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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

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 173, *Assistive products*, Subcommittee SC 1, *Wheelchairs*.

This third edition cancels and replaces the second edition (ISO 7176-14:2008), which has been technically revised.

The main changes compared to the previous edition are as follows:

— addition of provisions on the following:
  — wireless communication technology;
  — thermal drive test;
  — occupant operable battery isolation switch;
  — battery chemistries other than lead-acid.

A list of all parts in the ISO 7176 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Electronic control systems in electric powered wheelchairs and scooters are critical for the safety, functionality and reliability of the vehicle.

This document 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.

With inter-module wireless communication becoming more common with the possibility that the communication may cause changes in the behaviour of other devices, a subclause has been added to assist with an associated safety assessment.

Wheelchairs —

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

1 Scope

This document 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 document 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 documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

EN 12182, *Assistive products for persons with disability — General requirements and test methods*

IEC 60332-1-2, *Tests on electrical and optical fibre cables under fire conditions - Part 1-2: Test for vertical flame propagation for a single insulated wire or cable - Procedure for 1 kW pre-mixed flame*

IEC 60417, *Graphical symbols for use on equipment*

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 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)*

IEC 62304, *Medical device software – Software life cycle processes*

ISO 10993-1, *Biological evaluation of medical devices — Part 1: Evaluation and testing within a risk management process*

ISO 7176-2, *Wheelchairs — Part 2: Determination of dynamic stability of electrically powered wheelchairs*

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

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

ISO 7176-5, *Wheelchairs — Part 5: Determination of dimensions, mass and manoeuvring space*

ISO 7176-6, *Wheelchairs — Part 6: Determination of maximum speed of electrically powered wheelchairs*

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

ISO 7176-9:2009, *Wheelchairs — Part 9: Climatic tests for electric wheelchairs*

ISO 7176-10, *Wheelchairs — Part 10: Determination of obstacle-climbing ability of electrically powered wheelchairs*

ISO 7176-13, *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 7176-21:2009, *Wheelchairs — Part 21: Requirements and test methods for electromagnetic compatibility of electrically powered wheelchairs and scooters, and battery chargers*

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

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

ISO 13732-1, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 1: Hot surfaces*

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

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.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
analogue signal
signal in which the characteristic quantity representing information can at any instant assume any value within a continuous interval

Note 1 to entry: An analogue signal can follow continuously the values of another physical quantity representing information.

[SOURCE: IEV 702-04-02]

3.2
battery
one or more cells that are electrically connected together and fitted with devices necessary for use

EXAMPLE Case, terminals, marking and protective devices.

[SOURCE: IEV 482-01-04, modified]

3.3
battery charger
device that is connected to supply mains and to a battery set for the purpose of charging the batteries

3.4
battery compartment
removable or non-removable enclosure for one or more batteries

3.5
battery set
set of interconnected batteries used to power a wheelchair

3.6
battery terminal
terminal on a battery to which a cable or connector can be connected

3.7
capacity
electric charge that a cell or battery can deliver under specified discharge conditions

Note 1 to entry: The SI unit for electric charge is the coulomb, C [1 C = 1 A·s (ampere-seconds)] but in practice, capacity is usually expressed in ampere-hours (A·h) or watt-hours (Wh).

[SOURCE: IEV 482-03-14, modified]

3.8
charge completion voltage
voltage, normally specified by the battery manufacturer, to which a battery is charged in defined circumstances, required to assure that a battery can be fully charged

3.9
charge rate
electric current at which a secondary cell or battery is charged

Note 1 to entry: 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.

[SOURCE: IEV 482-05-45]

3.10
coexistence
ability of two or more spectrum-dependent devices or networks to operate without harmful interference.

Note 1 to entry: Spectrum dependence may include, but is not limited to radio, ultrasound and infrared.

[SOURCE: IEEE Std 1900.1:2008, B28]

3.11
command signal
electrical signal from the control device

3.12
control device
device with which the operator indicates the desired speed and/or direction of movement of the wheelchair and can optionally control their position within the wheelchair

Note 1 to entry: A control device can be an integral part of a controller.

3.13
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 that is supplied to the motor(s)

3.14
cut-off voltage
voltage specified by the battery manufacturer at which the discharge of a battery is considered finished

[SOURCE: IEV 482-03-30, modified]

3.15
discharge rate
electric current at which a battery is discharged

Note 1 to entry: The discharge rate is calculated as the rated capacity divided by the corresponding discharge time, which results in an electric current.

[SOURCE: IEV 482-03-25]

3.16
draught-free environment
space in which the results of experiments are not significantly affected by the local air speed

Note 1 to entry: A qualitative example is a space in which a wax candle flame remains essentially undisturbed. Quantitative examples are small-scale fire tests in which a maximum air speed of 0,1 $m \cdot s^{-1}$ or 0,2 $m \cdot s^{-1}$ is sometimes specified.

[SOURCE: ISO 13943:2017, 3.83]

3.17
enclosure
part providing protection of equipment against certain external influences and, in any direction, protection against contact

Note 1 to entry: Enclosures provide protection of equipment against harmful effects of mechanical impacts.

Note 2 to entry: 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.

3.18
entry point
output terminals of the battery charger for on-board, off-board and carry-on chargers

3.19
harm
physical injury or damage to the health of people or animals, or damage to property or the environment

[SOURCE: IEC 60601-1:2005+AMD1:2012, 3.38]

3.20
hazard
potential source of harm

[SOURCE: IEC 60601-1:2005+AMD1:2012, 3.39]

3.21
hazardous situation
circumstance in which people, property or the environment are exposed to one or more hazard(s)

[SOURCE: IEC 60601-1:2005+AMD1:2012, 3.40]

3.22
latched control
function that remains active without continuous input from the operator

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

[SOURCE: IEV 151-15-49]

3.24
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

3.25
single fault condition
condition in which a single means for reducing a risk is defective or a single abnormal condition is present

[SOURCE: IEC 60601-1:2005+AMD1:2012, 3.115, modified]

3.26
switch
mechanical switching device capable of making, carrying and breaking currents under normal operating conditions which might include specified operating conditions, overload conditions and also carrying for a specified time currents under specified abnormal circuit conditions such as those of short circuit

Note 1 to entry: A switch may be capable of making but not breaking short circuit currents.

[SOURCE: IEV 441-14-10]

3.27
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

Note 1 to entry: Removable bolts, screws and fasteners are not considered part of a terminal.

[SOURCE: IEV 151-12-12]

3.28
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

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 document to be performed and with a marker from which wheelchair stopping distance can be measured.

The inclined test plane shall be able to be fixed at 3°, 6° or 10° to the horizontal. The 6° gradient shall be used unless the loaded wheelchair (see 5.2) is unable to climb at a speed greater than 0,5 km/h or where its primary purpose specified by the manufacturer is for indoor use in which case the gradient shall be set at 3°.

NOTE A ramp approximately 10 m × 3 m is normally of sufficient area, but the testing of larger and/or faster wheelchairs might need a larger ramp.

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 document to be performed.

NOTE An area of approximately 10 m × 3 m is normally of sufficient size but the testing of larger and/or faster wheelchairs might need a larger test plane.

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.

The room shall also have a mean reverberation time (R_t) less than 0,5 s for frequencies from 125 Hz to 4 kHz at the position where sound pressure levels are measured. See Annex B for guidance on estimation of reverberation time.

The test floor shall be uncoated concrete in the area where the chair is driven.

4.4 Means for measuring and recording speed up to 5 m/s, with an accuracy of ±0,1 m/s and a sample rate of at least 60 Hz. for digital measuring devices.

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, but are not limited to:

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.

