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Principles for selecting and using test persons for testing anthropometric aspects of industrial products and designs

Principes de choix et d'utilisation de sujets d'essai pour l'essai des aspects anthropométriques des produits industriels et leur conception

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Foreword

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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.

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ISO 15537 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 122, *Ergonomics*, in collaboration with Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 3, *Anthropometry and biomechanics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Introduction

An investigation into how far ergonomic requirements are taken into consideration with regard to industrial products and designs is often performed using test equipment, giving possibilities to register only one parameter (for example only the body height) or perhaps a few parameters. With regard to the concurrent multifunctional testing and/or determination of product characteristics for which no technical testing procedures have been laid down, one or several persons are often designated as test persons and are observed and/or questioned while or after using the product under test.

The reliability of any findings established in this way is very much dependent on the extent to which the test persons represent the intended user group in different aspects. How well a product or design is adjusted to the anthropometrics of the intended user population is dealt with in this International Standard.

According to EN 614-1, work equipment, e.g. machinery, has to be designed with proper regard to the body dimensions of the intended user population. One means to verify that a product or a design fulfils this requirement is to set up a panel of test persons and let them test the product in different ways.

An example of the use of this International Standard is given in Annex A (informative).

Principles for selecting and using test persons for testing anthropometric aspects of industrial products and designs

1 Scope

This International Standard establishes methods for determining the composition of groups of persons whose anthropometric characteristics are to be representative of the intended user population of any specific object under test.

This International Standard is applicable to the testing of anthropometric aspects of industrial products and designs having direct contact with the human body or dependent on human body measurements, e.g. machinery, work equipment, personal protective equipment (PPE), consumer goods, working spaces, architectural details or transportation equipment.

This International Standard is also applicable to the testing of such safety aspects of products that are dependent on human body measurements. It does not deal with other aspects of the task or other requirements, such as perception of information (except geometrical arrangement of the viewing targets) and the use of controls (except their geometrical placement).

Although this International Standard deals with selecting test persons from an anthropometric perspective, similar general principles could be applied for other test variables, e.g. biomechanical aspects.

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 7250:1996, *Basic human body measurements for technological design*

ISO 15534-3:2000, *Ergonomic design for the safety of machinery — Part 3: Anthropometric data*

3 Terms and definitions

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

3.1
critical dimension of a product to be tested
dimension estimated to cause a major limitation for the usage from an anthropometrical point of view, for the whole body or body parts, depending on the function of the product in question

NOTE 1 Critical dimension is related to reach, clearance, posture, contact pressure or other factors which may result in difficulties of use, discomfort or health risks.

NOTE 2 A product to be tested can have more than one critical dimension, for example, a combination of a reach- and a clearance-dimension.

EXAMPLE The critical dimension for an access opening could be the width, or a combination of two dimensions, for example the width and the opening height.

3.2
critical anthropometric measurement
anthropometric measurement which is most affected by the critical dimensions of the product

NOTE For instance, the critical anthropometric measurement for a person entering an opening for whole body access is the one with the greatest constraint (for example, the body height and/or the body width, depending on the form of the access opening).

3.3
worst-case combination of critical dimensions and anthropometric measurements
combination of critical dimensions of the product, additional equipment and the critical anthropometric measurement imposing the biggest restriction on a person who is able to use the product or design as intended

3.4
slim body type
person for whom at least two width measurements (preferably shoulder width and hip breadth) and two depth measurements (preferably chest depth and abdominal depth) are smaller than the figure representing the 25th percentile or, where this figure is not available, the average value of the 5th and the 50th (mean) percentile for the population in question

EXAMPLE For the European shoulder breadth (see Table 1) the figure in question is $\frac{395\ \text{mm} + 474\ \text{mm}}{2} = 434{,}5\ \text{mm}$.

