INTERNATIONAL STANDARD

ISO 20685-2

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Ergonomics — 3-D scanning methodologies for internationally compatible anthropometric databases —

Part 2: Evaluation protocol of surface shape and repeatability of relative landmark positions

Ergonomie — Méthodologies d'exploration tridimensionnelles pour les bases de données anthropométriques compatibles au plan international —

Partie 2: Protocole d'évaluation de la forme extérieure et de la répétabilité des positions relatives de repères

Reference number
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Foreword

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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 document 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).

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This document was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 3, *Anthropometry and biomechanics*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 122, *Ergonomics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 20685-2:2015), which has been technically revised.

The main changes are as follows:

— landmark names in Table 1 and Table B.2 and subclause numbers in Table 1 harmonized with those in ISO 7250-1:2017;

— standard deviation of radial distances deleted from Clause 3;

— calculation of quality parameter for the repeatability of landmark positions, Annex B and Annex D revised.

A list of all parts in the ISO 20685 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Anthropometric measures are key to many International Standards. These measures can be gathered using a variety of instruments. An instrument with relatively new application to anthropometry is a three-dimensional (3-D) scanner. 3-D scanners generate a 3-D point cloud of the outside of the human body that can be used in a number of situations, including clothing and automotive design, engineering and medical applications. Recently, digital human models have been created from a 3-D point cloud and used for various applications related to technological design process. Quality control of scan-extracted anthropometric data is important since required quality can differ according to applications.

There are a number of different fundamental technologies that underlie commercially available systems. These include stereophotogrammetry, ultrasound and light (laser light, white light and infrared). Furthermore, the software that is available to process data from the scan varies in its methods. Additionally, methods to extract landmark positions differ between commercially available systems. In some systems, anthropometrists decide landmark locations and paste marker stickers, and scanner systems calculate locations of marker stickers and identify their names. In other systems, landmark positions are automatically calculated from the surface shape data. The quality of landmark locations has a significant effect on the quality of scan-extracted 1-D measurements, as well as digital human models created based on these landmarks.

As a result of differences in fundamental technology, hardware and software, the quality of body surface shape and landmark locations from several different systems can be different for the same individual. Since 3-D scanning can be used to gather these data, it was important to develop an International Standard that allows users of such systems, as well as users of scan-extracted measurements, to judge whether the 3-D system is adequate for these needs.

The intent of this document is to ensure the quality control process of body scanners, especially that of surface shape and locations of landmarks as specified by ISO 7250-1.

This document is not intended to be used for an acceptance test.

Ergonomics — 3-D scanning methodologies for internationally compatible anthropometric databases —

Part 2: Evaluation protocol of surface shape and repeatability of relative landmark positions

1 Scope

This document establishes protocols for testing of 3-D surface-scanning systems in the acquisition of human body shape data and measurements. It does not apply to instruments that measure the motion of individual landmarks.

While mainly concerned with whole-body scanners, this document is also applicable to body-segment scanners (head scanners, hand scanners, foot scanners). It applies to body scanners that measure the human body in a single view. When a hand-held scanner is evaluated, the human operator can contribute to the overall error. When systems are evaluated in which the participant is rotated, movement artefacts can be introduced; these can also contribute to the overall error. This document applies to the landmark positions determined by an anthropometrist. It does not apply to landmark positions automatically calculated by software from the point cloud.

The quality of surface shape of the human body and landmark positions is influenced by the performance of scanner systems and humans, including measurers and participants. This document addresses the performance of scanner systems by using artefacts rather than human participants as test objects.

Traditional instruments are required to be accurate to the millimetre. Their accuracy can be verified by comparing the instrument with a scale calibrated according to an international standard of length. To verify or specify the accuracy of body scanners, a calibrated test object with known form and size is used.

The intended audience is those who use 3-D body scanners to create 3-D anthropometric databases, the users of these data, and body scanner designers and manufacturers. This document intends to provide the basis for agreement on the performance of body scanners between scanner users and scanner providers as well as between 3-D anthropometric database providers and data users.

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 7250-1:2017, *Basic human body measurements for technological design — Part 1: Body measurement definitions and landmarks*

ISO 20685-1:2018, *3-D scanning methodologies for internationally compatible anthropometric databases — Part 1: Evaluation protocol for body dimensions extracted from 3-D body scans*