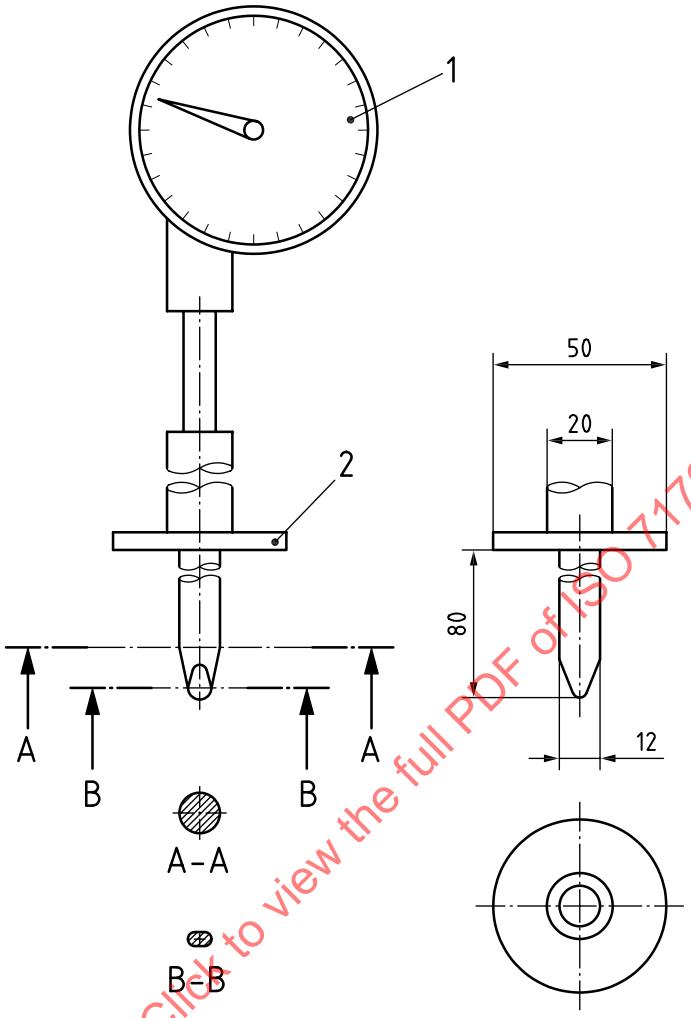
The voltage source shall be capable of supplying the peak current drawn from the battery set during wheelchair operation and shall be capable of sinking the peak current returned to the battery during wheelchair operation. Any change in the voltage shall be no greater than 5 % of U_B while the current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

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:

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

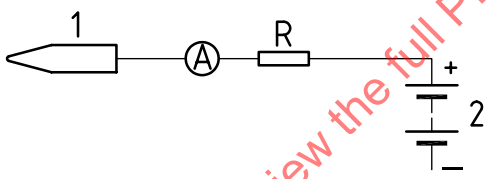
where U_B is the nominal voltage of the battery set.

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:

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

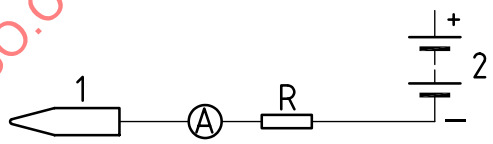
c) test probe 11 (4.9).



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 ±5 % of the maximum stall current of the wheelchair motors, e.g. a clamp-on ammeter.

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 ±1 %.

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

4.24 Adjustable resistive load or constant current load selected so that it can be adjusted for the required current and rated to carry the current capacity of the protection device in the circuit under test.

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 this document;

b) a human test occupant that conforms with the Human Test Occupant requirements of ISO 7176-22.

Where a dummy is fitted to a wheelchair that has an anterior pelvic support, the support should be used to restrain the dummy. Upper thoracic restraints shall be used to limit forward rotation of the dummy trunk to between 20° and 25°.

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 might 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.

NOTE The wheelchair set-up might not be changed or modified for these tests.

Measure and record the stopping distance, L_1, at speed (0,5 ± 0,05) × 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 applicable 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. The justification for the configuration shall be noted in the test report;

c) the battery manufacturer and battery type reference and any certifications that the battery might carry;

d) the mass and configuration of the dummy or human load if used and shall conform with the human test occupant requirements of ISO 7176-22.

6 Guidance for tests

WARNING — The use of this document can involve hazardous materials, operations and equipment. It does not purport to address all of the safety or environmental problems associated with its use. It is the responsibility of users of this document to take appropriate measures to ensure the safety and health of personnel and the environment prior to application of the standard and fulfil statutory and regulatory requirements for this purpose.

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 cut-off voltage of the battery set.

6.3 Test conditions

Carry out the tests in a draught-free environment with an ambient temperature of 20 °C ± 5 °C.

7 Single fault safety

7.1 Single fault conditions

7.1.1 General

The manufacturer shall adopt appropriate means to eliminate or reduce as low as reasonably possible the probability of a hazardous situation developing in the event of a single fault condition. The method for the risk assessment process used is described in ISO 14971.

7.1.2 Requirements

The manufacturer shall declare to test personnel the means by which the wheelchair is made safe under the conditions and for the purposes of intended wheelchair use against single fault conditions.

The manufacturer shall employ ISO 14971 to manage risk.

The manufacturer shall consider the following in the risk management process for a single fault condition:

— fire and/or explosion;

— software;

— electric shock;

— technical knowledge, experience, education or training of intended operator;

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

— short and open circuits of conductors and wiring;

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

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

— drive-train failures.

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

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 2,0 × L_I. L_I is defined in 5.3.

7.2.2.1 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 that 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 that 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.

Conformal coating cannot be relied upon to protect tracks or components on printed circuit boards from moisture induced leakage currents. Coatings for printed circuits in accordance with IEC 60335-1:2020, Annex J can only ensure protection against pollution degree 2 or better. Therefore, it is necessary to ensure enclosures limit pollution to degree 2. If such tracks are not protected by enclosures that offer pollution degree 2 or better protection, they shall be tested as per 7.2.3.3 and 7.2.3.4.

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 ± 0,05) × *v* is achieved. When the marker is reached, open the switch.

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

Switch off the controller and close the switch.

Reset and/or replace any circuit protection devices.

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(±0,05) × *v* is achieved. When the marker is reached, open the switch and put the control device to its stop position.

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

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 ± 0,05) × *v* is achieved. When the marker is reached, close the switch.

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

Switch off the controller and open the switch.

Reset and/or replace any circuit protection devices.

Switch on the controller. Note the position of the marker on the test plane and drive the wheelchair forwards in a straight line down the inclined test plane towards it until a speed of (0,5 ± 0,05) × *v* is achieved. When the marker is reached, close the switch and put the control device to its stop position.

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

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 2,0 × L_I (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 can 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 ± 0,05) × 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.

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. 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, so that, when the switch is operated, the device's state simulates the intended failure condition. Ensure that the power switch input is not left to float when it is open circuited.

NOTE If needed, it is possible to 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.)