3.5
corpulent body type
person for whom at least two breadth measurements (preferably shoulder breadth and hip breadth) and two depth measurements (preferably chest depth and abdominal depth) are bigger than the figure representing the 75th percentile or, where this figure is not available, the average value of the 50th percentile (mean) and the 95th percentile for the population in question

EXAMPLE For the European hip breadth, standing (see Table 1) the figure in question is $\frac{359\ \text{mm} + 400\ \text{mm}}{2} = 379{,}5\ \text{mm}$.

3.6
medium body type
person belonging neither to the slim nor to the corpulent body type

4 Types of tests

4.1 General

Depending on the accuracy of the test results required and the availability of test persons, either a screening or a detailed test can be performed. In addition to critical dimensions of the product, at least the following shall be taken into account as selection criteria:

— the geographical origin of the user population (global, European Union or a specific population);

— the age of the user population (all or specific age groups);

— the gender of the user population (both or specific);

— occupation (if relevant).

4.2 Screening test

The screening test is not as complete or accurate as a detailed test and is used in the preliminary assessment of the usability of products and designs for a defined intended user population.

NOTE Where appropriate, particularly early in the design process, screening tests can also be performed with the help of computer manikins or body templates, representing the variation of the intended user population defined in 4.1. For more information on computer manikins, see ISO 15536-1.

Screening tests are never sufficient for complete assessment of safety aspects.

4.3 Detailed test

The detailed test takes account of all dimensions of a product or design (for example by using a mock-up, prototype or other physical model), in relation to anthropometric dimensions. The selection of anthropometric measurements and percentiles depends on the features of the product or design under test. The duration of a detailed test shall be long enough to give a good representation of the intended use of the product, including foreseeable non-regular or emergency use and maintenance.

5 Test with test persons

5.1 General requirements and recommendations

Test persons shall be selected to represent the anthropometric measurements of the relevant percentile of the intended user population.

The test shall be reproducible, as far as possible.

5.2 Procedure for testing

The following shall be taken into account:

— identify the intended user population (see 4.1);

— identify critical tasks that the user will perform in or with the product design, and the type of clothing and equipment used during these tasks;

— define the critical dimensions of the product under test;

— define worst-case combinations of critical dimensions and anthropometric measurements, including critical measurements with additional equipment;

— define safety margins, absolute (figures) or relative (percentile) to be added to the dimensions;

— select test persons according to 5.3 or 5.4, respectively;

— run the test(s), taking the following into account:

  — the measuring of critical dimensions and corresponding anthropometric measurements of the test persons,

  — registration of the test persons' subjective opinions during and/or after using the product,

  — observation of the test persons' behaviour and ability to perform the task when using the product as intended;

— document the test procedure and the test results (see 5.7).

Any individual test should cover at least one whole utilisation cycle for each element of the object under test (adjustment gear, displays, controls, visibility, etc.). Any deviation from this recommendation shall be documented. The reliability of some tests can be improved by repeating them at least three times. Requirements for specific tests might be found in some product standards.

5.3 Selection of test persons within the intended user population for screening test

For each critical dimension, select at least three persons, representing the part of the user population anticipated to be limiting in this aspect. That is, if it is a clearance-dimension that shall be tested, the persons should as far as possible represent the 95th percentile for that dimension. If it is a reach-dimension to be tested, the persons should as far as possible represent the 5th percentile. The same test person can be used for testing more than one critical dimension (see Table 1 for European human body measurements and Table 2 for world-wide human body measurements, or relevant regional data should be used).

5.4 Selection of test persons within the intended user population for detailed test

The following shall be taken into account.

— For each critical dimension, select at least seven persons, representing the part of the user population anticipated to be limiting in this aspect. That is, if it is a clearance-dimension that shall be tested, the persons should, as far as possible, represent the 95th percentile for that dimension. If a reach-dimension is to be tested, the persons should, as far as possible, represent the 5th percentile.

— If the 95th and/or the 5th percentile for the critical dimensions are not known in the intended user population, then at least seven test persons representing the limiting (95th or 5th) percentile of stature shall be used. Of these seven test persons, at least two should be of slim, medium and corpulent body type, respectively. It is also recommended that at least one person representing the 95th or the 5th percentile of the breadth or depth measurement be included in the test group. A test person can be used for testing more than one critical dimension.

