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Ergonomic requirements for office work with visual display terminals (VDTs) —

Part 9:
Requirements for non-keyboard input devices

Exigences ergonomiques pour travail de bureau avec terminaux à écrans de visualisation (TEV) —

Partie 9: Exigences relatives aux dispositifs d'entrée autres que les claviers

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 part of ISO 9241 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 9241-9 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*.

ISO 9241 consists of the following parts, under the general title *Ergonomic requirements for office work with visual display terminals (VDTs)*:

— *Part 1: General introduction*

— *Part 2: Guidance on task requirements*

— *Part 3: Visual display requirements*

— *Part 4: Keyboard requirements*

— *Part 5: Workstation layout and postural requirements*

— *Part 6: Guidance on the work environment*

— *Part 7: Requirements for display with reflections*

— *Part 8: Requirements for displayed colours*

— *Part 9: Requirements for non-keyboard input devices*

— *Part 10: Dialogue principles*

— *Part 11: Guidance on usability*

— *Part 12: Presentation of information*

— *Part 13: User guidance*

— *Part 14: Menu dialogues*

— *Part 15: Command dialogues*

— *Part 16: Direct manipulation dialogues*

— *Part 17: Form filling dialogues*

Annexes A, B, C and D of this part of ISO 9241 are for information only.

Introduction

Non-keyboard input devices are commonly used by operators to perform tasks with interactive office computer systems. Input device design can have a significant impact on efficiency, effectiveness and satisfaction. The requirements and recommendations are based on ergonomic principles.

The design requirements and recommendations are intended to address the fifth to ninety-fifth percentile of the population. However, when possible, non-keyboard input devices should be designed to accommodate the anthropometric characteristics of the intended user population.

Annexes A to D are included to provide information on potential methods of testing input devices and to encourage institutions or individuals to conduct research on these methods such that further validation can be supplied.

Ergonomic requirements for office work with visual display terminals (VDTs) —

Part 9:
Requirements for non-keyboard input devices

1 Scope

This part of ISO 9241 provides requirements and recommendations for the design of non-keyboard input devices. It only includes devices for which there exists sufficient published ergonomic information.

This part of ISO 9241 applies to several types of non-keyboard input devices designed for stationary use. It provides guidance based on ergonomic factors for the following input devices: mice, pucks, joysticks, trackballs, tablets and overlays, touch-sensitive screens, styli, and light pens. It gives guidance on the design of these devices used for typical office tasks so that the limitations and capabilities of users are considered. This part of ISO 9241 specifies methods for determining conformance through observation, performance, and by measuring the physical attributes of the various devices.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 9241. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 9241 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 9241-3, *Ergonomic requirements for office work with visual display terminals (VDTs) — Part 3: Visual display requirements*.

ISO 9241-3:1992, Amendment 1:—[1)], Annex C (normative): *Visual performance and comfort test*.

ISO 9241-5, *Ergonomic requirements for office work with visual display terminals (VDTs)— Part 5: Workstation layout and postural requirements*.

ISO 9241-7, *Ergonomic requirements for office work with visual display terminals (VDTs) — Part 7: Requirements for display with reflections*.

ISO 9241-8, *Ergonomic requirements for office work with visual display terminals (VDTs) — Part 8: Requirements for displayed colours*.

ISO 13406-2, *Ergonomic requirements for work with visual displays based on flat panels — Part 2: Requirements for flat panel displays*.

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1) To be published.

3 Terms and definitions

For the purposes of this part of ISO 9241, the following terms and definitions apply. The illustrations of the devices used in this clause do not necessarily represent the design requirements and recommendations of this part of ISO 9241.

3.1 Actions

3.1.1
click
depression and release of a button or actuation point on an input device

3.1.2
drag
moving one or more objects on a display by translating it along a path determined by a pointer

3.1.3
free-hand input
input where the input device controls the movement of the cursor without any constraints following the manual input of the user

3.1.4
pointing
operation with a graphic user interface in which an input device is used to move a small display image (such as a pointer) to a specific location on the display

3.1.4.1
direct pointing
hitting a target unaided by system feedback

EXAMPLE By direct pointing with a finger or stylus.

3.1.4.2
indirect pointing
using system visual feedback to hit a target

EXAMPLE When the system is controlling a screen pointer in response to a mouse movement.

