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Wheelchairs —

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

Fauteuils roulants —

Partie 21: Exigences et méthodes d'essai pour la compatibilité des fauteuils roulants électriques et scooters motorisés

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

Page

Foreword

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

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

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

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

ISO 7176-21 was prepared by Technical Committee ISO/TC 173, *Assistive products for persons with disability*, Subcommittee SC 1, *Wheelchairs*.

This second edition cancels and replaces the first edition (ISO 7176-21:2003), which has been technically revised.

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

— *Part 1: Determination of static stability*

— *Part 2: Determination of dynamic stability of electric wheelchairs*

— *Part 3: Determination of effectiveness of brakes*

— *Part 4: Energy consumption of electric wheelchairs and scooters for determination of theoretical distance range*

— *Part 5: Determination of dimensions, mass and manoeuvring space*

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

— *Part 7: Measurement of seating and wheel dimensions*

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

— *Part 9: Climatic tests for electric wheelchairs*

— *Part 10: Determination of obstacle-climbing ability of electrically powered wheelchairs*

— *Part 11: Test dummies*

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

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

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

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

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

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

— *Part 22: Set-up procedures*

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

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

— *Part 26: Vocabulary*

A Technical Report (ISO/TR 13570-1, *Wheelchairs — Part 1: Guidelines for the application of the ISO 7176 series on wheelchairs*) is also available, giving information on how to use the ISO 7176 standards when selecting a wheelchair and helping readers to understand the purpose for, and content of, the International Standards on wheelchairs.

Introduction

Electrically powered wheelchairs and their battery chargers are meant to operate without introducing significant electromagnetic disturbances into the environment and without significant degradation of operational performance in the presence of electromagnetic disturbances expected in normal use. Wheelchairs are often used near roads and therefore should be immune to radio frequency fields from both static and mobile communications equipment, as well as from other sources of electromagnetic disturbance. Injury could occur in the event of unintentional movement or change in direction of movement of a wheelchair.

This part of ISO 7176 specifies requirements and test methods for wheelchairs and their battery chargers to minimize the risks associated with their exposure to reasonably foreseeable electromagnetic interference and electrostatic discharge and with their production of electromagnetic fields that could impair the operation of other devices or equipment in their usual environment.

The upper frequency limit and test level for radiated r.f. immunity requirements are selected according to the environment in which the wheelchair is used and the related risk. Hence the requirements for a wheelchair while it is driving are consistent with its use as a medical device, but the requirements for charging are consistent with use of the wheelchair and charger as domestic electrical equipment.

Wheelchairs —

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

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

1 Scope

This part of ISO 7176 specifies requirements and test methods for electromagnetic emissions and for electromagnetic immunity of electrically powered wheelchairs and scooters with a maximum speed of not more than 15 km/h intended for indoor and/or outdoor use by people with disabilities. It is also applicable to manual wheelchairs with an add-on power kit. It is not applicable to vehicles designed to carry more than one person.

This part of ISO 7176 also specifies requirements and test methods for the electromagnetic compatibility of battery chargers intended for use with electrically powered wheelchairs and scooters.

A reference configuration is specified for adjustable wheelchairs and scooters in order to enable test results to be used for comparison of performance.

NOTE The term “wheelchair” is used in this part of ISO 7176 to cover electrically powered wheelchairs, scooters and manual wheelchairs with an add-on power kit.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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

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

IEC 61000-3-2, *Electromagnetic compatibility (EMC) — Part 3-2: Limits — Limits for harmonic current emissions (equipment input current $\leqslant$ 16 A per phase)*

IEC 61000-3-3, *Electromagnetic compatibility (EMC) — Part 3-3: Limits — Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current $\leqslant$ 16 A per phase and not subject to conditional connection*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) — Part 4-3: Testing and measurement techniques — Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) — Part 4-4: Testing and measurement techniques — Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) — Part 4-5: Testing and measurement techniques — Surge immunity test*

IEC 61000-4-6, *Electromagnetic compatibility (EMC) — Part 4-6: Testing and measurement techniques — Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8, *Electromagnetic compatibility (EMC) — Part 4-8: Testing and measurement techniques — Power frequency magnetic field immunity test*

IEC 61000-4-11, *Electromagnetic compatibility (EMC) — Part 4-11: Testing and measurement techniques — Voltage dips, short interruptions and voltage variations immunity tests*

CISPR 11, *Industrial, scientific and medical (ISM) radio-frequency equipment — Electromagnetic disturbance characteristics — Limits and methods of measurement*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
drive wheel
wheel, or one of a set of wheels, that propels the wheelchair

3.2
front vertical plane
plane normal to the forward direction of travel and tangential to the front edge of the furthest forward wheel

See Figure 1.

3.3
rear vertical plane
plane normal to the forward direction of travel and tangential to the back edge of the rearmost wheel

See Figure 1.