— In a more complicated test situation, for example, where both clearance- and reach-dimensions are of concern, the sample of test persons should be specifically determined for it's purpose.

— It is recommended to use the 1st and the 99th percentile, instead of the 5th and the 95th wherever possible.

For safety considerations (for example, for testing the access openings or safety distances), at least one person representing the 1st or the 99th percentile of the relevant body measurement shall be employed in the test.

Table 1 — European human body measurements for persons aged between 18 and 60 years

Human body measurement	Value, mm			Definition, see
	P5	P50	P95	
Stature (body height)	1 530 [a]	1 719 [a]	1 881 [b, c]	ISO 7250:1996; 4.1.2
Eye height	1 420 [a]	1 603 [a]	1 750 [a]	ISO 7250:1996; 4.1.3
Shoulder height	1 260 [a]	1 424 [a]	1 570 [a]	ISO 7250:1996; 4.1.4
Elbow height	930 [b]	1 078 [a]	1 195 [b]	ISO 7250:1996; 4.1.5
Crotch height	665 [b]	816 [a]	900 [b]	ISO 7250:1996; 4.1.7
Tibial height	397 [a]	472 [a]	530 [a]	ISO 7250:1996; 4.1.8
Lower leg length (popliteal height)	340 [b]	444 [a]	505 [b]	ISO 7250:1996; 4.2.12
Knee height, sitting	460 [a]	530 [a]	602 [a]	ISO 7250:1996; 4.2.14
Hip breadth, standing	300 [a]	359 [a]	400 [a]	ISO 7250:1996; 4.1.12
Hip breadth, sitting	333 [a]	368 [a]	440 [a, b]	ISO 7250:1996; 4.2.11
Elbow-to-elbow breadth	390 [a]	478 [a]	545 [c]	ISO 7250:1996; 4.2.10
Shoulder (bideltoid) breadth	395 [a]	474 [a]	485 [a]	ISO 7250:1996; 4.2.9
Chest depth, standing	170 [a]	215 [a]	250 [a]	ISO 7250:1996; 4.1.9
Abdominal depth, sitting	195 [a]	237 [a]	350 [a]	ISO 7250:1996; 4.2.15
Hand length	152 [c]	182 [a]	202 [a]	ISO 7250:1996; 4.3.1
Hand breadth with thumb	[d]	[d]	120 [c]	ISO 15534-3:2000
Hand breadth at metacarpals	72 [a]	81 [a]	97 [c]	ISO 7250:1996; 4.3.3
Foot length	211 [c]	255 [a]	285 [b, c]	ISO 7250:1996; 4.3.7
Foot breadth	84 [a]	96 [a]	113 [c]	ISO 7250:1996; 4.3.8
Head length from tip of nose	[d]	[d]	240 [c]	ISO 15534-3:2000

NOTE For further information, see ISO 15534-1 to ISO 15534-3.

[a] Source: Jürgens, H.W.; Matzdorff, I. Windberg, J.: *International Anthropometric Data for Work-Place and Machinery Design* ([13] in the Bibliography).

[b] Source: ISO 14738:2002.

[c] Source. ISO 15534-3:2000.

[d] There are no data available.

Table 2 — World-wide human body measurements for persons between 25 and 45 years of age, divided into two categories, i.e. "smaller type" and "larger type"

Human body measurement [a]	Smaller type [b]			Larger type [b]	
	Value, mm				
	P5	P50	P95/P5	P50	P95
Stature (body height)	1 390	1 520	1 650	1 780	1 910
Sitting height (erect)	740	800	870	935	1 000
Eye height, sitting	620	690	750	815	880
Forward reach (fingertips)	670	740	810	880	950
Shoulder (bideltoid) breadth	320	365	410	455	500
Shoulder (biacrominal) breadth	285	325	360	395	430
Hip breath, standing	260	300	335	375	410
Knee height	405	455	505	550	600
Lower leg length (popliteal height)	320	365	410	460	505
Elbow-grip length	270	305	340	375	410
Buttock-knee length	450	505	560	615	670
Buttock-heel length	830	920	1 010	1 100	1 190
Hip breadth, sitting	260	305	350	395	440
Hand length	140	155	170	185	200
Hand breadth at metacarpals	65	75	90	100	110
Foot length	200	225	250	275	300
Head circumference	475	505	540	570	600
Head length	160	175	185	195	205
Head breadth	120	135	145	160	170

NOTE For children and elderly populations, separate data sets are sometimes are needed.

