the wires and terminals (except for batteries that cannot be misconnected);

b) the location and pictorial instructions for use, of all circuit protection devices intended to be serviced by the occupant or an assistant;

c) the current rating and type of any fuses intended to be serviced by the occupant or an assistant.

The diagram should be resistant to deterioration from battery gases and acid.

15.3 Operation of wheelchair

Instructions provided with the wheelchair shall include the following:

a) safety information as specified in 15.4;

b) a statement stating that only specified products are to be used with the wheelchair;

c) instructions for who can safely perform specified set up procedures;

d) the information necessary to verify whether the wheelchair is properly set up and can operate correctly and safely, including adjustments that affect stability, and details of the nature and frequency of maintenance needed to ensure that the wheelchair continues to operate correctly and safely;

e) correct use of brakes.

15.4 Safety information provided to operators

The following safety information shall be provided to wheelchair operators:

a) instructions not to install, maintain or operate equipment without reading the manual;

b) a warning that the wheelchair should be turned off prior to entering or exiting the wheelchair;

c) if applicable, a warning that the wheelchair may come to a sudden stop at any time during operation;

d) a warning not to operate the wheelchair if it is behaving abnormally or erratically;

e) any special environmental storage conditions;

f) instructions on the interpretation of the battery gauge;

g) a warning not to operate the wheelchair with depleted batteries, since the occupant could be stranded;

h) an instruction to have the wheelchair serviced at specified intervals and if a fault is indicated;

i) safety warnings related to pinch points in electrically powered mechanisms;

j) the causes of electromagnetic interference and possible effects on the wheelchair.

15.5 Removable parts

Instructions shall be provided that describe the correct fitting of removable parts.

15.6 Residual risks

Information regarding the residual risks due to any shortcomings of the protection measures adopted shall be marked clearly and durably on the wheelchair, or included in the user manual.

16 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;

c) a statement that the tests have been carried out in accordance with ISO 7176-14;

d) the name and address of the manufacturer of the wheelchair tested;

e) the product name, code or other type identification for the wheelchair and, where the information is available, for the controller, motor(s) and batteries;

f) a statement as to which requirements were met by the wheelchair and/or charger;

g) a statement as to which requirements were not met by the wheelchair and/or charger;

h) the forces and/or pressures required to operate control devices;

i) the speed, v, and stopping distance, L_{I}, measured in 5.3.

17 Disclosure

The following information shall be disclosed as specified in ISO 7176-15:

a) that the product met all the requirements of ISO 7176-14;

b) the forces necessary to operate the control devices;

c) pressures necessary to operate pneumatic switches (sip and puff operation).

Annex A
(informative)

Guidance on wheelchair wire sizing and protection

A.1 General

This informative annex provides guidance on selecting sizes for single 105 °C rated PVC insulated copper wires in free air with an ambient temperature no greater than 30 °C.

For each table, use the values in the first column to determine the applicable row.

Reduce the allowable current or increase the wire size if lower temperature insulation is used.

For two to five wires in a bundle, de-rate the allowable current to 80 % or increase the size of each wire by 25 %.

A.2 Traction wiring

Table A.1 shows recommended minimum sizes for traction wires.

Table A.1 — Recommended traction wire sizing and protection ratings

Controller current limit (A)		**Battery cut-out rating** (A)		**Battery wire size** (mm^2)			**Motor wire size** (mm^2)	
Maximum r.m.s. motor current	Motor continuous current (typical)			for length < 1 000 mm	for length 1 000 mm to 1 500 mm		for length < 1 000 mm	for length 1 000 mm to 1 500 mm
		Dual channel	Single channel	Any	Dual channel	Single channel	Any	
30	8	30	20	2,5	3,0	2,5	2,5	2,5
40	10	40	30	3,0	4,0	3,0	2,5	3,0
50	15	50	30	4,0	5,0	4,0	3,0	4,0
60	20	60	40	6,0	8,0	6,0	3,0	4,0
80	30	70	50	6,0	No guidance	8,0	4,0	5,0
100	40	No guidance	60	6,0	No guidance	No guidance	6,0	6,0
150	50	No guidance	70	8,0	No guidance	No guidance	8,0	8,0

NOTE The r.m.s. motor current is specified for an integration period of one second.

A.3 Charger wiring

Table A.2 shows recommended minimum sizes for battery charger wires and related fuse ratings.

Table A.2 — Recommended charger wire sizing and protection

Rated charger current (A)	**Fuse rating** (A)	**Cable length** (m)	**Minimum wire size** (mm^2)
3	7,5	1	0,5
3	7,5	2	0,75 [a]
5	10	1	0,75
5	10	2	1,0 [a]
8	15	1	1,0
8	15	2	1,5 [a]
12	20	1	1,5
12	20	2	2,5 [a]

[a] Voltage drop limited (see 8.10).

A.4 Actuator and lighting wiring

Table A.3 shows recommended minimum sizes for lighting and actuator wires and related fuse ratings.

Table A.3 — Recommended lighting and actuator wire sizing and protection

Lighting/actuator current rating (A)	**Fuse rating** (A)	**Minimum wire size** (mm^2)
3	7,5	0,5
5	10	0,75
10	15	1,0
15	20	1,5

Bibliography

[1] IEC 60050-151, *International Electrotechnical Vocabulary — Part 151: Electrical and magnetic devices*

[2] IEC 60050-482, *International Electrotechnical Vocabulary — Part 482: Primary and secondary cells and batteries*

[3] IEC 60050-702, *International Electrotechnical Vocabulary — Chapter 702: Oscillations, signals and related devices*

ICS 11.180.10

Price based on 53 pages