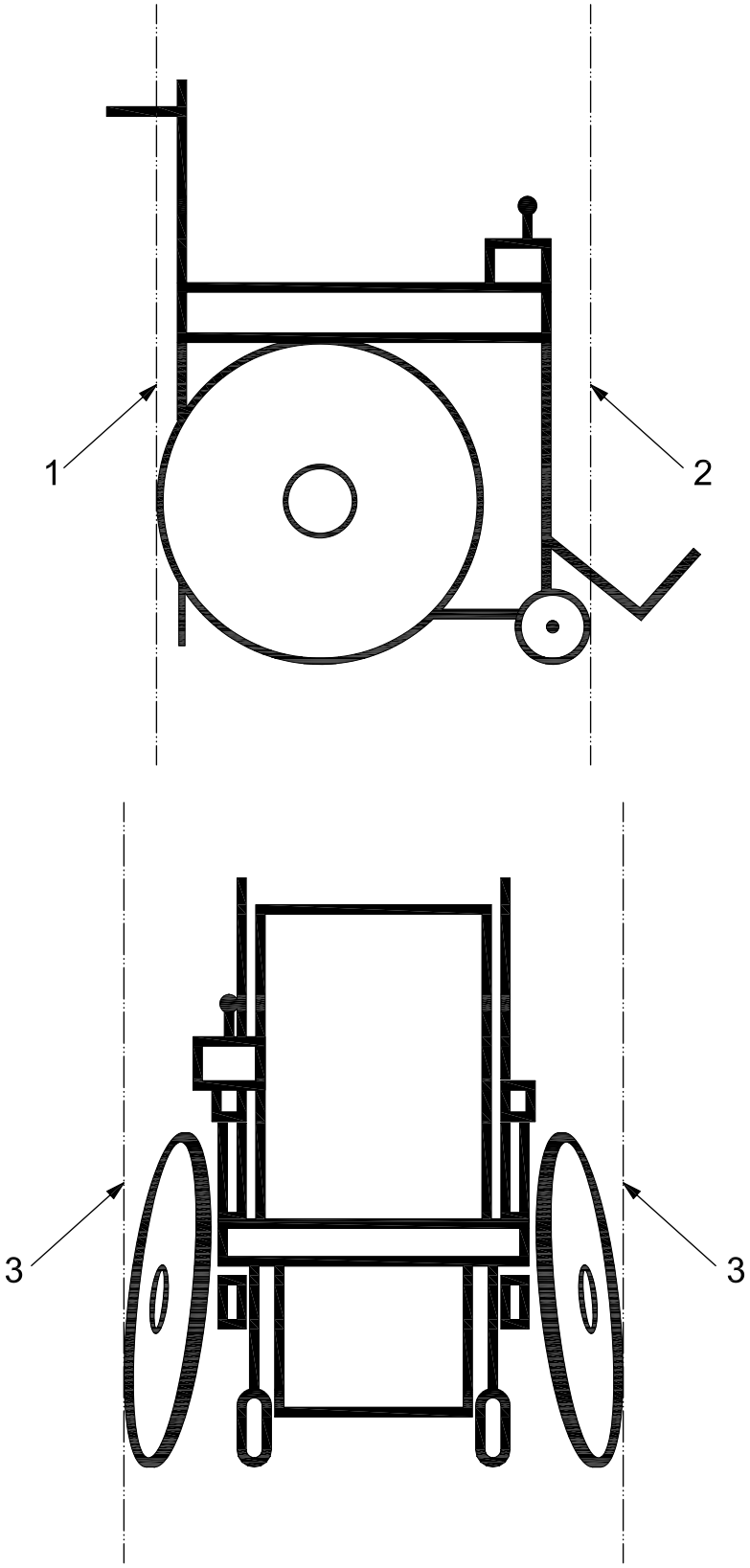
3.4
side vertical plane
plane parallel to the forward direction of travel and tangential to the outer edge of the outermost wheel on the side of the wheelchair

See Figure 1.

3.5
off-board battery charger
free-standing, self-contained battery charger separate from the wheelchair

3.6
carry-on battery charger
off-board battery charger intended for transportation on the wheelchair

3.7
on-board battery charger
battery charger that is built into the wheelchair and cannot be removed without the use of tools



Key

1 rear vertical plane
2 front vertical plane
3 side vertical plane

Figure 1 — Reference planes

4 Classification of electrically powered wheelchairs

Electrically powered wheelchairs are classified as follows:

— category A: wheelchairs with electronic differential steering and electronic brake control;

— category B: wheelchairs with electronic speed control, electronic servo steering and electronic brake control;

— category C: wheelchairs with electronic speed control, manual steering and electronic brake control;

— category D: wheelchairs with electronic differential steering and manual brake control;

— category E: wheelchairs with electronic speed control, electronic servo steering and manual brake control;

— category F: wheelchairs with electronic speed control, manual steering and manual brake control;

— category G: wheelchairs with a simple on-off motor, manual steering and manual brake control.

NOTE A wheelchair can fall into more than one category.

5 Requirements

5.1 General

All wheelchairs shall meet the requirements of 5.2.

Wheelchairs with an on-board battery charger shall also meet the requirements of 5.3.

Off-board and carry-on battery chargers shall meet the requirements of 5.4.

NOTE An observation period of 2 s is specified in many of the requirements of 5.2, 5.3 and 5.4. This is not intended to imply that it is acceptable for the wheelchair or charger under test to fail after the observation period has elapsed. An indefinite observation period is impractical and it is assumed that if the wheelchair or charger does fail during a test, it will fail within 2 s of a test event.

5.2 Wheelchair drives

5.2.1 Radiated emissions

When tested in accordance with 9.2.1, the wheelchair shall meet the radiated emissions limits specified in CISPR 11 for group 1, class B equipment.

5.2.2 Electrostatic discharge immunity

Prior to and at the conclusion of testing in accordance with 10.1.1.1 and 10.1.1.2, the wheelchair shall meet the functional requirement specified in ISO 7176-9 (see also Clause 8).

When the wheelchair is tested in accordance with 10.1.1.1, using test levels of ± 2 kV, ± 4 kV and ± 6 kV for contact discharges and test levels of ± 2 kV, ± 4 kV and ± 8 kV for air discharges, and when the wheelchair is tested in accordance with 10.1.1.2 using a test level of ± 8 kV:

a) the drive system of the wheelchair shall meet the requirements of 5.2.5 during each discharge and for 2 s following each discharge or set of discharges if a programmable ESD generator is used;

b) electrically powered devices that are not used for driving (such as servo-assisted leg supports and seating systems with stand-up functions) shall not move during each discharge and for 2 s following each discharge or set of discharges if a programmable ESD generator is used.

5.2.3 Radiated r.f. field immunity

Prior to and at the conclusion of testing in accordance with 10.2.1, the wheelchair shall meet the functional requirement specified in ISO 7176-9 (see also Clause 8).

When the wheelchair is tested in accordance with 10.2.1, using a test level of 20 V/m, from 26 MHz to 2,5 GHz:

a) the drive system of the wheelchair shall meet the requirements of 5.2.5 in the presence of the applied radio frequency (r.f.) field;

b) electrically-powered devices that are not used for driving (such as servo-assisted leg supports and seating systems with stand-up functions) shall not move in the presence of the applied r.f. field.