[a] Source: Hans W. Jürgens, Ivar A. Aune, Ursula Pieper: *International Data on Anthropometry* ([12] in the Bibliography).

[b] Both types should be considered when testing products designed for the whole world. "Smaller type" and "Larger type" categories are given if it is not possible to create a product design for the whole world. "Smaller type" data are based on females from "smaller type" populations. "Larger type" data are based on males from "larger type" populations.

5.5 Experienced or inexperienced persons

In many situations, it is appropriate that persons with different acquaintance with the product in question are engaged for the test, as long as they belong to the intended user population. When analysing the test data, a distinction should be made between experienced and inexperienced (naive) test persons, concerning the use of the product or the design under test. In some cases, it may be useful to have an even finer differentiation concerning acquaintance with the test situation.

5.6 Criteria for acceptance of a product with regard to anthropometric aspects

General criteria for acceptance are defined in certain standards (for example, ISO 14738 and EN 614-1). The set of acceptance criteria for a given product is dependent on the product/design. For some products, acceptance criteria are formulated in specific product standards. For other products, or when specific user groups are intended, the designers may have to formulate their own acceptance criteria, based on applicable anthropometric information.

For safety aspects, negative results concerning one single item shall lead to redesign.

NOTE Additional allowances for safety may be needed to provide protection for the whole population.

5.7 Documentation of the test procedure and the results

Identification of the product/design tested, the intended user population, defined critical dimensions and critical anthropometric measurements, test procedures, acceptance criteria and test results shall be documented and made available on request.

Annex A
(informative)

Example of a test procedure for testing of anthropometric aspects of an elevator

A.1 Scope

A ten person elevator which is planned for public use in a big five-floor department store in Europe has to be tested. Two parking levels are situated on top of the store (6th and 7th floor).

The test in this example case has to do with comfort, selective aspects of ergonomic-anthropometric relevance, as well as aspects of entry/exit. In particular, this Annex does not address safety issues of elevators. For this purpose, ISO 4190-1, ISO 4190-2 and EN 81 should be consulted.

A.2 Test procedure (see Table A.1)

Step 1: Determine the critical dimensions of the products and equipment and the critical anthropometric measurements of the users (see Table A.1, step 1).

Step 2: Determine the worst case (see Table A.1, step 2).

Step 3: Determination of different types of test

For checking rough anthropometric data (for example for ten persons) a screening test as well as a computer application can be used. As time aspects (duration of transport in the worst case: from basement to the 7th floor with a stop at every floor level) will influence the acceptance of space inside an elevator, a detailed test with persons should be preferred.

Step 4: Selecting of test persons

As the elevator is for use in a European department store, European anthropometric data will normally be sufficient. Although the data represent an average value for both sexes, it is advisable to form a test group by a mixed male and female population to achieve better subjective test results.

The test persons should be experienced in using an elevator.

The test persons can be formed into three groups (see Table A.1, step 4):

— Group 1 (worst case): Ten persons representing the 95th percentile (corpulent), for testing the door width and the space inside the elevator. Probably the seven test persons needed for the press-button size test (big hand/index fingers) can be included in this group.

— Group 2: Seven children (aged 12 years) representing the 5th percentile, for testing the highest push button.

— Group 3 (realistic): Mixed adult group representing the 95th (three persons), the 50th (fourpersons) and the 5th (three persons) percentile (including one wheel-chaired person or one person with a pram), instead of Group 1.

