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Ergonomics of human-system interaction —

Part 5: Workstation layout and postural requirements

Ergonomie de l'interaction homme-système —

Partie 5: Aménagement du poste de travail et exigences relatives aux postures

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Contents

Page

Foreword

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This document was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*, 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 9241-5:1998), which has been technically revised.

The main changes are as follows:

— Expansion and correction of Clause 3.

— Additional information added to Clause 4.

— Additional requirements and recommendations given in Clause 5.

— Revision of Annex A.

A list of all parts in the ISO 9241 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

The purpose of this document is to promote and enhance performance and comfort while minimizing risks to users' safety and health. Users of interactive systems typically adopt a range of postures, such as seated with leaning, upright or reclining torso, standing or a combination of both. Workplaces which accommodate such usage can encourage movement, promote comfort and reduce physical, mental and visual problems.

This document is intended for use by product and workstation designers and implementers.

Ergonomics of human-system interaction —

Part 5:
Workstation layout and postural requirements

1 Scope

This document specifies ergonomic guiding principles which apply to the user requirements, design and procurement of workstation equipment for using interactive systems with visual displays.

In particular, the general principles and requirements specified in this document apply to the standards specifying technical design of furniture and equipment constituting the workplace. They are intended for use by product and workstation designers and implementers.

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 9241-11:2018, *Ergonomics of human-system interaction — Part 11: Usability: Definitions and concepts*

ISO 9241-302:2008, *Ergonomics of human-system interaction — Part 302: Terminology for electronic visual displays*

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
angle of view
angle between the line of sight and the line orthogonal to the surface of the display at the point where the line of sight intersects the image surface of the display

[SOURCE: ISO 9241-302:2008, 3.3.5, modified — Definition revised.]

3.2
anthropometric data
data relating to the study and measurement of the physical dimensions of the human body

3.3
armrest
support for the lower arms

3.4
back rest
part of a work chair which provides support for the back

3.5
castor
wheeled component on the bottom of furniture to facilitate appropriate movement on the floor surface

3.6
design reference posture
posture specified for the purpose of workstation design to define relative positions and dimensions

3.7
deviation
alteration from the neutral position

3.8
dynamic posture
body position which changes with relative movements of the limbs or other parts of the human body in relation to one another or with respect to a fixed object (e.g. a workstation)

3.9
extension
movement that increases the angle between two adjacent bones

Note 1 to entry: Dorsal pertains to the back of the hand, and palmar pertains to the palm.

Note 2 to entry: Hand extension is the movement of the hand in the dorsal direction.

Note 3 to entry: Neck extension (cervical extension) is the movement of the head backward.

3.10
flexion
movement that decreases the angle between two adjacent bones

Note 1 to entry: Palmar pertains to the palm of the hand.

Note 2 to entry: Hand flexion is the movement of the hand in the palmar direction.

Note 3 to entry: Neck flexion is the movement of lowering the chin down to the chest.

3.11
gloss
mode of appearance by which reflected highlights of objects are perceived as superimposed on the surface due to the directionally selective properties of that surface

[SOURCE: CIE S 017:2020, 17-24-080]

3.12
gloss unit
measure for quantifying the gloss of a surface

3.13
intended user population
people for whom the design is intended, specified according to relevant characteristics

Note 1 to entry: Relevant characteristics include, for example, the skill level or physical characteristics, such as anthropometric dimensions, of these people. Gender and age can be related to variations in these characteristics. In addition to these intrinsic characteristics, extrinsic factors (e. g. cultural differences) can also be relevant.

3.14
interactive system
combination of hardware and/or software and/or services and/or people that users interact with in order to achieve specific goals

Note 1 to entry: This includes, where appropriate, packaging, user documentation, online and human help, support and training.

[SOURCE: ISO 9241-11:2018, 3.1.5]

3.15
kyphosis
convex curvature of the thoracic spine

3.16
line-of-sight angle
angle between a horizontal line and the visual axis of the eye

Note 1 to entry: The visual axis of the eye is the line connecting the point of fixation and the centre of the pupil.

3.17
lordosis
concave curvature of the spine

3.18
lumbar
region of the back between the thorax and the pelvis

3.19
popliteal
of or pertaining to the back of the knee

3.20
posture
overall position of the body, or body parts in relation to each other, with respect to the workplace and its components

3.21
reference plane
surface designed to support the feet

Note 1 to entry: If not otherwise indicated, the reference plane is the ground. Any other level higher or lower than ground level may be used as a reference plane for the calculation of the height of support surfaces.

3.22
static posture
adoption of a body position which is fixed over time and where there is muscle contraction without motion

3.23
task analysis
analytical process employed to determine the specific behaviours required of people when operating equipment or doing work, including the identification of the information and controls required to accomplish those behaviours or tasks

Note 1 to entry: The task analysis is not a risk assessment of the workplace according to legal requirements.

3.24
workplace
arrangement of resources allocated to one person to complete a task

3.25
workspace
volume of space allocated to one or more persons in the work system to complete a work task

3.26
worksurface
surface on which equipment and task materials are used

3.27
workstation
assembly comprising display equipment, with or without a central processing unit, which can be provided with either or all of the following:

— keyboard;

— input device;

— software determining the operator–machine-interface

and includes optional accessories, peripherals and the immediate work environment

4 Guiding principles

4.1 General considerations

Workplace design should be based on the task requirements. Therefore, it should be preceded by an analysis of the tasks that it is to support. Such an analysis should give information about the different tasks and subtasks which are performed and about the use of related equipment. It should also identify the relative priority given to different information sources within the user's task, with respect to placement of displays, equipment location and job aids. For example, in many data-entry tasks, viewing of the hard copy has greater priority than viewing of the display. For many other tasks, the visual display is the main source of information and needs to be placed accordingly.

The task analysis should take into account:

a) major tasks and their interrelationships: frequency, importance, position of visual objects, duration and type of use of all associated equipment and their interrelationships;

b) the position and use of the hands: implications for posture, reach and device manipulation by the relative positioning of the equipment and task materials, frequency, duration and complexity of movements.