5.2.4 Power frequency magnetic field immunity

Prior to and at the conclusion of testing in accordance with 10.6, the wheelchair shall meet the functional requirement specified in ISO 7176-9 (see also Clause 8).

When the wheelchair is tested in accordance with 10.6, using test level 4 specified in IEC 61000-4-8, at 50 Hz and 60 Hz:

a) the drive system of the wheelchair shall meet the requirements of 5.2.5 in the presence of the applied field;

b) electrically-powered devices that are not used for driving (such as servo-assisted leg supports and seating systems with stand-up functions) shall not move in the presence of the applied field.

NOTE Other magnetic field immunity requirements are under consideration.

5.2.5 Stability of speed and direction

5.2.5.1 Speed

For category A, B, C, D, E and F wheelchairs (wheelchairs with electronic speed control), the average wheel speed change, ΔS_{avg}, calculated as specified in Clause 11, shall not exceed $\pm$ 20 %.

NOTE A positive value indicates a speed increase, while a negative value indicates a speed decrease.

For category G wheelchairs (wheelchairs without electronic speed control), the speed requirement does not apply.

5.2.5.2 Steering

For category A and D wheelchairs (wheelchairs with electronic differential steering), the differential wheel speed change, ΔS_{diff}, calculated as specified in Clause 11, shall not exceed $\pm$ 25 %.

NOTE A positive value corresponds to a right turn, while a negative value corresponds to a left turn.

For category B and E wheelchairs (wheelchairs with electronic servo steering), the maximum permissible change in steering servo position or steered wheel angle is that corresponding to a turning radius of 4 m, as specified in ISO 7176-5.

For category C, F and G wheelchairs (wheelchairs with manual steering), the steering requirement does not apply.

5.3 Wheelchairs with an on-board battery charger

5.3.1 Mains terminal disturbances

When tested in accordance with 9.1.1, the wheelchair shall meet the mains terminal disturbance limits specified in CISPR 11 for group 1, class B equipment.

5.3.2 Radiated emissions

When tested in accordance with 9.2.2, the wheelchair shall meet the radiated emissions limits specified in CISPR 11 for group 1, class B equipment.

5.3.3 Harmonic current emissions

When tested in accordance with 9.3.1, the wheelchair shall meet the requirements of IEC 61000-3-2.

5.3.4 Voltage fluctuations and flicker

When tested in accordance with 9.4.1, the wheelchair shall meet the requirements of IEC 61000-3-3.

5.3.5 Electrostatic discharge immunity

Prior to and at the conclusion of testing in accordance with 10.1.2, the wheelchair shall meet the functional requirement specified in ISO 7176-9 (see also Clause 8).

When the wheelchair is tested in accordance with 10.1.2, using test levels of $\pm$ 2 kV, $\pm$ 4 kV and $\pm$ 6 kV for contact discharges and test levels of $\pm$ 2 kV, $\pm$ 4 kV and $\pm$ 8 kV for air discharges, during each discharge and for 2 s following each discharge or set of discharges if a programmable ESD generator is used:

a) drive wheels shall not move;

b) automatic brakes shall not release;

c) electrically-powered devices that are not used for driving (such as servo-assisted leg supports and seating systems with stand-up functions) shall not move.

At the conclusion of testing in accordance with 10.1.2, the battery charger shall continue to operate in accordance with its specification without operator intervention.

5.3.6 Radiated r.f. field immunity

Prior to and at the conclusion of testing in accordance with 10.2.2, the wheelchair shall meet the functional requirement specified in ISO 7176-9 (see also Clause 8).

When the wheelchair is tested in accordance with 10.2.2, using a test level of 3 V/m from 80 MHz to 1,0 GHz:

a) drive wheels shall not move;

b) automatic brakes shall not release;

c) electrically-powered devices that are not used for driving (such as servo-assisted leg supports and seating systems with stand-up functions) shall not move.

At the conclusion of testing in accordance with 10.2.2, the battery charger shall continue to operate in accordance with its specification without operator intervention.

5.3.7 Fast transient/burst immunity

Prior to and at the conclusion of testing in accordance with 10.3.1, the wheelchair shall meet the functional requirement specified in ISO 7176-9 (see also Clause 8).

When the wheelchair is tested in accordance with 10.3.1, using test level 2 specified in IEC 61000-4-4:

a) drive wheels shall not move;

b) automatic brakes shall not release;

c) electrically-powered devices that are not used for driving (such as servo-assisted leg supports and seating systems with stand-up functions) shall not move.

At the conclusion of testing in accordance with 10.3.1, the battery charger shall continue to operate in accordance with its specification without operator intervention.

5.3.8 Surge immunity

Prior to and at the conclusion of testing in accordance with 10.4.1, the wheelchair shall meet the functional requirement specified in ISO 7176-9 (see also Clause 8).

When the wheelchair is tested in accordance with 10.4.1, using test level 3 specified in IEC 61000-4-5, during each surge and for 2 s following each surge:

a) drive wheels shall not move;

b) automatic brakes shall not release;

c) electrically-powered devices that are not used for driving (such as servo-assisted leg supports and seating systems with stand-up functions) shall not move.

At the conclusion of testing in accordance with 10.4.1, the battery charger shall continue to operate in accordance with its specification without operator intervention.

5.3.9 Conducted disturbance immunity

Prior to and at the conclusion of testing in accordance with 10.5.1, the wheelchair shall meet the functional requirement specified in ISO 7176-9 (see also Clause 8).

When the wheelchair is tested in accordance with 10.5.1, using test level 2 specified in IEC 61000-4-6, from 150 kHz to 80 MHz:

a) drive wheels shall not move;

b) automatic brakes shall not release;

c) electrically-powered devices that are not used for driving (such as servo-assisted leg supports and seating systems with stand-up functions) shall not move.

At the conclusion of testing in accordance with 10.5.1, the battery charger shall continue to operate in accordance with its specification without operator intervention.

5.3.10 Voltage dips and short interruptions immunity

Prior to and at the conclusion of testing in accordance with 10.7.1, the wheelchair shall meet the functional requirement specified in ISO 7176-9 (see also Clause 8).

