AS/NZS ISO 7176.2:2020
ISO 7176-2:2017

Australian/New Zealand Standard™

# Wheelchairs

# Part 2: Determination of dynamic stability of electrically powered wheelchairs




AS/NZS ISO 7176.2:2020

This Joint Australian/New Zealand Standard™ was prepared by Joint Technical Committee ME-067, Assistive Technology. It was approved on behalf of the Council of Standards Australia on 10 December 2019 and by the New Zealand Standards Approval Board on 18 December 2019.

This Standard was published on 24 January 2020.

The following are represented on Committee ME-067:

Assistive Technology Suppliers Australasia
Assistive Technology Suppliers New Zealand
Australian Nursing and Midwifery Federation
Australian Rehabilitation & Assistive Technology Association
Canterbury Employers' Chamber of Commerce
Heavy Vehicle Industry Australia
Independent Living Centres Australia
Medical Aids Subsidy Scheme (Australia)
National Disability Insurance Agency (Australia)
Novita Children's Services (Australia)
Occupational Therapy Australia
Royal Perth Hospital
TAD Australia

This Standard was issued in draft form for comment as DR AS/NZS ISO 7176.2:2019.



**Keeping Standards up-to-date**

Ensure you have the latest versions of our publications and keep up-to-date about Amendments, Rulings, Withdrawals, and new projects by visiting:

www.standards.org.au

www.standards.govt.nz

ISBN 978 1 76072 719 2

AS/NZS ISO 7176.2:2020
ISO 7176-2:2017

Australian/New Zealand Standard™

# Wheelchairs

# Part 2: Determination of dynamic stability of electrically powered wheelchairs

Originated in Australia as AS 3696.2—1992.
Jointly revised and redesignated as AS/NZS 3696.2:2008.
Second edition 2020.

# Preface

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME-067, Assistive Technology, to supersede AS/NZS 3696.2:2008, *Wheelchairs, Part 2: Determination of dynamic stability of electric wheelchairs*.

The objective of this Standard is to specify test methods for determining the dynamic stability of electrically powered wheelchairs.

This Standard is applicable to electrically powered wheelchairs, including scooters, with a maximum nominal speed not exceeding 15 km/h, intended to carry one person.

This Standard is not applicable to manual wheelchairs with add-on power kits used for, or to assist, propulsion.

This Standard is identical with, and has been reproduced from, ISO 7176-2:2017, *Wheelchairs — Part 2: Determination of dynamic stability of electrically powered wheelchairs*.

As this document has been reproduced from an International Standard, a full point substitutes for a comma when referring to a decimal marker.

Australian or Australian/New Zealand Standards that are identical adoptions of international normative references may be used interchangeably. Refer to the online catalogue for information on specific Standards.

The terms “normative” and “informative” are used in Standards to define the application of the appendices or annexes to which they apply. A “normative” appendix or annex is an integral part of a Standard, whereas an “informative” appendix or annex is only for information and guidance.

# Contents

# 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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document 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 7176-2:2001), which has been technically revised.

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

— revision of ramp requirements;

— provision for remote control testing.

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

# Introduction

It is important to understand the dynamic stability characteristics of a wheelchair for prescription and adjustment purposes. Wheelchair users and prescribers should understand the safety implications of dynamic stability, particularly when setting up seating systems that offer a large range of configurations. They should consider the environment in which the wheelchair is to be used and the hazards that are likely in that environment while considering possible configurations of the wheelchair when meeting those hazards.

This document specifies tests for dynamic stability under a range of operating conditions with various wheelchair configurations. The effectiveness of stability controlling systems are evaluated by the procedures listed in this document.

Wheelchair instability is a significant contributor to accidents causing injury. Consequently, it is desirable that all parties involved in the supply of wheelchairs understand the factors that contribute to instability. Parties interested in this document could be wheelchair designers and manufacturers, prescribers, therapists, building designers, public facility providers and test houses.

The purpose of this document is to define tests that will consistently demonstrate dynamic stability limits under a variety of proven stability challenges. Tests are designed to reveal the effects of adjustments and configurations.

This document will help interested parties define suitable environments and intended use of the wheelchair.

Although this document does not specify requirements, it is an essential reference document for other documents that do specify stability.

# Australian/New Zealand Standard

## Wheelchairs

## Part 2: Determination of dynamic stability of electrically powered wheelchairs

## 1 Scope

This document specifies test methods for determining the dynamic stability of electrically powered wheelchairs.

This document is applicable to electrically powered wheelchairs, including scooters, with a maximum nominal speed not exceeding 15 km/h, intended to carry one person. This document is not applicable to manual wheelchairs with add-on power kits used for, or to assist, propulsion.

## 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

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

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 7176-22, *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.

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

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

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

**3.1**
**wheel lift**
loss of contact between a wheel and the test surface during conditions of instability

Note 1 to entry: This does not include transient loss of contact due to surface irregularity or transitions.

Note 2 to entry: This does not include loss of contact such as a transition onto or rotation of cluster wheels.

## 4 Principle

The wheelchair is subjected to a number of driving tests, simulating use of a wheelchair, while its movements are observed for the occurrence of a range of defined conditions of instability. Accessories are not accounted for during these tests.

# 5 Apparatus

**5.1 Rigid, flat, horizontal test plane,** with coefficient of friction of greater than 0,6 measured by the method specified in ISO 7176-13 and of sufficient size to conduct the tests. The test plane shall have a surface that lies between two imaginary horizontal planes 20 mm apart and has no more than 0,5 ° variation in slope or cross slope throughout the test.

The test plane shall be long enough to allow the wheelchair to reach maximum speed.

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.

**5.2 Rigid, flat, inclined area,** with run up and run down, shall be long enough to allow the wheelchair to reach maximum speed and come to a stop within the stated inclination.

The test area of the ramp shall be long enough to allow the wheelchair to come to a stop within the stated inclination which shall be within the tolerance of ±1°.

The testing area of the ramp shall have a surface that lies between two imaginary parallel planes 50 mm apart.

The test ramp shall have a coefficient of friction in the test area that meets the requirements of ISO 7176-13.

The test area shall run immediately from the horizontal test plane via a transition with a radius of less than 25 mm.

The traversed surface shall be free of loose material and steps greater than 5 mm in height.