Task analysis should also reference type of work, for example individual or collaborative, as well as whether it is a shared workspace.

For the design and selection of workplaces, the following five interrelated principles apply:

— versatility-flexibility;

— fit;

— postural change;

— user information;

— maintainability-adaptability.

Clause 4 provides general principles and guidelines underlying the requirements and recommendations given in Clause 5.

4.2 Versatility and flexibility

Workstations should enable the intended user population to perform a range of tasks comfortably and efficiently. In addition, workstation design should be appropriate for the range of tasks to be performed at the workstation, taking into account user characteristics (e.g. keyboard skills, anthropometric variation and user preferences). It should also be dependent upon usage times, such that the longer the time spent at the interactive system, the more important is the observance of good workstation design.

4.3 Fit

Selection and design of furniture and equipment necessitates a fit to be achieved between a range of task requirements and the needs of users. The concept of fit concerns the extent to which furniture and equipment (e.g. work chairs, worksurfaces, visual display units, input devices) can accommodate individual users' needs.

Good fit is needed for the intended user population, including users sharing workstations and users with special needs. Fit can be accomplished by furniture built for a specified use (or user) or provided in a range of sizes and forms or by adjustability and combinations thereof.

Since workstations cannot be custom-made for individual users, except under special circumstances, some alternative forms of ensuring a good fit are needed. The extent to which the workstation provides a good fit between the requirements of users and their work should be of primary consideration.

There is an important limitation regarding the fit estimates achieved when using percentile values to define workspace parameters; for example, the use of 5th to 95th percentile anthropometric values as suggested in 5.4.2. The range between the minimal 5th percentile value and the maximal 95th percentile value always accommodates at least 90 % of the intended users for that single dimension. However, combining two or more dimensions defined by percentile values generally reduces the percentage of users accommodated. For example, a chair seat has dimensions of height, length and width. Each dimension can accommodate 90 % of the users separately, but the actual fit or accommodation on all three variables at the same time is almost always less than 90 %, theoretically ranging approximately between 70 % and 90 %. For further discussion of the limitations of percentile values in multivariate designs, see Reference [11]. For an introduction to some multivariate techniques used to estimate multivariate fit, see ISO/TR 9241-514.

4.4 Postural change

Postural change concerns the extent to which the user can move between various postures.

Postural change facilitates user performance and comfort and avoids biomechanical stress and fatigue.

NOTE Postures adopted by users and the need for changes in posture are markedly influenced by work organization and, in particular, task requirements.

The organization of the workspace and the furniture utilised should encourage active postural changes and movement.

4.5 User information

Users should be informed why and how the furniture and other devices (e.g. support for the visual display unit) should be adjusted.

Where specific skills are required for achieving a comfortable and efficient workplace, adequate user information and training in such skills should be provided. For example, in adjusting work chair or worksurface heights or finding a satisfactory viewing distance. The design of furniture should be intuitive and minimize the need for training and for user information.

Guidance and training on these factors should be given to users to ensure that they are fully acquainted with the design and functioning of the workplace and feel competent and confident to use the workplace properly. In particular, training should ensure that users are familiar with the mechanisms of adjustment and how to decide when furniture adjustment is needed for the individual user and task.

4.6 Maintainability-adaptability

Requirements for task performance, in addition to workplace design, should also take into account factors such as maintenance, accessibility and the ability of the workplace to adapt to changing requirements.

Workstation designers should take into account whether access for maintenance can be accomplished easily and how disruption to ongoing task performance can be minimized.

Workstation design should also facilitate the adaptation of furniture and equipment in response to changing requirements and circumstances.

5 Design requirements and recommendations

5.1 General

Clause 5 contains requirements and recommendations for the configuration of workstations that facilitate comfortable and efficient operation. Subclauses 5.2 to 5.7 identify the parameters aimed at accommodating an individual user in terms of performance requirements, body clearance, acceptable and preferred postures and comfort.

The main factors in determining appropriate workstation arrangements are seat and worksurface, line-of-sight angle, worksurface and keyboard height, knee clearance, forearm inclination, arm abduction and elbow height.

Furniture, equipment and work environment may be designed for use in the seated or standing position and where sitting and standing alternate. Workstations must be capable of supporting several tasks (e.g. screen viewing, keyboard input, non-keyboard input device usage, writing). Workstations should therefore be designed with such functions in mind. Work organization, job content and furniture design should encourage user movement. Prolonged static sitting posture should be minimized and continuous voluntary adjustments of the posture should be able to be made.

5.2 Postures

5.2.1 Design reference posture(s)

Requirements in relation to comfort and performance necessitate a design reference posture aligned with anthropometric data. While empirical evidence has indicated that certain postures can be comfortable for users carrying out certain tasks over short periods, they are not the optimum posture.

The following reference posture should be used for the seated position (see Annex A):

a) the thighs positioned approximately horizontally and the lower legs vertically; the seat height should be at, or a little below, the popliteal height of the user;

b) the upper arms hanging vertically with the forearms horizontal;

c) no deviation or extension of the wrists;

d) an erect spine;

e) the sole of the foot making an angle of 90° with the lower leg;

f) no twisting of the upper torso;

g) the line of sight between horizontal and 35° below the horizontal; the design reference posture is shown in Figure 1.

NOTE 1 The distance between the forearms and the thighs depends on body dimensions and body proportions and varies widely between humans. For a substantial percentage of persons, it is smaller than the distance shown in Figure 1.

The line of sight in the relaxed seated position is inclined approximately by 35° below the horizontal (see Figure 1). The optimum position for the most important visual display is within ±15° in the vertical and horizontal direction from the line of sight. If more than one display or a large display is employed, the optimum position should be taken in line with the most relevant display or image.

NOTE 2 Placing a visual display in this position can cause glare problems if certain types of luminaires are used.