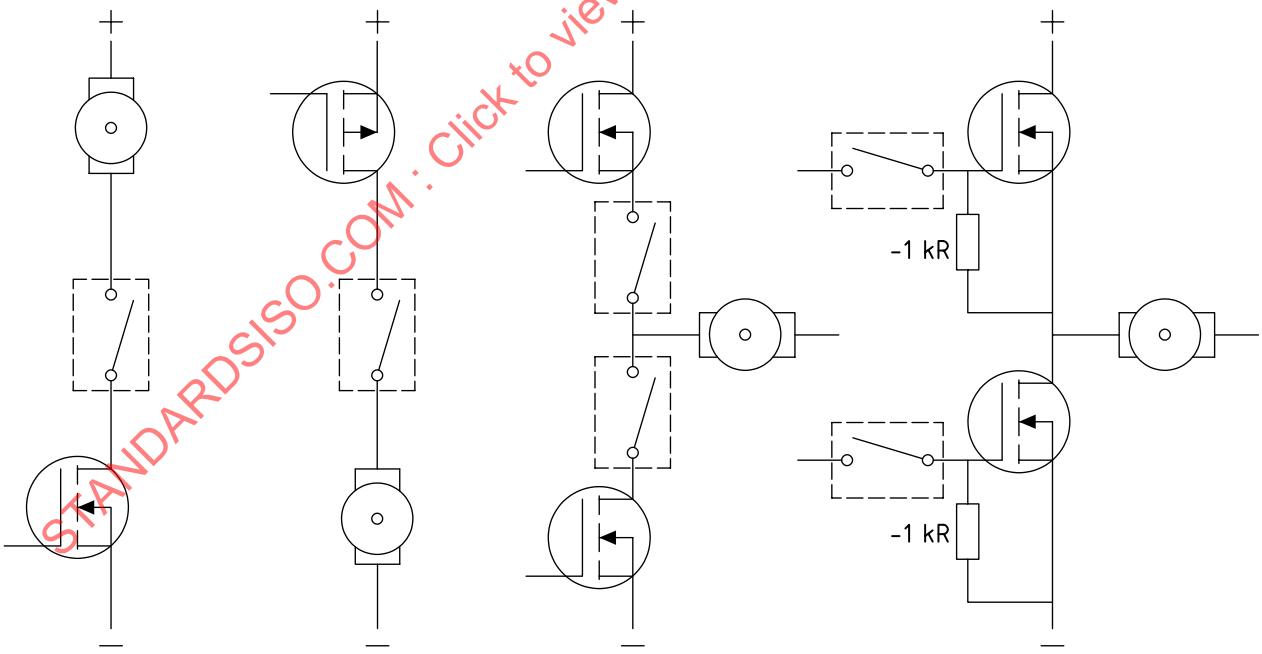


Figure 4 — Open circuit testing switches installed

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 ± 0,05) × *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 2,0 × L_I, 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.

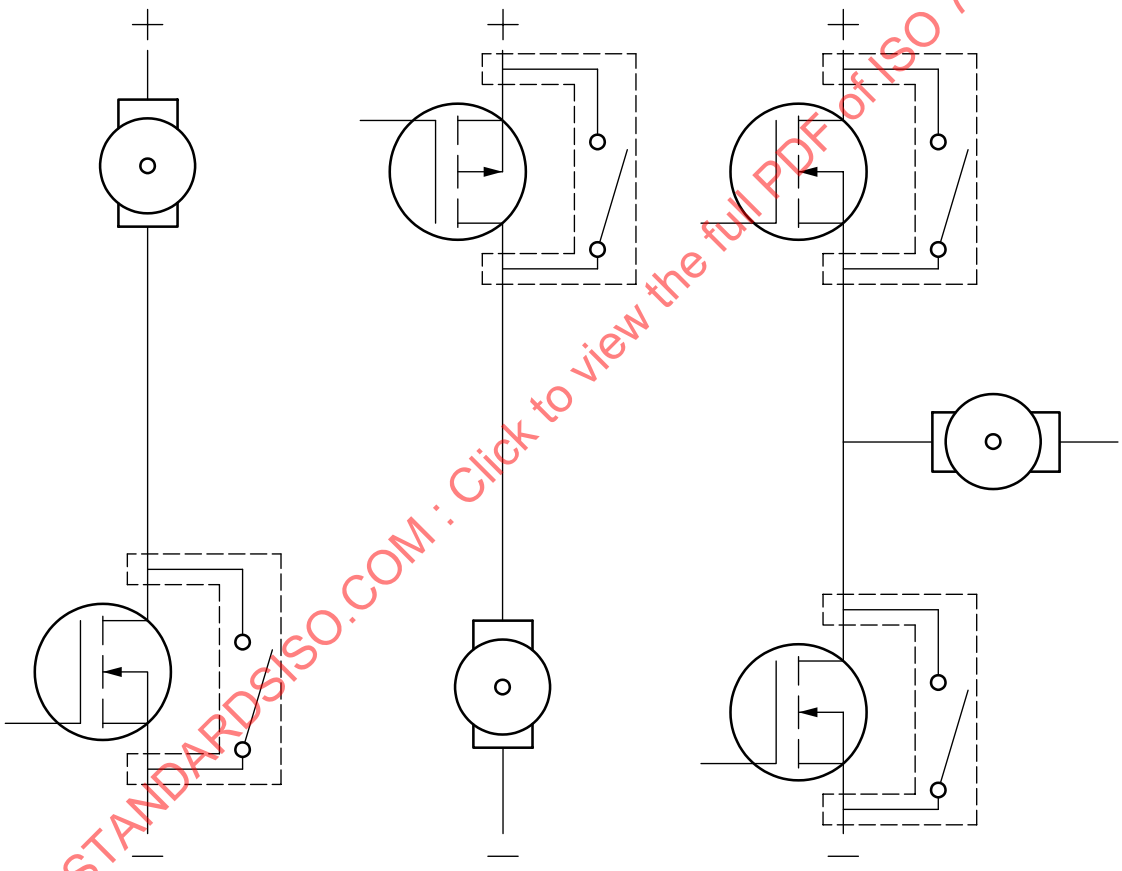
Measure along the centreline of the track of the driving wheels the distance taken to stop to an accuracy of ±100 mm.

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 ± 0,05) × 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 2,0 × L_I, 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 can 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 not result in a hazardous situation.

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 2,0 × L_I (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 2,0 × L_I 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 might 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 ± 0,05) × 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 ±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 2,0 × L_I, 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 ±100 mm.

g) If the wheelchair does not stop, or does not stop within a distance of 2,0 × 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 ±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

8.1.1.1 There shall be available at least one means to;

— switch on the wheelchair;

— switch off the wheelchair.

Any OFF switch shall over-ride any ON switch.

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

The symbol shall be an appropriate power symbol specified in IEC 60417.

8.1.1.2 If the wheelchair is configured to be operated by the occupant, at least one means for switching on the wheelchair provided for the occupant and at least one means for switching off the wheelchair should be provided for the occupant**.**

8.1.1.3 If the wheelchair is configured to be operated by the assistant, at least one means for switching on the wheelchair provided for the assistant and at least one means for switching off the wheelchair should be provided for the assistant.

These means may be combined into a single device.

8.1.1.4 When the wheelchair is tested as specified in 8.1.2, it shall not allow the drive wheels to revolve more than 10 mm measured on the outer wheel surface except when brake release or free-wheel devices have been operated.

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

The smallest battery specified for the wheelchair shall have sufficient capacity to supply the off-state current for a minimum of 120 days.

8.2.3 Test method

Disconnect the wheelchair's battery set.

Ensure that the battery charger is not connected.

Connect a voltage source (4.6) adjusted to the nominal voltage of the battery set +10 %, -0 % in place of the battery set via the circuit breaker (4.16) and an ammeter with a logging function of sufficient time resolution to measure the mean current flow with an accuracy better than 5 % of $I_{2\,900}$, calculated from:

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

where

$I_{2\,900}$ is the numerical value of the current, expressed in amperes (A), drawn from the battery set corresponding to a 120-day discharge period (2 900 h);

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

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.

The supply current may take up to 1 hour to drop to its lowest value and after such time, power may be drawn in pulses.

Record the mean current drawn by the wheelchair over a period of 24 h to 72 h after the wheelchair has been switched off and compare it to the maximum limit, $I_{2\,900}$.