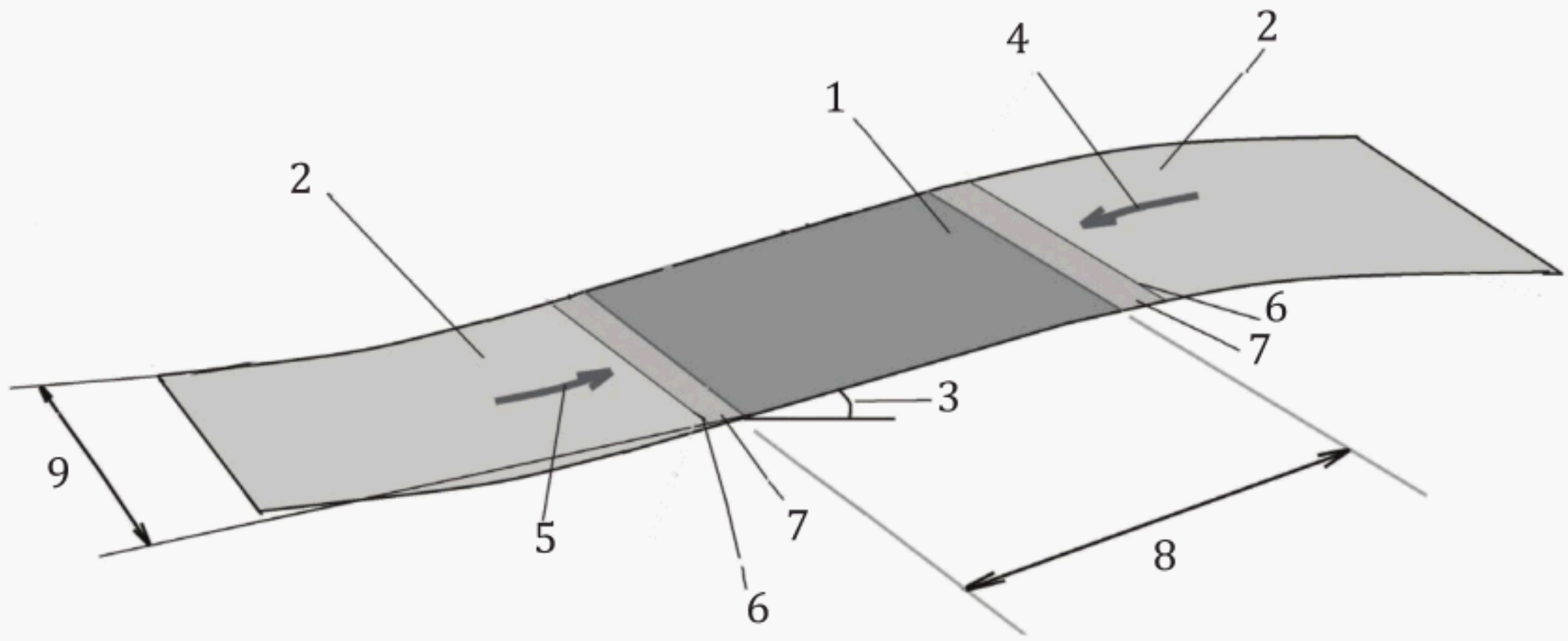
A ramp approximately 10 m × 3 m is normally of sufficient area, but the testing of larger and/or faster wheelchairs may need a larger ramp.

NOTE 1 The ramp can be of a variable angle type or individual ramps for each required angle.

NOTE 2 Run up and run down areas on either end of the test area need not meet the above criteria.

NOTE 3 Figure 1 provides a recommended configuration for the test area and transition.

NOTE 4 A ramp of approximately 10 m × 3 m is normally of sufficient area but the testing of larger and/or faster wheelchairs might need a larger ramp.




**Key**

1 test area
2 run up/run down area
3 defined slope angle
4 downward path
5 upward path
6 transition
7 transition zone
8 length of test area
9 test area width - sufficient to allow the wheelchair to complete the test in Clause 10

**Figure 1 — General arrangement of test area**

**5.3 Rigid vertical step transition**, with the following properties:

a) immediately adjacent to a horizontal test plane and followed by a further horizontal plane onto which a wheelchair can be driven via the step from the horizontal test plane;

b) step heights of 15 mm, 25 mm, 50 mm, and multiples of 25 mm above that if claimed by the manufacturer;

c) a top edge of the step with a radius of 6 mm ± 1 mm;

d) the tolerance on total step height shall be ±2 mm.

NOTE 1 This can be either a single step with adjustable height or separate fixed steps.

NOTE 2 An area of approximately 1 m × 5 m is normally of sufficient size for the higher plane.

**5.4 Test dummy**, in accordance with ISO 7176-11.

**5.5 Means for remote control**, for use at the discretion of test personnel, to control the speed of the wheelchair and to cause a turn through 90 ° on a predetermined radius.

EXAMPLE 1 For joystick-controlled wheelchairs, a remote control apparatus with proportional servos to control fore/aft and lateral movement of the joystick (see Annex A).

EXAMPLE 2 For tiller-steered wheelchairs, a remote controlled proportional servo for the speed control and a spring load with a remote controlled release for the tiller, so that when the tiller is released, the spring causes the tiller to turn on a predetermined radius (see Annex A). For tests requiring a variable turn radius required in 10.6, the steering tether can be replaced by an actuator. Alternatively, a device to limit the tiller rotation at predetermined turn angles can be used.

# 6 Initial set-up of test wheelchair

## 6.1 General

Prepare the test wheelchair in accordance with ISO 7176-22, set-up level 2, modified as specified in 6.2.

## 6.2 Anti-tip devices

Test the wheelchair with anti-tip devices if they are provided and the instructions for use state that they are to be used. If the anti-tip devices are adjustable, set them to their least effective position. If they can be adjusted so that they will not contact the ground if the wheelchair tips, this may be considered the least effective position.

If anti-tip devices are not provided, or the instructions for use do not state that they are to be used, test the wheelchair without them.

## 6.3 Batteries

The wheelchair should be equipped with batteries as specified by the manufacturer. However, batteries containing free electrolyte can be hazardous if spillage occurs during testing. Such batteries may be replaced by the nearest capacity equivalent valve-regulated, absorbent glass mat, or gel-type batteries, with supplementary weights if necessary to give an equivalent mass distribution.

## 6.4 Test load

### 6.4.1 General

Select the test load and set it up as specified in 6.4.2 or 6.4.3.

### 6.4.2 Test dummy

a) Select, position and secure the appropriate dummy in accordance with ISO 7176-22.

b) Set up the means to remotely control the wheelchair, if a remote control system is chosen. If using remote control, set up the means (see Annex A).

### 6.4.3 Human test occupant

For some tests, it might be necessary to use a human test occupant. For such cases, select a suitable human test occupant as specified in ISO 7176-22 and see Annex B for safety recommendations.

# 7 Test procedure

Conduct the tests specified in Clauses 8, 9 and 10 using the scoring system specified in Annex C to quantify the dynamic response of the wheelchair.

Wherever practicable, test using a test dummy as specified in 6.4.2. Where a test dummy can not be used, use a human test occupant as specified in 6.4.3.

For safety reasons, perform each test at slow speed initially and repeat using gradually increasing speeds until a score of 0 or the maximum speed is achieved.

