INTERNATIONAL STANDARD

ISO 16840-2

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Wheelchair seating —

Part 2: Determination of physical and mechanical characteristics of devices intended to manage tissue integrity — Seat cushions

Sièges de fauteuils roulants —

Partie 2: Détermination des caractéristiques physiques et mécaniques des dispositifs de répartition de pression — Coussins d'assise

Reference number
ISO 16840-2:2007(E)

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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 16840-2 was prepared by Technical Committee ISO/TC 173, *Assistive products for persons with disability*, Subcommittee SC 1, *Wheelchairs*.

ISO 16840 consists of the following parts, under the general title *Wheelchair seating*:

— *Part 1: Vocabulary, reference axis convention and measures for body segments, posture and postural support surfaces*

— *Part 2: Determination of physical and mechanical characteristics of devices intended to manage tissue integrity — Seat cushions*

— *Part 3: Determination of static, impact and repetitive load strengths for postural support devices*

— *Part 4: Seating systems for use in motor vehicles*

Introduction

Wheelchair seating is a sub-speciality of rehabilitation services involving the selection and provision of wheelchair seating products that provide improved body support and injury prevention to the wheelchair user. Seating products are designed and manufactured to meet the needs of persons with varying types and degrees of disability. Some products, such as wheelchair cushions, are designed to manage tissue integrity for persons who are at risk or have pressure ulcers.

The tests described herein are intended to differentiate performance characteristics between cushions and are not appropriate for ranking or scoring cushions or for directly matching these characteristics with the requirements of individual users. The link to clinical efficacy, although implied, has not been validated. It is intended that this part of ISO 16840 will evolve when the evidence of clinical relevance is confirmed. This part of ISO 16840 specifically describes test methods that characterize the physical and mechanical properties of seat cushions. Further parts of ISO 16840 are planned that describe test methods for disclosing the pressure distributing characteristics of seat cushions and their heat and water vapour dissipation characteristics.

Wheelchair seating —

Part 2: Determination of physical and mechanical characteristics of devices intended to manage tissue integrity — Seat cushions

1 Scope

This part of ISO 16840 specifies apparatus, test methods and disclosure requirements for wheelchair seat cushions intended to maintain tissue integrity and prevent tissue trauma. It does not include test methods or requirements for determining the fire resistance of cushions. Annex B provides guidance on selecting cushions with appropriate fire resistance characteristics. This part of ISO 16840 does not address the interface pressure distributing characteristics of seat cushions nor the heat and water vapour dissipation characteristics of seat cushions that will be addressed in further parts of ISO 16840.

This part of ISO 16840 can also be applicable to tissue integrity management devices used as other support systems, as well as to cushions used in situations other than a wheelchair.

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 554:1976, *Standard atmospheres for conditioning and/or testing — Specifications*

ISO 1302:2002, *Geometrical Product Specifications (GPS) — Indication of surface texture in technical product documentation*

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

ISO 9073-8:1995, *Textiles — Test methods for nonwovens — Part 8: Determination of liquid strike-through time (simulated urine)*

ISO 10993-1:2003, *Biological evaluation of medical devices — Part 1: Evaluation and testing*

ISO 10993-10:2002, *Biological evaluation of medical devices — Part 10: Tests for irritation and delayed-type hypersensitivity*

ISO 16840-1:2006, *Wheelchair seating — Part 1: Vocabulary, reference axis convention and measures for body segments, posture and postural support surfaces*

GUM:1993, *Guide to expression of uncertainty in measurement, BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML*

BS 3424-10:1987, *Testing coated fabrics. Methods 12A and 12B. Determination of surface drag*

ECE Regulation 16, *Uniform provisions concerning the approval of safety belts and restraint systems for adult occupants of power-driven vehicles,* Revision 3, Amendment 3, 27 February 1996

FMVSS 209, Standard No. 209; *Seat Belt Assemblies. Federal Motor Vehicle Safety Standards*, 49 CFR part 571.209, 1 October 1992

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7176-26, ISO 16840-1 and the following apply.

3.1
cushion loading indenter
CLI
apparatus that is used to apply indentation forces to a seat cushion to determine its support characteristics

NOTE A cushion loading indenter can comprise loading components that are compliant or rigid.

3.2
impact damping rigid contoured loading indenter
IDRCLI
apparatus that is used to rapidly apply loads to the cushion to determine its capacity to absorb impact energy by measuring the rate of deceleration of the indenter as its weight is rapidly transferred to the cushion

3.3
loaded contour depth
maximum depth of contour resulting from load on the cushion's surface at the site designed for buttock loading

3.4
loaded contour jig
LCJ
means of loading cushions with an indenter representing the ischial tuberosities and trochanters used to measure bottoming and ability of seat cushion to contour under load by representing buttock loading

3.5
overload deflection
additional deflection imparted by a 33 % overload condition

3.6
rigid cushion loading indenter
RCLI
cushion loading indenter with a rigid exterior surface contour

3.7
sliding tendency
measure of the propensity for a CLI to slide off a seat cushion

NOTE This quantity is affected by both the frictional properties of the CLI (3.1) and the cushion as well as the cushion surface geometry.

4 Symbols and abbreviated terms

a acceleration

l overall length

t time for the recording period (associated units: s = seconds; d = days)

h_{th} cushion thickness

5 Apparatus

5.1 Loading rig, a means of applying a vertical load of up to 830 N to a seat cushion and with the ability to measure displacement to ± 1 mm to the reference plane surface of the RCLI as specified in Figure 1 so that the load remains normal to the reference plane throughout the test.

a) The load is applied at the point specified in Table A.1 on the mid-line of the RCLI reference plane surface in the range 0 N to 830 N as shown in Figure A.1.

   NOTE The load accuracy required is specified in each test method.

b) The seat cushion is supported on a rigid horizontal surface such that the base of the cushion does not flex during loading.

5.2 Rigid cushion loading indenter (RCLI), a means of loading a cushion with a rigid exterior surface contour shall:

a) be manufactured from a rigid material such as wood or fibreglass;

b) have the dimensions specified in Table A.1.

NOTE Detailed construction/assembly information is found in Annex A.

5.3 Impact damping rigid cushion loading indenter (IDRCLI), a means of loading a cushion using an RCLI with a uniformly distributed mass of 500 N ± 10 N with an accelerometer attached to the reference plane at the location specified in 5.6 b) to measure the deceleration of the indenter as it suddenly loads the cushion.

5.4 Force application rig, a means of applying a load in the range of 0 N to 180 N ± 5 N to the loaded contour jig.

5.5 Displacement gauge, a means of measuring the displacement of the top surface of the RCLI during loading to an accuracy of ± 1 mm in the range 0 mm to 200 mm.

5.6 Impact damping rig, a means of measuring the dissipation of impact loading to the seat cushion.

a) Such that a shell is formed representing the outer contour of a RCLI. Metal spheres are poured into the bottom of the RCLI of uniform diameter then glued or melted to form a total mass of the IDRCLI of 500 N ± 10 N.

   NOTE Lead shot can be used for this purpose.

b) Capable of applying an impact load to the cushion using the IDRCLI as shown in Figure 2.