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 of the slope outside the slope test outline shown in Figure 6;

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.

NOTE 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.

Set the test slope at the maximum slope as follows:

For compact, manoeuvrable wheelchairs not necessarily capable of negotiating outdoor obstacles, set the slope to 3 degrees.

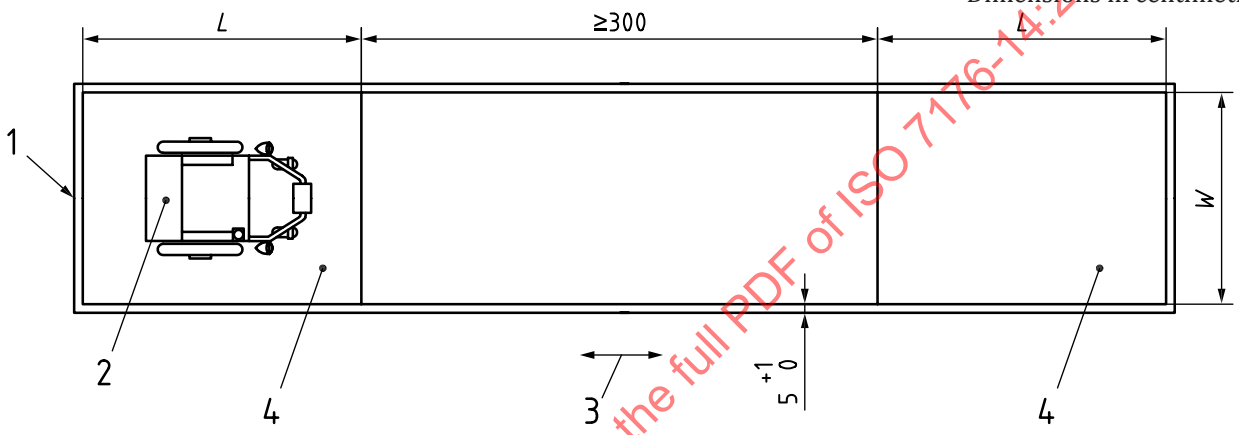
For wheelchairs sufficiently compact and manoeuvrable for some indoor environments and capable of negotiating some outdoor obstacles, set the slope to 6 degrees.

For wheelchairs, usually large in size, not necessarily intended for indoor use but capable of travelling over longer distances and negotiating outdoor obstacles set the slope for 10 degrees.

NOTE 1 Scooters are included within the classes above.

NOTE 2 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

Mark the position of any motor-driven device that is not intended to move during the test so that any unintended motion can be recorded.

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.

8.4.3.4 Unintended motion

At the conclusion of the test, note and record any unintended motion of any motor-driven device identified in 8.4.3.1.

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.

The necessary protection may be provided by a battery integrated battery management system.

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.

Where the battery protection is provided within the battery, consult the manufacturer for the most appropriate test method.

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 × 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, and

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 ± 0,05) × 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.

Confirm normal operation of the wheelchair by completing the functional check specified in ISO 7176-9:2009, Clause 9.

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.

During the test, the wheelchair shall achieve a stability score of 2 or better when assessed against ISO 7176-2 stability scoring system.

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) Whilst commanding full speed, operate the means to switch off the wheelchair identified in a).

d) Record the wheelchair stability score as specified in 8.7.2.

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.

At the time of indicating the critical charge, sufficient reserve charge shall be available to allow timely reaction.

The remaining battery charge shall provide greater than 10 % of the theoretical driving range as determined in ISO7176-4. The manufacturer shall disclose information describing the critical charge indication and 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

Ensure that the battery set is at a state of charge greater than the state that activates the indicator. If there is insufficient charge to complete the test, charge the batteries until there is sufficient charge to complete the test.

Discharge the battery set by driving the wheelchair on the test track (4.21), stopping once per lap and completing one power OFF/ON cycle every four laps until the indicator is activated.

Continue the drive routine 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 and record if it is greater or not than 10 % of the theoretical range of ISO 7176-4.

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 of lead-acid batteries 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. The following requirements only apply to the charging of lead-acid batteries.

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.

If the voltage drop associated with a charger port that is integrated with the remote joystick unit does not allow satisfactory charge performance, a supplementary charger port may be included elsewhere on the wheelchair. The function of this port might be described in the operator's manual.

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 better than ±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 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 better than ±0,5 %.

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

Commence charging.

Charge for 5 min ± 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 $I_{chg,max}$:

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

Record if dU is less than 3,5 % of the nominal battery voltage or not.

To assure the correct charge completion voltage that is specified by the battery manufacturer, and to reveal any non-linearity repeat 8.10.3 at near charge completion when the current is less than 20 % of $I_{chg,max}$, but greater than 5 %. Record if dU is less than 3,5 % of the nominal battery voltage or not.

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 occupied wheelchair.

8.11.2 Requirements

The force required to maintain motion of the occupied wheelchair (see 5.2) moving in a straight line on the horizontal without electrical power shall not exceed 155 N.

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) require the use of tools, or

c) 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, or

— 60 N for operation by pulling with a foot.

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.

The method of selecting freewheel operation should be shown in the operator's manual and/or marking on the wheelchair.

If any automatic brake is disengaged, and electrical power is restored, it shall not be possible to drive the wheelchair unless a visual and/or audible alarm is activated

NOTE The phrase "partial engagement" indicates a condition of neither full engagement nor full disengagement. It 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.

8.11.3 Brake release

Manual brake-release mechanisms shall be maintained in their operative and non-operative states by mechanical means that do not rely on friction

If the solution includes a brake disengage as opposed to a declutching operation of the transmission, it shall not be possible to drive the chair with any one brake disengaged.

8.11.4 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.

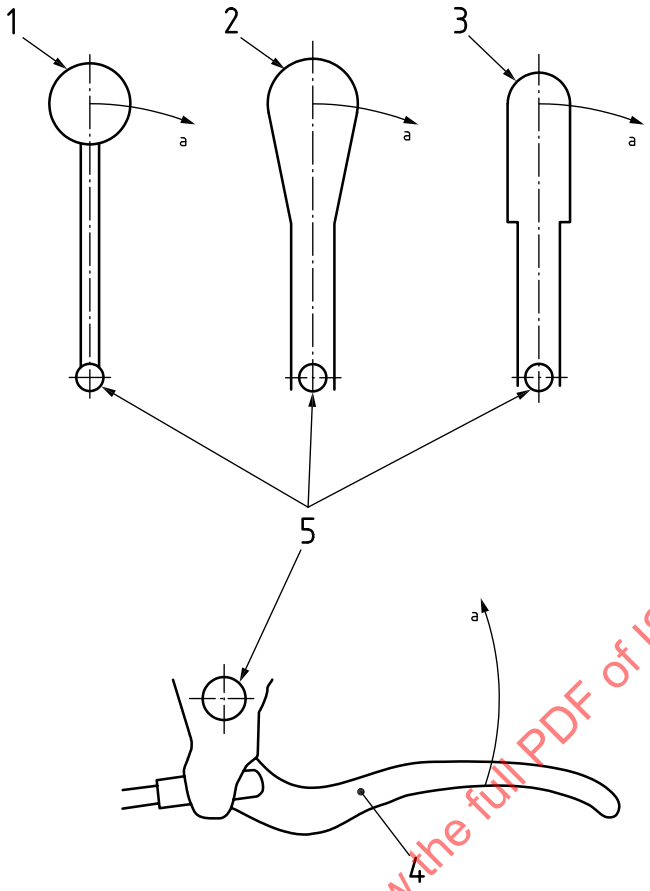
Operate each means to disengage the drive and braking system that can be operated without the use of a tool.

