PD ISO/TS 16840-12:2015

BSI Standards Publication

Wheelchair seating

Part 12: Apparatus and method for cushion envelopment testing

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National foreword

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Foreword

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is 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*

— *Part 6: Simulated use and determination of the changes in properties — Seat cushions*

— *Part 10: Resistance to ignition of non-integrated seat and back support cushions — Requirements and test methods*

— *Part 11: Determination of perspiration dissipation characteristics of seat cushions intended to manage tissue integrity* [Technical Specification]

— *Part 12: Apparatus and method for cushion envelopment testing* [Technical Specification]

The following parts are under preparation:

— *Part 9: Clinical interface pressure mapping guidelines for seating* [Technical Report]

Future parts dealing with methods for determining heat and water vapour characteristics and clinical guideline for the measurement of postural support surfaces and body segments are planned.

Introduction

This part of ISO 16840 provides details of test equipment and a method for the measurement of "performance" of a wheelchair cushion intended to use immersion and envelopment to reduce local areas of pressure (by effectively supporting more tissue). The primary elements that represent the basic cushioning effect of a cushion are immersion and envelopment. Immersion into the cushion (the depth that a body penetrates into the surface) and the envelopment of the body (the intimacy of the cushion to the body) combine to define the potential cushioning performance of the cushion. In this test, the distribution of forces across the surface of the indenter is evaluated with multiple indenter sizes and masses. The accommodation of the cushion to the changes in indenter size and mass are representative of the changes in size and mass of the occupant that can occur in the life of a wheelchair user or between different users.

Issues related to the use of devices that measure the forces between the body and a support surface (i.e. pressure mapping systems) have led to the use of an instrumented indenter, which has fewer sensors, but sensors which are high quality and exhibit repeatability, accuracy, and thus reliability.

Wheelchair seating —

Part 12:
Apparatus and method for cushion envelopment testing

1 Scope

This part of ISO 16840 specifies apparatus, test methods, and disclosure requirements for characterization of wheelchair seat cushion immersion and envelopment properties using instrumented indenters to characterize the interface pressure of each indenter and the test cushion by measuring the cushioning effects of immersion and envelopment. This part of ISO 16840 can be considered to expand the characterization of products intended to manage tissue integrity (ISO 16840-2) and provide a standardized indenter for other wheelchair seating tests. It does not provide information specific to cushion performance for a particular individual user.

This part of ISO 16840 includes a method that is specific to 220 mm and 255 mm indenters. Dimensions and loads are provided for the 380 mm indenter to allow for extension of the methods for bariatric applications.

2 Normative references

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

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

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

3 Terms and definitions

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

3.1
adjustable cushion
cushion in which adjustments can be made in a reversible fashion

Note 1 to entry: See 3.2.

3.2
cushion adjustment
modification to the volume, size, hardness, pressure, or other physical characteristics of the cushion surface to accommodate the applied load and the indenter size in accordance with the manufacturer's instructions

3.3
base points
lowest two points of indenter when ready for use

Note 1 to entry: See Figures 6 and 7.

Note 2 to entry: The base points correspond with the ischial tuberosities on the human pelvis.

3.4
elevation
sensor locations relative to the base points of indenter when ready for use

Note 1 to entry: See Figure 6.

Note 2 to entry: — Elevation$_1$: Sensors at the base points of the indenter (a total of two sensors).

— Elevation$_2$: All sensors 5 mm superior to the base points (a total of eight sensors).

— Elevation$_3$: All sensors 20 mm superior to the base points (a total of six sensors).

— Elevation$_4$: Sensors 40 mm superior to the base point (a total of two sensors).

Note 3 to entry: When in use, the base points of the indenter (Elevation 1) aim to represent the lowest points of the ischial tuberosities.

3.5
envelopment
ability of a cushion to conform, so as to fit or mould around the irregular shape of the body

3.6
immersion
depth to which a body penetrates into a cushion from an uppermost plane

3.7
instrumented indenter
anatomical form that is loaded with a prescribed force and has embedded sensors that return pressure values

3.8
multiplexer
electronics board that converts the signal from the sensors into pressure data

3.9
load distribution
relative comparison of force or pressure values read by the sensors

3.10
offloading
clinical practice of reducing or removing pressure from one area of the body to another in an effort to reduce risk of injury

EXAMPLE Reducing the pressure under the ischial tuberosities and increasing pressure on the thighs or other parts of the seated body.