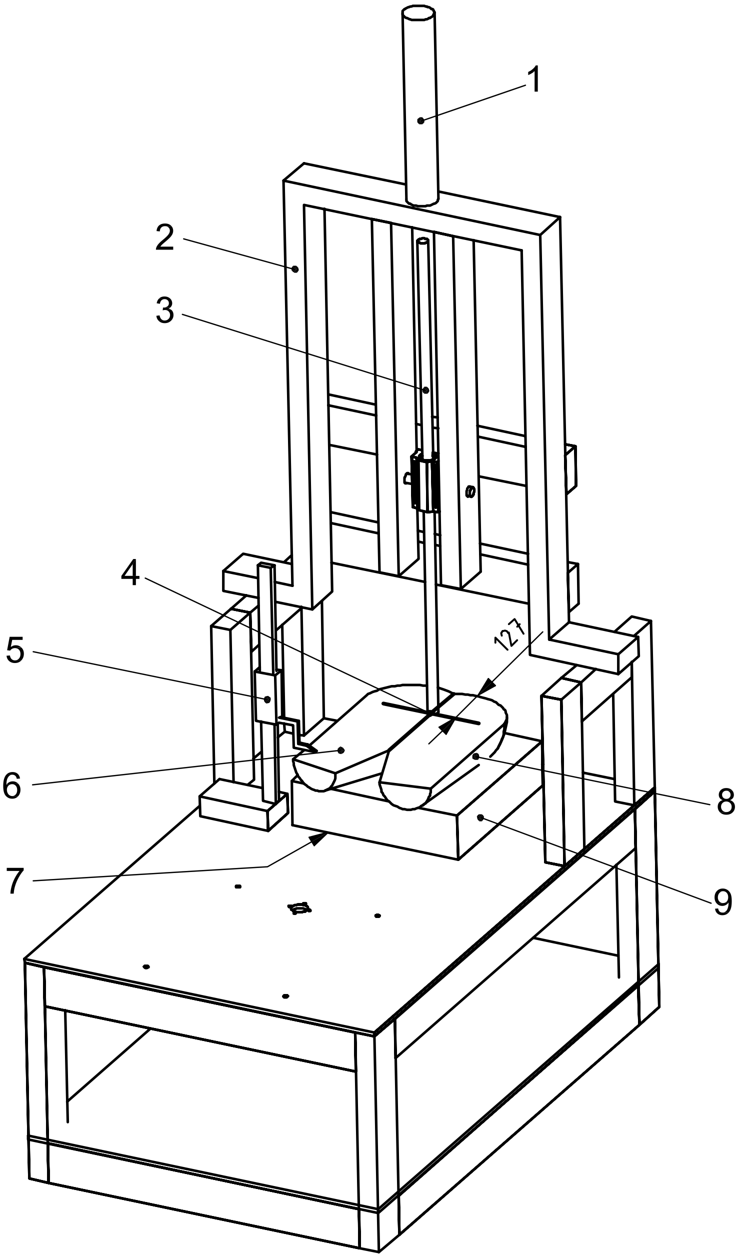
c) Capable of recording acceleration in at least one axis, oriented to measure normal to the surface of the IDRCLI in the range 0 ms^{-2} to 10 ms^{-2} with a frequency response in the range 0 Hz to at least 200 Hz incorporating an appropriate anti-aliasing filter, fixed to the top surface of the IDRCLI, on the centre line, 127 mm ± 25 mm forward of the rear edge of the IDRCLI.

d) Including a rigid plate (plywood or equivalent) measuring 500 mm ± 10 mm × 500 mm ± 10 mm × 15 mm ± 1 mm and hinged at one edge providing a means of supportting the cushion and IDRCLI at an angle of 10° ± 1°.

e) Including two 25 mm ± 5 mm diameter hard rubber cylindrical stops located with their centres at the corners of the rigid plate, 25 mm from the front and lateral edges of the plate, with a hardness of Shore A 60 ± 0 supporting the edge of the plate opposite the hinge such that it is horizontal when resting on the stops.

f) Including a block to support the rigid plate at an angle of 10° ± 1° to the horizontal which can be removed in less than 0,5 s resulting in the plate falling to horizontal.

Dimensions in millimetres



Key

1 actuator to apply load

2 frame

3 solid rod

4 point of application of load

5 displacement gauge

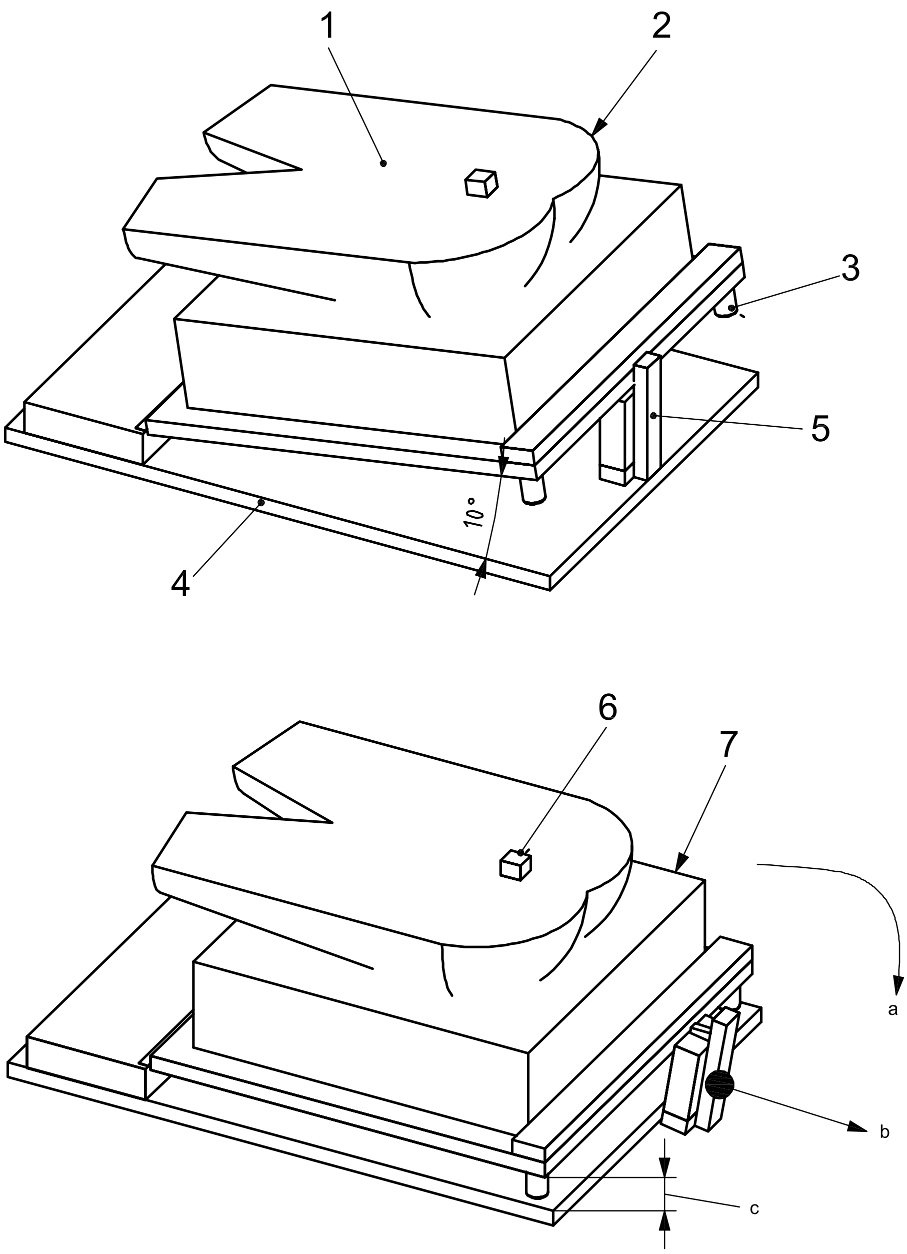
6 reference plane

7 Velcro method of restraint under cushion

8 RCLI

9 cushion

Figure 1 — Loading rig showing the reference plane on the top surface of the RCLI in plan view and a displacement gauge



Key

1 top surface
2 IDRCLI
3 stop
4 plate
5 support block
6 accelerometer
7 cushion

a Direction of fall.
b Direction of pull.
c Boards are parallel.