When the wheelchair is tested in accordance with 10.7.1, using the Class 2 test level specified in IEC 61000-4-11, during each dip/interruption and for 2 s following each dip/interruption:

a) drive wheels shall not move;

b) automatic brakes shall not release;

c) electrically-powered devices that are not used for driving (such as servo-assisted leg supports and seating systems with stand-up functions) shall not move.

During and following testing in accordance with 10.7.1, the battery charger may exhibit a temporary loss of function or degradation of performance, but it shall cease when the disturbance ceases, and the charger shall recover its normal performance without operator intervention.

5.4 Off-board and carry-on battery chargers

5.4.1 Mains terminal disturbances

When tested in accordance with 9.1.2, the battery charger shall meet the mains terminal disturbance limits specified in CISPR 11 for group 1, class B equipment.

5.4.2 Radiated emissions

When tested in accordance with 9.2.3, the battery charger shall meet the radiated emissions limits specified in CISPR 11 for group 1, class B equipment.

5.4.3 Harmonic current emissions

When tested in accordance with 9.3.2, the battery charger shall meet the requirements of IEC 61000-3-2.

5.4.4 Voltage fluctuations and flicker

When tested in accordance with 9.4.2, the battery charger shall meet the requirements of IEC 61000-3-3.

5.4.5 Electrostatic discharge immunity

At the conclusion of testing the battery charger in accordance with 10.1.3, using test levels of ± 2 kV, ± 4 kV and ± 6 kV for contact discharges and test levels of ± 2 kV, ± 4 kV and ± 8 kV for air discharges, during each discharge and for 2 s following each discharge or set of discharges if a programmable ESD generator is used, the battery charger shall continue to operate in accordance with its specification without operator intervention.

5.4.6 Radiated r.f. field immunity

At the conclusion of testing the battery charger in accordance with 10.2.3, using a test level of 3 V/m from 80 MHz to 1,0 GHz, the battery charger shall continue to operate in accordance with its specification without operator intervention.

5.4.7 Fast transient/burst immunity

At the conclusion of testing the battery charger in accordance with 10.3.2, using test level 2 specified in IEC 61000-4-4, the battery charger shall continue to operate in accordance with its specification without operator intervention.

5.4.8 Surge immunity

At the conclusion of testing the battery charger in accordance with 10.4.2, using test level 2 specified in IEC 61000-4-5, the battery charger shall continue to operate in accordance with its specification without operator intervention.

5.4.9 Conducted disturbance immunity

At the conclusion of testing the battery charger in accordance with 10.5.2, using test level 2 specified in IEC 61000-4-6, from 150 kHz to 80 MHz, the battery charger shall continue to operate in accordance with its specification without operator intervention.

5.4.10 Voltage dips and short interruptions immunity

During and following testing in accordance with 10.7.2, using the Class 2 test level specified in IEC 61000-4-11, the battery charger may exhibit a temporary loss of function or degradation of performance, but it shall cease when the disturbance ceases, and the charger shall recover its normal performance without operator intervention.

6 Test apparatus

6.1 Support system, comprised of blocks, tyres, ropes, straps and/or similar devices capable of supporting the wheelchair so that the wheelchair is secure, with the drive wheels free to rotate.

The support system shall be made of electrically insulating materials. It shall not provide a conductive path between the wheelchair and its surroundings.

NOTE Use of bulk non-conducting materials prevents the support system from disturbing the electromagnetic fields produced during testing and prevents accidental earthing of the wheelchair under test. A metal structure with an insulating coating (such as paint) is not suitable. Some types of wood may be unsuitable for use in a support system for the charged frame ESD test (10.1.1.2).

The support system shall not raise the wheelchair by more than 0,1 m. Different wheels may be raised to different heights (within the limit specified above), thus the wheelchair is not required to remain level after being placed on the support system.

6.2 Discharge ground strap, comprised of wire cable or braided wire, not more than 2 m in length, capable of providing a low impedance path between a wheelchair and the metal ground plane.

If the strap is wire cable, the cross-sectional area shall not be less than 15 mm^2.

If the strap is braided wire, the braid shall be woven in the same manner utilized for the outer conductor of good quality radio frequency coaxial cables. The width of this braid, when flattened, shall not be less than 20 mm.

6.3 Wheel speed monitor, capable of monitoring the rotational speed of each of the drive wheels to an accuracy of 5 % and calculating the average wheel speed change and the differential wheel speed change from the measured rotational speed of each of the drive wheels, as given by the equations in Clause 11.

The time constant of the wheel speed monitor shall not exceed 0,1 s. The wheel speed monitor shall not introduce any conductive path between the wheelchair and the ground plane. The wheel speed monitor shall not perturb, nor shall it be susceptible to, the electromagnetic fields measured or generated during a test.

6.4 Steering monitor, capable of monitoring the steering servo position or steered wheel angle to an accuracy of 10 %.

NOTE The steering monitor is used only while testing wheelchairs in categories B and E.

The time constant of the steering monitor shall not exceed 0,1 s. The steering monitor shall not introduce any conductive path between the wheelchair and the ground plane. The steering monitor shall not perturb, nor shall it be susceptible to, the electromagnetic fields measured or generated during a test.

6.5 Charger test load, comprising the following items as specified by the battery charger manufacturer, connected together in a manner suitable for use with the charger:

1) a battery set with the nominal voltage, type and smallest nominal capacity specified for use with the battery charger;

2) conductors with suitable length, cross-sectional area and insulation;

3) connections compatible with the battery set and with the battery charger's output connections.

Where the battery charger manufacturer does not specify a length for the conductors used to connect the battery charger to the battery set, use a cable with a length of 2 m ± 0,1 m in addition to the charger's output cable. If the charger manufacturer does not specify the cross-sectional area of the conductors, use conductors of cross-sectional area not less than those of the corresponding conductors in the charger's output cable.

Where the conductors connecting the battery charger to the battery set are separated to connect to the battery terminals, route them for minimal loop area.