4 Indenter construction

4.1 Materials

The indenter shall be constructed from hardwood or similar material that is sufficiently rigid to not deform when subjected to the forces required for simulating the application of human body mass to surfaces. The material shall be treated (if necessary) to minimize the effects of moisture, and shall not be adversely affected by normal laboratory testing conditions (0 °C to 35 °C; 25 % to 75 % relative humidity). Surface finish to at least N7 (according to ISO 1302; approximate average surface roughness).

4.2 Tolerances and finishes

Unless otherwise stated, all dimensions in Clause 4 shall be ±0,5 mm and all edges and corners shall be finished with a minimum 5 mm radius. Surface finish to at least N7 (according to ISO 1302; approximate average surface roughness).

4.3 Indenter elements

4.3.1 Trochanter bar

Use a 375 mm × 50 mm × 20 mm bar with a series of slots carved in the beam to allow for wire routing. The bulbous indenter halves and trochanter buttons are fixed to the trochanter bar. Refer to Figure 1.

Dimensions in millimetres

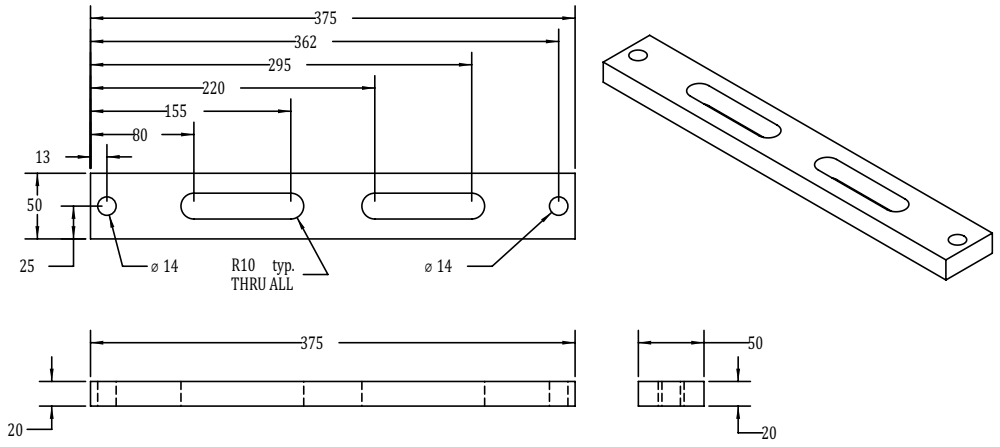

Figure 1 — Trochanter bar construction

4.3.2 Trochanter buttons

51 mm × 25 mm × 19 mm blocks emulate the trochanters. Each trochanter button shall have a flat section where the sensor is located. Refer to Figure 2.

NOTE Trochanter buttons are not required on the 380 mm indenter.