3 Terms and definitions

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

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

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

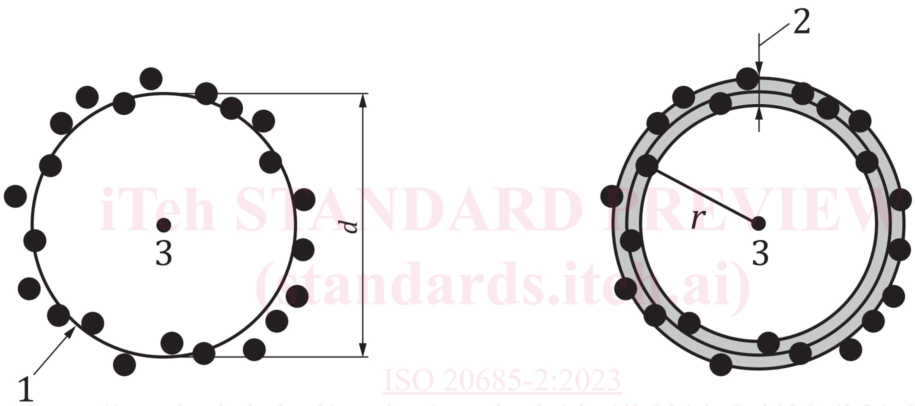
— IEC Electropedia: available at https://www.electropedia.org/

3.1
error of spherical form measurement
error within the range of the Gaussian radial distance, determined by a least-squares fit of measured data points on a test sphere

Note 1 to entry: Error of spherical form measurement is associated with the performance of the body scanner and the sphericity of the test sphere.

3.2
spherical form dispersion value (*n*)
smallest width of a spherical shell that includes *n* % of all the measured data points

Note 1 to entry: See Figure 1.



Key

1 best-fit sphere

2 spherical form dispersion value (*n*)

3 centre of the best-fit sphere

d diameter of the best-fit sphere

r radial distance of a measured data point from the centre of the best-fit sphere

NOTE 1 Best fit sphere is a sphere determined by a least-squares approximation of the measured points of the test sphere.

NOTE 2 Spherical form dispersion value (*n*), in which *n* % of the measured data points are located, is shown as the radial thickness of the shaded area of the right-hand image. Spherical form dispersion value (*n*) is calculated as the 100 – $n/2$ percentile value minus $n/2$ percentile value of the radial distances of the measured data points from the centre of the best-fit sphere.

Figure 1 — Error of diameter measurement and spherical form dispersion value

3.3
error of diameter measurement
error of the diameter of a least-squares fit of measured data points on a test sphere

Note 1 to entry: See Figure 1.

Note 2 to entry: See 4.3.2.

4 Test protocol for evaluating surface shape measurement

4.1 General aspects

The environmental conditions shall correspond to the operating conditions of the 3-D body scanner. When operation mode needs to be modified to measure the test object, it shall be specified in the report.

4.2 Test sphere

Spheres made of steel, ceramic or other suitable materials with a diffusely reflecting surface are used to determine the quality parameter spherical form dispersion value and error of diameter measurement. The diameter of the sphere should be close to the size of a part of the human body, such as the head.

The diameter and form of the test sphere shall be calibrated using precision measuring equipment such as a coordinate-measuring machine that has traceability to the international standard of the length; a calibration certificate shall be available.

The spherical form dispersion value (100) of the test sphere shall be smaller than 0,1 mm.

The surface properties of the test sphere can significantly affect the test results. The material of the test sphere shall be reported.

The reference sphere supplied with the body scanner for calibration purposes shall not be used for this test.

An example of a sphere is shown in Annex A.