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 force indicated by the force measuring instrument to maintain motion. 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 requirements for single fault safety of Clause 7 also apply to wheelchair braking systems. For example, vehicles with a single brake or a single brake driver can lose the ability to brake in the event of a single failure of a transmission or electronic component, which could lead directly to a safety hazard. The protective measures might not be obvious to an examiner. In such cases the manufacturer shall provide documentation to the examiner to prove the safety of measures taken.

8.12.2 Requirement

If the safety of the braking system is not obvious to the examiner such as there being redundant braking systems provided, the manufacturer shall provide a risk-based analysis using the methods of ISO 14971 to quantify the safety of the braking system from the operator brake activation command through to mechanical means to brake the vehicle. Product history of brake reliability may be used to quantify safety.

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.

The battery compartment shall provide adequate protection to prevent damage during use and normal conditions of transport. Where the battery is not afforded adequate protection during transport, the battery shall be designed so it is easily removable by the operator or assistant.

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

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

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 (A·h).

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

For battery protection, conformity is confirmed by inspection.

For testing for spillage or leakage, 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 and IEC 60417.

NOTE See also 10.1.

8.15 Safety of moving parts

8.15.1 General

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

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

Latched control of moving parts may be used provided the benefit to the occupant or assistant outweighs any risk as assessed under ISO 14971.

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 Software faults

8.16.1 General

Devices that incorporate electronic programmable systems, including software, shall be designed to ensure repeatability, reliability and performance in line with their intended use. In the event of a single fault condition, appropriate means shall be adopted to eliminate or reduce as far as possible consequent risks or impairment of performance.

8.16.2 Requirements

For devices that incorporate software, the software shall be developed and manufactured in accordance with the state of the art taking into account the principles of development life cycle, risk management, including information security, verification and validation.

Manufacturers shall set out requirements concerning hardware, IT networks characteristics and IT security measures, including protection against unauthorised access, necessary to run the software as intended.

Software that is embedded in the wheelchair or is an integral part of the wheelchair, shall be developed and maintained in accordance with IEC 62304.

Conformity is confirmed by the review of documentation provided by the manufacturer.

8.17 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, such as a respirator, the whole combination, including the connection system, shall conform to this document.

The attachment or addition of electrically powered devices shall be done in accordance with the manufacturer's recommendations and the test report shall indicate if the combined device system maintains its intended functional performance. Consult ISO 7176-22 for testing setup procedures.

Connections which the operator or assistant must handle, such as electrical or mechanical coupling, shall be designed and constructed in such a way as to minimize all possible risks, such as misconnection.

Verification shall be done by inspection.

8.18 Wireless technology

8.18.1 General

Subclauses 8.18.2 to 8.18.4 were developed in consideration with common radio frequency technologies such as Bluetooth and Wi-Fi, however for all types of wireless technologies integrated into a wheelchair system or subsystem, including other radio frequencies, light, magnetic fields, acoustic, etc., the intended functions shall be described, labelled, and tested in accordance with risk assessment and its associated outcomes as far as possible as below.

This shall include cases where wheelchair components and accessories are intended to communicate over radio or other means of wireless transmission of data with other device(s) specified by the wheelchair manufacturer.

A device can either be a physical device or a device family that is certified for a specific wireless protocol/standard.

8.18.2 Wireless technology related labelling

Summary information about the wireless capabilities shall be included in the operator manual to provide the operator information about the characteristics and capabilities. The operator manual shall include a description of the wireless technology, its function, intended use, specifications and capabilities.

At least the following shall be included in the labelling:

— Certification labels

At least the following shall be included in the manual:

a) the use of the controller as a wireless device to control non-wheelchair functions that do not control the wheelchair;

b) which modes the device can operate under while wireless is enabled;

c) safety precautions for the normal operation of the device;

d) security measures shall include a statement to identify if other wireless products or devices are able to make a wireless connection to the device. If such connections are intended or possible then the description shall include summary information about all such products and devices, their function, and how the subject medical device functions are protected from adverse and unintended effects by connections to the other products or devices.

e) identification of the operating environment

f) how any risks and potential performance issues that might be associated with data rates, latency, and communications are addressed.

8.18.3 Risk assessment

Assessment of the hazards and risks associated with the wireless functions and connections shall be performed in accordance with ISO 14971.

AAMI TIR 69 may be used as a guide.

At least the following topics shall be addressed in the risk assessment.

a) Any risks and potential performance issues that might be associated with data rates, latency and communications.

b) Risk of unintended access over the wireless connection.

c) Risk of leaking sensitive information from the system, e.g. medical data.

d) Loss or delay of radio connection.

e) Data integrity.

f) Unintended wireless connection.

g) Intended use environment.

8.18.4 Wireless coexistence testing and verification

Wireless subsystem(s) on the wheelchair that requires certification testing need to address its associated standard or specification, e.g. BLE (Bluetooth Core Specification v5.0).

The information addressing wireless coexistence should include the following:

a) A summary of the coexistence testing, set-up, findings, and analysis.

b) The wireless products (interferers, e.g., Wi-Fi, Bluetooth) that were used in the coexistence testing, and their wireless RF frequencies, maximum output powers, and separation distances from the device.

c) The specific pass/fail criteria for this testing.

d) How the device and wireless functions were monitored during the testing and determined to meet the pass/fail criteria.

Risk mitigations shall be verified in the environment described in ISO 7176-21:2009, Clause 10, with any additions identified during the risk assessment.

Appropriate testing for wireless coexistence with other RF emitters or multiple units of the subject medical device that can be expected in the wheelchair use environment shall be performed in accordance with the methods required in associated, or regional, specifications, for example IEEE/ANSI C63.27-2017.

Testing and verification shall include evidence that risk mitigations work as intended.

8.19 Maintenance and evaluation

Devices shall be designed and manufactured in such a way that adjustment, calibration, and maintenance can be done safely and effectively.

The process by which calibration and maintenance can be performed shall be evaluated and recorded by inspection.

9 Protection against electric shock, burns, fire and explosion

9.1 Electrical Isolation of a wheelchair frame

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 DC 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 AC impedance, which are intended to provide protection for electromagnetic interference or electrostatic discharge.

This test is intended to determine if there is positive or negative leakage current present in the frame of the wheelchair.

NOTE If voltages greater than Safety Extra Low Voltage (SELV) are present in the wheelchair, additional design and safety requirements can be required outside of the scope of this document.

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 that 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 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.

WARNING — If fuses are used in place of thermal overloads, it can be necessary to use a current rating that is substantially higher than is typical for the thermal overload that they are replacing to stop unwanted fuse blowing. In such cases, battery wire sizes might need to be increased proportionally. See Table A.2 for suggested wire sizes in relation to a fuse sizes.

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, electronic component or connector, and wire insulators and connectors shall not exceed their dry air 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.

The necessary over-current protection may be provided by a battery integrated battery management system such as in a Lithium Ion battery.

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.

Infra-red thermography may be used to determine the location of high temperatures in the wiring loom to identify where the thermocouple is to be inserted.

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, any smoke, any burning smell, or if any wire insulation or connector exceeds its rated temperature or an electronic component fails.

