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Ergonomics — Computer manikins and body templates —

Part 1: General requirements

Ergonomie — Mannequins informatisés et gabarits humains —

Partie 1: Exigences générales

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Foreword

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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 15536-1 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).

ISO 15536 consists of the following parts, under the general title *Ergonomics — Computer manikins and body templates*:

— *Part 1: General requirements*

The following parts are under preparation:

— *Part 2: Structures and dimensions*

Introduction

The structure of safety standards in the field of machinery is as follows.

a) Type-A standards (basis standards) give basic concepts, principle for design, and general aspects that can be applied to machinery.

b) Type-B standards (generic safety standards) dealing with one or more safety aspect(s) or one or more type(s) of safeguards that can be used across a wide range of machinery:

— type-B1 standards on particular safety aspects (e.g. safety distances, surface temperature, noise);

— type-B2 standards on safeguards (e.g. two-hand controls, interlocking devices, pressure-sensitive devices, guards).

c) Type-C standards (machinery safety standards) dealing with detailed safety requirements for a particular machine or group of machines.

This part of ISO 15536 is a type-B standard as stated in ISO 12100-1.

When provisions of a type-C standard are different from those which are stated in type-A or type-B standards, the provisions of the type-C standard take precedence over the provisions of the other standards for machines that have been designed and built according to the provisions of the type-C standard.

This part of ISO 15536 concerns requirements which are, to a great extent, independent both of the state of the art in the currently rapidly developing field of computer manikins and body templates, and of the availability of up-to-date, detailed and representative anthropometric data.

The physical characteristics of the human body are one of the starting points in the design of spaces, furniture, machines and other equipment. Computer technology is advancing rapidly and allows the construction of computer manikins to model the human body and to simulate human activities. Anthropometrically accurate manikins or body templates can be used, for example, to visualize the geometric relationship between the human body and the physical environment. Various functions of evaluation can also be integrated into the manikin and manikin system, for example, indication of reach zones, visualization of viewing fields, biomechanical calculation of required strength, and simulation of movements.

Computer manikins are intended to reduce the need for real test persons and the evaluation of physical models and prototypes. However, real persons provide not only their true physical dimensions but also their differing functional and perceptual capabilities as well as their assessment of the ease of performance, comfort and other properties of the design (see ISO 15537).

The computer manikin permits quick, easy and early identification of possible dimensional shortcomings. Critical dimensions restricting operations, such as fitting into a confined space or reaching objects can be quickly assessed in relation to extreme body measurements. The dimensioning would otherwise require tests with a large number of test persons.

In the use of manikins, several ergonomic aspects (e.g. anthropometric, postural, visual, strength-related, dynamic) are addressed in one and the same test situation. As a universal design tool, the manikin is particularly useful for entirely novel designs, when no recommendations on the dimensions exist and no reference situations for full-scale evaluation are available. In the design process, the use of computer modelling with a manikin facilitates information exchange and collaboration between different specialists and users.

When used appropriately, computer manikins accelerate the entire design process and reduce the costs of designing. The ergonomic design process is presented as a whole in EN 614-1.

The use of computer manikins does not ensure appropriate design solutions automatically, and they can even be misused. The designer may use them inappropriately, for example, by permitting awkward postures, or by providing too little space for movements. It is possible that he or she is not aware of the inherent limitations of computer manikins, either in anthropometric, postural or biomechanical respects. As the complexity of the manikin systems increases, the links to the data on these human characteristics can also become difficult or impossible to trace.

The manikins and manikin systems available so far vary with respect to the functions and features they afford, as well as to their accuracy and usability. At the present developmental stage, the most sophisticated manikin systems may require powerful hardware and specially trained users, and they may be unavailable to many designers. The most simple ones may be easy to use but are of restricted value for designing. The systems may also differently emphasise such components as anthropometric accuracy, biomechanical capabilities, graphical visualisation, geometric design, simulation and animation. The choice of manikin and the associated design system is, to a great extent, a trade-off between these different features.

Broad experience of the field and a high level of care are necessary when choosing and using the manikin system, and for controlling the effects of other external parameters, however sophisticated the manikin system may be.

Ergonomics — Computer manikins and body templates —

Part 1:
General requirements

IMPORTANT — The application of this part of ISO 15536 should be verified by practical tests with real persons.