Figure 2 — Impact damping rig

5.7 Loaded contour jig (LCJ), a means of supporting an RCLI at the end of a rigid shaft allowing the RCLI to move in the lateral and forward directions on the seat cushion in one plane and with the following.

a) A mounting system to accept the RCLI, as defined in Annex A.

b) The capability of using a pivoting rigid member capable of swinging in an arc with a radius of 750 mm and free to move vertically in a linear bearing as shown in Figure 3.

c) A restraint system on a rigid base with a means of constraining the cushion.

NOTE 1 A hook and loop fastening strip or a restraint bar along the edge of the cushion base are effective means of constraining the cushion on the test base.

d) The capability of applying 500 N ± 10 N vertical load to the RCLI.

e) The capability of applying a force perpendicular to the vertical member, acting in the plane of the cushion in both the forward and lateral directions and generating an RCLI displacement of 10 mm ± 2 mm at a rate of 2 mm/s ± 1 mm/s.

f) Two 50 mm ± 2 mm diameter indenters, centres spaced 120 mm ± 5 mm apart, representing ischial tuberosities.

g) Two 25 mm ± 1 mm diameter indenters, centres spaced 380 mm ± 10 mm apart, representing the trochanters.

h) A rigid bar 25 mm ± 1 mm wide, 400 mm ± 20 mm long with a thickness of 10 mm ± 0,2 mm.

i) A 50 mm ± 2 mm wide webbing as specified in ECE Reg. 16 and in FMVSS 209 attached to the bar at 395 mm ± 10 mm centres using threaded mounting bolts to sandwich the belt between the 25 mm ± 1 mm diameter indenters and the bar. The webbing is secured to the bar so that it runs over the 50 mm indenters and under the 25 mm indenters.

j) A force application rig.

k) A displacement gauge.

NOTE 2 Dimensions have a tolerance of ± 5 % unless specified otherwise.

l) The capability of applying a displacement perpendicular to the vertical member, acting in the plane of the cushion at a rate of 5 mm/s.

m) The capability of recording (200 Hz minimum sampling rate) the force applied to the indenter.

n) Employing a 50 mm ± 2 mm diameter circular platen, attached to the displacement gauge mounted on the loading rig with a rigid coupling.

o) Allowing vertical displacement of the circular platen.

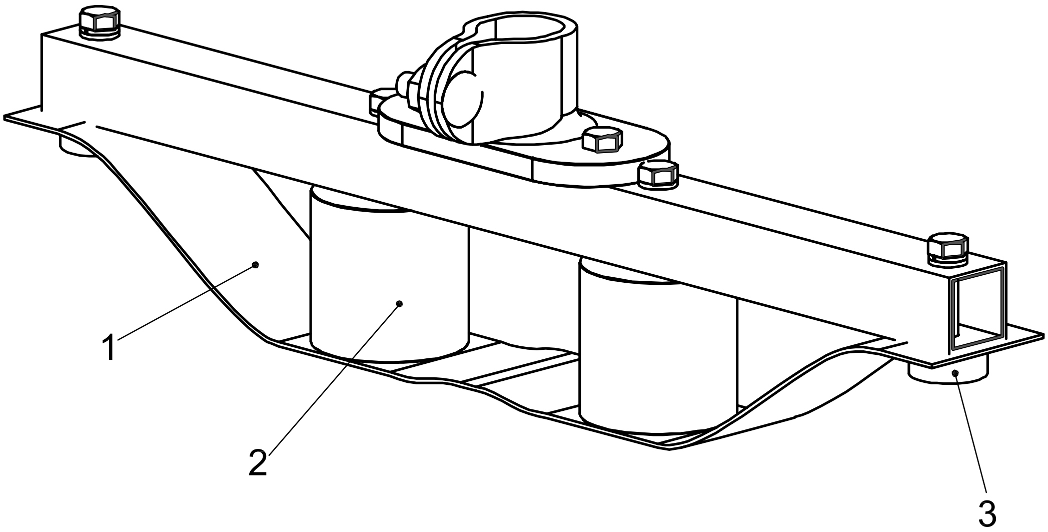
p) Capable of applying 3 N ± 1 N vertical load to the cushion.

q) Positioned over the test cushion located 125 mm ± 2 mm forward of the rear edge of the seat cushion and 55 mm ± 2 mm lateral to the midline.

NOTE 3 It may be desirable to design this rig so that the circular platen can be placed at other points on the top surface of the seat cushion.

6 Test environment

An environment with ambient temperature of 23 °C ± 2 °C and relative humidity 50 % ± 5 % which can be determined as specified in ISO 554.



Key

1 50 mm wide mesh webbing

2 50 mm × 50 mm indenters

3 10 mm × 25 mm diameter trochanter fasteners

Figure 3 — Components comprising the loaded contour, seat cushion thickness measurement rig, a means of supporting an RCLI at the end of a rigid shaft allowing the RCLI to move in the forward direction on the seat cushion in one plane [see 5.7 a) to d) and l) to q)]

7 Preparation of test cushion

7.1 Choice of cushion

Obtain an unused sample seat cushion for testing. If a cover is provided, ensure that it is fitted to the cushion in the orientation specified by the manufacturer.

7.2 Preconditioning the cushion

Perform the following:

a) condition the cushion, unloaded in the test environment for at least 12 h at ambient temperature (23 °C ± 2 °C) and 50 % ± 5 % relative humidity;

b) if indicated by the manufacturer, adjust the cushion to accommodate an 830 N ± 10 N load applied using the RCLI;

c) apply 830 N ± 10 N using the RCLI for a minimum of 120 s to a maximum of 180 s;

d) unload and reload within 120 s;

e) remove load after 120 s and before 180 s;

f) allow cushion to recover for a minimum 5 min to maximum 60 min.

7.3 Setup

Perform the following, prior to performing a test method on a cushion.

NOTE It is not necessary to set up the cushion between repetitions of any one test method on a cushion.

a) If indicated by the manufacturer, adjust cushion to accommodate a 500 N $\pm$ 10 N load applied using the RCLI.

b) If the cushion contains a material that remains displaced after loading, reset the cushion by flattening.

c) If the manufacturer specifies adjusting the cushion to the shape of the user, adjust cushion using the intended indenter to accommodate the intended test load.

d) Allow the cushion to recover 5 min to 60 min.

8 Sequence of testing

Conduct the tests specified in Clauses 9 to 17 in any sequence.

9 Load-deflection and hysteresis test

9.1 Rationale

The load-deflection test provides information about the resilience of seat cushions. As a person sits upon a cushion, it deflects or displaces. Resilience describes how much the cushion tries to return to its undeformed shape. In this situation, resilience is not necessarily a positive characteristic as the cushion pushes against the tissues. In the case when a user leans to the side to perform a task, a resilient cushion will facilitate this person in returning to an erect posture as the material seeks to recover from the leaning position. A less resilient cushion might facilitate an oblique posture as the material will not equalise after the person's trunk returns upright. In this case resilience is a positive feature.