Where the battery charger is specified for use with a particular wheelchair, the wheelchair, fitted with the smallest capacity batteries specified, may be used as the charger test load.

7 Preparation

7.1 Wheelchairs – driving

7.1.1 Set-up

Set up the wheelchair as specified in ISO 7176-22, but do not fit the dummy. If the wheelchair is fitted with spillable batteries and will be tipped during testing, replace the batteries with non-spillable batteries of the same nominal voltage and type.

NOTE The wheelchair batteries are discharged in preparation for some tests (see 7.3 and 7.4).

Support the wheelchair using the support system specified in 6.1. Place the support system on the ground plane or on a table top, as applicable for each test. Make provision to use the wheel speed monitor (6.3) and the steering monitor (6.4) as applicable for each test.

Prepare the wheelchair for operation in accordance with the manufacturer's instructions for use. Set all user-accessible adjustments that affect the response of the wheelchair for maximum response within the range specified in the manufacturer's instructions. Record the settings.

EXAMPLE Maximum forward speed, maximum reverse speed, maximum sensitivity, maximum acceleration, maximum deceleration, maximum braking and minimum time delay.

7.1.2 Operation

Switch on the wheelchair. Set the control device for a drive wheel speed of 50 % ± 10 % of the maximum speed in the forward direction. Additionally, for category B and E wheelchairs (wheelchairs with electronic servo steering), set the control device such that the steering servo is at the straight ahead position (the steered wheel angle is at 0° ± 1°).

7.2 Wheelchairs – non-driving

Prepare the wheelchair as specified in 7.1.1. Switch on the wheelchair. Set the control device such that the drive wheels are not turning and any automatic brakes are applied.

7.3 Wheelchairs with on-board battery chargers

Prepare the wheelchair as specified in 7.2. Unless otherwise specified for a particular test, discharge the wheelchair's battery set to the cut-off voltage specified by the battery manufacturer, within a tolerance of $^{0}_{+5}$ %. Operate the battery charger in accordance with the wheelchair manufacturer's instructions for use.

NOTE The battery set may be discharged by operating the wheelchair or by using an auxiliary load that does not discharge the battery set at a rate greater than its 5 h rate.

7.4 Off-board and carry-on battery chargers

Unless otherwise specified for a particular test, discharge the battery set of the charger test load (6.5) to the cut-off voltage specified by the battery manufacturer, within a tolerance of $^{0}_{+5}$ %. Operate the battery charger in accordance with the charger manufacturer's instructions for use, but using the charger test load in place of the load specified by the manufacturer.

NOTE The battery set may be discharged by operating the wheelchair or by using an auxiliary load that does not discharge the battery set at a rate greater than its 5 h rate.

8 Sequence of tests

The tests should be carried out on a single wheelchair and/or battery charger. The wheelchair and/or charger under test may be repaired or replaced in the event of a failure unrelated to exposure to the test conditions.

The tests may be performed in any order.

Verify the functional requirement specified in ISO 7176-9 after the completion of all immunity testing. It is not necessary to verify the functional requirement between each immunity test.

9 Test methods for emissions

9.1 Mains terminal disturbances

9.1.1 Wheelchairs with an on-board battery charger

Prepare the wheelchair as specified in 7.3.

Perform the mains terminal disturbance test specified in CISPR 11 on the wheelchair as floor-standing equipment.

9.1.2 Off-board and carry-on battery chargers

Prepare the battery charger as specified in 7.4.

Support the charger test load (6.5) as specified in CISPR 11 for floor-standing equipment.

Perform the mains terminal disturbance test specified in CISPR 11 on the battery charger as table-top equipment.

9.2 Radiated emissions

9.2.1 Wheelchair drives

Prepare the wheelchair as specified in 7.1.

Place the support system on the ground plane.

Prior to commencing each test, adjust the control device to maximize the level of disturbance for any single combination of wheelchair orientation and antenna height.

Perform the radiated emissions test specified in CISPR 11 on the wheelchair as floor-standing equipment. Maintain the setting of the control device throughout the test.

9.2.2 Wheelchairs with an on-board battery charger

Prepare the wheelchair as specified in 7.3.

Perform the radiated emissions test specified in CISPR 11 on the wheelchair as floor-standing equipment.

9.2.3 Off-board and carry-on battery chargers

Prepare the battery charger as specified in 7.4.

Support the charger test load (6.5) as specified in CISPR 11 for floor-standing equipment.

Perform the radiated emissions test specified in CISPR 11 on the battery charger as table-top equipment.

9.3 Harmonic current emissions

9.3.1 Wheelchairs with an on-board battery charger

Prepare the wheelchair as specified in 7.3.

Fully charge the wheelchair's battery set and then discharge the battery set at its 5 h rate, I_5, $\pm$ 5 %, for (60 $\pm$ 5) min.

Perform the harmonic current emissions test on the wheelchair as specified in IEC 61000-3-2.

9.3.2 Off-board and carry-on battery chargers

Prepare the battery charger as specified in 7.4.

Fully charge the battery set of the charger test load (6.5) and then discharge the battery set at its 5 h rate, I_5, $\pm$ 5 %, for (60 $\pm$ 5) min.

Perform the harmonic current emissions test on the battery charger as specified in IEC 61000-3-2.

9.4 Voltage fluctuations and flicker

9.4.1 Wheelchairs with an on-board battery charger

Prepare the wheelchair as specified in 7.3.

Perform the voltage fluctuations and flicker test on the wheelchair as specified in IEC 61000-3-3.

9.4.2 Off-board and carry-on battery chargers

Prepare the battery charger as specified in 7.4.

Perform the voltage fluctuations and flicker test on the battery charger as specified in IEC 61000-3-3.

10 Test methods for immunity

10.1 Electrostatic discharge immunity

10.1.1 Wheelchair drives

10.1.1.1 Human body model

Prepare the wheelchair as specified in 7.1.

Test the wheelchair as specified in IEC 61000-4-2 for floor-standing equipment, with exceptions as follows:

— perform indirect discharge testing only using the vertical coupling plane (VCP);

— do not use the horizontal coupling plane.