1 Scope

This part of ISO 15536 establishes the general requirements for the design and development of computer manikins, body templates and manikin systems. It addresses their anthropometric and biomechanical properties, taking into account their usability and restrictions for structural complexity and functional versatility, and is also intended as a guide for the selection of manikins and manikin systems and for the evaluation of their accuracy and usability for the specified use. It specifies the documentation of the characteristics of manikins and manikin systems and their intended use, for the guidance of their users. It provides means for ensuring that computer manikins and body templates for the design of work space are appropriately accurate and reliable in their anthropometric and biomechanical aspects. It aims to ensure that users of manikins are able to choose an appropriate manikin system for particular design tasks and use it in an appropriate way. It sets requirements only on the static accuracy of the manikin, but provides recommendations on the other factors that can influence the accuracy of the analyses and determinations performed using them.

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, *Basic human body measurements for technological design*

ISO 9241-11, *Ergonomic requirements for office work with visual display terminals (VDTs) — Part 11: Guidance on usability*

ISO 12100-1, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100-1 and the following apply.

3.1
computer manikin
two-dimensional (2D) or three-dimensional (3D) graphical computer representation of the human body based on anthropometric measurements, link and joint structure, and movement characteristics

3.2
computer manikin system
computer modelling system consisting of a computer manikin, tools for controlling and manipulating the manikin (e.g. posture, anthropometric measurements), functions for mimicking human characteristics and behaviour (e.g. biomechanical, strength, movements), and means to position the manikin in relation to the computer model of the physical environment

3.3
body template
physical two-dimensional, usually articulated, contour model of the human body based on anthropometric measurements

4 Accuracy

4.1 General

Several factors affect the accuracy of the analysis and determinations performed with the help of a manikin. Some depend on the anthropometric, structural, functional and biomechanical accuracy of the manikin itself; some on the knowledge and experience of the user of the manikin, for example, how appropriately the fine adjustments of the posture are done, or how deep the manikin is set in a cushioned seat surface. The required accuracy depends on the work tasks and the criticality of the dimensions (e.g. access, reach).

This part of ISO 15536 sets requirements only on the static accuracy of the manikin (see 4.2 to 4.3), but provides recommendations on the other factors which can influence the accuracy of the analyses and determinations performed with their help. These factors are described and discussed in Annex A.

4.2 Static accuracy of manikins

The structure and shape of the manikin shall conform with the shape and anthropometric measurements of the human body (see 6.4). Particular attention should be given to the design of a manikin so that the measurements of a manikin match the measurement of a human being in corresponding postures (e.g. standing and sitting).

The conformity of a computer manikin with the available population data on anthropometric measurements shall be checked by measuring the manikin in accordance with ISO 7250. By measuring horizontal or vertical distances between selected points, the measurements of the manikin can be compared with population data (or those presented for the European population in ISO 15534-3), and the accuracy in standard positions can be determined (see 6.5).

4.3 Specific issues of anthropometric accuracy

4.3.1 Effect of slump

The standardised postures in which the anthropometric measurements are taken are erect, whereas in natural postures the body is slightly slumped. The variation of the relevant measurements in standing and sitting postures should be considered by allowing the relevant fine adjustment in the posture of the trunk, or by a relevant slump factor (in upright postures this varies normally from 10 mm to 60 mm).

4.3.2 Soft tissue deformation

The body consists of both hard tissues such as bones which are rigid, and soft ones such as muscles and fat which deform when the posture is changed, or when subjected to pressure. The manikin should have provisions for taking account of deformable tissue, for example, in the area of the buttocks so that the height of the trunk remains correct when changing from standing to sitting.

4.3.3 Joint movement

Joint mobility affects anthropometric accuracy. For example, the shoulder and the centre of rotation of the shoulder joint are mobile, which greatly affects forward and upward reach. The user of the manikin should be made aware of the type of reach of the manikin (e.g. convenient/maximal reach). Consideration of the shoulder movement should be realized by the appropriate function of the manikin, or by providing the user of the possibility to adjust the location of the joint rotation centre within the range of its movement. For more information on joint movement, see A.3.3.

5 Usability

5.1 General

Computer manikin software systems shall be easy to use in order to be accepted and implemented into the design process according to EN 614-1. The usability of the manikin systems also affects the accuracy of the analysis performed with their help. Usability features of manikin systems are described in 5.2 to 5.8. General requirements on the usability of software applications shall be according to ISO 9241-11.

5.2 Clarity

The structure and interface of the manikin system shall be clearly understandable to allow quick learning and ease of use.

5.3 Consistency

The interface of the software, for example, dialogues and menus, should be as far as possible consistent with other computer programs that are used by the designer, such as the design software (CAD), animation software, and ergonomic/human factors application programs for evaluation.

5.4 Effectiveness

The software routines of computer systems should be short and simple. These include access routines needed to move from one software application to another, or to transfer the manikin or the environment from one application to another. Also, the number of steps in the user procedures should be limited and the difficulty of choice in each step should be kept as low as possible.