In the standing position, the inclination of the line of sight is about 30° (see Figure 2).

5.2.2 Sitting postures

The purpose of well-designed seating is to provide stable support which allows movement, comfort and task accomplishment. The workstation design should allow dynamic sitting (see 5.5.3).

5.2.3 Standing and sit and stand postures

The standing posture is recommended if it can alternate with a sitting position for low back pain prevention. This can be achieved if the workplace comprises either workstations or worksurfaces for sitting and standing postures or an adjustable workstation that can accommodate the same person in the seated and standing position (see Figure 3).

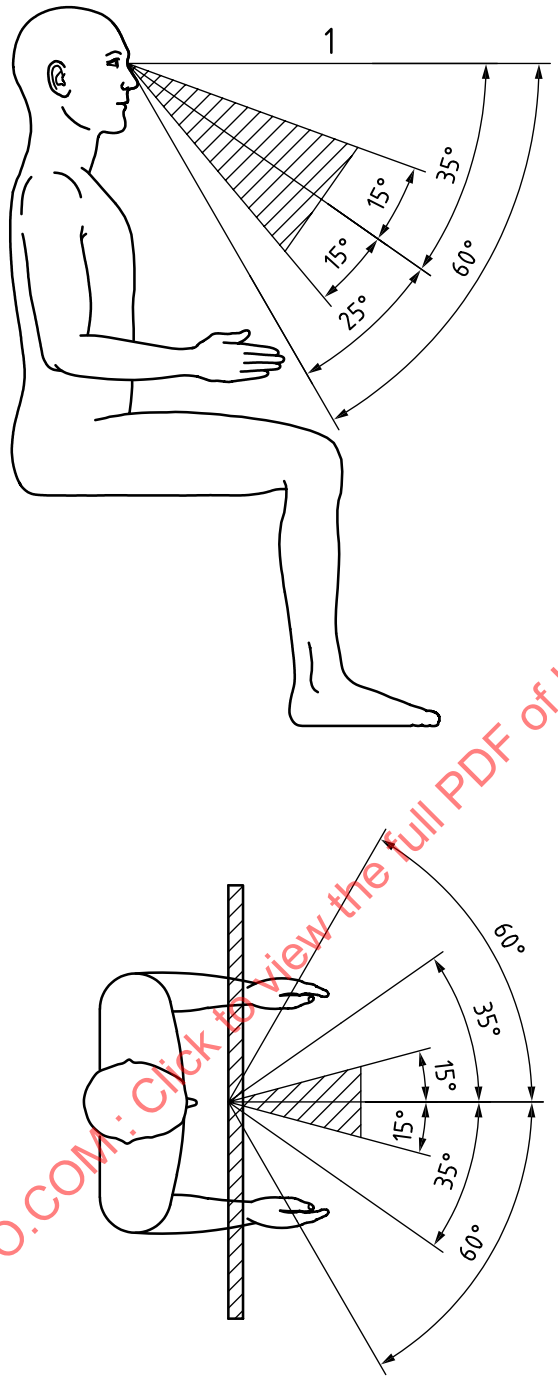
For chairs used at sit and stand workstations, stability aspects apply in both the seated and standing positions.

5.2.4 Intermediate postures between sitting and standing — Semi-standing

Sitting and standing postures are not the only alternatives users can take when working at adjustable workstations. A semi-standing posture is one between sitting and standing, where the seat and worksurface are slightly higher than normal. This elevates the person to a height where their pelvis is in a higher position to their knees and allows for the pelvis to be anteriorly rotated. In this position, a user's weight is distributed between their buttocks and feet, while their feet are flat on the floor. Typically, in this posture, the angle between the trunk and thigh is 128° ± 7° (see Reference [8]).

The seat should accommodate such positions by sloping, flexing or moving, so as to not pinch or cause irritation to the backs of the users' legs. When working in a semi-standing posture, pelvis and spine can find a more neutral position, where less lumbar support is needed to maintain a stable upright position. Additionally, as some extra weight is borne through the legs in a semi-standing posture, users can increase movement in the lower body as a result.

An elevated worksurface is also needed in order to move either the work or visual display, or both, to an appropriate height and to prevent slouching.

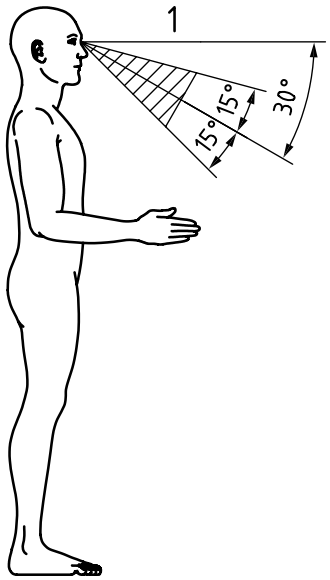


Key

1 horizontal

NOTE This posture serves solely for design purposes; it is not the optimum posture for sedentary work. The striped area (±15º) marks the optimum position for placing the most important visual items.

Figure 1 — Design reference posture for sitting position



Key

1 horizontal

NOTE This figure shows one way in which a workstation can support the postural change. The striped area (±15º) marks the optimum position for placing the most important visual items.

Figure 2 — Design reference posture for standing position

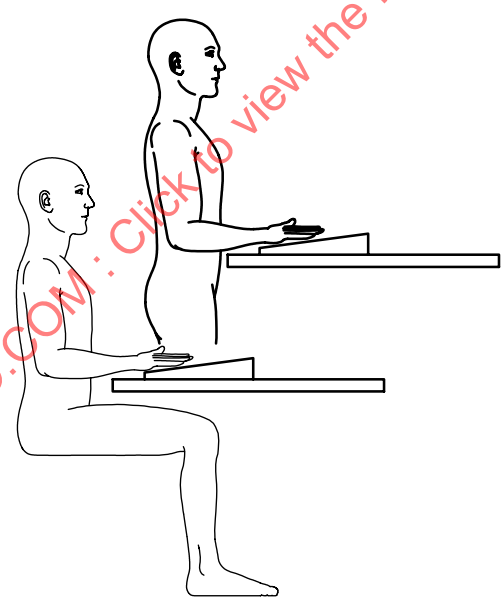


Figure 3 — Sit and stand posture and postural change support

5.3 Ease of adjustment

Ease of adjustment is not the ultimate goal of a design process. Eliminating the need for active intervention by the user should be considered. If this is not feasible, a substitution by simpler control mechanisms should be considered. Appropriate engineering of adjustment controls is needed if both fail.