The load deflection test also provides information about the hysteresis characteristics of a seat cushion. Hysteresis is a measure of the energy lost to the cushion during a cycle of loading and unloading. Hysteresis is related to impact damping (Clause 11). Cushions with larger hysteresis values will tend to absorb energy when used on rough surfaces or when dropping down steps, rather than transfer the impact energy to the user's tissues.

9.2 Test method

a) Precondition and adjust the cushion as specified in 7.2 and 7.3.

b) Bring the RCLI into contact with the test surface used to support the seat cushion; zero the height gauge or otherwise compensate for the height of the indenter portion of the fixture.

c) Raise the RCLI so that the cushion can be placed on the base of the rig.

d) Place the RCLI in contact with the cushion so that the ischial tuberosities of the indenter are 125 mm $\pm$ 25 mm forward of the back edge of the cushion or are aligned with the analogous part of the cushion.

e) Apply a starting vertical load of 8 N $\pm$ 3 N for 120 s $\pm$ 10 s.

f) Record height of the cushion at the RCLI to cushion interface h_{8c}.

g) Increase the load within a 10 s loading period so that the total load is 250 N $\pm$ 5 N.

h) Wait 120 s $\pm$ 10 s and record the height of the cushion at the RCLI to cushion h_{250c}.

i) Increase the total load to 500 N $\pm$ 10 N within a 10 s loading period.

j) Wait 120 s $\pm$ 10 s and record the height of the cushion at the RCLI to cushion h_{500c}.

k) Increase the load to 750 N $\pm$ 15 N within a 10 s loading period.

l) Wait 120 s $\pm$ 10 s and record the height of the cushion at the RCLI to cushion h_{750c}.

m) Remove the last applied loading increment within a 10 s unloading period, so that the total load on the cushion is 500 N $\pm$ 10 N.

n) Wait 120 s $\pm$ 10 s and record the height of the cushion at the RCLI to cushion interface h_{500u}.

o) Remove load within a 10 s unloading period so that the total load on the cushion is 250 N $\pm$ 5 N.

p) Wait 120 s $\pm$ 10 s and record the cushion height at the RCLI to cushion interface h_{250u}.

q) Remove load within a 10 s unloading period so that the total load on the cushion is 8 N $\pm$ 3 N.

r) Wait 120 s $\pm$ 10 s and record the cushion height at the RCLI to cushion interface h_{8u}.

s) Allow 300 s $\pm$ 10 s for cushion recovery.

t) Repeat steps e) to s) two more times to generate three total data sets consisting of both increasing and decreasing loads on the cushion.

NOTE The load deflection and hysteresis test may better define the characteristics of cushions that respond rapidly to load changes when performed in a continuous loading and unloading manner. For example, where load application and cushion height measurements are performed simultaneously in an automated test apparatus. See reporting requirements for deviations from described test methods.

9.3 Method of calculation

Determine the following:

a) The average compressive thicknesses from the three data sets:

— average compressive thickness at 8 N $\overline{h}_{8c} = \frac{\sum_{i=1}^{3} h_{8c_i}}{3}$

— average compressive thickness at 250 N $\overline{h}_{250c} = \frac{\sum_{i=1}^{3} h_{250c_i}}{3}$

— average compressive thickness at 500 N $\overline{h}_{500c} = \frac{\sum_{i=1}^{3} h_{500c_i}}{3}$

— average compressive thickness at 750 N $\overline{h}_{750c} = \frac{\sum_{i=1}^{3} h_{750c_i}}{3}$

b) The average unloading thicknesses:

— average unloading thickness at 500 N $\overline{h}_{500u} = \frac{\sum_{i=1}^{3} h_{500u_i}}{3}$

— average unloading thickness at 250 N $\overline{h}_{250u} = \frac{\sum_{i=1}^{3} h_{250u_i}}{3}$

— average unloading thickness at 8 N $\overline{h}_{8u} = \frac{\sum_{i=1}^{3} h_{8u_i}}{3}$

c) The hysteresis (resilience) indices:

— hysteresis at 250 N $= 1 - \dfrac{\overline{h}_{250u}}{\overline{h}_{250c}}$

— hysteresis at 500 N $= 1 - \dfrac{\overline{h}_{500u}}{\overline{h}_{500c}}$

9.4 Test report

a) Report the 250 N and 500 N hysteresis indices calculated in 9.3 c).

b) Plot the average compressive and unloading thicknesses calculated in 9.3 a) and 9.3 b).

10 Frictional properties

10.1 Rationale

Some cushions are designed for ease of transfer and others to contain the subject. This measurement provides an indication of the slipperiness of the cushion and its cover.

10.2 Test method

Apply test methods 12A and 12B specified in BS 3424-10:1987.

10.3 Test report

The requirements for reporting results are specified in Clause 16.

11 Impact damping under normal loading conditions

11.1 Rationale

This test identifies the characteristics of a wheelchair cushion, which reduce impact loading of tissues and help to maintain postural stability. The cushion's ability to absorb vibration and impact decreases peak pressures associated with impact loading such as rolling off a curb or other obstacle. Impact damping is related to hysteresis (see Clause 9).

11.2 Test method

Prepare cushion as specified in 7.2 and 7.3 and conduct the following tests in the sequence specified below.

a) Place the block under the rigid plate so there is an angle of $10^\circ \pm 1^\circ$ between the horizontal testing surface and the rigid plate.

b) Place the cushion in the impact damping rig.

c) Place the IDRCLI in contact with the cushion so that its ischial tuberosities are positioned at the location intended by the manufacturer.

NOTE On flat cushions the position of the ischial tuberosities of the IDRCLI is 127 mm $\pm$ 25 mm forward of the back edge of the cushion.

d) Start recording the acceleration of the IDRCLI, the accelerometer should be applied such that it produces a positive signal during free-fall of the IDRCLI in order to produce results compatible with the example given below.