Place the support system (6.1) on the ground plane.

Establish test points at the following locations, which are accessible to the discharge tip of the ESD generator after the wheelchair has been prepared for the test:

a) one test point on each motor casing, gearbox casing, cable, connector housing, switch lever or button, control knob and indicator;

b) for each cuboidal enclosure housing electronic circuitry, one test point on each face;

c) for each non-cuboidal enclosure housing electronic circuitry, one test point on each surface that would most closely approximate that of a cuboidal enclosure of similar size, to a maximum of six points;

d) if the frame of the wheelchair is approximately cuboidal, one test point on each face;

e) if the frame of the wheelchair is non-cuboidal, one test point on each surface that would most closely approximate that of a cuboidal frame of similar size, to a maximum of six points.

Apply ten discharges of each polarity (positive and negative), at each applicable test level, to each test point.

Apply contact discharges and/or air discharges in accordance with the guidance given in IEC 61000-4-2.

10.1.1.2 Charged frame

The wheelchair is tested to simulate the accumulation of charge in the frame that can occur when the wheelchair is driven over a carpet and the subsequent discharge when the wheelchair approaches a grounded metal object.

Use a ground reference plane as specified in IEC 61000-4-2 for testing floor-standing equipment.

Prepare the wheelchair in accordance with 7.1. Place the support system on the ground plane.

Connect one end of the discharge ground strap (6.2) and the discharge return cable of the ESD generator ground strap to the ground plane with low impedance bonds.

Establish one test point at each location around the perimeter of the wheelchair that may come into contact with grounded metal structures during normal operation.

Set up the test generator for air discharges.

NOTE The use of the test generator in air-discharge mode ensures consistent charging of the wheelchair frame.

For each test point perform the following test.

Place the discharge tip of the ESD generator in direct electrical contact with that part of the wheelchair frame that is closest to the test point. Charge the frame to the test level using the ESD generator. Keeping the tip of the ESD generator in place, make a discharge by moving the discharge strap to the test point as quickly as practicable.

Make ten discharges of each polarity (positive and negative) to each test point.

10.1.2 Wheelchairs with an on-board battery charger

The test method is identical to 10.1.1.1, with the following modifications:

1) prepare the wheelchair in accordance with 7.3;

2) fully extend the supply cord;

3) establish an additional test point on the supply cord as close as practicable to the location where the cord exits the body or frame of the wheelchair.

10.1.3 Off-board and carry-on battery chargers

Prepare the battery charger as specified in 7.4. Support the charger test load (6.5) as specified in IEC 61000-4-2 for floor-standing equipment.

Test the battery charger as specified in IEC 61000-4-2 for table-top equipment.

Establish test points at the following locations:

a) one test point on each cable, connector housing, switch lever or button, control knob and indicator;

b) one test point on each face if the enclosure of the battery charger is approximately cuboidal;

c) one test point on each surface that would most closely approximate that of a cuboidal enclosure of similar size, to a maximum of six points if the enclosure of the battery charger is non-cuboidal.

Apply ten discharges of each polarity (positive and negative), at each applicable test level, to each test point.

Apply contact discharges and/or air discharges in accordance with the guidance given in IEC 61000-4-2.

10.2 Radiated r.f. field immunity

10.2.1 Wheelchair drives

10.2.1.1 General

Prepare the wheelchair as specified in 7.1.

Perform the radiated r.f. field immunity test specified in IEC 61000-4-3 on the wheelchair as table-top equipment. Ensure that each frequency step does not exceed 1 % of the current frequency.

NOTE The wheelchair is tested as table-top equipment to make it easier to achieve the required field uniformity.

Tests may be performed at field strengths greater than the specified level by appropriately adjusting the forward power applied to the antenna.

At each frequency step, adjust the forward power to the level obtained during calibration or, if appropriate, to that required for a higher field strength. Monitor the output of the power amplifier to ensure that it is not saturating. Maintain the output at the required level for at least 2 s. Measure the wheel speed and the servo steering angle, if applicable, at the conclusion of the 2 s dwell time while the r.f. field is still applied.

Either of the two test procedures specified in 10.2.1.2 and 10.2.1.3 may be used. One procedure may be used in a given portion of the frequency range while another procedure is used in the remainder of the range.

10.2.1.2 Anechoic or semi-anechoic chamber test method

Use an anechoic or semi-anechoic chamber as specified in IEC 61000-4-3. Orient the wheelchair so that:

a) the forward direction of travel is toward the antenna;

b) the rearward direction of travel is toward the antenna;

c) the forward direction of travel is perpendicular to the axis of the antenna, with the antenna facing the side of the wheelchair on which the control device is located or, in the case that the control device is centrally located, the side of the wheelchair where most of the electronic control units are located or most of the cables are routed.

Position the wheelchair so that the appropriate vertical plane (from Figure 1) closest to the antenna coincides with the uniform field area (UFA). For each orientation of the wheelchair, carry out the test with both horizontal and vertical polarization.

10.2.1.3 GTEM cell test method

Use a gigahertz transverse electromagnetic cell (GTEM) that has a maximum size for equipment under test (EUT), specified by the GTEM manufacturer and that is not less than the size of the wheelchair.

Orient the wheelchair so that:

a) the wheelchair is upright with its front closest to the apex of the GTEM (vertical polarization);

b) the wheelchair is placed on its back with its top closest to the apex of the GTEM (horizontal polarization).

For vertical polarization, position the wheelchair so that the uniform field area (UFA) is located in the geometric centre of the wheelchair as measured from the front vertical plane to the rear vertical plane. For horizontal polarization, position the wheelchair so that the UFA is central between the uppermost part of the wheelchair and the bottom of its wheels (see Figures 2 and 3).

10.2.2 Wheelchairs with an on-board battery charger

The test method is identical to that specified in 10.2.1, except that the wheelchair is prepared as specified in 7.3.