Dimensions in millimetres

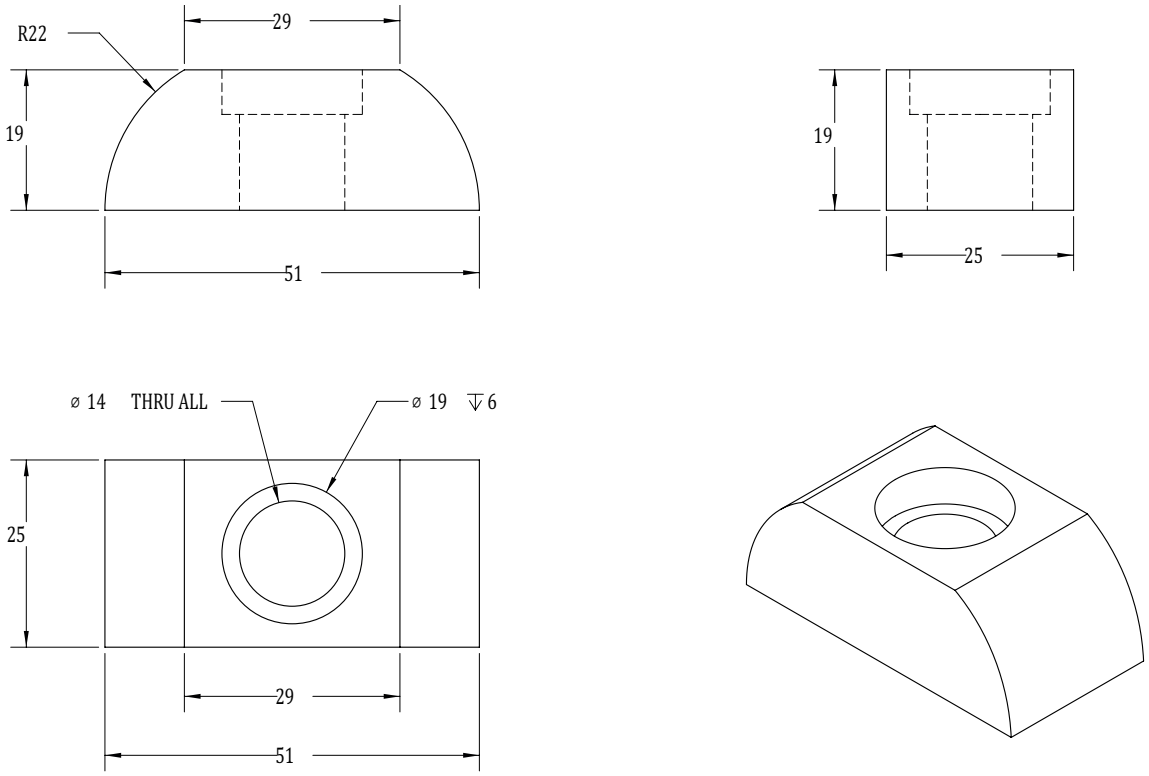

Figure 2 — Trochanter button construction

4.3.3 Bulbous indenter half

This is a disc with a convex curve outwards (see Figure 3). The outwards curve diameter defines the size of the indenter (e.g. a 220 mm indenter has a 220 mm diameter) as referenced in Table 1. The disc diameter is a function of the outward curve and the height of the curve. Each half has eight sensor locations, as described in 4.5.