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

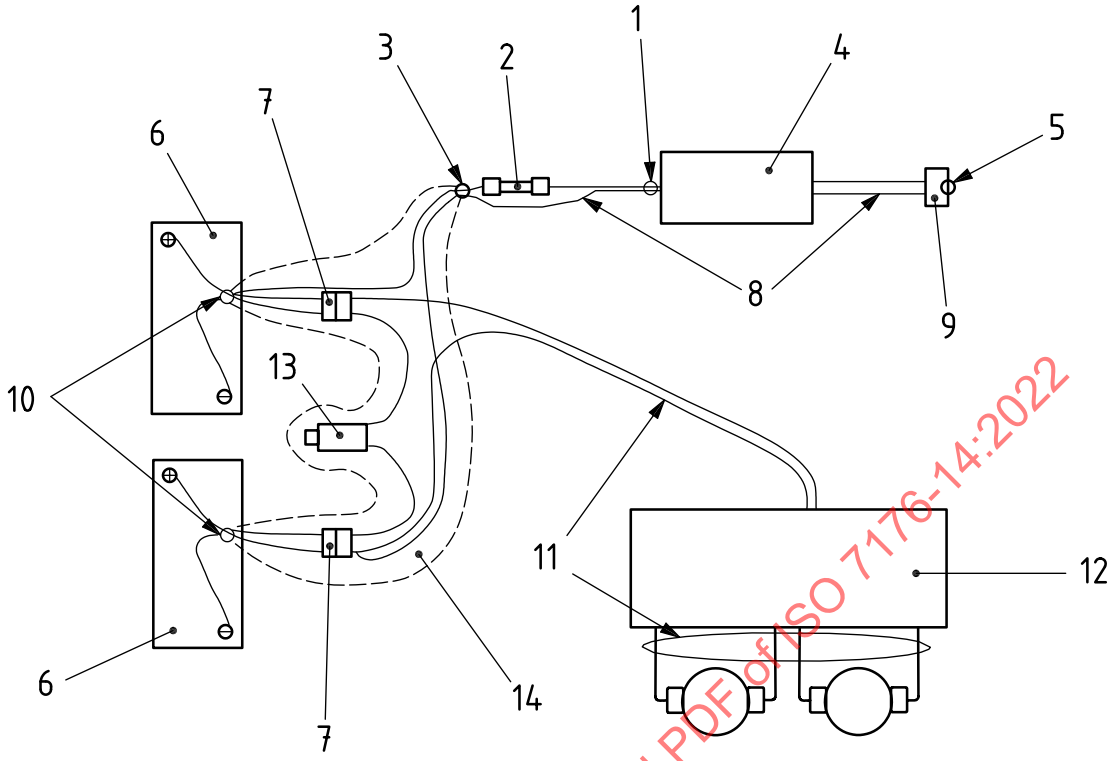
Identify the current-carrying capacity of the circuit protection device that is installed to protect the wheelchair wiring that carries battery charging current. The wheelchair fails the test if there is no circuit protection device suitably installed to protect the wiring.

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 ±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

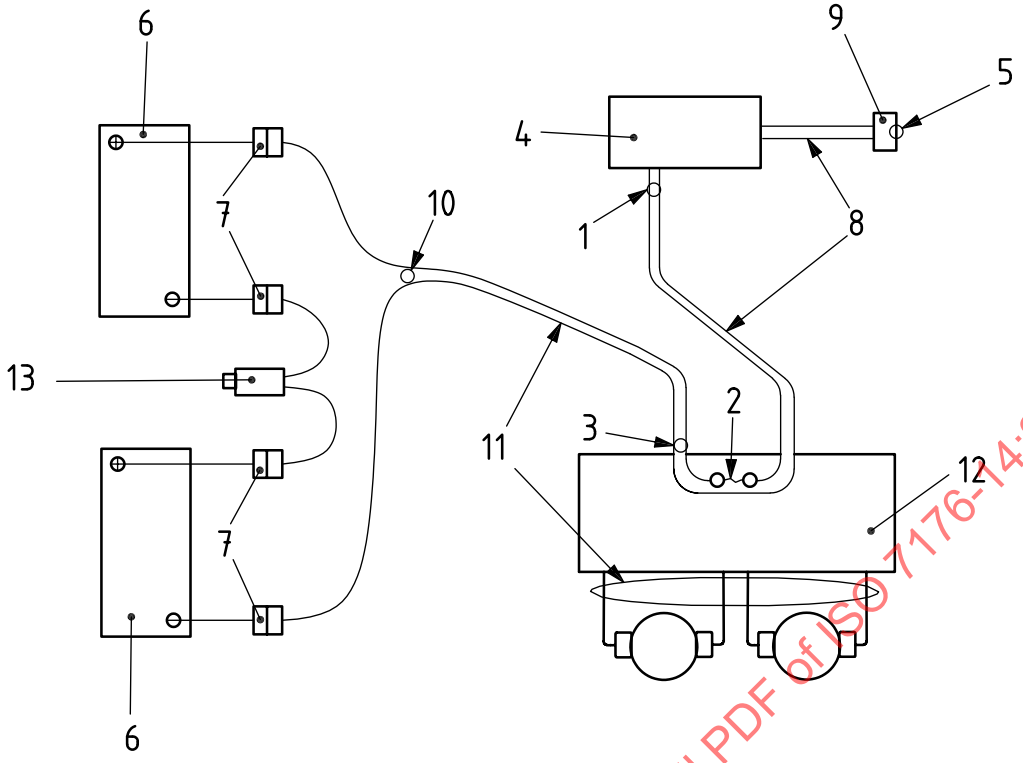
1	test point D	8	charger and/or control wiring
2	control wiring fuse	9	charger socket
3	test point B	10	test point A
4	low power controls	11	traction wiring
5	test point C	12	wheelchair drive controller
6	battery	13	circuit protection device
7	connector	14	unprotected wiring

Figure 8 — Example of poor protection

Unsafe protections comments related to Figure 8:

Insulation failure on battery wiring near battery could cause unprotected short-circuits at test point 10.

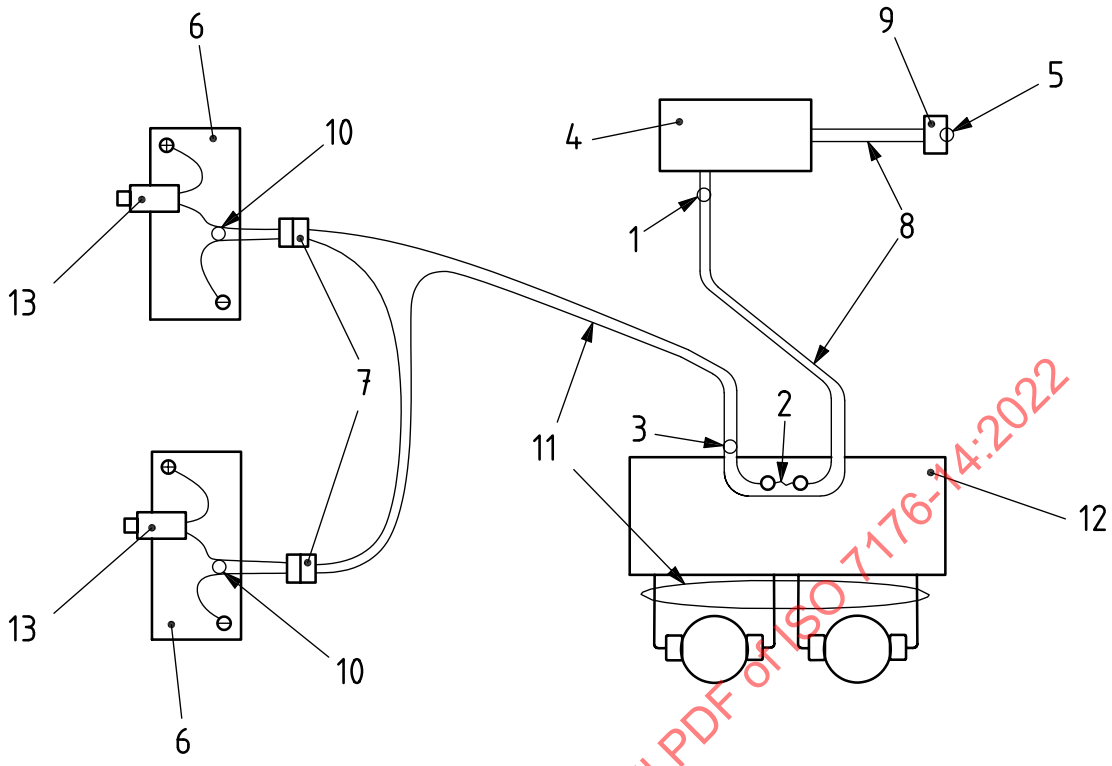
Lengths of unprotected wiring upstream from its protection could be liable to unprotected short-circuits at test point 3.