3.1.5
selecting
choosing one or more items on a display

3.1.6 Touch strategies

3.1.6.1
first-contact touch strategy
actuation of display area upon touching the display surface

3.1.6.2
last-contact touch strategy
actuation of display area upon withdrawing touch from the display surface

3.1.7
tracing
following the outline of an image by moving the cursor or input device over the lines or shape of an image

3.1.8
tracking
moving a pointer or predefined symbol across the surface of a display screen in order to follow a target

3.2 Feedback

3.2.1
feedback
indicators (such as tactile, auditory or visual) sensed by a user of an action (such as movement or actuation of an input device)

NOTE Display feedback refers to a change on the display resulting from an input device movement or activation.

3.2.1.1
kinesthetic feedback
action perceived by the mechano-receptors in joints, muscles, and tendons resulting in awareness of position, movement, weight, and resistance of the limbs or other body parts

3.2.1.2
tactile feedback
indication of the results of a user action transmitted through the sense of touch

3.3 Hardware

3.3.1
button
mechanical object integrated into an input device, which responds to force when depressed, and provides input to the computer

3.3.2
goniometer
instrument which measures the angle of the joints

3.3.3
input device
user-controlled device that transmits information to a system

3.3.4
joystick
lever mounted on a fixed base (see Figure 1) used to control the movement of objects displayed on a screen and which controls the relationship between the force or movement applied to the lever and the movement of a pointer

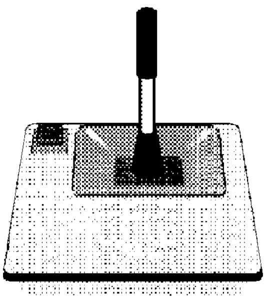


Figure 1 — Side view of example of a joystick

3.3.4.1
displacement joystick
joystick with a lever that tilts in the direction of applied force from a home position moving the display pointer in proportion to the displacement distance

3.3.5
light-pen
light-sensitive input device that, when pointed onto a specific location on a display, identifies its position to the system (see Figure 2)

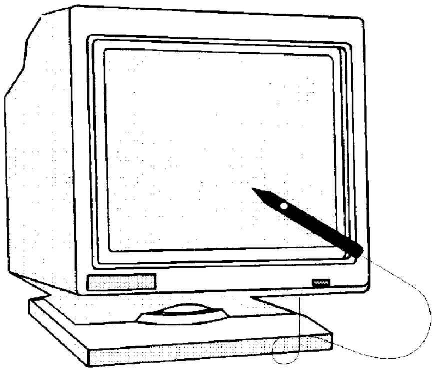


Figure 2 — Example of a light-pen against a display

3.3.6
mouse
computer input device having one or more buttons and capable of two-dimensional rolling motion which can drive a cursor on the display and performs a variety of selection options or commands

3.3.7
overlay
thin template on the surface of a tablet (see Figure 3) used to indicate the graphic functions available to the user

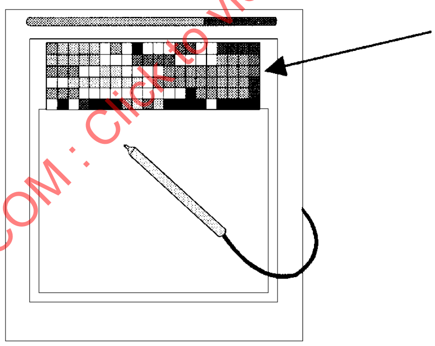


Figure 3 — Top view of example of a tablet with a graphic overlay (indicated by arrow)

3.3.8
palm rest
surface which supports the palm of the hand when using an input device (see Figure 4)

NOTE A palm rest is smaller than a wrist rest which provides support for both the palm and wrist, or the wrist only.

Figure 4 — Top view and side view examples of palm rests used with mice

3.3.9
pointer
symbol on a display which indicates the input or selection position whose movement is controlled by an input device

3.3.10
puck
hand-held device similar to a mouse but with a reticle view port and that is typically used with a digitizing tablet (see Figure 5)