Furniture adjustment controls should be convenient and designed so that they encourage correct use (see 4.5). For the design and placement of controls, the principles described in ISO 6385 apply.

— They should be operable from the usual working position.

— They should not need undue force for actuation.

— They should not need any special training or special tools before adjustment can be made.

— Controls should be designed to prevent unintentional actuation.

— Actions of controls should be intuitive.

The following criteria should be considered for placing adjustment controls:

— system engineering factors, e.g. nature and frequency of use;

— placement of the equipment;

— location(s) for the performance of task elements;

— placement of the furniture with relation to walls and partitions;

— ambient environmental conditions;

— placement of additional items (e.g. filing cabinets).

The controls should be designed so as not to pose a safety problem during actuation. When the controls are not in use, they should not violate the clearance envelopes under worksurfaces specified in 5.4.2.

5.4 Support surfaces

5.4.1 General recommendations

The worksurface should provide support for display and input devices, associated equipment and material, as well as for the hands and arms of the user.

Support surfaces for displays and input devices and associated equipment and materials should allow adequate clearance for the user's anthropometric characteristics and postural changes.

For input device use, the height of the support surface should allow comfortable and efficient posture of the upper arms, forearms and hands. The furniture should therefore be sufficiently flexible to allow postural changes and to provide sufficient comfort to conduct the tasks efficiently. The worksurface should be height adjustable and, when required by the task, tiltable.

For most workstations, it is important to consider a keyboard and a pointing device. ISO 9241-410 defines a minimum of two keyboards (full-size and compact keyboard). For interactive systems, the keyboard to be used can range between a numeric pad with some function keys and a full-size keyboard with all four sections (alphanumeric, numeric, editing and function sections). In addition, a variety of pointing devices from pucks to touch-sensitive screens are described.

The space requirements for input devices (size, shape and location) depend on the combination selected for a given task. The design of a workstation for a known task should include sufficient support for all intended input devices (ease of operation and ease of access). If the intended use of a workstation is unknown, it should be possible to comfortably use a full-size keyboard and a mouse right and left of it.

5.4.2 Clearances under worksurfaces

For seated and standing work, sufficient vertical, horizontal and lateral clearance between the torso and lower limbs of users (legroom height, width and depth) and workstation components (e.g. underside of worksurface, desk drawers, table legs) is needed. The considerations are for:

— postural changes and comfort;

— ease of use of the equipment and associated tasks;

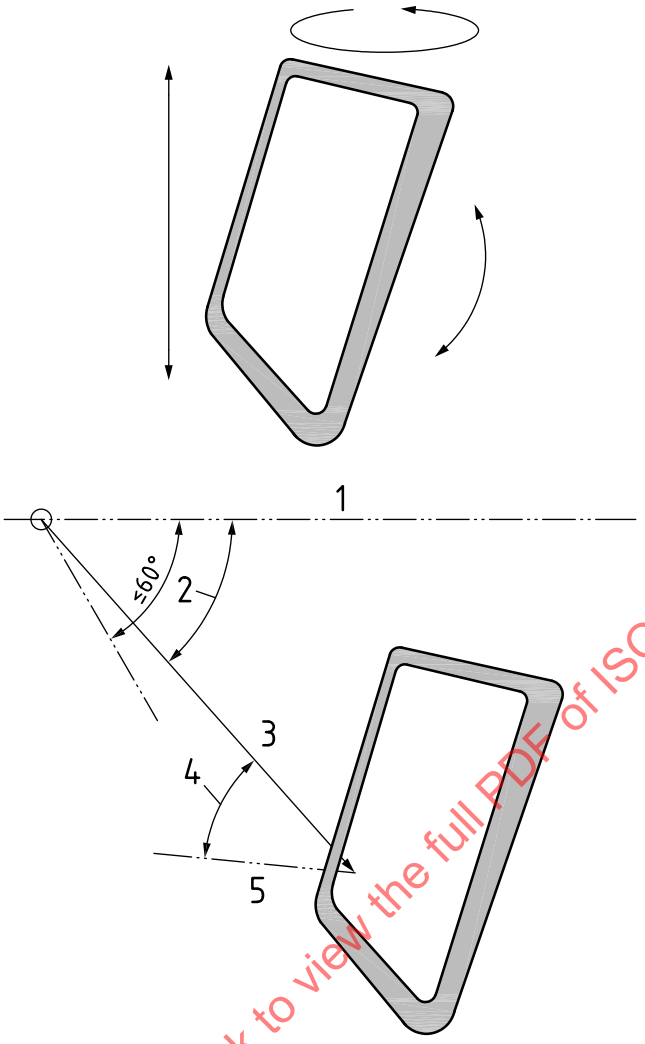
— safety (stability, structural integrity, lack of injury);

— ease of standing and sitting.

These considerations apply to single workstations and combinations of workstations. The main considerations are for clearance for thighs, knees, lower legs and feet. Furniture designed to accommodate a specified user population shall achieve fit for the range suitable for the intended user population. This range can be covered by applying the concept of fit. If fit (in vertical, lateral and horizontal directions) is achieved by adjustable surfaces only, it shall be able to accommodate a minimum range from the 5th percentile female (at the lower setting) to the 95th percentile male (at the upper setting) of the intended user population. While designing non-adjustable furniture as industrial products, the clearance envelope for 95th percentile males shall be used. Where particularly tall or particularly short individuals are not accommodated by such requirements, and depending upon task and criticality factors, they can often require other approaches to fit (e.g. custom built). General guidance is given for information in Annex A.

