TECHNICAL SPECIFICATION

ISO/TS 16976-2

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Respiratory protective devices — Human factors —

Part 2: Anthropometrics

Appareils de protection respiratoire — Facteurs humains — Partie 2: Anthropométrie

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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 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).

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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 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 15, *Respiratory protective devices*.

This second edition cancels and replaces the first edition (ISO/TS 16976-2:2010), which has been technically revised. It also incorporates the Technical Corrigendum ISO 16976-2 Corr.1:2011.

The major technical changes are:

a) Inclusion of ISO/TS 16976-2 TECHNICAL CORRIGENDUM 1:2011

b) Change of values for W_5 and W_6 in 8.3.

ISO/TS 16976 consists of the following parts, under the general title *Respiratory protective devices — Human factors*:

— *Part 1: Metabolic rates and respiratory flow rates* [Technical Specification]

— *Part 2: Anthropometrics* [Technical Specification]

— *Part 3: Physiological responses and limitations of oxygen and limitations of carbon dioxide in the breathing environment* [Technical Specification]

— *Part 4: Work of breathing and breathing resistance: Physiologically based limits* [Technical Specification]

— *Part 5: Thermal effects* [Technical Specification]

— *Part 6: Psycho-physiological effects* [Technical Specification]

— *Part 7: Hearing and speech* [Technical Specification]

— *Part 8: Ergonomic factors* [Technical Specification]

Introduction

For an appropriate design, selection, and use of respiratory protective devices, basic physiological demands of the user must be considered. Type and intensity of work affect the metabolic rate (energy expenditure) of the wearer. Weight and weight distribution of the device on the human body can also influence metabolic rate. Metabolic rate is directly correlated with oxygen consumption, which determines the respiratory demands and flow rates. The work of breathing is influenced by the air flow resistances of the device and the lung airways. The work (or energy cost) of a breath is related to the pressure gradient created by the breathing muscles and the volume that is moved in and out of the lung during the breath. Anthropometric and biomechanical data are required for appropriate design of various components of a respiratory protective device, as well as for the design of relevant test methods.

This Technical Specification forms one part of a series of documents providing basic anthropometric measurement methods and data on humans. It contains information about the description, definition, and diagram of landmarks and dimensions, up-to-date head and face data for various race/ethnic groups, and human test panels.

Respiratory protective devices — Human factors —

Part 2: Anthropometrics

1 Scope

This part of ISO/TS 16976 is one part of a series of Technical Specifications that provide information on factors related to human anthropometry, physiology, ergonomics, and performance for the preparation of standards for design, testing, and use of respiratory protective devices. This part of ISO/TS 16976 contains information related to anthropometry. In particular, information is given for:

— anthropometric measurement methods;

— anthropometric data for head, face, and neck dimensions;

— anthropometric data for torso dimensions;

— human test panels;

— models of headforms.

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.

EN 14143, *Respiratory equipment — Self-contained re-breathing diving apparatus*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in Annexes A and B apply.

4 Anthropometric measurements

4.1 Anthropometric instrument and software

The standard measurement tools which are recommended are the anthropometer, a spreading calliper, a sliding calliper, a pupillometer, and a steel measuring tape. A suitable data entry, editing, and analysis software is described in References [3] and [4].

4.1.1 Anthropometer, a specialized tool for measuring linear distance between points on the body and standard reference surfaces, such as the floor or a seat platform.

4.1.2 Spreading and sliding callipers, used for measuring the breadth and depth of body segments, as well as the distance between reference marks.

4.1.3 Measuring tape, used for measuring the arc and circumference of body segments.

4.1.4 Pupillometer, a standard ophthalmic device used for measuring the interpupillary distance.

4.2 Measurement procedures

4.2.1 Landmarking

Landmarks are generally, although not always, skeletal points that are usually marked on the skin overlying the point. Selected landmarks are listed in Table 1 and described in Annex A. Subjects are landmarked with a surgical marker or an eyeliner pencil prior to measurement.

Table 1 — List of landmarks

Landmarks	Landmark positioning
Alare	Right and left
Cheilion	Right and left
Chin	—
Ectocanthus	Right and left
Frontotemporale	Right and left
Glabella	—
Gonion	Right and left
Infraorbitale	Right and left
Menton	—
Nasal root point	Right and left
Pronasale	—
Pupil	Right and left
Sellion	—
Subnasale	—
Top of head	—
Tragion	Right and left
Zygion	Right and left
Zygofrontale	Right and left

4.2.2 Measuring

After landmarking, subjects are measured for each of the dimensions. Data are recorded on data sheets and simultaneously entered into computer software. The data entry and editing software evaluate each measurement as it is entered and indicate when a measurement value is out of the previously measured range or is otherwise unexpected. In such cases, the measurement shall be repeated or data input errors corrected.

4.3 Dimensions to be measured

The dimensions to be measured are listed in Table 2. The detailed dimension descriptions are provided in Annex B. All dimensions are measured in millimetres and body weight is measured in kilograms.

Table 2 — List of face dimensions

Dimensions	Common terms
Bigonial breadth	Jaw width
Bitragion chin arc	
Bitragion coronal arc	
Bitragion frontal arc	
Bitragion subnasale arc	
Bizygomatic breadth	Face width
Head breadth	
Head circumference	
Head length	
Interpupillary distance	
Lip length	
Maximum frontal breadth	
Menton-sellion length	Face length
Minimum frontal breadth	
Nasal root breadth	
Neck circumference	
Nose breadth	
Nose protrusion	
Subnasale-sellion length	Nose length
Stature	Height
Weight	

5 Anthropometric data for head, face, and neck dimensions

Test panels for the development of an International Standard must be representative of the world population. An anthropometric study of the US work population was conducted by the National Institute for Occupational Safety and Health (NIOSH) in 2003 (see Reference [3]). The survey consisted of three age strata (18 years to 29 years, 30 years to 44 years, 45 years to 66 years), two gender strata (male and female), and four racial/ethnic group strata (white, African American, Hispanic, and other). The selected test panel could be seen as almost representative for the worldwide population, since the US population is multi-ethnic. Height, weight, 19 face dimensions, and neck circumferences were measured using traditional methods. A total of 3 997 subjects (2 543 male and 1 454 female) were measured. The sampling strategy called for equal representation in each of the sampling cells. This was done to ensure that we had adequately captured the anthropometric variability in all segments of the population. NIOSH research has resulted in the development of Table 3.

The NIOSH data were supplemented with additional measurements in China and other data for various countries. See References [5] and [6]. The data were compared to the NIOSH US Data and were found to be within the 5th and 95th percentiles for US population in Table 3.

Table 3 — Anthropometric data for head, face, and neck dimensions by gender
(weight in kilograms, all other values in millimetres)

Dimension	Number	Mean	Standard deviation	Min.	Max.	Percentiles		
						5th	50th	95th
Males								
Bigonial breadth	2 543	120,4	10,4	90	160	105	120	140
Bitragion chin arc	2 543	331,2	15,5	271	393	306	330	355
Bitragion coronal arc	2 543	350,7	13,9	310	405	330	350	375
Bitragion frontal arc	2 543	304,1	13,0	263	349	282	305	326
Bitragion subnasale arc	2 543	294,8	13,2	253	345	275	295	315
Bizygomatic breadth	2 543	143,5	6,9	120	170	132	143	155
Head breadth	2 543	153,0	6,0	135	179	144	153	163
Head circumference	2 543	575,7	17,1	520	639	547	575	604
Head length	2 543	197,3	7,4	174	225	185	197	210
Interpupillary distance	2 543	64,5	3,6	53	79	59	65	71
Lip length	2 543	51,1	4,2	40	70	44	51	58
Maximum frontal breadth	2 543	112,3	5,5	95	131	104	112	122
Menton-sellion length	2 543	122,7	7,0	100	156	111	123	135
Minimum frontal breadth	2 543	105,5	5,7	90	127	95	105	115
Nasal root breadth	2 543	16,6	2,3	10	29	13	16	20
Neck circumference	1 023	406,7	32,6	312	570	355	403	465
Nose breadth	2 543	36,6	4,1	26	58	31	36	45
Nose protrusion	2 543	21,1	2,7	13	32	17	21	26
Stature	2 543	1 753,9	67,7	1 488	2 012	1 642	1 754	1 866
Subnasale-sellion length	2 543	52,0	4,1	40	66	45	52	59
Weight	2 540	90,4	17,5	42,9	167,8	65,7	88,4	122,7
Females								
Bigonial breadth	1 454	110,1	8,9	88	150	98	110	125
Bitragion chin arc	1 454	303,9	14,9	248	375	280	305	328
Bitragion coronal arc	1 454	339,3	15,0	290	425	315	340	365
Bitragion frontal arc	1 454	287,4	11,9	250	330	270	287	305
Bitragion subnasale arc	1 454	277,5	13,1	238	335	258	277	300
Bizygomatic breadth	1 454	135,1	6,5	115	157	124	135	146
Head breadth	1 454	146,8	5,6	129	165	137	146	156
Head circumference	1 454	554,9	17,8	475	654	527	555	585
Head length	1 454	187,5	7,2	152	215	175	187	199
Interpupillary distance	1 452	61,9	3,5	52	78	56	62	68
Lip length	1 454	48,0	4,0	35	63	42	48	55
Maximum frontal breadth	1 454	108,6	5,3	92	130	100	108	117
Menton-sellion length	1 454	113,4	6,1	91	135	104	113	124
Minimum frontal breadth	1 454	102,9	5,4	84	126	94	103	111
Nasal root breadth	1 454	16,3	2,0	10	25	13	16	20
Neck circumference	793	339,5	30,9	260	505	295	335	395

Table 3 *(continued)*

Dimension	Number	Mean	Standard deviation	Min.	Max.	Percentiles		
						5th	50th	95th
Nose breadth	1 454	33,2	3,9	22	54	28	33	41
Nose protrusion	1 454	19,8	2,7	11	29	16	20	25
Stature	1 454	1 625,4	67,5	1 310	1 862	1 513	1 627	1 731
Subnasale-sellion length	1 454	48,2	3,8	32	59	42	48	55
Weight	1 454	75,7	18,7	34,2	176,4	51,8	72,1	112,1

6 Anthropometric data for torso dimensions

The application for the torso to be developed is to hold an RPD (respiratory protective device) designed to be worn on the human body, in position, during testing. The data given for this torso are not appropriate for use in the design of the RPD. Since there will be no test where ergonomic features are checked by using the torso, it has been agreed to use the ADULTDATA handbook[7] mean values of males and females. A subset of the ADULTDATA including anthropometric data for a number of surveys from UK, Sweden, Italy, France, China, Japan, and USA was used.

The mean values of the designated measurements identifying the main dimensions of a torso shown in Figure 1 are given in Table 4. The measure reference identification numbers have been taken from the ADULTDATA handbook as they are numbered originally to allow comparison.

The last column in Table 4 gives the mean for male and female mean data which leads to the neutral dimension to be taken for modelling of the torso.

The torso is positioned on an elliptical contoured platform with the axis a = 200 mm, b = 300 mm, and a minimum height of 150 mm. This generates some space for parts of an RPD extending beyond the torso, but which are not in contact with the plateau, whichever way the torso is placed. The RPD will be fixed to the torso by the harness without touching the plateau.

The torso will have a socket at the top for inserting the headforms described in this part of ISO/TS 16976.

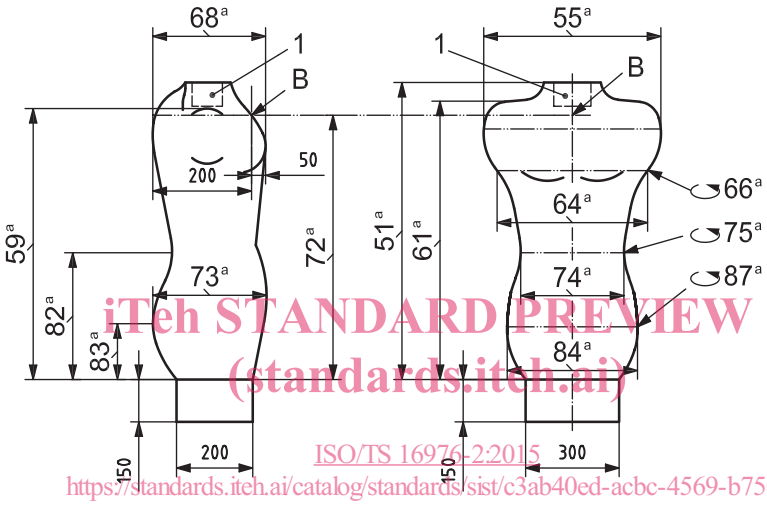
Table 4 — Mean anthropometric data for torso dimensions by gender and combined population

ADULTDATA measure reference identification number	Description	Dimension 50 % male mm	Dimension 50 % female mm	Dimension 50 % mean mm
51	Height of prominent neck vertebra, sitting	667	628	648
55	Shoulder breadth (deltoid)	458	416	437
59	Shoulder (acromion) height, sitting	605	569	587
61	Mid-shoulder height, sitting	632	579	606
64	Chest breadth, at level of nipples	329	282	306
66	Chest circumference, at level of nipples	916	921	919
68	Chest depth, at level of nipples	248	251	250
72	Trunk height to the top of breast bone, sitting	597	573	585
73	Lower abdominal depth	284	250	267
74	Waist breadth	259	264	262
75	Waist circumference – natural indentation	839	769	804
NOTE Measure reference numbers are taken from ADULTDATA handbook dimensions.				

Table 4 *(continued)*

ADULTDATA measure reference identification number	Description	Dimension 50 % male mm	Dimension 50 % female mm	Dimension 50 % mean mm
82	Height of maximum lumbar curvature, sitting	241	232	237
83	Sacral height, sitting	162	159	161
84	Hip breadth	327	321	324
87	Mid-hip circumference	1 060	1 056	1 058
NOTE Measure reference numbers are taken from ADULTDATA handbook dimensions.				

Dimension in millimetres



Key

1 socket for headform

B top of breast bone

a All numbers are reference numbers in accordance with Table 4.

Figure 1 — Torso contour given by measure references

7 Interface between headform and torso

The torso described in this part of ISO/TS 16976 will be able to carry the five different headforms by a socket at the top. In order to test the RPD in its operational position, the headforms will be used to connect the RPD with the breathing machine/simulator whilst fixed to the torso. The headform will have a fixed position in relation to the torso by using reference points (A and B) which are illustrated in Figure 1 and Figure 2. The reference for all headforms is the point A, the centre of the mouth opening. This point will be positioned always 165 mm above the top of the breast bone (point B) as defined by measure reference number 72 of the torso contour. The length of the headform necks have to be designed accordingly. This relation is based on the information given in EN 14143.