Dimensions in millimetres

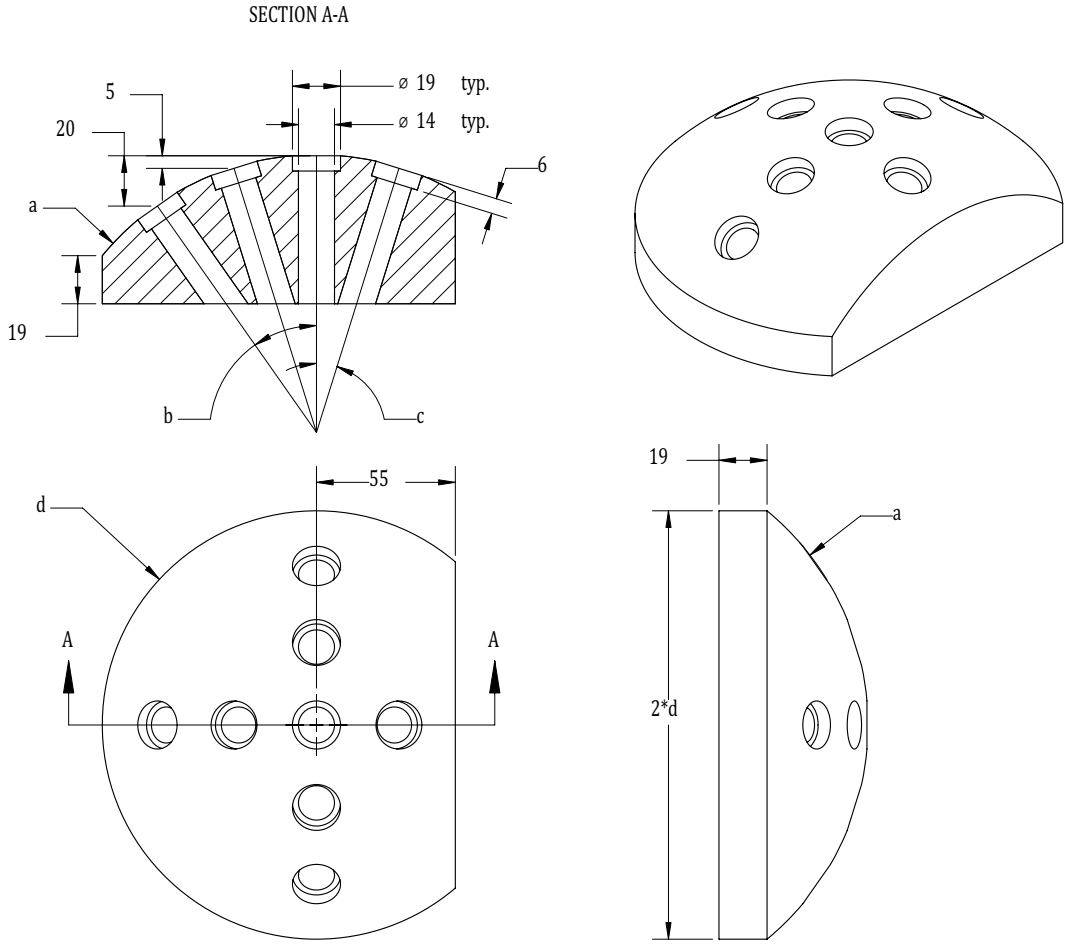

Figure 3 — Bulbous indenter half

Table 1 — Bulbous Indenter dimensions

INDENTER	a	b	c	d
220 mm	110 mm	35,0°	17,5°	85,0 mm
255 mm	127,5 mm	32,5°	16,0°	92,5 mm
380 mm	190 mm	26,5°	13,0°	128,5 mm

4.4 Indenter assembly

Assemble the indenter using appropriate fasteners that will maintain the structural integrity of the indenter in all aspects of testing. Assembly drawings are shown in Figure 3 for the 220 mm and 255 mm indenter and Figure 4 for the 380 mm indenter.

Dimensions in millimetres

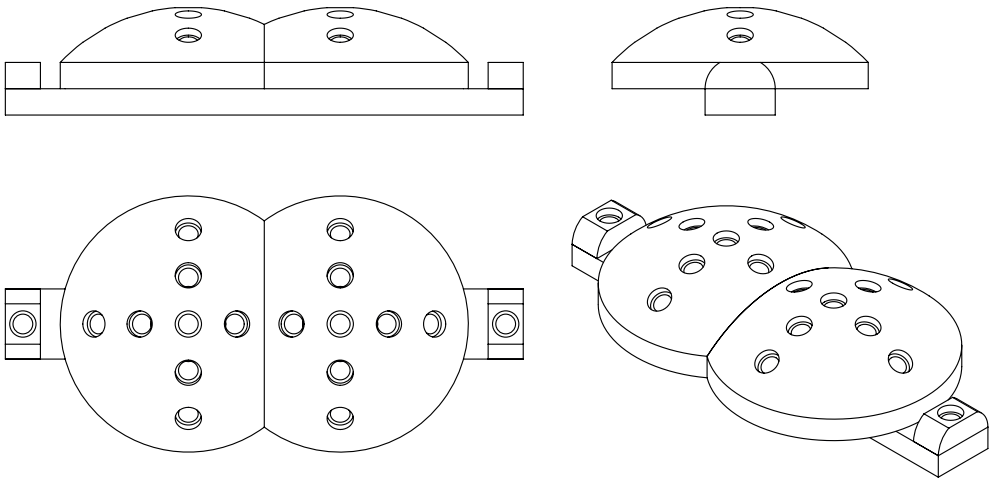

Figure 4 — Indenter assembly for 220 mm and 255 mm indenters

Dimensions in millimetres

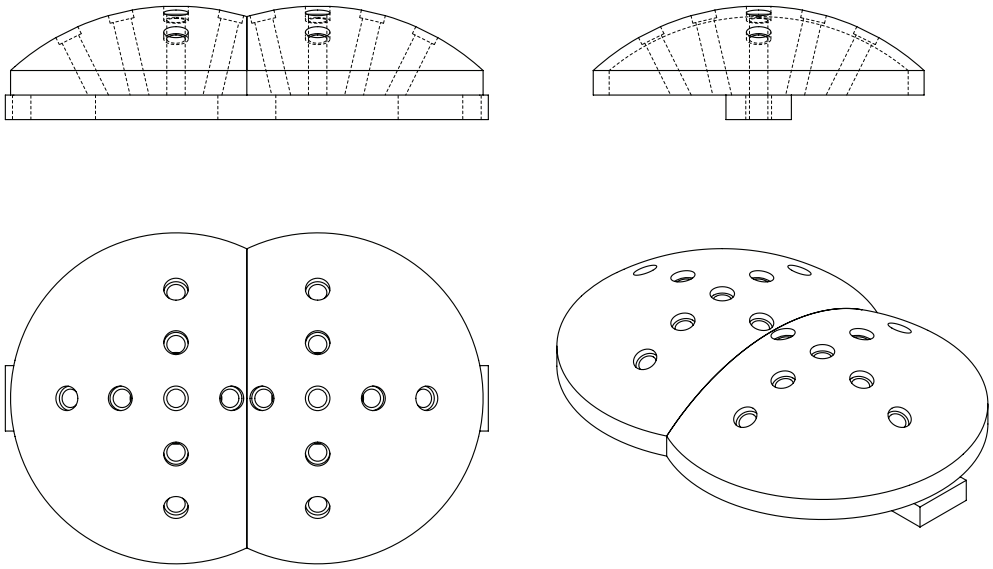

Figure 5 — Indenter assembly for 380 mm indenter

4.5 Sensor locations

4.5.1 General

The following is a list of sensor locations and abbreviations. All sensors are symmetric about the midline of the instrumented indenter. For left and right sensor location configurations, refer to Figure 6.