The tests may be performed in any sequence.

If the stability score is found to be 1 or 0 for a particular slope or step height, end the test and record a 0 for the higher levels for that test.

NOTE 1 Continuation of the test could be dangerous to the tester and damaging to the wheelchair.

NOTE 2 Video recordings of the movement of the wheelchair, replayed in slow motion and stop action, can assist observing and scoring the wheelchair responses.

# 8 Tests for rearward dynamic stability

## 8.1 General

While remaining within any constraints mandated by the manufacturer in the user manual, all user and dealer adjustable parts shall be adjusted to create a least stable configuration or, configurations, for a wheelchair. This determination may require several iterations to determine the configuration or configurations, that is or are the least stable.

Table 1 provides guidance for setting up the wheelchair in its least stable configuration. Some wheelchairs have drive configurations that limit the speed. It will often be necessary to explore a wide range of possible configurations, including those where speed is limited. The least stable configuration may be different between tests described in 8.3, 8.4, 8.5, 8.6, 8.7 and 8.8. The least stable configuration shall be determined for each test. The least stable configuration is the configuration that returns the lowest score in each test.

## 8.2 Wheelchair preparation

Prepare the wheelchair as specified in Clause 6 with the following additions: Set all adjustable components to their least stable configuration for the wheelchair in the rearward direction within the constraints specified by the manufacturer in the device user manual. These components include, but are not limited to, the rear wheel position, castor attachment to the frame, seat position, back position, seat-to-back angle, leg-to-seat angle, and seat height and speed. Typical adjustments for least stable rearward settings are mentioned in Table 1. If any of the adjustments results in an unwanted setting, e.g. the castor wheels contact any other part of the wheelchair, increase/decrease the adjustment just enough to ensure a proper function of the wheelchair. Make every effort to minimize castor shimmy during tests. There may be several ways of doing this including adjusting castor rake and castor cant.

**Table 1 — Least stable rearward stability typical settings**

| Adjustable wheelchair component | Least stable position |
|---|---|
| Rear wheel position, fore-aft | Forward |
| Castor attachment to frame, fore-aft | Back |
| Seat position, fore-aft | Back |
| Seat position, vertical | High |
| Seat back position, recline | Back |
| Seat position, tilt | Back |
| Back position, fore-aft | Back |
| Leg to seat angle | Minimum |
| Speed setting | Maximum |

## 8.3 Starting forward

NOTE This test determines stability when a wheelchair starts on a horizontal surface and on an uphill slope.

a) Position the wheelchair on the horizontal test plane.

b) From a stationary position, operate the control device to give maximum acceleration in the forward direction.

c) Observe the dynamic response of the wheelchair and score it according to Annex C.

d) Repeat b) and c) on the 3°, 6° and 10° ramps or other ramp angles as specified by the manufacturer or those commissioning the tests specifying requirements starting with the wheelchair on each ramp facing uphill. If the manufacturer recommends a technique for driving on a slope, test the wheelchair using the recommended technique. If the manufacturer specifies a maximum slope, testing is to be done for all ramp angles up to and including that slope, otherwise the test methods are unmodified.

## 8.4 Braking when travelling forward on horizontal or uphill

NOTE This test determines stability when a wheelchair stops on a horizontal surface and rocks backward as a counter movement. This test also determines stability when stopping on an uphill slope if the wheelchair rolls or rocks backward before coming to a complete stop.

a) Run the wheelchair at maximum forward speed on the horizontal test plane.

b) Apply retardation by releasing the control device.

c) Observe the dynamic response of the wheelchair and score it according to Annex C.

d) Repeat a) to c) applying retardation by turning the wheelchair power off.

e) Repeat a) to c) applying retardation by quickly applying full speed command in the opposite direction, keeping the control device at maximum retardation until the wheels turn in the opposite direction.

f) Record the lowest score from the three methods of a) to e) and the method which gave this result.

g) Repeat a) to f) travelling forward uphill on the 3°, 6° and 10° ramps or other ramp angles as specified by the manufacturer. If the manufacturer recommends a technique for driving on a slope, test the wheelchair using the recommended technique. If the manufacturer specifies a maximum slope, testing is to be done up to that slope, otherwise the test methods are unmodified.

## 8.5 Braking when travelling backward

NOTE This test determines stability when a wheelchair stops suddenly from maximum reverse speed travelling on the horizontal and also travelling downhill travelling backward.

a) Run the wheelchair at maximum reverse speed on the horizontal test plane.

b) Apply retardation by releasing the control device.

c) Observe the dynamic response of the wheelchair and score it according to Annex C.

d) Repeat a) to c) applying retardation by turning the wheelchair power off.

e) Repeat a) to c) applying retardation by quickly applying full speed command in the opposite direction, keeping the control device at maximum retardation until the wheels turn in the opposite direction.

f) Record the lowest score from the three methods of a) to e) and the retardation method which gave this result.

g) Repeat a) to f) travelling backward downhill on the 3°, 6° and 10° ramps or other ramp angles as specified by the manufacturer. If the manufacturer recommends a technique for driving on a slope, test the wheelchair using the recommended technique. If the manufacturer specifies a maximum slope, testing is to be done up to that slope, otherwise the test methods are unmodified.

## 8.6 Travelling forward up a step transition from a standing start

a) Test the wheelchair with kerb climbing devices in their normal position if they are available as standard or optional equipment on the wheelchair. Set kerb climbing devices to their normal position for climbing kerbs as specified by the manufacturer. Test the wheelchair without kerb climbing devices if they are removable without tools.

b) Position the wheelchair on the horizontal test plane with its front wheels in contact with the 15 mm step and in the trailing position for forward motion.

c) Operate the control device to give maximum acceleration in the forward direction until all wheels are up the step.

d) Observe the dynamic response of the wheelchair and score it according to Annex C.

e) Repeat b) to d) with step heights of 25 mm and 50 mm

f) If the manufacturer claims that the wheelchair is capable of handling higher step transitions, repeat b) to d) at intervals that are multiples of 25 mm, increasing the step height up to the level claimed by the manufacturer and terminating the test if the wheelchair can no longer travel up the step transition with a score of 2 or greater.

NOTE Increments of less than 25 mm can be used to achieve the step height level claimed by the manufacturer.

## 8.7 Travelling forward up a step transition at maximum speed

NOTE 1 The intent of this test is to use the impact with the step to induce a rearward tip regardless of whether the wheelchair climbs the step. This test procedure is very similar to 9.5 which configures the wheelchair for least stability forward.

a) Test the wheelchair with kerb climbing devices in their normal position if they are available as standard or optional equipment on the wheelchair. Set kerb climbing devices to their normal position for climbing kerbs as specified by the manufacturer. Test the wheelchair without kerb climbing devices if they are removable without tools.

b) Position the wheelchair on the horizontal test plane far enough from the 15 mm step transition to allow the wheelchair to achieve maximum speed.