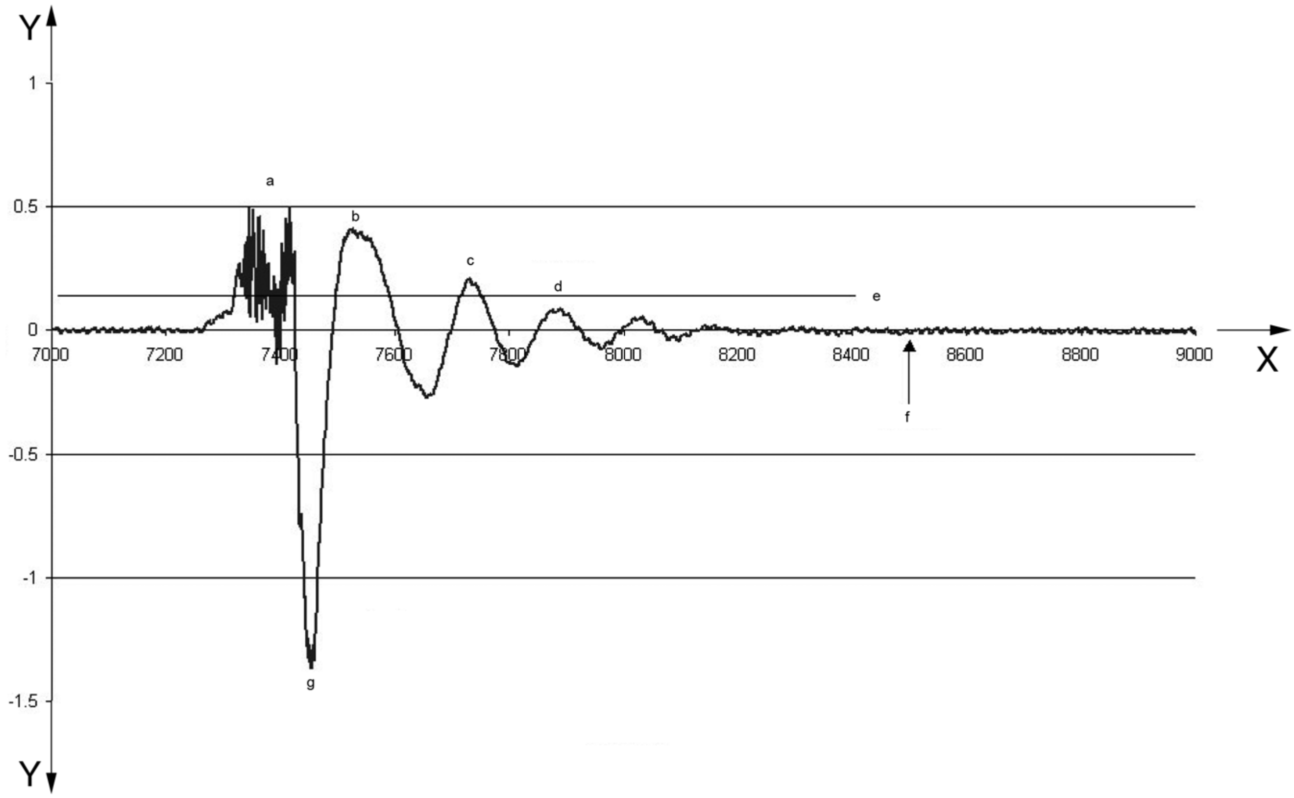
e) Slide the block away in less than 0,1 s, allowing the rigid plate to drop on to its rubber stops.

f) Stop recording after acceleration has diminished to 1 % of the maximum.

g) Allow 300 s $\pm$ 10 s between tests.

h) Repeat steps d) to f) two more times for a total of three repetitions.

A typical result is shown in Figure 4 with the vertical axis representing the acceleration of the IDRCLI and the horizontal axis representing time in seconds.



NOTE The “ragged” higher frequency components in the acceleration signal in this example are typical, reflecting vibration in the system. The envelope of the first negative peak is used to calculate the amplitude of the “first peak” and the 10 % threshold.

Key

X time in milliseconds

Y acceleration due to gravity

[a] Block removal and free-fall.

[b] 1st rebound.

[c] 2nd rebound.

[d] 3rd rebound.

[e] 10 % of peak at first impact.

[f] Baseline.

[g] Peak at first impact.

Figure 4 — Typical result for impact damping test, plotting acceleration against time in seconds

11.3 Method of calculation

Determine the damping properties of the cushion by calculating the following parameters:

a) mean number of rebounds greater than 10 % of the peak acceleration, $R_{10\ \%}$;

b) mean of the peak rebound acceleration relative to the baseline, a_a;

c) mean of the second highest rebound acceleration relative to the baseline, a_2;

d) mean of the ratio of a_2 to a_a as a percentage.

12 Recovery

12.1 Rationale

The recovery characteristic of a seat cushion indicates the ability of the cushion to return to its pre-loaded shape and dimensions following a period of loading. Recovery may be associated with repeated loading of the cushion and may be indicative of fatigue. A further part of ISO 16840 is being planned to address changes in cushion properties with use, such as recovery. Alternatively, some seat cushions are designed to mould to the shape of the user employing visco-elastic material properties and take significant time to return to their original shape. In some cases seat cushions employ materials with fluidic components that readily conform to the user and require manipulation to recover their original shape.

12.2 Test method

The following method should be performed without moving the cushion during testing. If movement of the cushion for thickness measurements is unavoidable, a note shall be made in the test report and the disturbances should be minimized.

a) Precondition and set up the cushion as specified in 7.2 and 7.3.

b) Place the RCLI in the loading rig as specified in 5.1.

c) On the test cushion, mark the IT-line, which corresponds to the anterior-posterior (A-P) location of the ischial tuberostities (ITs) of the RCLI defined such that the ITs of the RCLI are aligned with the analogous portion of the cushion; if no IT location is clearly defined by the cushion's contour, place the IT-line 125 mm $\pm$ 2 mm from the rear edge of the cushion.

d) On the test cushion, mark an IT-reference-point defined by the intersection of the IT-line, defined in c), and a line parallel to the centreline and located at half the distance of the IT spacing of the RCLI.

e) Without the cushion in place, bring the circular platen of the seat cushion thickness measurement rig in contact with the horizontal plane with a contact load of 3 N $\pm$ 1 N and record the vertical distance to the nearest 1 mm from a reference plane (measurement A).

f) Place the cushion in the static loading rig such that the ITs of the RCLI are aligned with the IT-line on the cushion and the centre lines of the RCLI and cushion are aligned $\pm$ 2 mm.

g) Bring the seat cushion thickness measurement rig in contact with the cushion such that it is centred within a 2 mm radius of the IT-reference-point marked on the cushion. Apply a 3 N $\pm$ 1 N contact load and record the vertical distance to the nearest 1 mm from the reference plane (measurement B).

h) Apply a load of 500 N $\pm$ 10 N with the RCLI within 5 s to 10 s and hold for 1 200 s $\pm$ 60 s.

i) Remove the load.

j) 25 s $\pm$ 2 s after load removal, bring the circular platen of the seat cushion thickness measurement rig in contact with the cushion such that it is centred within a 2 mm radius of the IT-reference-point marked on the cushion; apply a 3 N $\pm$ 1 N contact load and record the vertical distance to the nearest 1 mm from the reference plane (measurement C).

k) Remove the circular platen from the cushion surface.

l) 1 200 s ± 60 s after load removal, bring the circular platen of the seat cushion thickness measurement rig in contact with the cushion such that it is centred within a 2 mm radius of the IT-reference-point marked on the cushion; apply a 3 N ± 1 N contact load and record the vertical distance to the nearest 1 mm from the reference plane (measurement D).

m) Repeat steps e) to m) two more times for a total of three repetitions, allowing 600 s ± 10 s between measurements and resetting the cushion between measurements as specified in 7.3 b).

12.3 Test report

In addition to the information required as specified in Clause 16, report the following:

a) two-dimensional location of the IT-reference-point on the test cushion relative to the mid-line and back off the cushion;

b) whether the cushion was moved during testing to make measurements with the seat cushion thickness measurement rig;

c) the average original thickness of the cushion at the IT location (B–A);

d) the average ratio of the 25 s recovery thickness to the original thickness at the IT location:

$$\frac{25\ \text{s}}{\text{original}} = \frac{\text{C} - \text{A}}{\text{B} - \text{A}};$$

e) the average ratio of the 1 200 s recovery thickness to the original thickness at the IT location:

$$\frac{1\ 200\ \text{s}}{\text{original}} = \frac{\text{D} - \text{A}}{\text{B} - \text{A}}.$$

13 Loaded contour depth and overload deflection

13.1 Rationale

The ability of a cushion to maintain tissue integrity relates to its ability to envelop the pelvis. It is also important for the user to maintain a margin of safety in cushioning effect before an overload condition is experienced. Certain functional movements such as leaning and reaching effectively overload an aspect of the cushion. These transient events may exceed the margin safety.

The overload test measures the amount of deflection resulting from an increase in load of 33 % over the loaded test. A cushion that has been loaded beyond the margin of safety is identified when an increase in load does not produce a commensurate increase in deflection that is more than 5 mm.