5.5 Versatility

It has to be possible to manipulate the manikin (size, posture) and modify the environment within the same software application. It is necessary that the manikin system also allows the user to specify and illustrate the viewing fields, reach and angular limits, e.g. preferred and maximal working area (see ISO 14738). The versatility of the manikin system is greatly affected by the architecture and design of the software (e.g. modularity and open-system architecture, see A.7).

5.6 Ease of changing anthropometry

The anthropometric measurements of the manikin shall be readily changeable, e.g. by selecting the required percentile of the measurement or by changing the measurements directly; in both cases the percentiles shall be indicated to the user. Relevant to the design needs, the combinations of different body segment percentiles shall be available, and be suitably explained. It shall be possible to adjust the anthropometric measurements between the 1st and 99th percentile of the intended population (see A.5.2).

5.7 Ease of changing posture

The posture shall be easy to change for testing certain operations, e.g. for momentary reaching to an object and reverting back to the initial posture. The manikin system shall allow easy selection of, or change to, basic postures, e.g. standing, sitting, stooping and kneeling. The manikin shall also be easy to position, in order that it either is or is not in contact with objects in the environment.

5.8 Ease of visual judgements

The adjustments of the measurements or postures shall be easy to perceive by the user and facilitated in appropriate ways in order to achieve the required accuracy. This presupposes sufficient indication of the surface or contour of the body, in addition to indicating the joints to be moved, and the direction and magnitude of the movement. This may require the use of landmarks if the manikin has hair or wears clothing and shoes, or reference lines showing the change of the joint angles.

In order to judge whether a posture or object to be reached is within acceptable limits, it should be possible to display viewing fields, reach and comfort zones clearly when needed.

The positioning of the manikin in relation to the seating arrangements requires indication of certain reference points, e.g. the seat index point (SIP).

6 Documentation

6.1 General

The developer of the manikin and manikin system is responsible for documentation of their characteristics and intended use, as well as for the guidance to the user. Requirements for this documentation are presented in 6.2 to 6.9.

6.2 Intended use

The intended use of the manikin shall be documented, e.g. animation, anthropometric and biomechanical evaluations, together with any limitations in its use, particularly from an anthropometric point of view. Also documented shall be the types of analyses and evaluations for the manikin system, for example:

— automated evaluation functions or evaluation by visual judgement only;

— animation of movements or a still picture presentation only;

— analyses of geometric relations such as viewing, reach, access and collision;

— evaluation of strength requirements based on biomechanical calculations.

In addition, the intended user group shall be documented, e.g. engineers, ergonomics experts. The design domain shall be documented, e.g. machinery design, architectural design. The requirements concerning experience in anthropometry, workplace design and computing techniques to utilise the full power of the software in complex applications shall be documented as well.

6.3 Data sources

The sources of anthropometric data used shall be documented. If the data are combined from different sources or pooled gender data, the resulting data shall be specified and tabulated in at least 5th, 50th and 95th percentile values.

6.4 Anthropometric accuracy in standard positions

For assessing the static accuracy of the computer manikin (see 4.2), at least the basic anthropometric measurements presented in Table 1 shall be determined. For each, the initial data (source, original, combined or pooled) as specified in 6.3, shall be documented. In addition, the same measurements shall be measured directly from the manikin when they are set to represent 5th, 50th and 95th percentiles. The difference between these values shall also be documented as a percentage of the initial value. Table 1 shows how the documentation of this comparison can be performed. The comparison will show inherent differences due to compromises on the stature path and possible choices concerning body types. For certain applications, the 1st and 99th percentile should also be used (see A.5.2).

Table 1 — Comparison between initial data and directly measured measurements of manikin in standard positions

Basic anthropometric measurements [a]	P5			P50			P95		
	Initial data	Manikin, measured	Difference %	Initial data	Manikin, measured	Difference %	Initial data	Manikin, measured	Difference %
1. Stature (body height)									
2. Sitting height (erect)									
3. Forward reach (grip reach)									
4. Shoulder breadth (bideltoid)									
5. Hip breadth, (sitting)									
6. Chest depth (standing)									
7. Body depth (standing)									
8. Chest breadth (standing)									
9. Elbow height, (standing)									
10. Shoulder–elbow length									
11. Knee height									
12. Thigh clearance									

[a] Descriptions of these anthropometric measurements are given in ISO 7250.

6.5 Assumptions and corrections — Posture

Any assumptions and corrections concerning the dimensional differences between the standardized and actual postures of the manikin shall be documented, e.g. corrections due to the effect of slump (see 4.3.1) and movement of shoulder joint (see 4.3.3). If they are an integrated feature of the manikin, they should be taken into account in the comparisons required in 6.4.