5.4.3 Viewing distances and angles of view

The user should be able to angle, tilt or swivel the visual display unit in such a way that she or he maintains a relaxed working posture regardless of the eye height, minimizes accommodative effort and avoids disturbing reflections and glare. Height adjustment is also preferred (see Figure 4). Adjustability should be achieved by mechanisms built into the visual display unit or by special device(s) which form part of the furniture or the display itself. It should not be dependent upon the user propping up the unit with objects such as books or manuscripts. Mechanisms of adjustment should be intelligible, unambiguous and easy to operate.



Key

1 horizontal
2 line-of-sight angle
3 line of sight
4 angle of view: 40° max.
5 surface normal

Figure 4 — Recommendations for adjustability and angles of view

The angle of view (optimum 0°) should not exceed 40° anywhere on the active display area. The extent to which the angle of view can be greater than 0° without affecting the visibility of the information (acceptable visual performance) depends on the display technology. Specific constraints over viewing distances and angles should be considered in relation to users' visual correction and age. More importantly, viewing distances and angles should be related to task requirements and support a neutral working posture.

5.4.4 Finish of the worksurface

The finish of the worksurfaces should not exceed silky matt (corresponding to 45 gloss units or to a 60°reflectometer value of less than 20), in order to minimize specular reflections (see ISO 2813). Reflectance values for the visible parts of the worksurfaces should be selected to avoid undue luminance contrast to the equipment and other items within the field of view.

There should be no sharp edges or corners on worksurfaces or the accessible parts of the supporting framework which can cause injury or discomfort to users. The minimum radius on edges and corners should be 2 mm. However, a larger radius is recommended.

5.4.5 Safety and stability aspects of workstations

The level of inherent or transmitted vibrations should be as low as possible, suitable to the task and to ensure safe and comfortable use of the workstation and equipment.

The worksurface, loaded with intended equipment, should not tip over if a person leans on any side or sits on the edge. Parts of the equipment should not tip over when loaded with intended work items (e.g. paper, visual display units) and operated as intended.

NOTE In many countries, there are safety and stability requirements for workstations. The methods for testing such requirements are governed by local safety regulations.

If tables are height adjustable, the adjustment shall be stable and safe. Special attention should be paid to electrical and mechanical safety and shear and compression risks posed by the electrically operated worksurfaces or desks.

If drawers are part of the workstation, it shall not be possible to pull a drawer out unintentionally so that it falls.

5.4.6 Energy loss to contact surfaces

The worksurface and parts of the supporting framework which come into contact with the user during the intended use should not allow undue loss of energy from the body.

5.5 Work chair

5.5.1 General considerations

The purpose of good seating is to provide stable body support in a dynamic posture which is comfortable over a period of time, physiologically satisfactory and appropriate to the task or activity which is to be performed. The main considerations are that:

a) blood circulation in the lower limbs is not restricted;

b) it is easy to maintain and change posture;

c) support is provided for the spine;

d) the seat surface has a sufficient level of friction to avoid sliding off the seat;

e) for comfort, the surface is permeable to air and sweat.

Subclauses 5.5.2 to 5.5.5 specify requirements and recommendations to achieve these aims.

5.5.2 Parameters related to fit

5.5.2.1 Relevant design parameters

Fit is required for the following design properties (see Table 1):

— seat height;

— seat depth;

— seat width;

— back support;

— arm support, if provided.

Table 1 — Design properties and relevant reference parameters

Design property	Relevant reference parameters (see Annex A)
Seat height	Popliteal height, sitting
Seat depth	Buttock-popliteal length
Seat width	Maximum hip breadth, sitting
Back support	Height of the mid lumbar area over the seat[a]
[a] This is not an anthropometric dimension that is not easily measured and is not generally available in datasets.	

5.5.2.2 Seat height

The appropriate seat height for a user sitting in the upright position is the popliteal height plus the thickness of footwear. Work chairs designed to accommodate a specified user population shall achieve fit for the range suitable for the intended user population. This range can be covered by applying the concept of fit. The extent to which fit can be achieved by a certain design can be calculated using the methods described in ISO/TR 9241-514.

Within a selected range of adjustability, the seat height shall be user adjustable.

5.5.2.3 Seat depth

The fit for seat depth is achieved if the depth is less than the buttock-popliteal length of the user. Work chairs designed to accommodate a specified user population can achieve fit by either adjustability or by using different sizes of the seat pan for the range suitable for the intended user population.

Adjustable seat depth can be achieved either by adjusting the back rest in relation to the seat or by moving the seat pan in relation to the back rest. If the seat depth is fixed, priority should be given to proper back support since proper back support is more important than the support of the whole length of the thighs. The seat depth can also be adjusted by extending the front edge of the seat.

5.5.2.4 Seat width

For seat width, fit is achieved when the seat width is wider than the width of the hips. Work chairs with armrests designed to accommodate a specified user population should achieve fit for the maximum width of the hips.

5.5.3 Dynamic aspects of seating

5.5.3.1 Relevant design parameters

Together with job content and the design of other furniture elements, seating design plays an important role in encouraging movement. Thus, seat design should allow frequent posture adjustments by the user.

Four major aspects of seat design contribute directly to this goal: seat angle, movement of the seat pan and back support, castors and swivel.

5.5.3.2 Seat angle

The seat angle should allow users to vary their posture forward and backward. The benefit of changing postures in these directions is to ensure a good blood flow.

Seats may be designed with a fixed or adjustable seat angle. Adjustable seat pans may incorporate a forward as well as a rearward tilt.

5.5.3.3 Movements of the seat pan and back support

The inclination of the seat pan and the recline of back support should allow users to vary their posture to suit user comfort and changes to task requirements. The movements of the seat pan and the back rest can occur independently from each other, with one of the two elements fixed, or the angle can open up by simultaneous movement of the seat pan and the back rest in a preset ratio greater than one.