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	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 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,

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

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. Confirmation of operational life is determined through review of the circuit protection device datasheet.

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). The means of detecting the current shall indicate DC or AC current flow of more than 5 A without adding an impedance greater than 10 % of the motor stall impedance.

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 $^{+10}_{0}$ min.

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 Maximum thermal drive test

9.5.1 General

A wheelchair should be capable of climbing inclines and driving through soft terrain for extended periods without stopping or failing due to propulsion system or component damage.

Based on the experience of test labs, the parameters in the controller must often be adjusted to pass both 9.4 and 9.5. It is common for wheelchairs that have not been tested before to fail one or both of these tests until the controller is adjusted to protect the motors, the wiring and the controller itself.

A 6° slope is chosen to correspond to the load that occurs in the drive system when driving up a moderately steep slope or driving on a soft surface for an extended period of time. The slope that is chosen for this testing is similar to that of a standard ramp, which is 1 in 12 pitch (4,7 degrees) in some countries and 10 % (5,7 degrees) in other countries. The slope that is chosen for this test has nothing to do with the maximum safe slope for stability.

Other ramp angles higher than 6° may be used.

9.5.2 Test method

NOTE 1 This test can cause a motor, wiring or controller failure of some type.

Controller — set the user-adjustable speed control setting, or change the programming profile to any convenient speed that the driving speeds require.

Slope — adjust the slope of the test plane (4.1) to 6° unless the loaded wheelchair is unable to climb up at an average speed 125 mm/s ± 50 mm/s, in which case the slope shall be set at the maximum slope, in successive 1° increments below 6° down to a minimum of 3°, that the loaded wheelchair is able to climb at an average speed 125 mm/s ± 50 mm/s.

Speed — average Speed while driving up the inclined test plane shall be 125 mm/s ± 50 mm/s. Minimum average speed while reversing down the inclined test plane shall be 900 mm/s.

NOTE 2 Verification of average speeds using a tape measure and a stopwatch is considered acceptable.

Cooling - no fans are allowed to provide cooling during the testing unless they are an integral part of the system. All shrouds shall be installed on the wheelchair as designed and built by the manufacturer.

The Load Test - drive the wheelchair forward up the ramp, without allowing the wheelchair's forward movement to pulsate at the specified speed, then immediately back down to return to the base of the ramp at the specified speed and immediately continue driving up and down the ramp in the same

fashion. If the wheelchair stops, immediately cycle the power using the on/off switch and continue driving if possible until one of the conditions of a) to d) below occurs or b) and c) occur simultaneously.

Battery — outfit the wheelchair with the largest battery recommended by the manufacturer. Record the type, the 5-hour capacity of the battery in ampere hours and the make and model of battery used for testing the wheelchair and ensure the battery set is fully charged,

9.5.2.1 The following are acceptable reasons for stopping this test:

a) The wheelchair drives for 60 minutes.

b) The wheelchair battery set becomes depleted.

c) The wheelchair stops when the controller "folds back" after a minimum of 6 minutes.

d) The wheelchair slows down when the controller "folds back" after a minimum of 6 minutes.

e) The wheelchair has an automatic resetting circuit protection device that trips during testing after a minimum of 6 minutes and resets by turning the power off and then back on again or an automatic circuit protection device resets on its own.

f) The wheelchair has a manually resetting circuit protection device that trips during testing after a minimum of 6 minutes and is readily accessible to be reset by the operator and/or attendant.

9.5.2.2 The following results are considered non-acceptable reasons for stopping this test, which would result in a failure of this test:

a) The user is unable to maintain the forward direction of the wheelchair.

b) The wheelchair wiring insulation melts, causing the failure of insulation around the wiring.

c) The wheelchair stops after less than 6 minutes when the controller "folds back".

d) The wheelchair slows down to an average speed less than 75 mm/s after less than 6 minutes.

e) A circuit protection device trips that is not accessible to the operator and/or attendant, and requires a manual reset and immobilizes the wheelchair.

f) Inability of the wheelchair to climb a 3° ramp at 125 mm/s ± 50 mm/s.

9.5.2.3 After the motors return to room temperature and after fully charging the wheelchair, the wheelchair shall operate normally after the test procedure and meets the specific performance requirements listed here:

a) As outlined in ISO 7176-6, the wheelchair shall achieve a maximum speed as claimed by the manufacturer or specified by the requestor.

b) As outlined in ISO 7176-10, the wheelchair shall achieve an obstacle-climbing test result as claimed by the manufacture or specified by the requestor.

c) As outlined in ISO 7176-9, the wheelchair shall pass the functional check.

Record the maximum cumulative uphill climbing distance (do not count the downhill driving distance) and time that the wheelchair travelled (including the downhill travel time).

Record the reason for stopping the test.

NOTE This could be caused by the controller reaching thermal limit, operation of a protective device, battery depletion, or any other event.

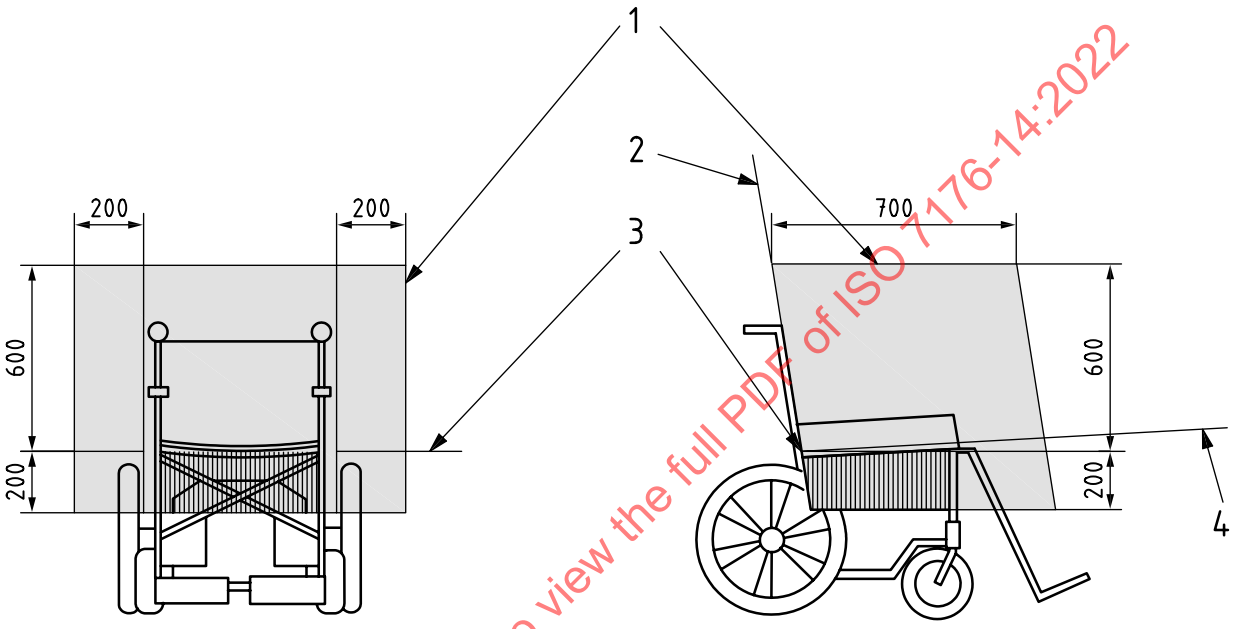
If the wheelchair is still functional after the test, record what was required to reset the wheelchair, such as a cool-down period for an automatic reset, or a reset of a manual circuit breaker, etc.