4.5.2 Elevation$_1$

The left and right lowest points along the bulbous surface on the instrumented indenter.

4.5.3 Elevation$_2$

The force sensor locations along the bulbous contour of the surface with a vertical height difference of 5 mm from the base points elevation. These sensors are placed to the outside of the base point locations and are off-axis from the normal load.

4.5.4 Elevation$_3$

The force sensor locations along the bulbous surface of the indenter with a vertical height difference of 20 mm from the base points elevation. These sensors are placed to the outside of the base point locations and are off-axis from the normal load.

4.5.5 Elevation$_4$

In the testing configuration, the sensor locations are 40 mm superior to the base point elevation in the vertical direction. These sensors are placed to the outside of the base point locations and are normal to the application load.

NOTE Elevation$_4$ represents the location of trochanter force.

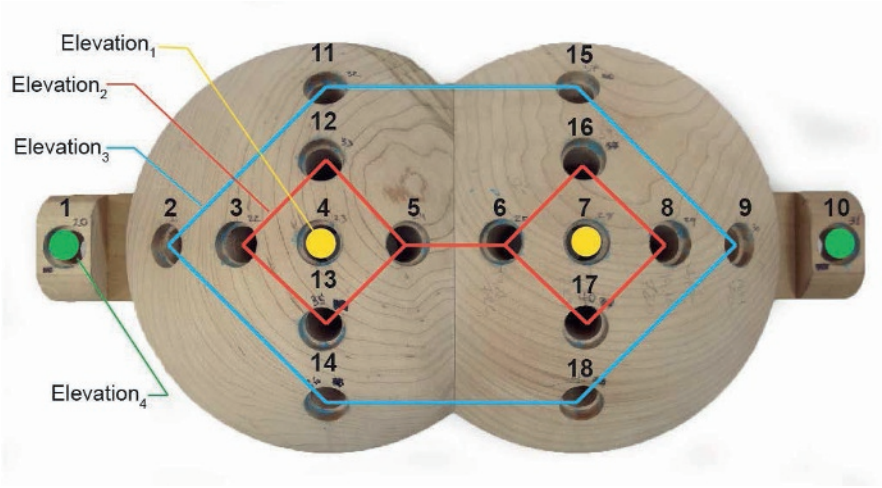

Figure 6 — Sensor port location layout

The 18 pressure sensor ports are distributed across the instrumented indenter as shown in Figure 6. The same sensor port design is applied to the three sizes of indenters.

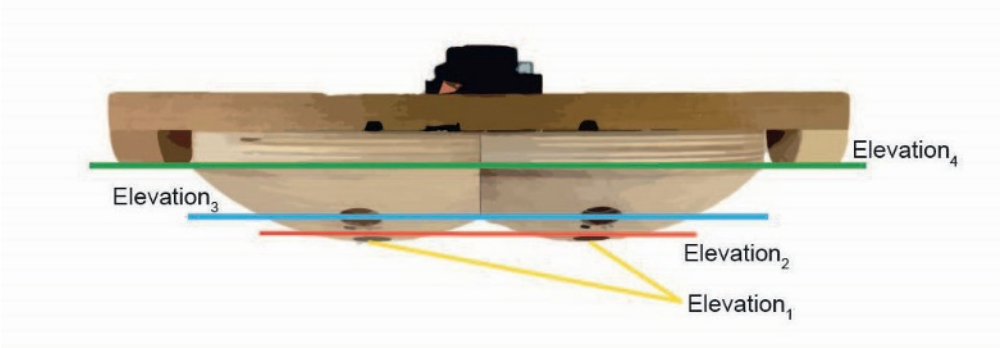

Figure 7 — Sensor elevation layout

5 Instrumentation hardware

5.1 Electronics

5.1.1 A series of 18 sensors with diameter less than 20 mm, mounted so the face of the sensor is flush with the indenter. These shall be pressure transducers with a pressure range of 0 mmHg to 370 mmHg and accuracy of 0,25 % with a response frequency of at least 1 Hz.