NOTE 2 A forward tip can occur at minimum speed, but is unlikely at a faster speed.

c) Run the wheelchair forward at maximum speed along the horizontal test plane to hit the step at 90° ± 5°.

d) Observe the dynamic response of the wheelchair and score it according to Annex C.

e) Repeat b) to d) with step heights of 25 mm and 50 mm.

f) If the manufacturer claims that the wheelchair is capable of handling higher step transitions, repeat b) to d) at intervals that are multiples of 25 mm, increasing the step height up to the level claimed by the manufacturer and terminating the test if the wheelchair can no longer travel up the step transition with a score of 2 or greater.

NOTE 3 Increments of less than 25 mm can be used to achieve the step height level claimed by the manufacturer.

## 8.8 Travelling backward down a step transition from a standing start

a) Position the wheelchair on the horizontal test plane above the step with its rear wheels at the edge of the 15 mm step.

b) Operate the control device at minimum speed in the reverse direction until all wheels are down the step.

NOTE 1 A rearward tip can occur at minimum speed, but is unlikely at a faster speed.

c) Observe the dynamic response of the wheelchair and score it according to Annex C.

d) Repeat a) to c) with step heights of 25 mm and 50 mm.

e) If the manufacturer claims that the wheelchair is capable of handling higher step transitions, repeat a) to c) at intervals that are multiples of 25 mm, increasing the step height up to the level claimed by the manufacturer and terminating the test if the wheelchair can no longer travel down the step transition with a score of 2 or greater.

NOTE 2 Increments of less than 25 mm can be used to achieve the step height level claimed by the manufacturer.

# 9 Tests for forward dynamic stability

## 9.1 General

While remaining within any constraints mandated by the manufacturer, all user and dealer adjustable parts shall be adjusted to create a least stable configuration. This determination may require several iterations to determine the configuration of minimum stability.

The settings recommended in Table 2 are not absolute. Finding the least stable configuration for a wheelchair may require an iterative process to determine the one configuration that is the least stable. Some wheelchairs have drive configurations that limit the speed. It will often be necessary to explore a wide range of possible configurations, including those where speed is limited. The least stable configuration may be different between tests described in 9.3, 9.4, 9.5 and 9.6. The least stable configuration shall be determined for each test. The least stable configuration is the configuration that returns the lowest score in each test.

## 9.2 Wheelchair preparation

Prepare the wheelchair as specified in Clause 6 with the following additions: Set all adjustable components to their least stable configuration for the wheelchair in the forward direction within the constraints specified by the manufacturer in the device user manual. These components include, but are not limited to the rear wheel position, castor attachment to the frame, seat position, back position, seat-to-back angle, and leg-to-seat angle, seat height and speed. Typical adjustments for least stable forward settings are mentioned in Table 2. If any of the adjustments results in an unwanted setting, e.g. the castor wheels contact any other part of the wheelchair, increase/decrease the adjustment just enough to ensure a proper function of the wheelchair. Make every effort to minimise castor shimmy during tests. There may be several ways of doing this including adjusting castor rake and castor cant.

**Table 2 — Least stable forward stability typical settings**

| Adjustable wheelchair component | Least stable position |
|---|---|
| Rear wheel position, fore-aft | Forward |
| Castor attachment to frame, fore-aft | Back |
| Seat position, fore-aft | Forward |
| Seat position, vertical | High |
| Seat position, tilt | Upright |
| Seat back position, recline | Upright |
| Back position, fore-aft | Forward |
| Speed setting | Maximum |

## 9.3 Braking when travelling forward on horizontal or downhill

a) Run the wheelchair at maximum speed forward on the horizontal test plane.

b) Apply retardation by releasing the control device.

c) Observe the dynamic response of the wheelchair and score it according to Annex C.

d) Repeat a) to c) applying retardation by turning the wheelchair power off.

e) Repeat a) to c) applying retardation by quickly applying full speed command in the opposite direction, keeping the control device at maximum retardation until the wheels turn in the opposite direction.

f) Record the lowest score from the three methods of a) to e) and the retardation method which gave this result.

g) Repeat a) to f) on the 3°, 6° and 10° ramps or other ramp angles as specified by the manufacturer when travelling forward downhill. If the manufacturer recommends a technique for driving on a slope, test the wheelchair using the recommended technique. If the manufacturer specifies a maximum slope, testing is to be done up to that slope, otherwise the test methods are unmodified.

## 9.4 Travelling forward down a slope onto a horizontal surface

a) Run the wheelchair forward down the 3° test area to reach the horizontal test plane at maximum speed.

b) Observe the dynamic response of the wheelchair and score it according to Annex C.

c) Repeat a) and b) using the 6° and 10° ramps or other ramp angles as specified by the manufacturer. If the manufacturer recommends a technique for driving on a slope, test the wheelchair using the recommended technique. If the manufacturer specifies a maximum slope, testing is to be done up to that slope, otherwise the test methods are unmodified.

## 9.5 Travelling forward up a step transition at maximum speed

NOTE 1 The intent of this test is to use the impact with the step to induce a forward tip. The wheelchair might or might not climb the step. This test procedure is very similar to 8.7 which configures the wheelchair for least stability rearward.

a) Test the wheelchair with kerb climbing devices in their normal position if they are available as standard or optional equipment on the wheelchair. Set kerb climbing devices to their normal position for climbing kerbs as specified by the manufacturer. Test the wheelchair without kerb climbing devices if they are removable without tools.

b) Position the wheelchair on the horizontal test plane far enough from the step transition to allow the wheelchair to achieve maximum speed.

c) Run the wheelchair forward at maximum speed along the horizontal test plane to hit the 15 mm step at 90° ± 5°.

d) Observe the dynamic response of the wheelchair at the transition and score it according to Annex C.

e) Repeat a) to d) with step heights of 25 mm and 50 mm.

f) If the manufacturer claims that the wheelchair is capable of handling higher step transitions, repeat a) to d) at intervals that are multiples of 25 mm, increasing the step height up to the level claimed by the manufacturer and terminating the test if the wheelchair can no longer travel up the step transition with a score of 2 or greater.

NOTE 2 Increments of less than 25 mm can be used to achieve the step height level claimed by the manufacturer.

### 9.6 Travelling forward down a step transition from a standing start

NOTE 1 This test determines stability when a wheelchair very slowly drops down a step.

a) Position the wheelchair on the horizontal test plane above the step, so that the front wheels are at the edge of the step.

b) Run the wheelchair at minimum and maximum practical speed, forward down the 15 mm step and in a direction 90° ± 5° to the front of the step.

c) Observe the dynamic response of the wheelchair and score it according to Annex C.

d) Repeat a) to c) with step heights of 25 mm and 50 mm.

e) If the manufacturer claims that the wheelchair is capable of handling higher step transitions, repeat a) to c) at intervals that are multiples of 25 mm, increasing step heights up to the level claimed by the manufacturer and terminating the test if the wheelchair can no longer travel down the step transition with a score of 2 or greater.