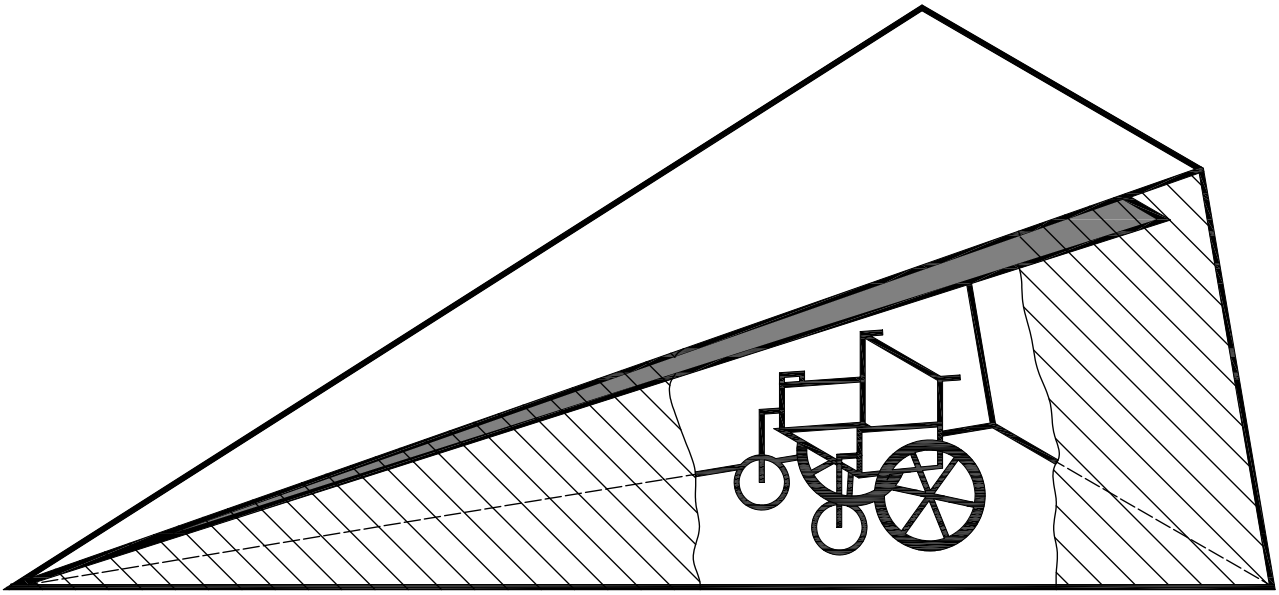


Figure 2 — Wheelchair orientation for vertical polarization in a GTEM cell

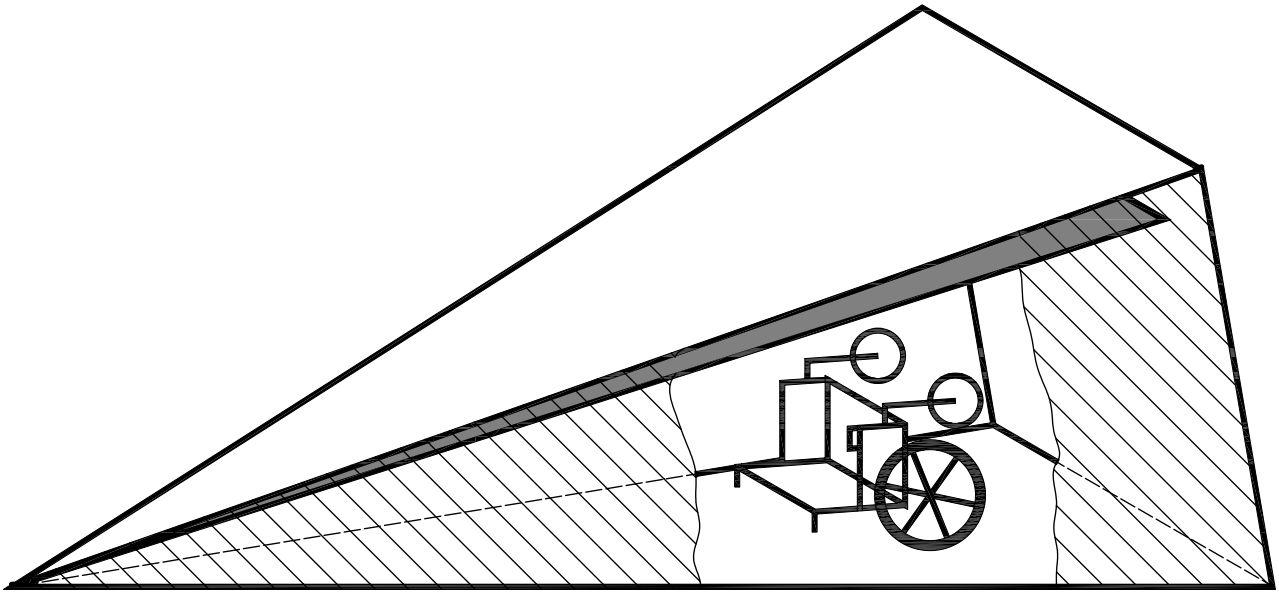


Figure 3 — Wheelchair orientation for horizontal polarization in a GTEM cell

10.2.3 Off-board and carry-on battery chargers

Prepare the battery charger as specified in 7.4. Support the charger test load (6.5) as specified in IEC 61000-4-3 for floor-standing equipment.

Perform the radiated r.f. field immunity test specified in IEC 61000-4-3 on the battery charger as table-top equipment.

Where the frequency is increased in a continuous sweep, the rate of increase shall not be greater than 1 % per 500 ms.

Where the frequency is increased in steps, ensure that each frequency step does not exceed 1 % of the current frequency and that the dwell time at each frequency is not less than 500 ms.

Carry out the test with the antenna facing each side of the battery charger, using both horizontal and vertical polarization.

10.3 Fast transient/burst immunity

10.3.1 Wheelchairs with an on-board battery charger

Prepare the wheelchair in accordance with 7.3.

Perform the laboratory type test specified in IEC 61000-4-4 on the a.c. mains port of the on-board battery charger as floor-standing equipment, with the following provisions:

— use a repetition rate of 100 kHz;

— use both polarities of test voltage;

— test for not less than 1 min and not more than 2 min for each polarity of test voltage.