5.1.2 The values from each sensor shall be captured at 1 Hz or higher, on a computer or other data logging device.

5.1.3 As loads are applied to the indenter, each sensor is sampled and the force value recorded.

5.1.4 A device for measuring time up to 30 min with an accuracy of ±1 s.

5.2 Loading equipment

5.2.1 A vertical load-application device capable of applying 800 newtons, with an accuracy of ±5 N, at a rate of 1 mm/s.

5.2.2 An instrument with the capacity to measure the height of the cushion, with a resolution of 1 mm.

6 Preparation of test cushion

6.1 Cushion adjustment

If a cushion is adjustable, it is to be adjusted per manufacturer's instructions to accept the load and respective indenter for each of the testing conditions.

6.2 Preconditioning the cushion to the test environment

Allow cushion to rest at 23 °C ± 2 °C and 50 % ± 5 % relative humidity for a minimum of 24 h prior to adjustment (if applicable).

7 Envelopment test method

7.1 Rationale

This test characterizes and compares wheelchair cushions by their ability to envelop the body. The test applies two loads (425 N and 525 N) to each of two indenters (220 mm and 255 mm bulbous indenter) to the cushion. The pressure relief magnitude, immersion, and pressure distribution are examined through the use of pressure sensors mounted in a bulbous indenter loaded onto the cushion surface.

7.2 Method

7.2.1 Setting the datum height for the indenter

Place the cushion on a horizontal testing surface and attach the indenter to the load applicator, parallel to the testing surface. Apply a 5,0 N ± 0,5 N load to the indenter and set the height above the testing surface to zero (the datum height).

7.2.2 Pre-conditioning the cushion

a) The cushion shall be preconditioned with the 220 mm indenter, without sensors, every 24 h. Allow the cushion to recover 5 min to 60 min after preconditioning.

b) Adjust cushion to accommodate the testing conditions.

c) Apply 782 N ± 10 N for 120 s ± 10 s using the 220 mm indenter, positioned 125 mm ± 25 mm from the rear of the cushion, or a location appropriate for the contour of the cushion. The 220 mm indenter is to be used for preconditioning regardless of the indenter to be used for the testing condition.

d) Unload and allow the cushion to recover for 60 s ± 10 s.

e) Repeat loading and unloading two more times for a total of three compression cycles.

7.2.3 Measuring the seat cushion thickness

a) If the cushion contains a material that remains displaced after loading, re-set the cushion by flattening or according to the manufacturer's instructions in preparation for measuring the thickness.

b) Place the cushion under the indenter so that the base points are positioned at the location intended by the manufacturer. Unless otherwise indicated for flat cushions, anterior-posterior position of the base points of the indenter shall be 125 mm ± 25 mm from the rear of the cushion or a location appropriate for the contour of the cushion.

c) Place between the indenter and the cushion a rigid board of known thickness across the cushion laterally 125 mm ± 25 mm from the rear of the cushion or as necessary to correspond to the designed location for placing human ischial tuberosities on the cushion.

d) Apply a vertical force of 5,0 N ± 0,5 N to the board at the centreline of the cushion over the line defined in c).

e) Measure the height above the base of the cushion at its centreline to the underside of the board

f) Repeat a) to e) three times.

g) Report the average thickness. This is defined as the seat cushion thickness (SCT).

7.2.4 Load application and data collection

7.2.4.1 For each of the following conditions, adjust the cushion according to the manufacturer's instructions to accommodate the specified load and shape. The following are the four sets of test conditions that are to be followed:

a) a load of 425 N ± 5 N, with the 220 mm indenter;

b) an overload of 525 N ± 5 N, with the 220 mm indenter;

c) a load of 425 N ± 5 N, with the 255 mm indenter;

d) an overload of 525 N ± 5 N, with 255 mm indenter.

The loading of the 380 mm indenter is not specified and should be selected by the test facility based on the mass of the intended cushion user.

7.2.4.2 Each condition is to be tested as follows (see Figure 8).

a) If the cushion contains a material that remains displaced after loading, re-set the cushion by flattening or according to the manufacturer's instructions.

b) Gradually lower the indenter to avoid an impact that could disrupt the cushion setting.

c) Apply the load for 60 s.

d) Remove the load for 5 s, then reapply the load for 130 s.

e) Record data from the sensors in the last 15 s.

f) Record the cushion thickness below a base point of the loaded indenter 125 s after loading (d_{190}).

With the indenter constrained to avoid tilt, the two base points should always be at the same elevation.

g) Apply the overload condition (if applicable) for 60 s.

h) Record data from the sensors in the last 15 s.

i) Record the cushion thickness below a base point of the loaded indenter 55 s after commencing the overload (d_{250}).

j) Remove the load and allow cushion to recover for a minimum of 300 s.

k) Repeat a) to j) for a total of 5 trials per condition.

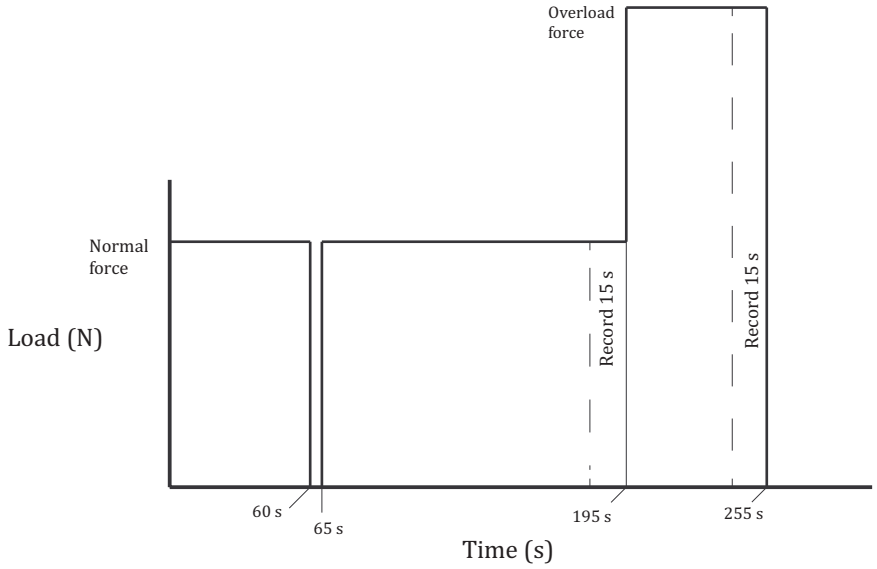

Figure 8 — Load application description for 7.2.4.2

7.2.4.3 Any trials that demonstrate a difference greater than 20 % between two pressure sensor values in the same location or trials that have greater than 2 % variation in the height at 120 s should be discarded and repeated.

7.3 Calculations

7.3.1 Calculate and report the average forces during the last 10 s of the recording periods, at each elevation for nominal and overload conditions, with confidence interval according to ISO/IEC Guide 98-3.

Reporting the averages of forces at each of the four elevations provides a quick reference to a cushion's ability to redistribute forces over the entire surface of the cushion. A cushion where reported elevation values are similar would be considered a high-envelopment cushion.

— Elevation$_1$: Average of the three trials of sensors (4 and 7);

— Elevation$_2$: Average of the three trials of sensors (3, 5, 6, 8, 12, 13, 16, and 17);

— Elevation$_3$: Average of the three trials of sensors (2, 9, 11, 14, 15, and 18);

— Elevation$_4$: Average of the three trials of sensors (1 and 10).

Report as: Elevation$_1$:Elevation$_2$:Elevation$_3$:Elevation$_4$ for each loading condition.

7.3.2 Calculate the immersion.

Absolute immersion represents the total travel of the indenter from the height of the thickest part of the cushion to the final loaded thickness. It should be calculated for both normal (t_{190}) and overload conditions (t_{250}). Absolute immersion is calculated by

$$d_{sc} - d_{xx} \quad (1)$$

where

d_{sc} is seat cushion thickness, in mm;

d_{xx} is the average cushion thickness under the loaded indenter at 190 s (for normal load) or 250 s (for overload) from the five trials for the given mass and model, in mm.

8 Test report

The test report shall contain the following information:

a) a reference to this part of ISO 16840, i.e. ISO 16840-12;

b) the name, address, and accreditation status 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 number and internal tracking numbers, if available;

f) a colour photograph showing the cushion in isometric view with any cover removed;

g) the cushion cover used;

h) the preparation of the test cushion including set up and adjustment, including the diameter of the pressure sensors used;

i) any deviations from the test methods of this part of ISO 16840;

j) the results of the calculations in 7.3 and disclosure of uncertainty, as specified in ISO/IEC Guide 98-3;

k) Graphs of the data may be included. Suggested formats include the following:

   1) a line graph of the average of each of the sensors 1 to 10 (Figure 9);

   2) a bar graph of elevations 1 to 4 (Figure 10).