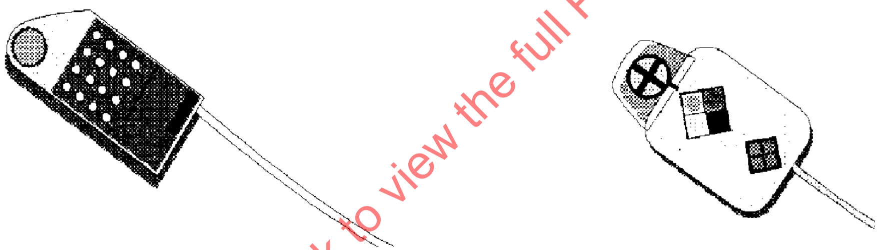


Figure 5 — Top view examples of two types of pucks

3.3.11
reticle
orthogonal lines in the lens of a puck used to visually align the puck to an image (see Figure 6)

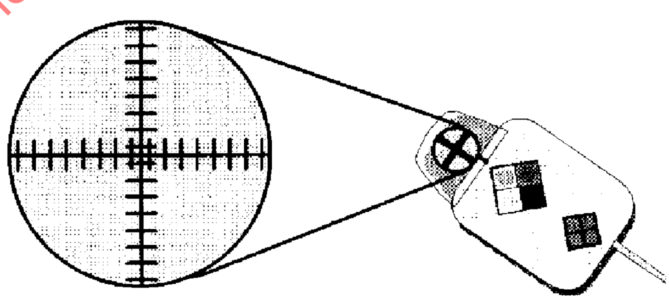


Figure 6 — Top view of example of a puck with reticle (indicated in exploded view on left)

3.3.12
selector button
actuator located on an input device

3.3.13
stylus
pen-shaped pointing device which, when touched to a display or graphics tablet (see Figure 7), can be used to draw images on a display or select displayed objects typically by depressing the stylus tip or actuating a button located along the side of the stylus

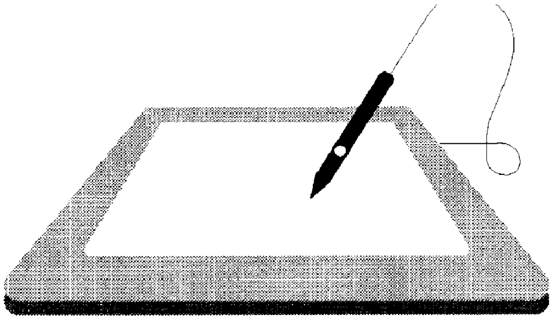


Figure 7 — Side view of example of a stylus over a graphics tablet

3.3.14
tablet
special flat surface with an input device (such as a stylus or puck) for selection, drawing, or indicating position of images to be displayed (see Figure 3)

3.3.15
touch-sensitive screen (TSS)
input device that produces a position and selection input signal from a finger touching, lifting off, or moving across a display

3.3.16
trackball
ball in a fixed housing that can be rolled in any direction by the fingers to control pointer movement, and that often has adjacent buttons (see Figure 8)

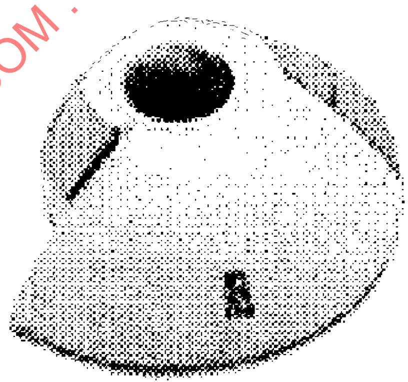


Figure 8 — Example of top view of a trackball device with buttons

3.3.17
workstation
assembly comprising display equipment with or without a central processing unit, which may be provided with a keyboard and/or input device and/or software determining the operator/machine-interface, optional accessories, peripherals and the immediate work environment

[ISO 9241-5:1998]

3.4 Measures

3.4.1
biomechanical load
effect of work posture and effort on the musculo-skeletal system

3.4.2
colour difference
difference between two colour stimuli, defined as the Euclidean distance between the points representing them in the CIE 1976 L*u*v*

NOTE See ISO 9241-8:1997.

3.4.3
design reference posture
posture specified for the purpose of workstation design to define relative positions and dimensions

[ISO 9241-5:1998]

3.4.4
design viewing distance
distance or range of distances (specified by the display supplier) between the screen and the operator's eyes for which the images on the display meet the requirements of this part of ISO 9241, such as that character size, raster modulation, fill factor, spatial instability (jitter) and temporal instability (flicker)

NOTE Adapted from ISO 9241-3:1992.

3.4.5
gain
relationship of the movement or change of an indicator on a display to the movement of a control

3.4.6
intended user population
groups of human beings for which a product or a workstation is designed

EXAMPLE Male and female workers of Southeast Asian origin aged between 45 and 65 years.

3.4.7
movement time
time to move a pointing device from a start position to a target position excluding stimulus presentation time and button actuation time

3.4.8
parallax
difference in the apparent relative positions of objects when viewed from different points

3.4.9
resolution (resolving power)
smallest detectable movement, or actuation force, of an input device that results in a pointer displacement on a display

3.4.10
task primitive
fundamental action (like pointing, selecting and dragging) associated with using a non-keyboard input device

NOTE User tasks contain a mix of task primitives.

3.4.11
throughput
measure of the rate of information transfer when a user is operating an input device to control a pointer on a display

NOTE Throughput is measured in bits per second.

3.5 Posture

3.5.1
abduction of the arm
lateral moving or turning of the arm away from the body and position of arm and shoulder after this movement

3.5.2
adduction of the arm
lateral moving or turning of the arm towards the body, and position of arm and shoulder after this movement

3.5.3
deviation
moving or turning of the hand in its own plane away from the axis of the forearm, and position after this movement

3.5.4
displacement
change of position in the location of a point with respect to some reference coordinate

3.5.5
dorsal
pertaining to the back of the hand (see Figure 9)

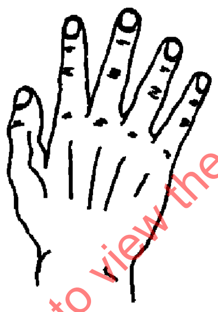


Figure 9 — Dorsal view of hand

3.5.6
extension
moving a limb segment in the dorsal direction, and position of the segment and joint after this movement (see Figure 10)

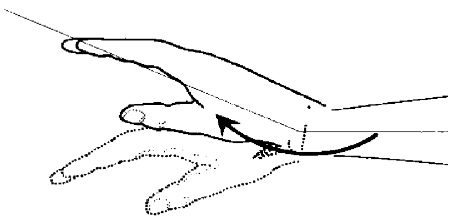


Figure 10 — Example of hand extension

3.5.7
flexion
moving a limb segment in the ventral direction (for example, moving the hand and fingers toward the palm) and position of the segment and joint after this movement (see Figure 11)

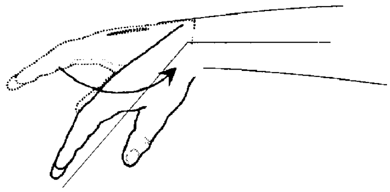


Figure 11 — Hand flexion

3.5.8
neutral posture
position that the body (and parts of the body) assumes when completely relaxed, that is, without any intentional bending at the joints

3.5.9
palm
ventral area of the hand between wrist and base of fingers (see Figure 12)

Figure 12 — Palmar area (indicated by the circle) of the hand

3.5.10
pronation
medial rotation of the forearm (see Figure 13)

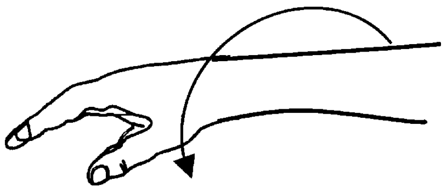


Figure 13 — Pronation (rotation indicated by arrow)

3.5.11
radial hand deviation
bending the hand at the wrist in the direction of the thumb (see Figure 14)

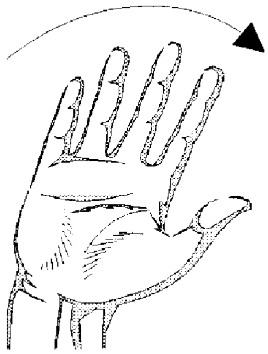


Figure 14 — Radial hand deviation (direction indicated by arrow)

3.5.12
reach envelope
optimum or maximum space accessible to the intended user population with respect to a specified user position

3.5.13
supination
lateral rotation of the forearm (see Figure 15)

Figure 15 — Supination (rotation indicated by arrow)

3.5.14
ulnar deviation
bending the hand at the wrist in the direction of the little finger (see Figure 16)

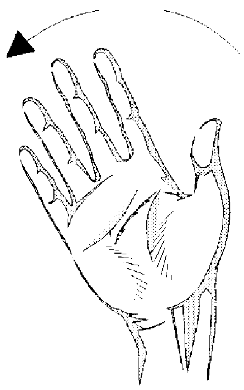


Figure 16 — Ulnar deviation of hand (direction indicated by arrow)

3.6 Usability indicators

3.6.1
effectiveness
accuracy and completeness with which users achieve specified goals

[ISO 9241-11: 1998]

3.6.2
efficiency
resources expended in relation to the accuracy and completeness with which users achieve goals

[ISO 9241-11: 1998]

3.6.3
satisfaction
freedom from discomfort, and positive attitudes of users towards the use of the product

[ISO 9241-11: 1998]

3.6.4
usability
extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use

[ISO 9241-11:1998]

4 Guiding principles

4.1 General

This clause describes basic ergonomic principles that apply to all input devices and are the basis for the general and specific requirements and recommendations given in clause 6.

4.1.1 Appropriateness

An appropriate input device is effective, efficient and satisfactory for the tasks being performed and the intended work environment.

NOTE Input device appropriateness may be enhanced by software.

4.2 Operability

4.2.1 Obviousness

The intended use of an appropriately designed input device for a task primitive is either obvious or easily discovered.

4.2.2 Predictability

The use of an input device is predictable when it is designed to operate and respond according to the expectations of the intended user population.

4.2.3 Consistency

The use of an input device is consistent when it operates and responds in the same manner when used in similar situations.

4.2.4 Compatibility

An input device is user compatible when its design accommodates anthropometric characteristics and biomechanical capabilities of the intended users.

4.2.5 Efficiency

An input device is most efficient when it functions with the least amount of time and effort.

4.2.6 Effectiveness

A device is effective when its design takes into consideration factors that lead to enhanced or optimized user performance by means of accuracy and completeness.

4.2.7 Feedback

An input device provides effective feedback when the user is given immediately perceptible and understandable indication that the device is reacting to user actuation.

4.2.8 Satisfaction

An input device design is satisfactory when its design incorporates factors that lead to freedom of discomfort and enhance positive attitudes of users towards its use.

4.3 Controllability

4.3.1 Responsiveness

An input device is considered to be responsive when feedback following its actuation is consistent and accurate.

4.3.2 Non-interference

An appropriately designed input device does not interfere with its own use; for example, the user's hand or arm does not block an infrared beam and cables do not interfere with movement or control of the device during its intended use.

4.3.3 Grip surface

Control of an input device is adequate when its grip and contact surface prevents unintended slipping during its intended use.

4.3.4 Device access

Access of an input device is adequate when it can be grasped, positioned and manipulated quickly and easily without adversely affecting performance.

NOTE The positioning of a device depends on its design, the design and adjustment of the workstation and the position of the user.

4.3.5 Control access

Access to input device controls is adequate when they can be located and actuated quickly and easily.

4.4 Biomechanical load

4.4.1 Postures

An appropriately designed input device can be operated by the user without undue deviation from a neutral posture.

4.4.2 Effort

An appropriately designed input device can be operated without excessive effort.

4.4.3 User training

Users who are informed of the proper use of input devices, and make use of such information, can avoid excessive effort and obtain improved performance.

5 Performance criterion

The input device shall be useable for its designated purpose. It is considered useable if users can achieve a satisfactory level of performance on a given task and maintain an acceptable level of effort and satisfaction. This objective is considered to be met when the guidelines in clause 4 are considered and the design requirements in clause 6 are satisfied and recommendations considered.

6 Design requirements and recommendations

This clause contains design requirements and recommendations for the input devices addressed in this part of ISO 9241.

6.1 General requirements and recommendations

Test methods to evaluate the conformance of normative requirements are described in clause 7.

6.1.1 Anchoring

If the input device is designed to be used for fine-positioning accuracy, it shall be possible to anchor some part of the fingers, hand, wrist, or arm on either the input device or the worksurface to create a stable relationship between the hand and the point of action.

6.1.2 Resolution

The input device should be designed for achieving a resolution that supports the precision required by the task primitive. The overall resolution of a device is a result of the interaction between hardware and software.

6.1.3 Repositioning

If the use of the input device requires repositioning, then it shall be repositioned manually without the use of tools.

6.1.4 Button design

6.1.4.1 Button activation

The input device should be designed to be resistant to inadvertent button activation during its intended use.

6.1.4.2 Button shape

Buttons should be shaped to assist finger positioning and button actuation.

6.1.4.3 Button force

Buttons should have a displacement force within the range of 0,5 N to 1,5 N until actuation.

NOTE Button force should be minimized without compromising usability.

6.1.4.4 Button displacement

Buttons intended to provide kinaesthetic feedback should have a minimum displacement of 0,5 mm. The maximum displacement shall be 6 mm.

6.1.4.5 Inadvertent pointer movement

The input device should be designed such that inadvertent button actuation does not cause unintended movement of the pointer.

6.1.4.6 Button lock

The input device shall be designed so that a hardware or software lock can be provided for buttons which need to be continuously depressed for the duration of a task primitive such as, dragging, tracing, and free-hand input.

6.1.5 Consideration of handedness

Input devices should be operable by either hand; or right and left-handed devices should be available.

6.1.6 Pressure points

Input devices should be designed so that during use they do not cause pressure points that cause discomfort or degrade performance.

6.1.7 Grasp stability

Grip surfaces should be of sufficient size, shape and texture to prevent slipping.

6.1.8 Access

The design of an input device should allow it to be located and be accessible within the user's reach envelope.

6.1.9 Cabling

Cables attached to input devices should be located, or attached to, the input device such that they do not interfere with use. The weight, flexibility, tension, and attachment location of the cable, and its potential to become entangled, should be taken into account when designing cabling.

6.1.10 Pointer movements

The relation between the movement of the input device and the movement of the pointer on a display shall follow user expectations in cardinal directions.

6.1.11 Feedback

6.1.11.1 Event feedback

Feedback shall be provided for button actuation or data entry acquisition.

6.1.11.2 Signal speed

The feed forward signal from the input device to the system should occur within 20 ms.

NOTE Any delay in the hand/eye control loop is likely to cause loss of user performance. A delay of up to 20 ms does not degrade user performance because it is usually not perceived. A delay of 40 ms results in a 10 % reduction in user performance and a delay of 100 ms causes a 50 % reduction in user performance compared with a situation in which no perceptible delay occurs.

6.1.12 Upper extremity and head posture

Input devices should be designed so that they can be operated without requiring undue deviations of the hand, fingers, arm, shoulder and head from their respective neutral positions.

6.1.13 Shape and size

Finger, hand-held or grasped input devices should be designed to accommodate the hand size of the intended user population.

6.1.14 Stability

The input device should be sufficiently stable, such that the accuracy of the input device should not be degraded during normal operation.

NOTE Instability can affect performance, comfort and biomechanical load.

6.1.15 Surface temperature

The temperature of the device surface in contact with the user's skin for contact periods of 10 min or more should not be greater than 40 °C.

6.1.16 Consideration of parallax

Input devices (such as light-pens and touch screens) and software applications that are subject to parallax and refractive displacement of target images should be designed to tolerate the user's perception of target location due to these optical characteristics.

6.1.17 Weight

The weight, and hence inertia, of the input device should not degrade the accuracy of the device during use under a defined normal range of actions including translation, rotation, and button activation.

6.1.18 Gain

The gain of relative-positioning input devices should be appropriate to the task and should be user adjustable.

6.1.19 Throughput

Input devices which are used for indirect pointing, selecting or dragging should be designed so that users can achieve the throughput given in Table 1 within the range of task precision for which the device is intended. Input devices should not reduce the functioning of muscles of the body extremity used for their control.

Table 1 — Examples of throughput for input devices controlled by two different extremities

Controller	**Throughput** bit/second
Finger	3
Hand (wrist)	2

6.1.20 Maintainability

The input device shall be designed such that the user is able to clean or adjust the device without special tools.

6.2 Specific input device requirements and recommendations

6.2.1 Mice

6.2.1.1 Sensor location

The motion sensing point (such as the rolling ball on the underside of a typical mouse) should be located under the fingers rather than under the palm of the hand.

NOTE The term “finger” includes the thumb.

6.2.1.2 Button motion

The device should be designed such that during its intended use the fingers should be able to make contact and actuate buttons without excessive deviation from a neutral posture.

NOTE “Excessive” means, for example, interfering with accuracy or causing muscular strain.

6.2.1.3 Button actuation

It should be possible to press the buttons on the mouse without reducing control of the device.

6.2.1.4 Resolution consistency

The resolution of a mouse should be independent of both the position of the device on the worksurface and the position of the pointer on the display.

NOTE However, the resolution may be changed by the software or the user.

6.2.2 Pucks

6.2.2.1 Button motion

The device should be designed such that, during normal use, the fingers should be able to make contact and actuate buttons without excessive deviation from a neutral posture. See the note in 6.2.1.2.

Button contact surfaces should be perpendicular to the displacement direction of the button and to the motion of the finger during flexion.

6.2.2.2 Button actuation

It should be possible to press the buttons on a puck without causing unintentional movement of the device.

6.2.2.3 Reticle window

The reticle window should be sufficiently transparent and free of aberrations to allow appropriate legibility.

6.2.2.4 Reticle location

The reticle window should be designed and located on the puck to allow it to be operated without requiring the user's head to be excessively deviated (flexion) by more than 15°.

6.2.2.5 Unintended slippage

The puck should be resistant to unintended slippage if it is used on an inclined surface.

6.2.2.6 Target obstruction

The size of the input device should not visually obstruct the target on the viewing area to the extent that user performance is impaired.

6.2.3 Joysticks

6.2.3.1 Actuation force

The force to displace finger-operated joysticks should be between 0,05 N and 1,1 N.

6.2.3.2 Displacement

For hand-operated displacement joysticks, the displacement should not exceed 45° in the left and right directions, 30° in the forward direction (away from the user), and 15° in the backward direction (towards the user).

6.2.3.3 Button location

The function buttons of a finger-operated joystick should be located on top of the handle so that the buttons can be actuated by the index finger.

The function buttons of a hand-operated joystick should be located on the top or side so that they can be actuated by the thumb, index or middle digit.

6.2.4 Trackballs

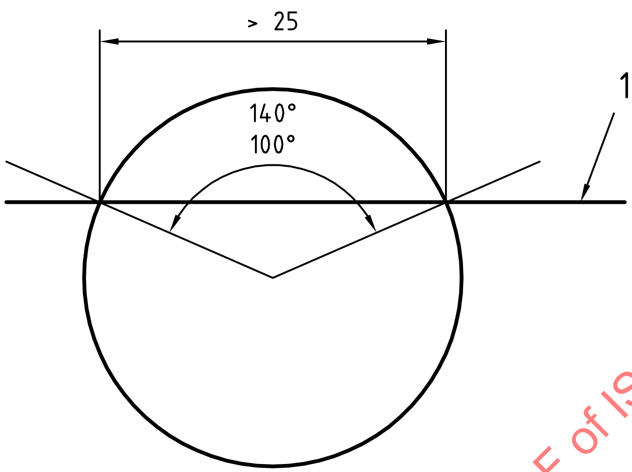
The factors to consider when selecting a trackball include

- pointer movement,
- precision required in the task, and
- ability to reposition fingers or thumb.

6.2.4.1 Size

The chord length of the exposed area of the trackball should be at least 25 mm. The exposed arc, measured from the centre of the trackball, should be not less than 100° and not greater than 140° (see Figure 17). The recommended exposed arc is 120°.

Dimensions in millimetres



Key

1 Input device surface

Figure 17 — Chord length and exposed arc of a trackball

6.2.4.2 Rolling force

The rolling force of a trackball should be 0,2 N to 1,5 N.

6.2.4.3 Starting resistance

The starting resistance should be 0,2 N to 0,4 N.

6.2.5 Tablets and overlays

NOTE For large digitizer tablets operated from a standing position, it is assumed that the user can move laterally in order to allow the requirements and recommendations in this subclause to be met.

6.2.5.1 Tablet height and slope

The design of the tablet (height, depth and slope) should allow the user to adopt the design reference posture if the tablet is incorporated into the workstation.

6.2.5.2 Tablet and overlay contact surface

The user contact surface of the tablet and overlay should be flat and smooth.

6.2.5.3 Tablet and overlay surface reflections

Reflections or glare from the tablet and overlay surface should not interfere with the visibility of imprinted images on the tablet or overlay, nor reduce visual efficiency or comfort.

NOTE Overlay images can be imprinted onto tablets or be of removable material.

6.2.5.4 Actuation force on tablet or overlay

For functions that require intermittent input against the tablet or overlay, the maximum force required for input should not exceed 1,0 N.

6.2.5.5 Control display gain

The control display gain should be adjustable according to intended user needs and task requirements.

6.2.5.6 Legibility of legends and graphic symbols

All legends on the tablet and overlay shall be legible from the design viewing distance. Graphical symbols should be identifiable from the design viewing distance.

6.2.5.7 Size of legends and graphic symbols

The nomenclature for the symbols, capital letters and numbers on a tablet and overlay shall have a minimum perceived height of 16 ′ of visual arc at the design viewing distance.

The perceived height includes the user position.

The recommended perceived height is 20 ′ of visual arc.

6.2.5.8 Width to height ratio of legend

The ratio of the width of a capital letter (except capital i: I) to the height of the letter shall be between 0,5: 1 and 1: 1 of the character height.

6.2.5.9 Height to stroke width ratio of legend

The ratio of the height of a capital letter to its stroke width shall be between 5: 1 and 14: 1.

6.2.5.10 Contrast of legends and graphic symbols

Primary legends and symbols shall have a minimum luminance contrast ratio of at least 3: 1. A lower luminance contrast ratio, for legends and symbols other than primary ones, is acceptable provided that colour differences ensure that they are recognizable.

6.2.5.11 Colour of legends and graphic symbols

For colours that are intended to differentiate information, the colour difference should be obvious and easily perceivable.

6.2.5.12 Function grouping

Groups of functions on an overlay or tablet should be easily and quickly distinguishable.

6.2.5.13 Overlay attachment

The overlay should be easily and simply attached to, and removed from, the tablet.

6.2.5.14 Unintended overlay movement

The overlay should not accidentally become detached from the tablet during normal operation.

6.2.5.15 Overlay flatness

The overlay should be flat when placed on the tablet.

6.2.6 Styli and light-pens

6.2.6.1 Grasp surface

The grasp surface of the stylus and light-pen should be slip resistant.

6.2.6.2 Activation force

For continuous input using styli, the force requirements to activate the stylus on a tablet should be not greater than 1,5 N.

6.2.6.3 Selector button force

The activation force of the selector button should be between 0,3 N and 1,5 N.

6.2.6.4 Contact area of selector button

A selector button should have a contact surface that contains a circular area with a diameter not less than 5 mm.

6.2.6.5 Size

Cylindrical styli and lightpens should be between 120 mm and 180 mm in length and 7 mm to 20 mm in diameter.

6.2.6.6 Weight

Styli and lightpens should have a mass between 10 g and 25 g.

6.2.7 Touch-sensitive screens

6.2.7.1 Target location

Vertically oriented touch-sensitive screens shall allow touch targets to be positioned below shoulder height.

NOTE This means that a vertically oriented touch-sensitive screen is tiltable, moveable and height-adjustable so it can be operated with the arm/elbow supported by the work surface and inside the reach envelope of the intended user population.

Horizontally oriented touch-sensitive screens shall allow touch targets to be positioned at or below elbow height and inside the reach envelope of the intended user population.

6.2.7.2 Touch-sensitive area

For systems using a first contact touch strategy, the size of the touch-sensitive area should be at least equal to the size of the ninety fifth percentile male distal (digit 2) joint breadth. The touch-sensitive area should be increased if parallax results in a degradation in performance.

6.2.7.3 Character size and contrast

The area of the screen within the touch-sensitive location shall conform with the relevant requirements of ISO 9241-3, ISO 9241-7, ISO 9241-8 and ISO 13406-2.

6.2.7.4 Repeat function delay

When a repeat function is provided, there should be an initial delay of from 500 ms to 750 ms to prevent unintended activation.

6.2.7.5 Inactive space of target

For touch-sensitive screens designed for first-contact touch activation, an inactive space of a width of at least 5 mm should be provided around each touch target.

NOTE For touch-sensitive screens designed for last-contact touch actuation, the inactive space can be less than 5 mm.

6.2.7.6 Target tracking

During a drag operation, the object or pointer being moved should track the finger or stylus, both temporally and spatially.

6.2.7.7 Static electricity

To avoid or reduce discomfort due to the discharge of static electricity when the user touches the screen, touch-sensitive screens should have an anti-static treatment.

7 Measurement conditions and conventions

7.1 General

In this clause, methods of measurement are provided for each normative requirement indicated by the use of “shall” in clause 6. The method of conformance associated with each requirement contains

— an identification of the test method required,

— a description of the method, and

— a response associated with conformance.

7.2 Types of measurements

7.2.1 Direct measurement

Direct measurement requires the use of a standard instrument or tool to obtain a quantifiable measure of a feature.

7.2.2 Direct observation

Direct observation is the perception or notation of specific characteristics of the input device by one or more independent observers. