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ISO 7176-4

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Wheelchairs —

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

Fauteuils roulants —

Partie 4: Consommation d'énergie des fauteuils roulants et des scooters électriques pour la détermination de la distance théorique

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Foreword

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

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

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

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

ISO 7176-4 was prepared by Technical Committee ISO/TC 173, *Assistive products for persons with disability*, Subcommittee SC 1, *Wheelchairs*.

This third edition cancels and replaces the second edition (ISO 7176-4:1997), 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 electric wheelchairs*

— *Part 11: Test dummies*

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

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

- *Part 15: Requirements for information disclosure, documentation and labelling*
- *Part 16: Resistance to ignition of upholstered parts — Requirements and test methods*
- *Part 19: Wheeled mobility devices for use as seats in motor vehicles*
- *Part 21: Requirements and test methods for electromagnetic compatibility of electrically powered wheelchairs and motorized scooters*
- *Part 22: Set-up procedures*
- *Part 23: Requirements and test methods for attendant-operated stair-climbing devices*
- *Part 24: Requirements and test methods for user-operated stair-climbing devices*
- *Part 26: Vocabulary*

Introduction

The distance range of an electrically powered wheelchair is affected by energy consumption and battery condition. Energy consumption is affected by a number of factors such as ambient temperature, total weight and weight distribution of the occupant, topography, surface characteristics and tyres. Battery condition is affected by factors such as temperature, age, charging history and discharging history. Hence the result obtained from the tests specified in this part of ISO 7176 cannot be used to derive an accurate range estimate for a particular wheelchair and occupant. However, it can be used to give a basis for comparison between different wheelchairs under similar test conditions.

Distance range is also strongly dependent on the way in which a wheelchair is driven, and a single value for theoretical range can be insufficient to provide an understanding of the performance of a wheelchair. Two methods for determining theoretical range are provided in this part of ISO 7176, for driving and for manoeuvring. These values are intended to facilitate wheelchair comparison in a manner analogous to the extra-urban and urban fuel consumption figures published for motor vehicles.

Wheelchairs —

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

1 Scope

This part of ISO 7176 specifies methods for determining the theoretical distance range of electrically powered wheelchairs, including scooters, using measurements of energy consumed while driving and the nominal energy capacity of the wheelchair's battery set. It is applicable to electrically powered wheelchairs with a maximum nominal speed no greater than 15 km/h, intended to provide indoor and/or outdoor mobility for one disabled person whose mass is within the range represented by ISO 7176-11. This part of ISO 7176 also includes requirements for test reports and information disclosure.

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

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

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

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

3 Terms and definitions

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

3.1
wheelchair
electrically powered wheelchair

NOTE A scooter is an electrically powered wheelchair.

4 Principle

Energy consumption is measured for two types of driving: continuous driving and manoeuvring. For continuous driving, the wheelchair is driven around a test track ten times clockwise and ten times anti-clockwise, and the energy consumed is measured. For manoeuvring, the wheelchair is driven in a circuit between two markers 5 m apart, stopping and turning outside them, ten times in each direction while the energy consumed is measured. Theoretical range values are calculated from the energy consumed, the nominal distance travelled, and the battery capacity.

In the manoeuvring test, the total energy consumed by the wheelchair is measured, including both the energy consumed while it is between the markers and the energy consumed while it is outside them. However, the distance used to calculate the theoretical manoeuvring range is the nominal distance travelled between the markers; the distance travelled outside them is ignored. This implies that more-manoeuvrable wheelchairs will tend to have higher values of theoretical manoeuvring distance range than similar but less-manoeuvrable wheelchairs.

5 Test equipment

5.1 Test track, as shown in Figure 1, marked upon a flat, hard, horizontal surface in an area free from draughts, in a location where the temperature is between 18 °C and 25 °C.

The length of the centreline of the test track shall be between 50 m and 100 m. Each long side, L, shall be of sufficient length that the wheelchair can achieve its maximum speed. Each short side, W, shall be of sufficient length that the wheelchair can turn without stopping.

NOTE 1 The use of a shorter test track within the specified range will result in a lower theoretical range.

NOTE 2 The floor of a typical large building used for manufacturing or indoor leisure activities with, for example, a concrete, asphalt or wooden floor is acceptable. Any minor deviations from flat or horizontal are accommodated by reversing the direction of the test after the first ten laps, and starting and finishing the test in the same place on the track.