NOTE 2 Increments of less than 25 mm can be used to achieve the step height level claimed by the manufacturer.

## 10 Tests for dynamic stability in lateral directions

### 10.1 General

While remaining within any constraints mandated by the manufacturer, all user and dealer adjustable parts shall be adjusted to create a least stable configuration. This determination may require several iterations to determine the configuration of minimum stability. If there are configurations that are not stable, the product shall have a warning label positioned adjacent to the adjustments to consult the manufacturer's set up procedures in the user manual.

The settings recommended in Table 3 are not absolute. Finding the least stable configuration for a wheelchair may require an iterative process to determine the one configuration that is the least stable. Some wheelchairs have drive configurations that limit the speed. It will often be necessary to explore a wide range of possible configurations, including those where speed is limited. The least stable configuration may be different between tests described in 10.3, 10.4, 10.5 and 10.6. The least stable configuration shall be determined for each test. The least stable configuration is the configuration that returns the lowest score in each test.

## 10.2 Wheelchair preparation

Prepare the wheelchair as specified in Clause 6 with the following additions: Set all adjustable components to their least stable configuration for the wheelchair in the lateral direction within the constraints specified by the manufacturer in the device user manual. These components include, but are not limited, to the rear wheel position, castor attachment to the frame, seat position, back position, seat-to-back angle, seat height and speed. Typical adjustments for least stable lateral settings are mentioned in Table 3. If any of the adjustments results in an unwanted setting, e.g. the castor wheels contact any other part of the wheelchair, increase/decrease the adjustment just enough to ensure a proper function of the wheelchair. Make every effort to minimise castor shimmy during tests. There may be several ways of doing this including adjusting castor rake and castor cant.

**Table 3 — Least stable lateral stability typical settings**

| Adjustable wheelchair component | Least stable position |
|---|---|
| Rear wheel position | Narrowest track |
| Castor attachment to frame, fore-aft | Back |
| Castor attachment to frame, inside-outside | Inside |
| Seat position, fore-aft | Forward |
| Seat position, vertical | High |
| Seat back position, tilt | Upright |
| Back position, fore-aft | Forward |
| Speed setting | Maximum |
| Seat position, tilt | Upright |

## 10.3 Turning from a stationary start

a) Position the wheelchair on the horizontal test plane.

b) From a stationary start, apply maximum speed command turning to the left, with the minimum turning radius achievable by the control device, until the wheelchair is facing in the reverse direction. If the wheelchair has direct steering, operate the steering control for a minimum radius turn and then apply maximum forward power.

c) Observe the dynamic response of the wheelchair and score it according to Annex C.

d) Repeat a) to c) turning to the right and record the lower score together with the side toward which the wheelchair tips.

e) Repeat b) to d) on the 3°, 6° and 10° test areas or other ramp angles as specified by the manufacturer, starting with the wheelchair facing downhill and finishing with the wheelchair facing uphill. If the manufacturer recommends a technique for driving on a slope, test the wheelchair using the recommended technique. If the manufacturer specifies a maximum slope, testing is to be done up to that slope, otherwise the test methods are unmodified.

## 10.4 Turning in a circle at maximum speed

a) Run the wheelchair at maximum speed in the forward direction on the horizontal test plane.

b) Turn the wheelchair in circles of decreasing radius while continuing to command maximum possible speed. For each circle, note the score as in Annex C.

c) Determine the minimum diameter circle to the nearest 100 mm in which the wheelchair will run at maximum possible speed with a score of 2 or greater.

d) Measure the diameter of the circle traced by the centreline of the wheelchair.

e) Repeat a) to d) turning in the opposite direction.

f) Record the larger diameter together with the corresponding direction in which the wheelchair is turning.

NOTE A wand with chalk attached and projecting from the wheelchair might assist in following a circle.

## 10.5 Turning suddenly at maximum speed

Most wheelchairs with direct steering will not remain stable during this test. Caution should be exercised during the testing process.

a) Run the wheelchair at maximum speed in the forward direction in a straight path on the horizontal test plane.

b) Operate the control device to produce a 90° turn with a minimum turning radius.

c) Observe the dynamic response of the wheelchair and score it according to Annex C.

d) Repeat a) to c) turning in the opposite direction.

e) Record the lower score together with the corresponding direction in which the wheelchair is turning.

## 10.6 Travelling forward at an oblique angle to a downward step

a) Run the wheelchair at minimum and maximum practical speed in the forward direction with the centre line of the wheelchair at an angle of 10° ± 2° relative to the edge of the 15 mm step transition until all of the wheelchair traverses the step transition.

b) Observe the dynamic response of the wheelchair and score it according to Annex C.

c) Repeat a) and b) using the opposite side of the wheelchair to drop down the step.

d) Record the lower score together with the side at which this occurs.

e) Repeat a) to d) with step heights of 25 mm and 50 mm.

f) If the manufacturer claims that the wheelchair is capable of handling higher step transitions, repeat a) to d) at intervals that are multiples of 25 mm, increasing step heights until up to the level claimed by the manufacturer and terminating the test if wheelchair can no longer travel down the step transition with a score of 2 or greater.

NOTE Increments of less than 25 mm can be used to achieve the step height level claimed by the manufacturer.

# 11 Test report

The test report shall contain the following information:

a) a reference to this document, i.e. ISO 7176-2:2017;

b) the name and address of the test institution and whether it complies with the requirements of ISO/IEC 17025;

c) the name and address of the manufacturer of the wheelchair;

d) the date of issue of the test report;

e) the wheelchair type and any serial and batch numbers;

f) the mass of the dummy used or, if a person is used, the mass of the test occupant and weights;

g) the details of the set-up of the wheelchair as specified in ISO 7176-22, including equipping and adjustments, and any additional details of the set-up of the wheelchair as specified in Clause 6;

h) a minimum of two photographs showing both sides, front and back of the wheelchair as equipped during the test;

i) a description of the changes, including supplementary photographs, of the wheelchair in the final configuration which was tested in Clauses 8, 9 and 10;

j) whether the wheelchair was provided with or without anti-tip devices and kerb climbing devices;

k) the details of the wheelchair's control device, indicating if it includes direct steering; and

l) the results of the tests specified in Clauses 8, 9 and 10.

NOTE Annex D gives a recommended format for recording these results.