10.3.2 Off-board and carry-on battery chargers

Prepare the battery charger as specified in 7.4.

Perform the laboratory type test specified in IEC 61000-4-4 on the a.c. mains port of the battery charger as table-top equipment, with the following provisions:

— support the charger test load (6.5) as specified in IEC 61000-4-4 for floor-standing equipment;

— use a repetition rate of 100 kHz;

— use both polarities of test voltage;

— test for not less than 1 min and not more than 2 min for each polarity of test voltage.

10.4 Surge immunity

10.4.1 Wheelchairs with an on-board battery charger

Prepare the wheelchair in accordance with 7.3.

Perform the surge immunity test specified in IEC 61000-4-5 on the a.c. mains port of the on-board battery charger, with the following provisions:

— apply five positive and five negative pulses each at 0°, 90°, 180° and 270°;

— apply successive pulses at a period of 60 s or less.

10.4.2 Off-board and carry-on battery chargers

Prepare the battery charger as specified in 7.4.

Perform the surge immunity test specified in IEC 61000-4-5 on the a.c. mains port of the battery charger, with the following provisions:

— apply five positive and five negative pulses each at 0°, 90°, 180° and 270°;

— apply successive pulses at periods of 60 s or less.

10.5 Conducted disturbance immunity

10.5.1 Wheelchairs with an on-board battery charger

Prepare the wheelchair in accordance with 7.3.

Perform the conducted disturbance immunity test specified in IEC 61000-4-6 on the a.c. mains port of the on-board battery charger as floor-standing equipment. Ensure the dwell time at each frequency is not less than 2 s.

10.5.2 Off-board and carry-on battery chargers

Prepare the battery charger as specified in 7.4.

Perform the conducted disturbance immunity test specified in IEC 61000-4-6 on the a.c. mains port of the battery charger as table-top equipment. Ensure the dwell time at each frequency is not less than 2 s.

10.6 Power frequency magnetic field immunity

Prepare the wheelchair as specified in 7.1.

Perform the continuous field immunity test specified in IEC 61000-4-8 on the wheelchair as table-top equipment. Test the wheelchair for not less than 1 min for each orientation of the applied field.

NOTE IEC 61000-4-8 specifies an induction coil of sufficient size to enclose the equipment under test. However, for the purposes of wheelchair testing, non-electrical parts can extend beyond the coil.

10.7 Voltage dips and short interruptions immunity

10.7.1 Wheelchairs with an on-board battery charger

Prepare the wheelchair as specified in 7.3.

Perform the voltage dips and short interruption tests specified in IEC 61000-4-11 on the a.c. mains port of the on-board battery charger.

10.7.2 Off-board and carry-on battery chargers

Prepare the battery charger as specified in 7.4.

Perform the voltage dips and short interruption tests specified in IEC 61000-4-11 on the a.c. mains port of the battery charger.

11 Wheel speed change calculations

For all wheelchairs with two drive wheels, calculate the average wheel speed change, ΔS_{avg}, as a percentage, as follows:

$$\Delta S_{avg} = 0{,}5 \times \left(\frac{S_{l,on} - S_{l,off}}{S_{l,off}} + \frac{S_{r,on} - S_{r,off}}{S_{r,off}} \right) \times 100$$

where

$S_{l,off}$ is the left wheel speed following set-up in accordance with 7.1.2 and prior to the test;

$S_{l,on}$ is the left wheel speed during the test;

$S_{r,off}$ is the right wheel speed following set-up in accordance with 7.1.2 and prior to the test;

$S_{r,on}$ is the right wheel speed during the test.

Alternatively, category B, C, E and F wheelchairs (wheelchairs without electronic differential steering) with two drive wheels and a mechanical differential may be tested with one wheel locked and the speed of the free-running drive wheel alone monitored. In this case, the average wheel speed change is calculated using the equation specified below for wheelchairs with a single drive wheel.

For wheelchairs with only a single drive wheel, and tests where the speed of only one wheel is monitored, calculate ΔS_{avg}, as a percentage, as follows:

$$\Delta S_{avg} = \left(\frac{S_{on} - S_{off}}{S_{off}} \right) \times 100$$

where

S_{off} is the wheel speed following set-up in accordance with 7.1.2 and prior to the test;

S_{on} is the wheel speed during the test.

Calculate the differential wheel speed change, ΔS_{diff}, as a percentage, as follows:

$$\Delta S_{diff} = \left(\frac{S_{l,on} - S_{l,off}}{S_{l,off}} - \frac{S_{r,on} - S_{r,off}}{S_{r,off}} \right) \times 100$$

where

$S_{l,off}$ is the left wheel speed following set-up in accordance with 7.1.2 and prior to the test;

$S_{l,on}$ is the left wheel speed during the test;

$S_{r,off}$ is the right wheel speed following set-up in accordance with 7.1.2 and prior to the test;

$S_{r,on}$ is the right wheel speed during the test.

12 Test report

The test report shall contain the following:

a) a reference to this part of ISO 7176, i.e., ISO 7176-21;

b) the name and address of the testing institution;

c) the name and address of the manufacturer of the wheelchair and/or battery charger;

d) the date of issue of the test report;

e) the type number and any serial number and/or batch number of the wheelchair and/or battery charger;

f) the configuration of the wheelchair and/or battery charger, including records specified in the set-up procedure (7.1.1);

g) a statement as to whether the wheelchair and/or battery charger meet the requirements of this part of ISO 7176.

NOTE Those commissioning tests might require further information such as identification of the point(s) in the test procedures when any failures occurred.

13 Disclosure

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

a) the type number or any other information that will uniquely identify the wheelchair and/or battery charger;

b) whether the wheelchair and/or battery charger meet the requirements of this part of ISO 7176.

14 User manual

In addition to the contents specified in ISO 7176-15, the user manual shall contain a warning regarding the risks due to interference from sources of electromagnetic radiation in the environment of the wheelchair, including, but not limited to:

— mobile telephones;

— electronic article surveillance systems.

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