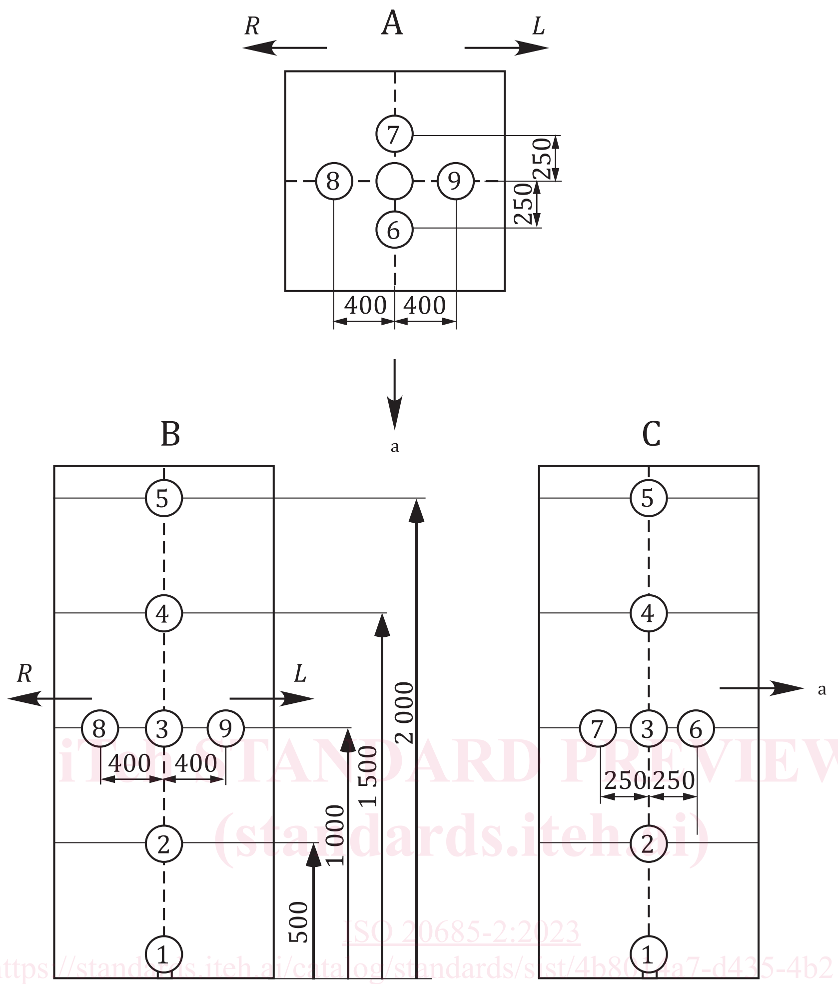
4.3 Procedure

4.3.1 Measurement of test sphere

The sphere shall be measured in at least nine different positions within the scanning volume. Measurement positions shall include the following nine positions (Figure 2): position 1 is the centre of the scanning volume on the floor; position 2 to position 5 are 500 mm, 1 000 mm, 1 500 mm and 2 000 mm off the floor, above position 1; position 6 and position 7 are 250 mm in front of or behind the centre position and 1 000 mm off the floor; position 8 and position 9 are 400 mm to the right or left of the centre position and 1 000 mm off the floor.

When the sphere cannot be measured in these positions due to a smaller scanning volume, measure the sphere at a position close to the intended position and record the exact position.

Dimensions in mm



Key

A top view
B front view
C right-side view
L left
R right
[a] Anterior.

Figure 2 — Measurement positions of the sphere

4.3.2 Calculation of quality parameters

Data points from objects other than the test sphere, such as a tripod, shall be deleted manually. Outlying data points due to reflection can also be removed.

The best-fit sphere shall be calculated from the measured data points. Calculate radial distances from the centre of the best-fit sphere to all data points.

Error of diameter measurement shall be calculated as the diameter of the best-fit sphere minus the calibrated diameter.

Spherical form dispersion value (90) shall be calculated as 95 percentile value minus 5 percentile value of the radial distances.

The standard deviation of radial distances from all the measured data points to the centre of the best fit sphere shall be calculated. This is an indicator of error of spherical form measurement and highly correlated with error of spherical form dispersion value (90)

4.3.3 Report

Material and calibration results of the test sphere [diameter and spherical from dispersion value (100)] shall be reported.

For each position, actual measurement position, error of diameter measurement, spherical form dispersion value (90) and standard deviation of radial distances from measured data points and the best-fit sphere shall be reported at least to the nearest 0,1 mm. Figures for measured data points of the test sphere can help with interpreting results.

Examples of the test procedure and report are shown in Annex B, Clause B.1.

5 Test protocol for evaluating repeatability of landmark positions

5.1 General aspects

The environmental conditions shall correspond to the operating conditions of the 3-D body scanner. When operation mode needs to be modified to measure the test object, it shall be specified in the report.

5.2 Test object

An anthropomorphic dummy representing the size and shape of a natural human, rather than an idealized human, shall be used. The dummy should have no movable parts and the posture should be that recommended in ISO 20685-1 for circumferences. It should be made of fibre-reinforced plastics (FRP), metal or other suitable materials with a diffuse reflecting surface. The landmarks to be evaluated shall be premarked on the dummy.

Landmark positions on the dummy should be determined by an experienced anthropometrist as described in ISO/TR 7250-4[1)] when the dummy is not premarked. If the physical representation of the 3D scan of an actual human is used, actual landmark positions shall be used.

An example of a dummy is shown in Annex A.

5.3 Landmarks

Landmarks to be evaluated are listed in Table 1. Among the 47 landmarks, No 1 to No 15 and No 18 to No 25, as defined in ISO 7250-1, and No 26 and No 27, as defined in ISO 20685-1, shall be evaluated. Landmarks No 16, No 17 and No 28 to No 47 are optional. When landmarks other than those listed in Table 1 need to be evaluated, these landmarks are numbered from No 48.

Before measurement, marker stickers are pasted on landmark positions to be evaluated. Marker stickers should be chosen to be appropriate for the scanner being tested.

Table 1 — Landmarks to be evaluated

No	Landmark	Source
1	Vertex (top of head)	ISO 7250-1:2017, 5.22
2	Tragion, right	ISO 7250-1:2017, 5.20
3	Tragion, left	ISO 7250-1:2017, 5.20
4	Orbitale – Infraorbitale, right	ISO 7250-1:2017, 5.13
5	Orbitale – Infraorbitale, left	ISO 7250-1:2017, 5.13

1) Under preparation. Stage at the time of publication: ISO/DTR 7250-4:2023.