9.6 Surface temperatures

Surfaces that 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 ISO 13732-1.

Normal use is defined as the temperature reached on the completion of 25 laps (or until the chair comes to a stop if sooner) of the ISO 7176-4 manoeuvring range test. Driving during this test shall be done as quickly as possible.

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

9.7 Isolation of battery system

9.7.1 General

Disconnection of battery systems offers benefits to the user and maintenance personnel in the following scenarios:

a) Airline and other forms of transport.

b) Service and maintenance of the power wheelchair.

c) Responding to particular single fault conditions as specified in Clause 7.

d) In the event of a fire or other emergencies.

9.7.2 Requirement

The wheelchair shall be equipped with a means of electrically disconnecting and reconnecting the battery set, without the use of tools, to be used in the case of an emergency, for transportation or while waiting for repairs.

The means shall be clearly marked with at least the symbol shown in Figure 12 in a contrasting colour. The symbol shall be at least 12 mm in diagonal.

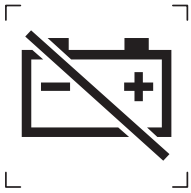


Figure 12 — Symbol to indicate battery isolation switch (IEC 7000–2063)

The requirement need not apply to wheelchairs that incorporate a single battery of less than 300 Wh that is removable without tools or two batteries each of less than 160 Wh that are removable without tools.

The required means of isolating the battery shall be accessible by an attendant and emergency personnel.

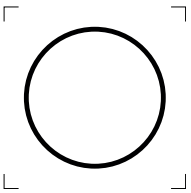
Accidental operation of the battery isolate system shall be minimized or prevented through suitable means such as by appropriate location.

Connector separation is an acceptable means of battery isolation provided the connection is clearly labelled and visible.

9.7.3 Isolate switch requirements

If the chosen means to isolate the battery is a switch, the symbols shown in Figure 13 shall indicate the status of the switch with “I” indicating the ON position and “O” indicating the OFF position.

a) IEC 60417-5007 "ON" (Power)



b) IEC 60417-5008 "OFF" (Power)

Figure 13 — Symbols to indicate status of the battery isolation switch

NOTE On battery isolations switches, the "ON" symbol can be displayed on top of the "OFF" symbol.

9.7.4 Implementation

End-users, maintenance personnel and caregivers should be made aware, through instructions in the user manual, of how to operate this mechanism and warned of situations when battery disconnection is appropriate.

9.7.5 Test Methods

Check that the means of electrically disconnecting the battery is accessible without tools, and is clearly labelled with the required symbol and readily accessible to an attendant and emergency personnel.

Confirm by inspection or testing that the provided device isolates the battery set as intended.

To verify that electrical circuits have been isolated, place the device into drive mode (i.e. not freewheel mode), observe if the mobility aid will power up and, if so, whether use of the joystick results in the wheelchair moving. It shall also be verified that the circuits of supplemental motorized systems such as seating systems have been isolated by operating the controls for those system.

9.8 Resistance to ignition

9.8.1 General

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

9.8.2 Requirements

9.8.2.1 Polymeric parts

Either of the following options a) or b) shall apply.

a) The manufacturer shall adopt appropriate means to eliminate or reduce as far as reasonably practicable the risk of a hazardous situation developing from the ignition of any part of the power and control system of the wheelchair. The manufacturer shall use the process specified in ISO 14971 to manage that risk.

b) Where the following parts other than wiring 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 the surface of any connected battery terminal;

   — components within 50 mm of the surface 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; (IEC 60695-11-10 may be used as an alternative to UL 94);

   — electrical enclosures including controller cases;

   — incandescent 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.

9.8.2.2 Wiring

Insulated wiring shall have a flammability classification equivalent to IEC 60332-1-2, or better.

10 Ergonomics

10.1 Operator interface

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

Where appropriate, information related to the function of the operator interface 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 IEC 60417 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 operator 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.

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 ±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 ±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) pressure measurement

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 can 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 14.

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 14 and maintains its maximum speed within it.

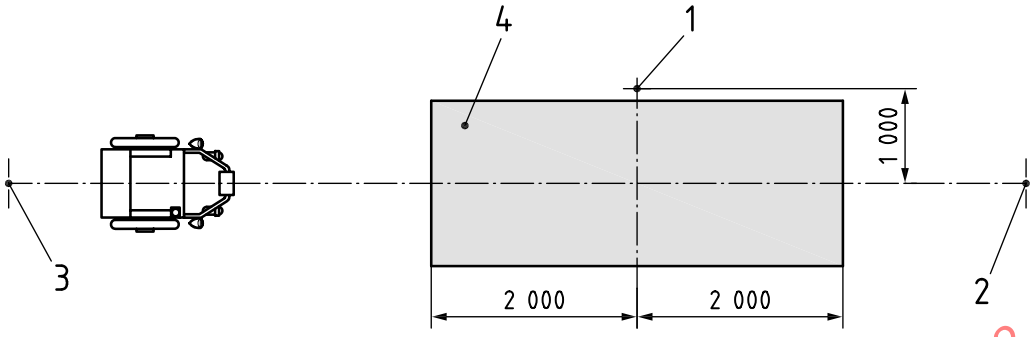
c) Measure and record the maximum time-weighted sound level to an accuracy of ±3 dB(A-weighted), using frequency weighting (A), time weighting (F), with the hold facility activated.

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 14 — 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 15, 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.

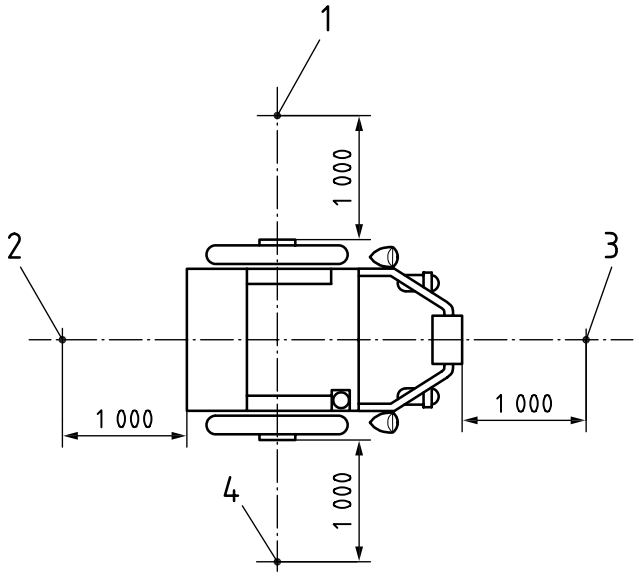
d) Measure and record the maximum time-weighted sound level to an accuracy of ±3 dB(A-weighted), using frequency weighting (A), time weighting (F), with the hold facility activated.

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 15.

Dimensions in millimetres



Key

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

Figure 15 — 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 or variable 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 15, 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 better than ±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 15.

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 1 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* ±5 %, and then gradually reduce the force to zero. This action constitutes one cycle.