The design should take into account that users should be able to change positions at any time.

The 5th percentile female through the 95th percentile male user should be able to move throughout the full range of backrest angle movement, maintain the fully reclined position and return to the upright position without undue effort.

5.5.3.4 Castors

Castors are generally recommended for work chairs used at workstations to enable users to easily and safely move for short distances within the workstation to facilitate desired proximity to equipment that supports changing task requirements.

The type of castor shall suit the properties of the floor surface. The work chair shall not travel unintentionally when occupied or unoccupied. The work chair shall not move away easily when unoccupied. Castors with a low resistance cannot be used safely on a hard floor surface.

5.5.3.5 Swivel

The swivel should enable users to easily and safely rotate their body orientation without rotating the spine or twisting the torso in order to facilitate desired proximity to equipment that supports changing task requirements.

5.5.4 Back support

The back rest should be capable of providing support to the back of the user in all sitting positions. Back rests can be designed to give support for different parts of the back.

Back rests should be designed to give support particularly for the lumbar region of the body. The pelvis should be supported in order to prevent it from rotating posteriorly. Providing support for both the lumbar and pelvis will help aid lordosis and prevent kyphosis. Postural changes should also be supported by movement of the back rest and seat-pan (see Figure 5).

For chairs designed with an opening between the back rest and the seat, the back rest should:

— commence at a level which clears the major protuberances of the buttocks;

— have a maximum prominence in the mid-lumbar region (to aid lordosis and to prevent kyphosis).

Chairs with low height back rests should conclude below the level of the shoulder blades, so as not to inhibit upper body movement.

For some types of work where reclining posture is essential or preferred, higher back rests which also provide support for the shoulder blades are recommended. Depending on the recline angle, a headrest or neckrest can provide support for the user's head and neck when working in a reclined posture.

Higher back rests should have a forward convexity in the lumbar region which gently merges into a plane surface or concavity.

5.5.5 Arm support

For special working tasks and for moments when work is interrupted, armrests can support the muscular system of neck and shoulders and can be an aid to standing up and sitting down. For armrests with height

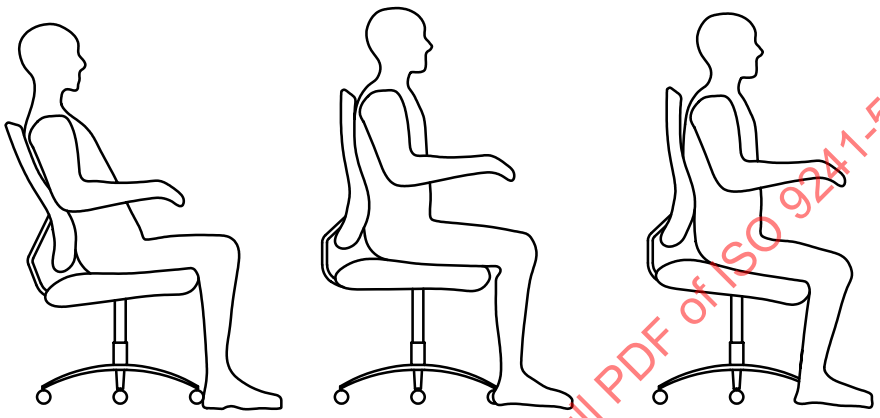
and width adjustability, the range should cover the range from 5th percentile female to 95th percentile male of the intended user population. Where armrests are provided, they:

a) should be height and width adjustable — the range should cover the 5th percentile female to 95th percentile male of the intended user population;

b) should adjust both front and back to allow users to adjust the armrest to a position that best fits them;

c) should not restrict the user's preferred working posture — if armrests obstruct the user, they should be adjustable or detachable;

d) should not restrict ease of access to the workstation — in particular, the protrusion of armrest pads should not prevent users from getting close to the worksurface.



NOTE This figure shows a support for postural changes by movement of the back rest and seat-pan.

Figure 5 — Support for postural changes

5.6 Additional support elements

5.6.1 Document holders

In tasks where the user works from hard copy, a document holder is recommended. It allows the source document to be positioned at a height, visual distance and plane similar to that of the display itself. The document holder reduces the amount of head, neck and eye movement required when scanning between different visual objects. To accommodate variations in legibility of source documents and visual requirements of individual users, the document holder should be adjustable both in angle and distance. Document holders that are to be placed at the same height as the visual display unit should be height adjustable.

The document holder should be of a size that comfortably accommodates the size of the documents, preferably slightly smaller than the size of the documents in both directions to allow easy access. The surface of the document holder and ruler should be non-glossy. No light should be transmitted through the document holder in order to avoid impairments of the readability of source documents. The document holder should be stable so that it is unaffected by movement of the worksurface and sufficiently robust to support heavy documents where they are needed.

5.6.2 Footrest

A footrest can be an additional support to obtain a comfortable angle between legs and feet and a means to create variations in the work postures. A foot support shall be supplied and used in cases where the work chair height is to be set in a position which does not allow a user's feet to rest flat on the floor.

It should be possible to position the footrest on the floor where needed and it should not move unintentionally while in use. Its surface should be nonslip and of sufficient size to allow some freedom of movement. The inclination of the support surface should be adjustable.

5.6.3 Support for the hands, wrists and forearms

Positioning of keyboards and of other input devices and provision of support for the hands, wrists and forearms should aim to reduce static loading of the upper limbs, reduce the work of neck and shoulder muscles and reduce the need for undue flexion, extension and deviation of the wrists. The operation of some input devices can require the anchoring of the body parts needed for holding and controlling the device on the worksurface.

Support can be accomplished by the following:

a) The provision of a free space of sufficient depth (at least 100 mm) on the support surface immediately in front of the input device. Care should be taken that the leading edge of the worksurface is designed so as not to cut into the wrist.

b) Incorporating a hand support into the design of the device.

c) Providing a hand or wrist support separately from the input device. The usefulness of such a device depends upon the characteristics of the workstation (especially keyboard design), the keying skill of the user and preferred posture.