## 12 Disclosure of results

The following results shall be disclosed in the manufacturer's specification sheets according to the format specified in ISO 7176-15:

— "Rearward dynamic stability on ramp: *x*°"

where *x* is the value of the maximum slope (e.g. 0°, 3°, 6°, 10°) on which the wheelchair achieves a score of 2 or greater in tests 8.3, 8.4 and 8.5;

— "Forward dynamic stability on ramp: *x*°"

where *x* is the value of the maximum slope (e.g. 0°, 3°, 6°, 10°) on which the wheelchair achieves a score of 2 or greater in tests 9.3 and 9.4;

— "Lateral dynamic stability on ramp: *x*°"

where *x* is the value of the maximum slope (e.g. 0°, 3°, 6°, 10°) on which the wheelchair achieves a score of 2 or greater in test 10.3;

— "Lateral dynamic stability while turning in a circle: *x* m"

where *x* is the minimum diameter of the turning circle at which the wheelchair achieves a score of 2 or greater in test 10.4;

— "Lateral dynamic stability while turning suddenly: *x*"

where *x* is "Yes" or "No" to the question of whether the wheelchair achieves a score of 2 or greater in test 10.5;

— "Rearward dynamic stability traversing step forward: *x* mm"

where *x* is the value of the maximum step height (e.g. 15 mm, 25 mm, 50 mm or higher, if specified by the manufacturer) on which the wheelchair achieves a score of 2 or greater in tests 8.6 and 8.7;

— "Rearward dynamic stability traversing step backward: *x* mm"

where *x* is the value of the maximum step height (e.g. 15 mm, 25 mm, 50 mm or higher, if specified by the manufacturer) on which the wheelchair achieves a score of 2 or greater in test 8.8;

— "Forward dynamic stability traversing forward up a step: *x* mm"

where *x* is the value of the maximum step height (e.g. 15 mm, 25 mm, 50 mm or higher, if specified by the manufacturer) on which the wheelchair achieves a score of 2 or greater in test 9.5;

— "Forward dynamic stability traversing forward down a step: *x* mm"

where *x* is the value of the maximum step height (e.g. 15 mm, 25 mm, 50 mm or higher, if specified by the manufacturer) on which the wheelchair achieves a score of 2 or greater in test 9.6;

— “Travelling forward at an oblique angle to a downward step: *x* mm”

where x is the value of the maximum step height (e.g. 15 mm, 25 mm, 50 mm or higher, if specified by the manufacturer) on which the wheelchair achieves a score of 2 or greater in test 10.6.

# Annex A
(informative)

# Wheelchair set-up for remote control

## A.1 Principle

In order to control the wheelchair, a radio control system, such as those used for radio control models is recommended. Servos for these units have low mass and are inexpensive. Minimal modification to the wheelchair is needed to fit the servos

## A.2 Apparatus

### A.2.1 General

The method of setup is determined by the method of steering the wheelchair, i.e. joystick control or tiller control (typically used for scooters).

Select and fit an ISO 7176-11 compliant test dummy as specified in ISO 7176-22. Record the dummy mass selected.

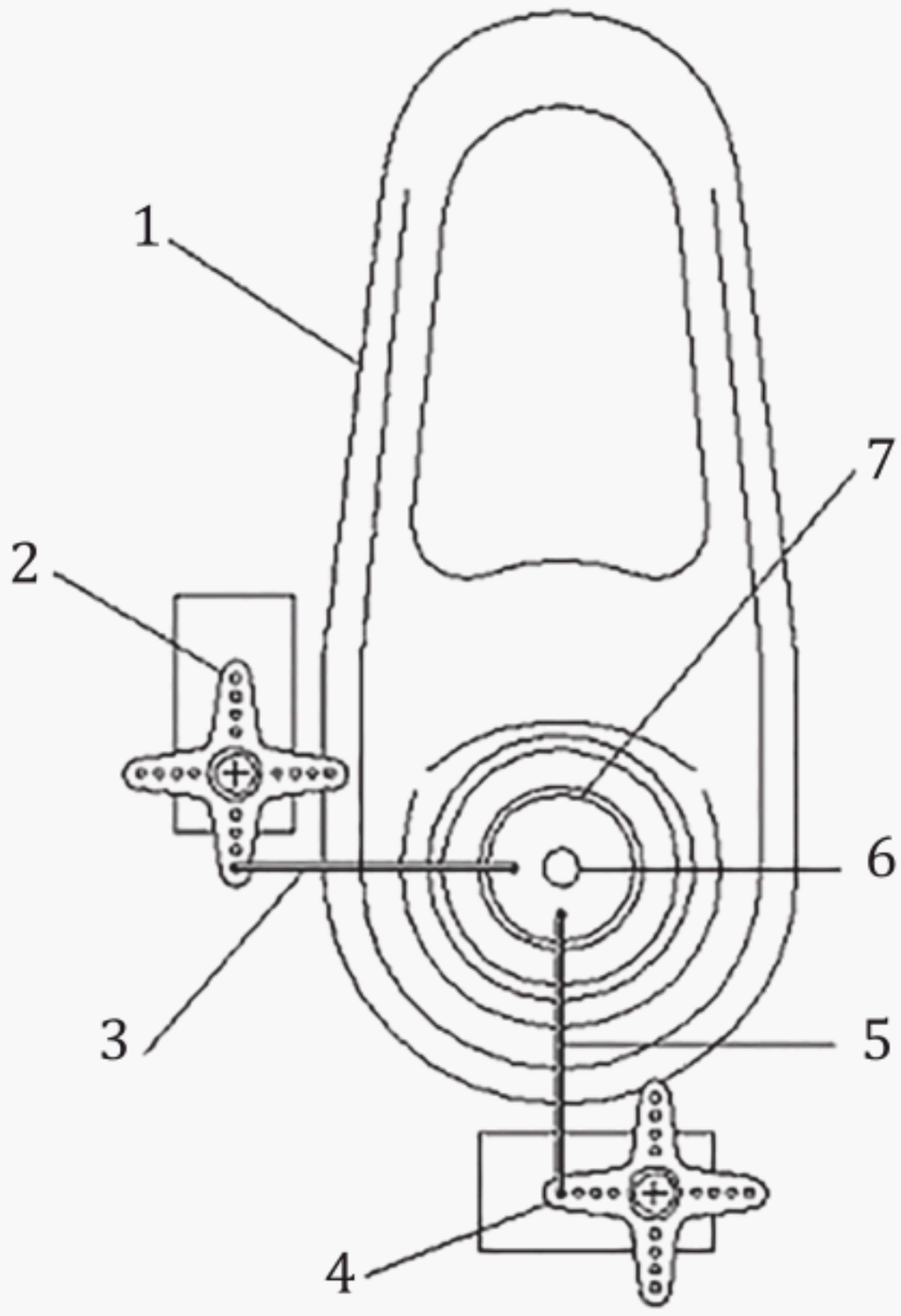
### A.2.2 Joystick control

The joystick can be controlled by two servos on a bracket attached to the joystick module and moving the joystick fore/aft and laterally as shown in Figure A.1.