The test track shall contain two markers across one side, perpendicular to the centreline and 5,00 m ± 0,01 m apart. It shall also contain a circular central marker, of diameter 0,13 m ± 0,03 m, the centre of which shall be located within 0,03 m of a point half way between the two markers on the centreline of the test track (see Figures 1 and 2).

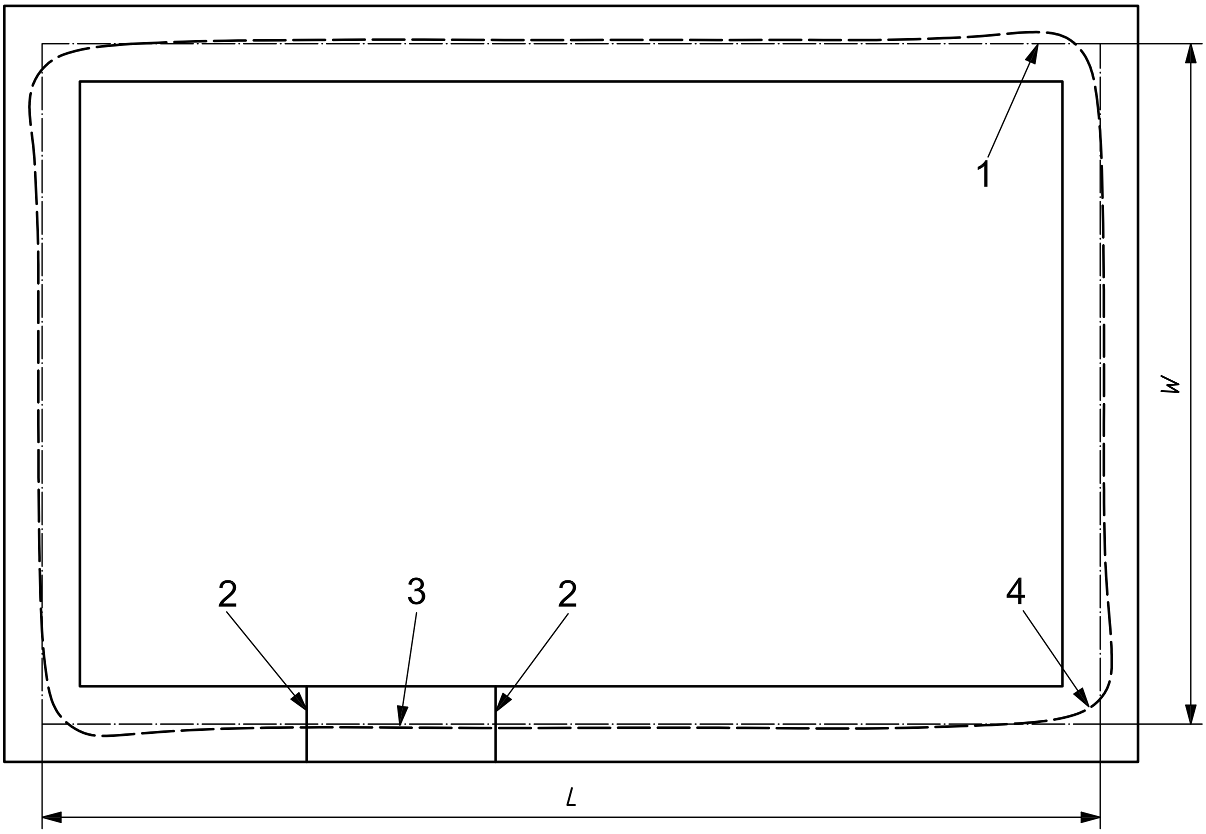
The preferred width of the test track is 2,0 m ± 0,1 m. No part of the track shall be wider than 2,1 m. The track shall not be narrower than 1,9 m in places where it would affect the performance of a test (e.g. the region containing the markers), or be narrower than 1,2 m at any point.

5.2 Energy consumption measurement apparatus, capable of measuring the electrical energy, expressed in watt hours, supplied by the terminals of the wheelchair's battery set, to an accuracy of ± 2 % and which does not itself use more than 0,5 % of the electrical energy supplied. A positive measurement shall represent energy supplied by the battery set to the wheelchair, while a negative measurement shall represent energy returned to the battery set by the wheelchair. Where the apparatus acquires discrete samples, the sampling period shall not be greater than that necessary to provide the required accuracy.

EXAMPLE 100 ms.

For simplicity of analysis it is recommended that the apparatus integrate the power consumption of the wheelchair over time. Annex A gives guidance on energy consumption measurement apparatus.

5.3 Distance measuring device, capable of measuring the length of the centreline of the test track to an accuracy of ± 100 mm.



Key

1 centreline of test track

2 marker

3 centre marker

4 example of wheelchair path (when driving around the track in an anticlockwise direction)

L length of long sides of test track

W length of short sides of test track

NOTE The group of markers 2 and 3 is at any position along the track convenient for performing the manoeuvring test.

Figure 1 — Test track

6 Preparation

a) Set up the wheelchair as specified in ISO 7176-22.

b) If the wheelchair is fitted with a controller that has adjustable settings accessible to the operator by means provided with the wheelchair, set each of them to the value that provides the maximum magnitude of speed and/or acceleration.

c) Make provision for the wheelchair to be loaded and controlled using one of the following:

1) a human test driver whose mass, when combined with weights if needed, conforms to the requirements for selection and fitting of dummies specified in ISO 7176-22;

2) a dummy selected and fitted as specified in ISO 7176-22, together with means for the wheelchair to be driven automatically or by remote control.

If a human test driver is used, ensure that the location of the centre of mass, including weights, is within 50 mm, in the fore-aft direction, of the position of the centre of mass for the corresponding dummy, and within 50 mm of the centre of the seat in the right-left direction.

If a dummy is used, ensure that the total mass of the load, including the additional control means, and the location of the centre of mass conform to the requirements of ISO 7176-11 for the applicable dummy mass.

NOTE Weights, such as sandbags or similar items, can be added to the body support system to supplement the mass of a human test driver and to adjust the location of the centre of mass. To determine the correct location of the centre of mass of a human driver, the weight distribution of the wheelchair with the seated driver (plus additional weights, if used) can be compared with the weight distribution of the wheelchair with the dummy fitted to the body support system as specified in ISO 7176-22.

d) Using the distance measuring device (5.3), measure the length of the centreline of the test track to the nearest multiple of 0,1 m.

e) Connect the energy consumption measurement apparatus (5.2) to the terminals of the battery set in a manner that will provide the required accuracy.

f) Fully charge the battery set in accordance with the manufacturer's instructions at an ambient temperature of between 18 °C and 25 °C.

g) Prior to the test, condition the wheelchair by maintaining it at a temperature between 18 °C and 25 °C for not less than 8 h.

NOTE Conditioning the wheelchair and charging the battery set can be done at the same time.

h) Immediately after completing g), to warm up the wheelchair drive system, drive the wheelchair around the test track ten times in the clockwise direction then ten times in the anticlockwise direction, at the maximum speed practicable while staying within the confines of the track. Stop the wheelchair within 2 m of the starting position. Record the energy consumed during the twenty warm-up laps, and then reset the energy consumption measurement apparatus.

Prior to conducting the tests, it is recommended that practise tests be conducted to enable test personnel to develop the driving skills needed to conduct the tests effectively.

7 Test procedure

7.1 Continuous driving test

a) Immediately after completing the preparation specified in Clause 6, drive the wheelchair around the test track ten times, in either the clockwise or anti-clockwise direction, at the maximum speed practicable while staying within the confines of the track. Use the energy consumption measurement apparatus (5.2) to measure the electric energy consumed by the wheelchair while it is in motion. Stop the wheelchair within 2 m of the starting position.

   If the wheelchair stops during the test due to a depleted battery set, measure and record the total distance it travelled, including the distance travelled in subclause 6 h).

NOTE The distance travelled is the number of whole laps the wheelchair travelled, multiplied by the length of the centreline of the track, plus any additional part of a lap it travelled, measured along the centreline of the track.

b) If the wheelchair did not stop in a) due to a depleted battery set, repeat a), but driving in the opposite direction around the track.

c) Record the total electrical energy consumed by the wheelchair, expressed in watt hours, as follows:

— if the wheelchair completed both a) and b), record the total electrical energy consumed in a) and b);

— if the wheelchair stopped due to a depleted battery set, record the total electrical energy consumed, including the energy consumed in the warm-up laps.

d) Calculate the specific energy consumption e_c using the following formula:

$$e_c = \frac{1\,000 \times E_c}{D_c}$$

where

e_c is the continuous driving specific energy consumption of the wheelchair, expressed in watt hours per kilometre;

E_c is the electrical energy consumed during the continuous driving test, expressed in watt hours;

D_c is twenty times the length of the centreline of the test track, or if the wheelchair stopped during the test, the distance recorded in a), expressed in metres.