Step 5: Procedures

Comfort in an elevator is a function of time and space. The detailed test should include the three test groups standing in the elevator, with the door closed for the worst case duration (the time it takes to go from the 7th floor to the ground floor, with stops). If more than two persons of the ten test persons experience discomfort, then changes to the interior elevator dimensions should be considered.

NOTE Some countries have national safety regulations that specify a fixed relationship between elevator interior space and a number of “standard persons”. In such cases, comfort in the worst case, as defined in this example, can only be achieved by lowering the capacity limit of the elevator (number of persons), or by designing the cabin for more “standard persons”.

A.3 Test results

Some test results can also be achieved by Computer Aided Design (CAD), concerning the door height, the width and the space inside the elevator. Especially when the time aspects are anticipated to influence the result, these CAD-tests are not sufficient. A test procedure, including subjective and/or a video-taped analysis will give better results, even if it is performed as a screening test according to this International Standard. A detailed test (A.2) will give the most valid results.

Table A.1 — Testing procedure of anthropometric aspects of an elevator design (for safety aspects, see ISO 4190-1, ISO 4190-2 and EN 81)

Step 1			Step 2	Step 3	Step 4	
Critical dimensions			Worst case	Type of test	Selecting test persons	Forming test groups
Product dimensions	Human body measurements	Allowances				
Door height	Body height, P95	Hat plus shoe allowance	One tall person, P95 with hat and high-heeled shoes	Screening test	Three persons (P95)	Group 1
Door width for getting in and out of two persons simultaneously (or leaving, respectively entering of two persons side by side)	Hip breadth, P95	Allowance for a bag or a basket	Two corpulent persons (hip breadth, P95) with two bags or baskets for each person	Screening test or detailed test	Forming of one sub-group (screening test) or four sub-groups of two corpulent P95-persons each (detailed test), European population	
Space inside, for example ten persons, standing	Hip breadth, P95; body breadth P95	Allowance for a bag/basket or allowance for a rucksack	Ten corpulent persons with one rucksack and two bags/baskets for each person	Screening test or detailed test	One group of ten corpulent P95-persons, European population (detailed test)	
					or one mixed group of 3 × P95, 4 × P50 and 3 × P5-persons (one corpulent and one slim person in each sub-group), European population (both sexes) or global population (screening test)	Group 3
Push-button size and distance between buttons	Index finger breadth (at tip) P95	Allowance for gloves	Use of gloves	Screening test, detailed test	Three persons (screening test) or seven persons with big hands, P95 (detailed test), European population	Group 1
Height of highest push button above floor	Reach height, children, P5 (Age: 12 years)	—	One child without accompanying adults [Age: 12 years (P1)]	Screening test, detailed test	Three small children (screening test) or seven small children (Age: 12 years), P5 (detailed test), European population, specific age group	Group 2

Explanation:

P5: 5th percentile
P50: 50th percentile
P95: 95th percentile

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[1] ISO 4190-1, *Lift (US: Elevator) installation — Part 1: Class I, II, III and VI lifts*

[2] ISO 4190-2, *Lift (US: Elevator) installation — Part 2: Class IV lifts*

[3] ISO 14738:2002, *Safety of machinery — Anthropometric requirements for the design of workstations at machinery*

[4] ISO 15534-1, *Ergonomic design for the safety of machinery — Part 1: Principles for determining the dimensions required for openings for whole-body access into machinery*

[5] ISO 15534-2, *Ergonomic design for the safety of machinery — Part 2: Principles for determining the dimensions required for access openings*

[6] ISO 15536-1, *Ergonomics — Computer manikins and body templates — Part 1: General requirements*

[7] EN 414, *Safety of machinery — Rules for the drafting and presentation of safety standards*

[8] EN 614-1, *Safety of machinery — Ergonomic design principles — Part 1: Terminology and general principles*

[9] EN 81-1, *Safety rules for the construction and installation of lifts — Part 1: Electric lifts*

[10] EN 81-2, *Safety rules for the construction and installation of lifts — Part 2: Hydraulic lifts*

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