The design of a separate hand or wrist support should incorporate the following features:

1) Since the hand or wrist support is used only occasionally or intermittently while the hands are resting, the design should minimize static posture and should not restrict the keying action or preferred working posture of the user in any way.

2) The surface geometry should match the height and slope of the keyboard surface.

3) The depth should be 50 mm to 100 mm, depending on the design of the specific input device.

4) The leading edges should be designed so as not to cut into the wrist or hand.

5) The width should be at least that of the keyboard or adequate for the task.

6) The support should be stable during use.

5.6.4 Workstations with monitor arm

Monitor arms can help organize workstations with multiple monitors without losing space under them. Good monitor arms include standard mounts that serve a range of sizes of mountable monitors. They can help adjust the monitor height from a sitting to a standing posture.

Thus, under special circumstances, the use of monitor arms can be helpful or even necessary (e.g. where worksurface space is limited). They provide 3D positioning of the screens and therefore support postural changes without changing the main support surface.

Where a monitor arm is installed, it is important to ensure that, in addition to the other requirements given in this document, the following are met:

a) the height of the top line on the display is not higher than eye-height;

b) the design mechanism and height adjustment ensure mechanical stability;

c) the dimensions of the display support on the monitor arm are commensurate with the size of the visual display unit and provide a secure footing for the equipment on the display support, for example in the form of recesses for the feet or raised edges.

To be usable, monitor arms should be securely mounted at the workstation. They should be easy to adjust in all directions and maintain their intended position.

5.7 Layout of workstations within the workspace

5.7.1 General considerations

The layout of workstations within a workspace should be planned and carried out by taking into account the relevant factors set out in ISO 6385. Special attention should be paid to the following:

a) Access for the user: the design of the workstation and its position within the workspace should not restrict a user's access to their workstations.

b) Access for maintenance purposes: the design of the workstation and its position within a room should not restrict access to parts of the equipment, positions of wiring or plug sockets for maintenance purposes.

c) Working groups: work flow, task requirements and social aspects.

d) Space availability: constraints (e.g. caused by artificial and natural lighting).

e) The need for shared workstations.

f) Lighting (see ISO 9241-6).

g) Access for cleaning purposes.

For detailed guidance, see ISO 9241-6.

5.7.2 Cable management

Cable management shall be planned and carried out by taking into account the layout of the workstations within a work environment.

The distribution of wiring and cables (e.g. mains, data, telephone) should be considered in relation to users' needs. Cable management should be arranged so that the following recommendations are met:

a) Safety: Connections should be securely fastened so that they do not represent a hazard by trailing across worksurfaces or floors. These should be carried in horizontal or vertical ducting to the required point.

b) Length: The length of the cables should be sufficient to accommodate actual and foreseeable user needs, taking particular note of a likely rearrangement of room layout. This includes the provision of excess space capacity in ducting for new cables.

c) Accessibility: The workstation should allow easy access for maintenance and cleaning without undue disruption to work activities.

d) Adjustable worksurfaces: The cabling should be capable of covering the total adjustment range if adjustable surfaces are provided.

6 Conformity

Conformity with this document can be achieved by meeting all the requirements specified in Clause 5.

Conformity with this document can only be achieved in relation to a specified user population, that is, the "intended user population". Unless otherwise declared, the intended user population is not restricted to certain user groups.

Current design practice for industrial products takes the relevant anthropometric dimensions of the 5^{th} percentile of female to 95^{th} percentile male working population into account. The relevant anthropometric dimensions are contained in Annex A.

Local safety regulations should be considered.

7 Measurement

7.1 Support surfaces

Adherence to 5.4.2 at a workstation is achieved if the height of the legroom is greater than thigh clearance height, sitting + popliteal height, sitting + allowance for footwear (see Annex A). For the design of industrial products, calculate the clearance using the statistical values for the intended user population. For furniture with fixed height, use thigh-clearance height and popliteal height, sitting for the 95th percentile male of the intended user population.

7.2 Safety and stability aspects of workstations

Adherence to 5.4.5 is achieved if all user-adjusted positions of support surfaces remain unchanged.

If the workstation is equipped with drawers, they must be protected against being pulled out completely during intended use (the pulling force exerted in the direction of movement).

7.3 Seat height

Adherence to 5.5.2.2 is achieved if the variability of the seat height is sufficient to allow persons from the 5th percentile female to 95th percentile male of the intended user population to adopt the design reference posture.

7.4 Castors

Adherence to 5.5.3.4 is achieved if castors for the specific type of floor surface (hard or soft) are used. The testing of resistance to unintentional travel is typically part of local safety testing of work chairs.

7.5 Layout of workstations within the workspace

Adherence to 5.7.2 can be achieved by producing a report stating how cable management has been planned, taking the layout of the workstation within the environment into account.

Annex A
(informative)

Anthropometric data needed for workstation design and selection

A.1 Selecting an anthropometric data set

When selecting anthropometric data sources, it is important to know how they have been derived and what factors govern their relevance to the required use.

In the context of International Standards, it is important that the anthropometric data set chosen should adequately reflect the body sizes and shapes of the intended user population.

If the anthropometric data have been collected from a small number (e.g. a sample of less than 1 000) or highly specific group of people, it is not likely to be appropriate for use in designing for the general population. However, a number of data sets are available which avoid these problems, either by being collected from very large samples or by the careful use of statistical techniques to extrapolate from smaller, but representative, data sets. The data used in furniture design should therefore be representative of a group closely related to the group being designed for and preferably from a large sample. In relationship to furniture design, this should be the adult population. In defining "adult", note that young people are not fully grown until the age of approximately 21. Therefore, an age range of 16 to 65 shall be defined in order to accommodate the working population.

Anthropometric data are usually separated into gender and age groups. This can be useful if the design is specifically for use by a single sex group or for a specific age range. However, if this is not relevant, the data from different groupings can be combined.