### A.2.3 Tiller control

Wheelchairs using a tiller mechanism have a loaded extension spring fitted to one handgrip of the tiller. The opposite handgrip is tethered by a flexible cord to allow the wheelchair to travel in a straight line. The flexible cord is released by a servo allowing the spring to turn the tiller. Preset stops added to the steering mechanism determine the turn radius. Another servo is fitted to control speed. The layout of the system is shown in Figure A.2

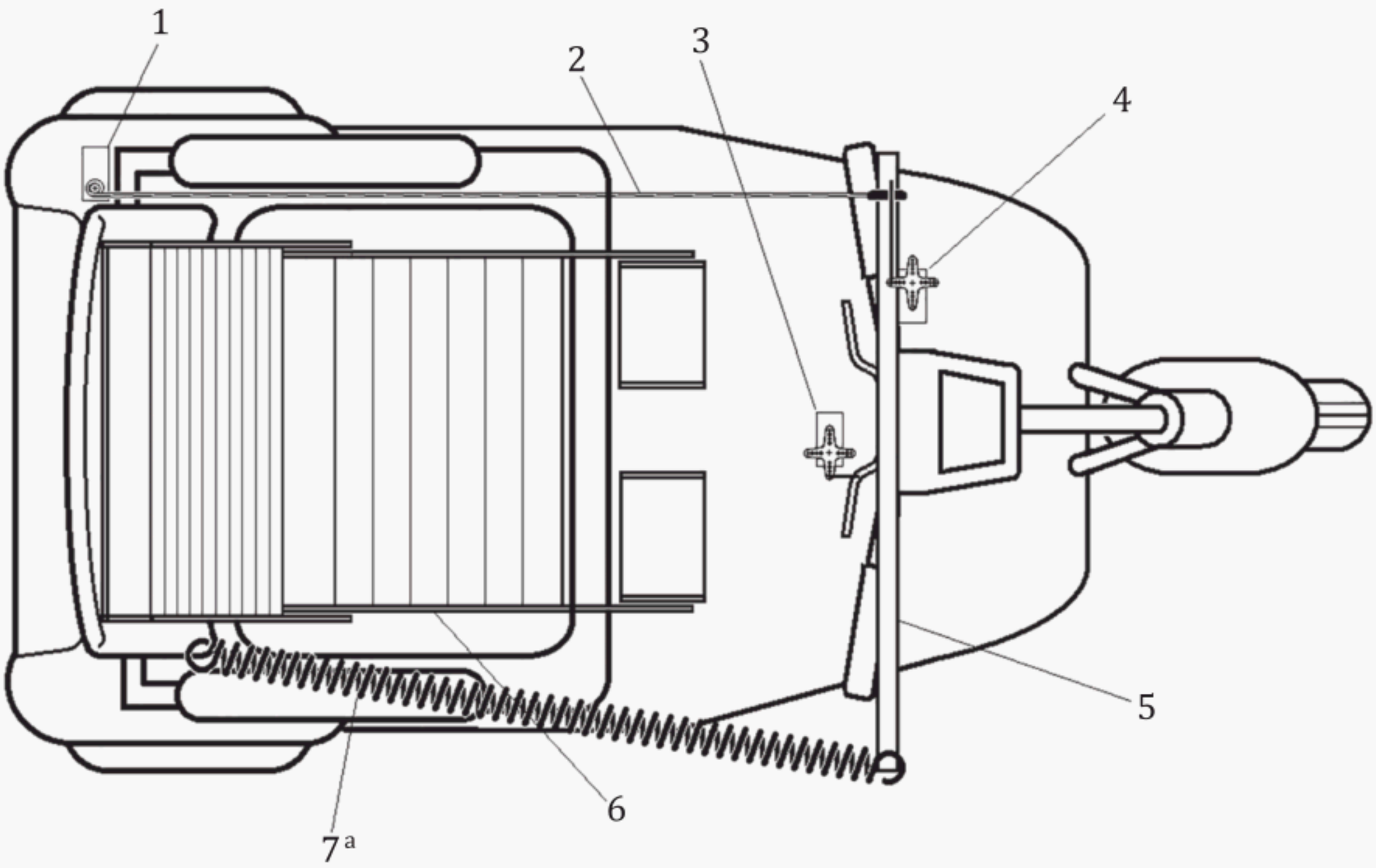
A third servo is recommended to adjust steering trim to allow the wheelchair to travel in a straight line.




**Key**

1 joystick control module
2 left/right servo crank
3 left/right servo link
4 forward/reverse servo crank
5 forward/reverse servo link
6 joystick shaft
7 collar (attaching links to shaft)

**Figure A.1 — Remote control attachments for joystick input device**




**Key**

1 steering trim servo (optional)
2 steering tether
3 speed control servo
4 steering tether release servo
5 tether and spring mount
6 test dummy
7 tiller extension spring (loaded)
a The mount is rigidly attached to the tiller.

**Figure A.2 — Remote control attachments for tiller input device**

# Annex B
(informative)

# Use of a human test occupant

## B.1 Principle

Test institutions are encouraged to use test dummies that comply to ISO 7176-11 as a means of loading a wheelchair in preference to a human test occupant. Many of the tests in this standard are dangerous and could cause injury. Furthermore a human test occupant tends to move their centre of mass to compensate for any wheelchair instability providing inconsistent results. Alternative methods described in Annex A should be considered in preference.

It is acknowledged that in some cases, it could be necessary to use a human test occupant and precautions must be taken to minimise the risk of injury and movement.

The use of a human test occupant is not recommended due to the potential to cause injury and bias in the results.

## B.2 Apparatus for using a human test occupant

If a human test occupant is to be used, all precautions should be taken to prevent injury to the test occupant. Appropriate protection should be worn including a crash helmet, gloves, motorcycle jacket and knee guards.

To constrain movement of the occupant in the wheelchair or scooter so that active movement of his/her mass is minimised, lateral thoracic supports and a headrest providing lateral support should be used.

## B.3 Criteria when a human test occupant is used

The occupant shall have more than four hours of wheelchair driving experience.

The occupant shall be constrained from leaning forward or sideways.

The occupant is not to be restrained using straps that will restrict egress from the wheelchair.

Select the human test occupant in accordance with ISO 7176-22.

# Annex C
(normative)

# Stability scoring system

The observed dynamic response of the wheelchair to the test manoeuvres shall be quantified as specified in Table C.1.