This test characterizes two cushion capabilities:

a) the ability to contour, taking into account the initial contour and contouring produced by loading;

b) the ability of the cushion to withstand overloading conditions.

13.2 Test method

a) Prepare the cushion for testing as specified 7.2 and 7.3.

NOTE 1 If loaded contour depth is the only test being performed, preconditioning for this test can be done using the LCJ by preconditioning as specified in 7.3.

b) Place test cushion on a flat, horizontal surface.

c) Measure the cushion thickness in relation to the horizontal supporting surface to the nearest 1 mm at a location 127 mm ± 25 mm from the rear border of the cushion while applying 1,5 N ± 0,5 N using the seat cushion thickness measurement rig; contoured cushions are measured at the lateral edge and convex or flat cushions are measured at midline.

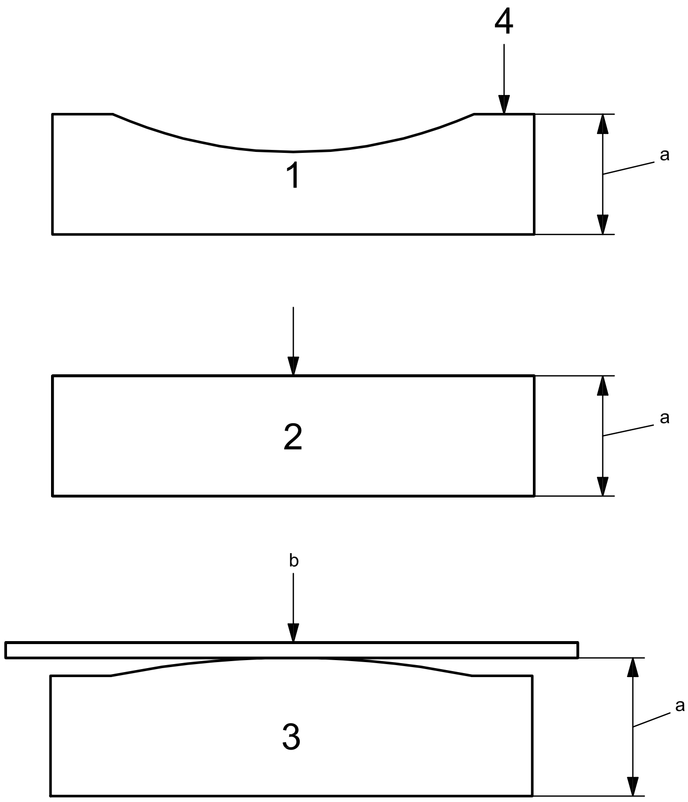
d) Repeat step c) two times for a total of three repetitions and determine the average cushion thickness, h, to the nearest 1 mm.

NOTE 2 A rigid sheet of material of known thickness can be used to insure a consistent thickness measurement without material deflection; this plank thickness must be subtracted before recording cushion thickness.

Figure 5 illustrates locations of measurement as described.

e) Place the LCJ in contact with the cushion so that its ischial tuberosities are positioned at the location intended by the manufacturer.

NOTE 3 On flat cushions the position of the ischial tuberosities of the LCJ is 127 mm $\pm$ 25 mm forward of the back edge of the cushion.



Key

1 contoured cushion

2 flat cushion

3 convex cushion

4 lateral border

[a] Unloaded thickness.

[b] Support surface thickness measured after placement of plank to level fluid/material.

Figure 5 — Measurement method for concave and convex seat cushion top surfaces

f) Apply a vertical load of 135 N $\pm$ 5 N.

g) Measure the vertical distance from the horizontal supporting surface to the inferior surface of the LCJ after 300 s to the nearest 1 mm (L_{135}).

h) Increase the load on LCJ to 180 N $\pm$ 5 N.

i) Re-measure vertical distance from the horizontal supporting surface to the inferior surface of the LCJ to the nearest 1 mm (L_{180}) 60 s $\pm$ 5 s after the increased load is applied.

j) Repeat steps e) to i) two times for a total of three measurements, allowing 300 s $\pm$ 10 s between measurements and resetting the cushion between measurements as specified in 7.3.

13.3 Method of calculation

a) Using the median L_{th} and L_{135} values, calculate loaded contour depth $= L_{\text{th}} - L_{135}$ and record to the nearest 5 mm.

b) Using the median L_{135} and L_{180} values, calculate overload depth $= L_{135} - L_{180}$ and record to the nearest 5 mm.

13.4 Test report

The requirements for reporting results are specified in Clause 16.

14 Water spillage

14.1 Rationale

Cushions may be exposed to spillage of liquids or exposure to urine. This test determines the time for penetration of liquids through the cover (strike-through).

14.2 Test method

Apply methods specified in ISO 9073-8.

14.3 Test report

The requirements for reporting results are specified in Clause 16.

15 Biocompatibility

15.1 Rationale

Tissue integrity can be compromised by contact between the skin and seat cushion components. This test method specifies how to test the biocompatibility of cushion components that could make direct contact with the skin in normal use, or if misused or if there is a failure to contain cushion components such that they make skin contact. This test is also intended to demonstrate biocompatibility if cushion components make contact with open wounds.

15.2 Test method

Apply the test method specified in ISO 10993-1 and ISO 10993-10 to any parts of the seat cushion that has the potential to make contact with the user's skin.

15.3 Test report

The requirements for reporting results are specified in Clause 16.

16 Test report

The test report shall contain the following information:

a) a reference to this part of ISO 16840, ie. ISO 16840-2:2007;

b) the name and address of the testing institution;

c) the date of issue of the test report;

d) the name and address of the manufacturer of the cushion;

e) the model, type and nominal size that uniquely describes the test cushion, including serial and batch numbers, and internal tracking numbers, if available;

f) the cushion cover used;

g) the preparation of the test cushion including set up and adjustment;

h) the characteristics of the test cushion as determined in Clauses 9 to 15;

i) calculations and disclosure of uncertainty as specified in GUM;

j) any deviations from the test methods defined herein.

17 Disclosure requirement

Manufacturers shall disclose, in their specification sheets for each cushion, the information below:

a) the model type and nominal size that uniquely describes the cushion;

b) the cover used during testing;

c) date of manufacture of cushion and cover.

Annex A
(normative)

Tapered uniform geometry RCLI

The RCLI is a modified version of an indenter designed by Staarink (1995) and is an easily reproducible geometrically based indenter shape relying on the combination of a cone and sphere to generate a representation of human anatomy. The method of cutting the cone and sphere components is represented diagrammatically in Figure A.1 and the dimensions of the components and the cut lines are tabulated in Table A.1.

Fabrication of the RCLI may be accomplished as follows using the dimensions of the components specified in Table A.1.

a) Turn a cone of the appropriate diameter and taper.

b) Dress the end to form a hemisphere.

c) Make the first cut through the cone parallel to tapered edge of the cone (2).

d) Make a cut that bisects the plane created by the first cut parallel to the major axis of the cone (3).

e) The two pieces generated by (3) are then located as represented in 4; these two pieces are then bonded together.

f) Surface finish to at least N7 (ISO 1302:2002; approximate average surface roughness $< 1{,}7\ \mu m$).

g) Attach to loading rig.

NOTE This RCLI is intended to approximate adult human anatomy. Other anatomical sizes may be readily developed by scaling the dimensions of the RCLI and modifying the loading applied to it. Future work is anticipated to validate other sizes of RCLI.