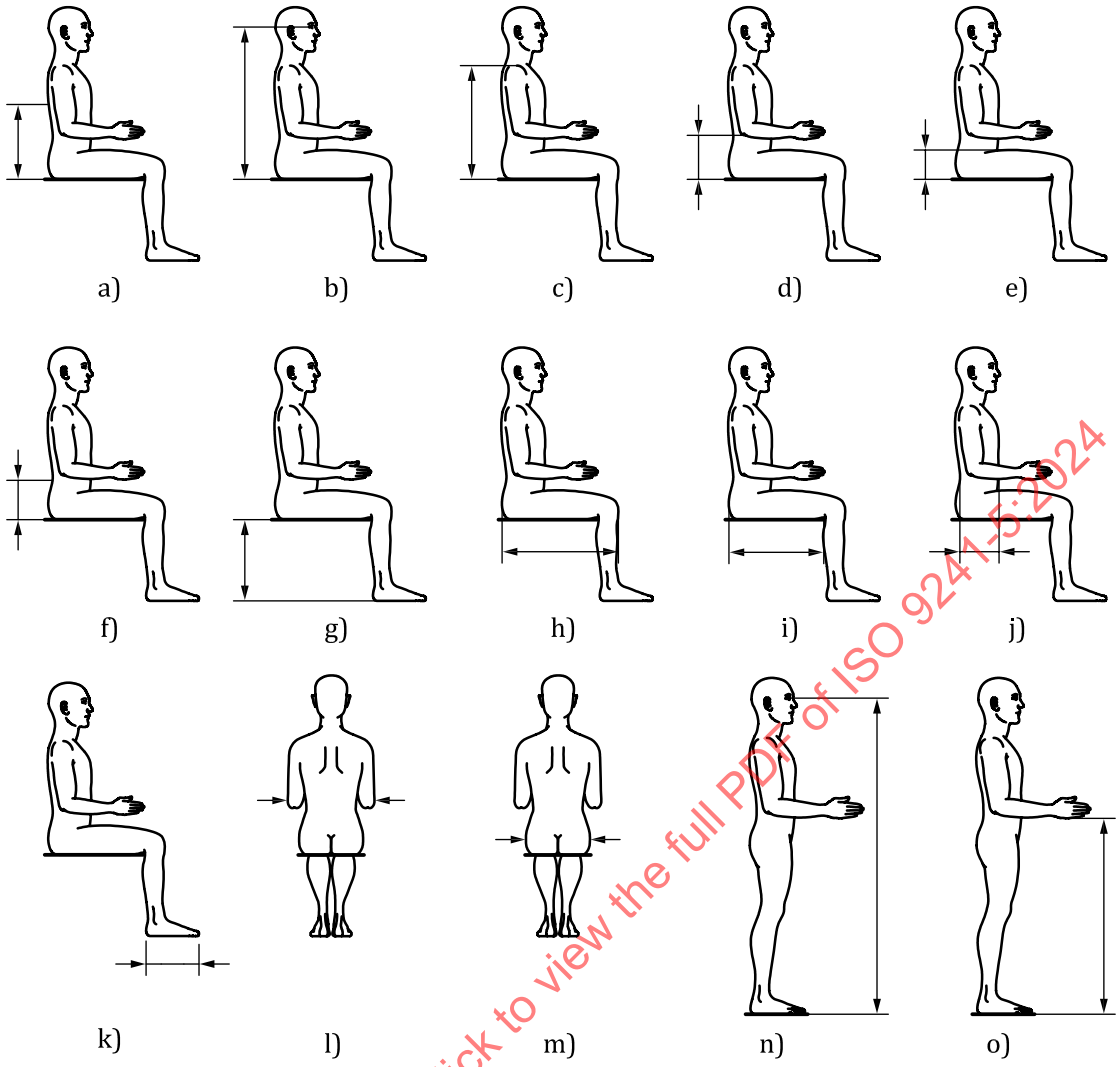
Most anthropometric data have been collected from nude, or near-nude, subjects, so some allowance needs to be made for clothing. Some data sources, however, already include clothing allowance on certain dimensions; it is therefore extremely important to read the information provided with the data very carefully before using it. Table A.1 shows some useful indicators of the type of allowance.

Table A.1 — Clothing and related allowances

	Dimension	Allowance
1	Seat height	+30 mm footwear
2	Seat depth	-10 mm clearance allowance
3	Width between armrests	+4 mm for clothing allowance
4	Height clearances for legs, knees and feet	+30 mm footwear
5	Depth clearance for knees and feet	+45 mm movement allowance
6	Width clearance for legs	+45 mm movement allowance
7	Worksurface height for input devices, sitting and standing	+30 mm footwear -25 mm input device thickness
8	Sitting and standing eye height	+30 mm footwear

Clothing and related allowances for other dimensions are minimal for indoor clothing under moderate temperature ranges.

For the purpose of workstation design, there are only a small number of external body dimensions of primary importance to be considered, as shown in Figure A.1. Definitions are derived from ISO 7250-1. For each dimension given, the relevant letter from Figure A.1 is shown.



Key

a	height of bottom corner of scapula	i	buttock popliteal length
b	eye height, sitting	j	buttock abdomen depth, sitting
c	shoulder height, sitting	k	foot length
d	elbow height, sitting	l	elbow-to-elbow breadth
e	thigh-clearance height, sitting	m	hip breadth, sitting
f	buttock height above seat level	n	eye height, standing
g	popliteal height, sitting	o	elbow height, standing
h	buttock knee length		

Figure A.1 — Important anthropometric dimensions for determining design of sitting and standing workplaces

NOTE See 4.3 regarding the estimation of anthropometric fit when combining multiple percentile values.

A.2 Use of selected anthropometric dimensions: seated posture

A.2.1 General

The relationship between anthropometric dimensions and some specified design parameters is summarized in Figure A.2. For actual workplace specifications, anthropometric data based upon the intended user population should be used.