**Table C.1 — Scoring system for quantifying response of wheelchair to test manoeuvres**

| Observed dynamic response | | Score |
|---|---|---|
| No tip | At least three wheels remain on the test plane at all times. | 3 |
| Transient tip | Fewer than three wheels are in contact with the test plane at some point during the test and then at least one wheel which has lost contact drops back onto the test plane, whether or not any anti-tip device contacts the test plane. | 2 |
| Stuck on anti-tip device[a] | At least one anti-tip device contacts the test plane, and the wheelchair remains stuck on the anti-tip device(s). | 1 |
| Full tip | The wheelchair tips completely over (at least one part of the wheelchair that is not a wheel or anti-tip device is in contact with the test plane) unless caught by a restraining device or testing personnel for test purposes. | 0 |

[a] When determining whether the wheelchair is "stuck" on the anti-tip device(s), this implies that the wheelchair occupant could not easily restore the wheelchair to the upright position without assistance while remaining seated in the wheelchair. If the wheelchair is not equipped with an anti-tip device, a score of 1 cannot be awarded.

# Annex D
(informative)

# Recommended format for reporting test results

Test load: Mass ..... kg

ISO dummy or human test occupant: .....

**Tests for rearward dynamic stability**

Description of wheelchair adjustments to achieve the least stable configuration for each test of rearward dynamic stability (see 8.2).

Photograph of wheelchair in least stable configuration.

**Tests for forward dynamic stability**

Description of wheelchair adjustments to achieve the least stable configuration for each test of forward dynamic stability (see 9.3).

Photograph of wheelchair in least stable configuration.

**Tests for dynamic stability in lateral directions**

Description of wheelchair adjustments to achieve the least stable configuration for each test of dynamic stability in lateral directions (see 10.2).

Photograph of wheelchair in least stable configuration.

Additional observations:

— Where braking is involved in the test, record the type of braking causing the instability according to the following:

  — R release of control device;

  — P by turning off power;

  — A application of reverse command with the control device.

— Record the occurrence of any skidding which takes place during the manoeuvre.

— Record "X" when a test cannot be performed and record the reason. This does not include failure to test because a score of 0 was achieved at a lower ramp angle, step transition height or speed. As specified in Clause 7, in such situations, a score of 0 should be recorded.

— For step height "xx", specify the height of the step transition.

— Stability score is derived in each test using the ordinal scale of Annex C.

— N/A = not applicable.

**Table D.1 — Recommended format for recording plane test results**

| Test | Anti-tip devices | Method of retardation | Stability score Ramp angle (°) | | | | Comments |
|---|---|---|---|---|---|---|---|
| | | | 0 | 3 | 6 | 10 | |
| **Rearward dynamic stability** | | | | | | | |
| 8.3 Starting forward | With anti-tip devices | | | | | | |
| | Without anti-tip devices | | | | | | |
| 8.4 Stopping after travelling forward | With anti-tip devices | R Release | | | | | |
| | | P Power off | | | | | |
| | | A Applying reverse | | | | | |
| | Without anti-tip devices | R Release | | | | | |
| | | P Power off | | | | | |
| | | A Applying reverse | | | | | |
| 8.5 Braking when travelling backward | With anti-tip devices | R Release | | | | | |
| | | P Power off | | | | | |
| | | A Applying reverse | | | | | |
| | Without anti-tip devices | R Release | | | | | |
| | | P Power off | | | | | |
| | | A Applying reverse | | | | | |
| **Forward dynamic stability** | | | | | | | |
| 9.3 Braking when travelling forward | N/A | R Release | | | | | |
| | | P Power off | | | | | |
| | | A Applying reverse | | | | | |
| 9.4 Travelling forward down a slope onto a horizontal surface | N/A | N/A | N/A | | | | |
| **Dynamic stability in lateral directions** | | | | | | | |
| 10.3 Turning from a stationary start | N/A | N/A | | | | | |
| 10.4 Turning in a circle at maximum speed (minimum diameter, in metres) | N/A | N/A | | N/A | N/A | N/A | |
| 10.5 Turning suddenly at maximum speed | N/A | N/A | | N/A | N/A | N/A | |

**Table D.2 — Recommended format for recording step test results**

| Test | Kerb climbing devices | Stability score<br>Step height (mm) | | | | | Comments |
|---|---|---|---|---|---|---|---|
| | | 15 | 25 | 50 | xx | xx | |
| **Rearward dynamic stability** | | | | | | | |
| 8.6 Travelling forward up a step transition from a standing start | With kerb climbing devices | | | | | | |
| | Without kerb climbing devices | | | | | | |
| 8.7 Travelling forward up a step transition at maximum speed | With kerb climbing devices | | | | | | |
| | Without kerb climbing devices | | | | | | |
| 8.8 Travelling backward down a step transition from a standing start | N/A | | | | | | |
| **Forward dynamic stability** | | | | | | | |
| 9.5 Travelling forward up a step transition at maximum speed | With kerb climbing devices | | | | | | |
| | Without kerb climbing devices | | | | | | |
| 9.6 Travelling forward down a step transition from a standing start | N/A | | | | | | |
| **Dynamic stability in lateral directions** | | | | | | | |
| 10.6 Travelling forward at an oblique angle to a downward step | N/A | | | | | | |

# Bibliography

[1] ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

**Standards Australia**
Standards Australia is an independent company, limited by guarantee, which prepares and publishes most of the voluntary technical and commercial standards used in Australia. These standards are developed through an open process of consultation and consensus, in which all interested parties are invited to participate. Through a Memorandum of Understanding with the Commonwealth government, Standards Australia is recognized as Australia's peak national standards body.

**Standards New Zealand**
The first national Standards organization was created in New Zealand in 1932. The New Zealand Standards Executive is established under the Standards and Accreditation Act 2015 and is the national body responsible for the production of Standards.

**Australian/New Zealand Standards**
Under a Memorandum of Understanding between Standards Australia and Standards New Zealand, Australian/New Zealand Standards are prepared by committees of experts from industry, governments, consumers and other sectors. The requirements or recommendations contained in published Standards are a consensus of the views of representative interests and also take account of comments received from other sources. They reflect the latest scientific and industry experience. Australian/New Zealand Standards are kept under continuous review after publication and are updated regularly to take account of changing technology.

**International Involvement**
Standards Australia and Standards New Zealand are responsible for ensuring that the Australian and New Zealand viewpoints are considered in the formulation of international Standards and that the latest international experience is incorporated in national and Joint Standards. This role is vital in assisting local industry to compete in international markets. Both organizations are the national members of ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission).

**Visit our websites**
www.standards.org.au www.standards.govt.nz


GPO Box 476 Sydney NSW 2001
**Phone** (02) 9237 6000
**Email** mail@standards.org.au
www.standards.org.au


PO Box 1473 Wellington 6140
**Freephone** 0800 782 632
**Phone** (04) 498 5990
**Email** enquiries@standards.govt.nz
www.standards.govt.nz

ISBN 978 1 76072 719 2

This page has been left intentionally blank.