EXAMPLE For an energy consumption of 44,25 Wh for twenty laps on a track of length 89,1 m, e_c would be recorded as 24,8 Wh/km.

e) Calculate the theoretical distance range R_c using the following formula:

$$R_c = \frac{E_{BAT}}{e_c}$$

where

R_c is the theoretical continuous driving distance range of the wheelchair, expressed in kilometres;

E_{BAT} is the nominal energy capacity of the wheelchair's battery set, expressed in watt hours.

EXAMPLE For a specific energy consumption of 24,8 Wh/km and a total energy capacity of 1 020 Wh, R_c would be recorded as 41,1 km.

If the battery manufacturer declares the nominal energy capacity, then E_{BAT} is the nominal energy capacity of each battery, declared for a discharge time of 5 h, multiplied by the number of batteries used to power the wheelchair. If the energy capacity is not declared for a discharge time of 5 h, use the energy capacity declared for the nearest shorter period. Otherwise, calculate E_{BAT} using the following formula:

$$E_{BAT} = V_{NOM} \times C_5$$

where

V_{NOM} is the nominal voltage of the battery set, expressed in volts;

C_5 is the charge capacity of the battery for a discharge time of 5 h, as declared by the battery manufacturer, expressed in ampere hours.

NOTE This formula is an estimate of the relationship between nominal energy capacity and nominal charge capacity for typical wheelchair batteries. It is preferable that the battery manufacturer declare the nominal energy capacity.

If the battery manufacturer does not declare the charge capacity of the battery for a discharge time of 5 h, calculate C_5 using the following formula:

$$C_5 = 0{,}80 \times C_{20}$$

where C_{20} is the charge capacity of the battery for a discharge time of 20 h, as declared by the battery manufacturer, expressed in ampere hours.

NOTE This formula is an estimate of the relationship between C_5 and C_{20} for typical wheelchair batteries.

7.2 Manoeuvring test

a) Repeat the wheelchair preparation specified in Clause 6 if it is necessary to recharge the battery set or if more than 5 min elapses between the end of the continuous driving test specified in 7.1 and the start of this test.

EXAMPLE It would be necessary to recharge the battery set if the wheelchair were considered unlikely to complete the manoeuvring test without stopping or slowing down due to a depleted battery.

b) Place the wheelchair on the test track with a front wheel touching one of the markers and facing the other marker 5 m away. Reset the energy consumption measurement apparatus.

c) Drive the wheelchair in a substantially straight line at the maximum speed practicable so that it passes over the centre marker. Continue driving until one of its front wheels touches the opposite marker, and then immediately release the control device. Ensure that the wheelchair does not leave the test track while it is driven between the markers.

d) After the wheelchair stops, turn the wheelchair to face the first marker by driving it in the smallest practicable distance without stopping.

   The wheelchair may be driven partially or completely outside the track to make the turn. See Figure 2.

e) Continue to drive the wheelchair back to the first marker in the same manner as in c).

f) Turn the wheelchair to face the second marker in the same manner as in d) but turning in the opposite direction.

NOTE This will result in a figure-of-eight driving circuit for the wheelchair as shown in Figure 2.

g) Repeat c) to f) for a total of ten complete circuits, while measuring the total electrical energy consumed by the wheelchair.

h) Record the total electrical energy consumed by the wheelchair, expressed in watt hours.