NOTE Abnormal test results can be created by cushion architecture, such as those that are designed to offload. Consider whether the method described in Annex A is appropriate.

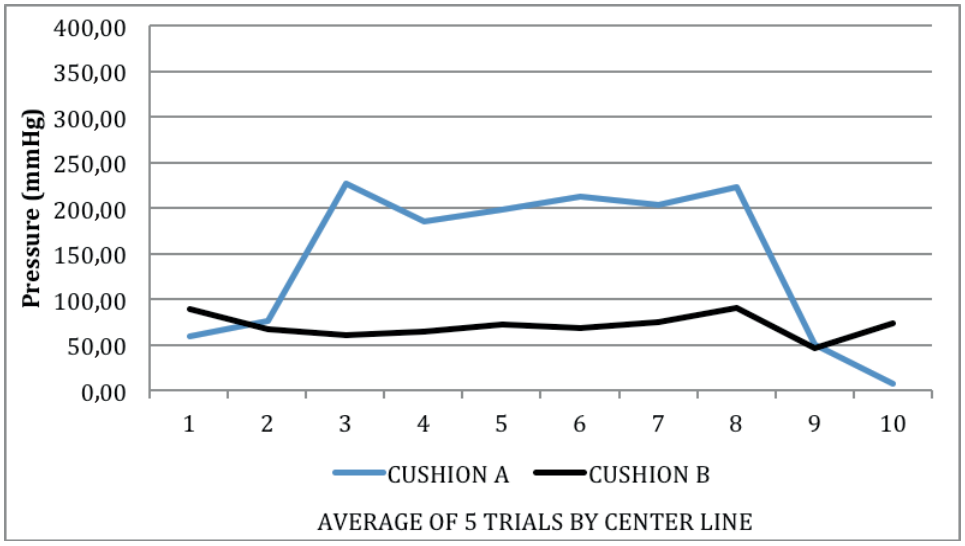

Figure 9 — Comparative line graph example

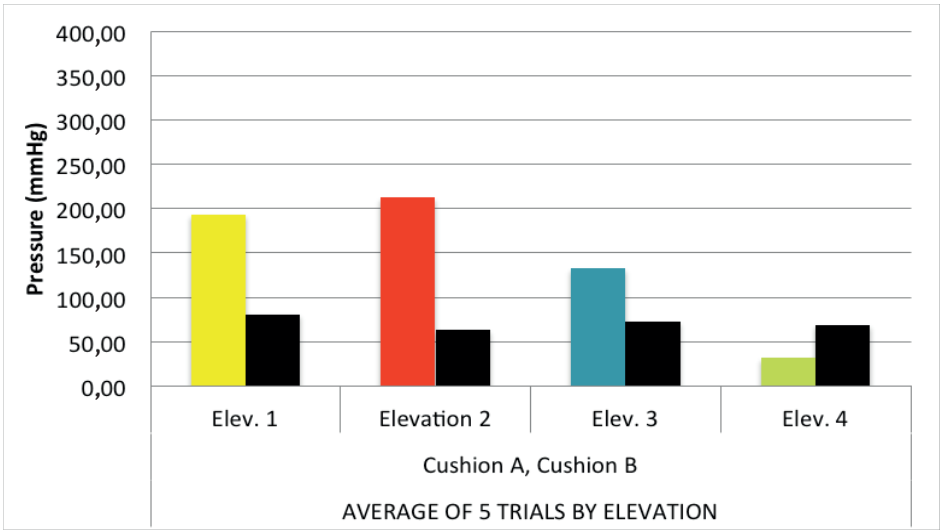

Figure 10 — Comparative bar graph example

Annex A
(normative)

Method adaptions for cushions that utilize offloading

A.1 Measuring modifications to create localized offloading

If a cushion is intended to be used to create offloading, repeat the tests in 7.2.4 while adjusting the cushion to offload the desired site/structure (for example, by moving material within the cushion away from the area to be offloaded).

a) Readjust elements within the cushion such that the cushion receives the load in a different location or distribution other than the original adjustment.

b) Perform steps in 7.2.4 for the new adjustment method, labelling the data as modified adjustment.

c) Report the values in a table against those from the original adjustment method.

Bibliography

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

[2] ISO 7176-26, *Wheelchairs — Part 26: Vocabulary*

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

[4] ISO 16840-2, *Wheelchair seating — Part 2: Determination of physical and mechanical characteristics of devices intended to manage tissue integrity — Seat cushions*

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