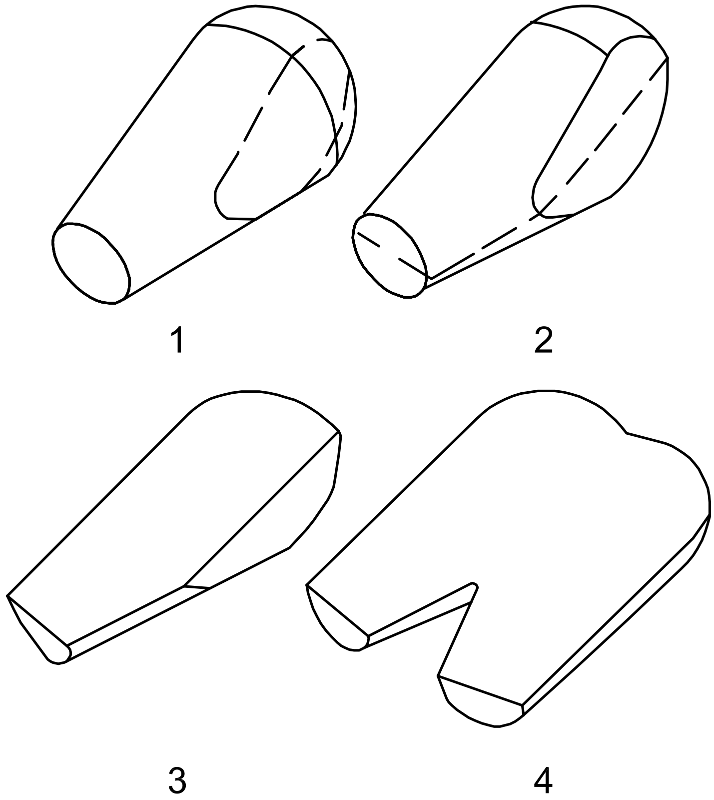


Figure A.1 — Assembly of components for RCLI

Table A.1 — Cone and sphere dimensions

Indenter width	Indenter length	Anterior-posterior location of load	Cone angle	Cone width at first cut	Cone height w/o sphere	Height with sphere	Major diameter of cone	Minor diameter of cone	Length of cone edge
mm	mm	mm	°	mm	mm	mm	mm	mm	mm
360	500	127	10	180	367	494	254	124	373

NOTE 1 All tolerances ± 2 mm.

NOTE 2 The RCLI is constructed from cones and spheres machined according to Figure A.1. These components are assembled to form the required shape according to Table A.1.

Annex B
(informative)

Fire resistance considerations

Wheelchair seat cushions that manage tissue integrity are medical devices. Their characteristics should therefore be aligned with the medical needs of the user rather than requirements developed for other applications, e.g. fire retardancy specifications for furniture.

There is considerable concern that wheelchair seating should not readily combust and emit toxic fumes that may cause injury to its occupant and people in their vicinity. Recent experience indicates that the fire resistance of wheelchair seating, especially of polyurethane foam components, is being enhanced to meet fire-resistance standards by the addition or variation of their chemical constituents. Unfortunately, this improvement usually occurs at the expense of the material's comfort, pressure distribution and durability characteristics. High fire resistance requirements may, therefore, render very good designs of cushions pointless in their application, and prevent useful products reaching the open market.

Hence, this part of ISO 16840 does not include any test methods or requirements for wheelchair seating fire resistance. Manufacturers, purchasers and users of wheelchair seating are recommended to consider the balance between the risk of developing tissue trauma, or discomfort against the risk of user injury from fire.

This may involve compromising fire resistance characteristics to achieve the performance required to prevent pressure ulcers. Work is continuing within ISO/TC173/SC1 to develop fire resistance standards which address the need for testing for different applications and environments. It is intended that ISO 7176-16:1997 will be revised for this purpose.

Annex C
(informative)

Horizontal and lateral stiffness

C.1 Apparatus

C.1.1 Lateral and forward stiffness rig, a means to support a RCLI at the end of a rigid shaft allowing the RCLI to move in the lateral and forward direction on the seat cushion in one plane and with:

a) a mounting system to accept the RCLI as described in Annex A;

b) the capability of using a pivoting rigid member capable of swinging in an arc with a radius of 750 mm and free to move vertically in a linear bearing as shown in Figure C.1;

c) a restraint system on a rigid base with a means to constrain the cushion;

NOTE A hook and loop fastening strip or restraint bar along the edge of the cushion base are an effective means of constraining the cushion on the test base.

d) the capability of applying 500 N ± 10 N vertical load to the RCLI;

e) the capability of applying a force perpendicular to the vertical member, acting in the plane of the cushion in both the forward and lateral directions and generating a displacement of 10 mm ± 1 mm at a rate of 25 mm/s ± 1 mm/s;

f) the capability of measuring the force applied to the RCLI.

C.1.2 Sliding resistance, a means of supporting an RCLI at the end of a rigid shaft allowing the RCLI to move in the forward direction on the seat cushion in one plane and with:

a) a mounting system to accept the RCLI as described in Annex A;

b) the capability of using a pivoting rigid member capable of swinging in an arc with a radius of 750 mm and free to move vertically in a linear bearing as shown in Figure C.2;

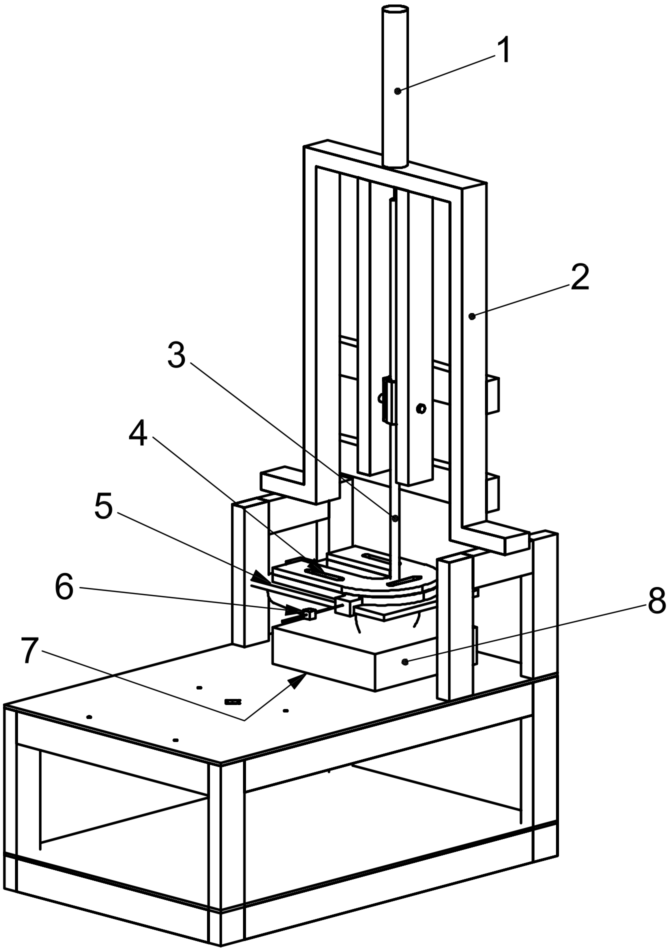
c) a restraint system on a rigid base with a means of constraining the cushion;

NOTE A hook and loop-fastening strip or a restraint bar along the edge of the cushion base are effective means to constrain the cushion on the test base.