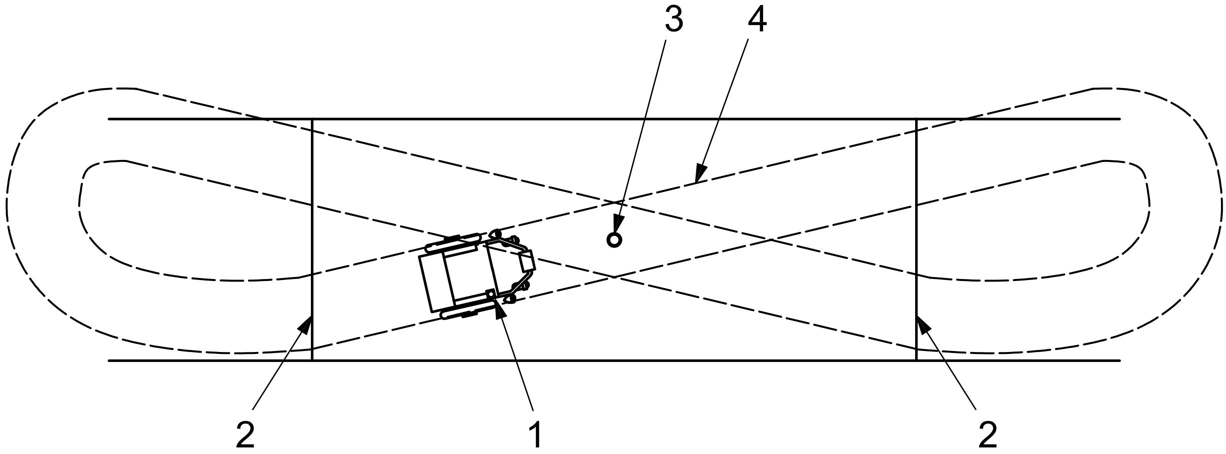
i) Calculate the specific energy consumption e_M using the following formula:

$$e_M = 10 \times E_M$$

where

e_M is the manoeuvring specific energy consumption of the wheelchair, expressed in watt hours per kilometre;

E_M is the electrical energy consumed during the manoeuvring test, expressed in watt hours.



Key
1 wheelchair
2 marker
3 centre marker
4 example of wheelchair path

Figure 2 — Manoeuvring test

j) Calculate the theoretical distance range R_M using the following formula:

$$R_M = \frac{E_{BAT}}{e_M}$$

where R_M is the theoretical manoeuvring distance range of the wheelchair, expressed in kilometres.

8 Test report

The test report shall contain the following information:

a) the name and address of the testing institution;

b) a statement that the tests were carried out in accordance with ISO 7176-4;

c) the name and address of the wheelchair manufacturer;

d) the model designation of the wheelchair;

e) the serial number or batch number of the wheelchair;

f) details of any adjustments made to controller settings in 6 b);

g) the mass of the human test driver (and weights, if used) or the dummy used in the tests;

h) the length of each side of the test track measured at the centreline, expressed in metres;

i) the specific energy consumed by the wheelchair during the continuous driving test 7.1, and during the manoeuvring test 7.2, each expressed in watt hours per kilometre and rounded to two significant figures;

j) the battery type, nominal energy capacity and discharge time for which the capacity is specified, as declared by the battery manufacturer or as calculated in 7.1;

k) the theoretical continuous driving distance range and the theoretical manoeuvring distance range of the wheelchair, as calculated in 7.1 and in 7.2 respectively, expressed in kilometres and rounded to two significant figures;

l) a unique test report reference.

9 Disclosure

Wheelchair manufacturers shall disclose in their specification sheet, in the manner and sequence specified in ISO 7176-15, the theoretical continuous driving distance range as calculated in 7.1, and the theoretical manoeuvring distance range as calculated in 7.2, each expressed in kilometres and rounded to two significant figures.

Annex A
(informative)

Energy consumption

The specific energy consumption of electric vehicles is usually expressed in watt hours per kilometre (Wh/km). An estimate of range can be calculated from the specific energy consumption and the energy capacity of the vehicle's battery set.

Wheelchair energy consumption can be measured as the time integral of battery power, typically calculated as the product of battery current and battery voltage, taken at sufficiently short time intervals. During discharge, battery voltage varies from approximately 10 % above to 10 % below its nominal voltage. It is essential that the accuracy of the measurement of power and the frequency of the measurements be sufficient to obtain the required accuracy for energy measurement.

A typical energy meter measures current and voltage at fixed time intervals, and calculates the product of the current (expressed in amperes), the voltage (expressed in volts), and the measurement interval (expressed in hours) to obtain energy (expressed in watt hours).

A suitable alternative to an energy meter is a charge meter and a voltmeter that records measurements at intervals such that the differences in voltage are sufficiently small to obtain the required accuracy for the energy measurement. The energy (expressed in watt hours) is the sum of the products of each measurement of charge (the difference between the present charge and the previous charge, expressed in ampere hours) over the measurement time interval and the average voltage (expressed in volts) over the same time interval.

For comparison purposes, if it is not declared, a battery's energy capacity (expressed in watt hours) can be estimated as the product of the nominal discharge capacity (expressed in ampere hours) and the nominal voltage (expressed in volts), because the nominal voltage represents approximately the average voltage during a constant-current discharge.

ICS 11.180.10

Price based on 9 pages