d) the capability of applying a 500 N ± 10 N vertical load to the RCLI;

e) the capability of applying a displacement perpendicular to the vertical member, acting in the plane of the cushion at a rate of 5 mm/s;

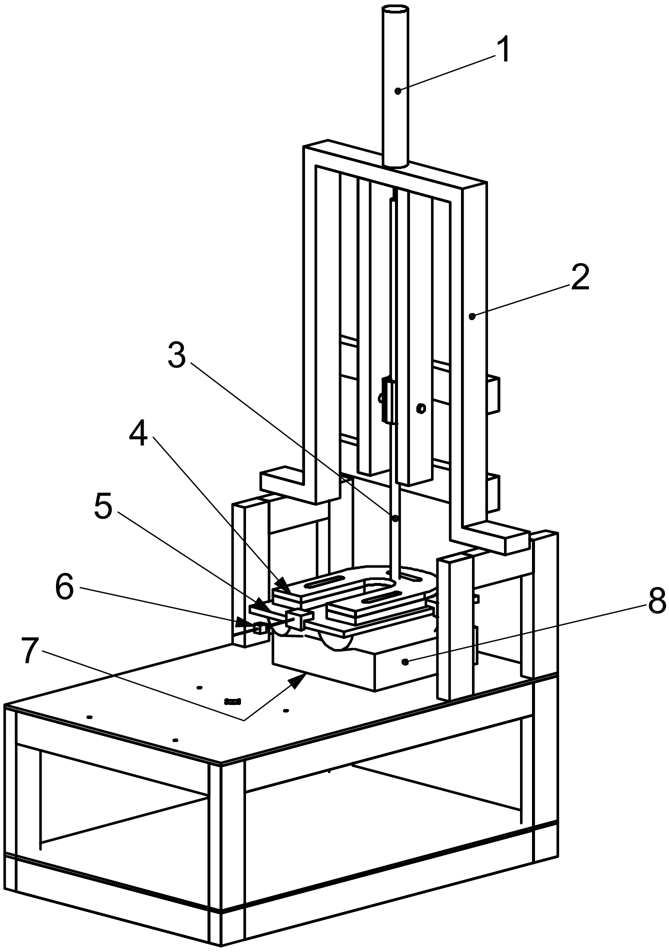
f) the capability of recording (200 Hz minimum sampling rate) the force applied to the indenter.



Key

1 lifting assist air cylinder
2 frame
3 solid rod
4 load of 500 N
5 RCLI
6 force transducer
7 Velcro method of restraint under cushion
8 cushion

Figure C.1 — Apparatus to measure lateral and forward stiffness



Key

1 lifting assist air cylinder

2 frame

3 solid rod

4 load of 500 N

5 RCLI

6 force transducer

7 Velcro method of restraint under cushion

8 cushion

Figure C.2 — Apparatus to measure sliding resistance

C.2 Lateral and forward stiffness

C.2.1 Rationale

Measurement of lateral or forward stiffness, characterize the interaction between the cushion and the skin following slight perturbations in the horizontal forces at the interface between the seat cushion and the buttocks. The cushion's ability to deform in response to these horizontal forces from slight body movements is based upon the theory that skin integrity is adversely affected by high shear strain. Lateral and forward stiffness can affect tissue integrity even if the pelvis does not move. A cushion that allows the soft tissue to move and relax without shear stress promotes integrity. However, stability could be reduced if the horizontal stiffness is decreased. Therefore, a cushion with high horizontal stiffness will be more stable but will impart more deformation and shearing to tissue with slight perturbations. A low horizontal stiffness cushion will not impart as much deformation and shearing but might be less stable for the user.

C.2.2 Test method

a) prepare cushion as specified in 7.2 and 7.3;

b) place the RCLI in the lateral and forward stiffness rig as illustrated in Figure C.1;

c) position the cushion under the RCLI such that the ischial tuberosities of the indenter are 125 mm ± 25 mm forward of the back edge of the cushion or are aligned with the analogous part of the cushion;

d) apply a vertical load of 500 N ± 10 N to the RCLI at the location specified in Annex A;

e) within 60 s ± 5 s, apply a relative displacement of 10 mm ± 2 mm between the RCLI and the cushion in a lateral direction at a rate of 2 mm/s ± 1 mm/s;

f) record the peak force;

g) while maintaining the displacement, at 60 s ± 5 s record the force applied to the indenter;

h) return the RCLI to the neutral position;

i) reset the cushion according to 7.3 b) and verify cushion has not moved relative to the base;

j) repeat steps c) to h) two times, for a total of three measurements, allowing 600 s ± 10 s between measurements;

k) reset the cushion according to 7.3 b);

l) reposition the cushion and the RCLI to allow for a displacement of 10 mm ± 1 mm in the forward direction, relative to manufacturer's suggested cushion orientation;

m) repeat steps c) to i) for the force applied in the forward direction.

C.3 Sliding resistance

C.3.1 Rationale

The sliding resistance test reflects the surface and bulk characteristics of the wheelchair cushion. Sliding resistance is important because high sliding resistance assists a user's ability to maintain an upright posture. A low sliding resistance enhances the user's ability to slide out of the cushion for transfer. The forces of gravity and the backrest may combine to nudge a person forward and out of the chair. This sliding tendency can have detrimental effects on both function and pressure distribution. Quantifying the sliding resistance of a cushion helps to define how the cushion performs in these respects. Sliding resistance is related to the frictional characteristics of the cushion.

C.3.2 Test method

a) precondition and se tup the cushion as specified in 7.2 and 7.3;

b) place the RCLI in the lateral and forward stiffness rig as illustrated in Figure C.2;

c) position the cushion so that the ischial tuberosities of the indenter are 125 mm ± 25 mm forward of the back edge of the cushion or are aligned with the analogous part of the cushion;

d) apply a vertical load of 500 N ± 10 N to the RCLI at the location specified in Annex A;

e) within 60 s ± 5 s, apply a horizontal force to displace the indenter in a forward direction in relation to the cushion at 5 mm/s ± 1 mm/s;

f) record the average force to the nearest 0,5 N, required to cause a displacement between the indenter and the surface of the cushion; the force at movement can be located on a graph of force over displacement by locating the peak force that occurs before a drop in the force indicating displacement of the indenter;

g) return the RCLI to the neutral position;

h) reset the cushion according to 7.3 b) and verify cushion has not moved relative to the base;

i) repeat steps c) to g) two times for a total of three measurements, allowing 600 s ± 10 s between measurements.

Bibliography

[1] ISO 554:1976, *Standard atmospheres for conditioning and/or testing — Specifications*

[2] ISO 7176-7:1998, *Wheelchairs — Part 7: Measurement of seating and wheel dimensions*

[3] ISO 7176-8:1998, *Wheelchairs — Part 8: Requirements and test methods for static, impact and fatigue strengths*

[4] ISO 7176-11:1992, *Wheelchairs — Part 11: Test dummies*

[5] ISO 7176-16:1997, *Wheelchairs — Part 16: Resistance to ignition of upholstered parts — Requirements and test methods*

[6] ISO 10012-2:1997[1)], *Quality asurance for measuring equipment — Part 2: Guidelines for control of measurement processes*

[7] ISO/IEC 17025:2005, *General requirements for the competence of testing and calibration laboratories*

[8] ISA S37.8:1995, *Specifications and Tests for Strain Gage Force Transducers*

[9] STAARINK, H.A.M, *Sitting posture, comfort and pressure*, Delft University Press, 1995

1) International Standard withdrawn and replaced by ISO 10012:2003.

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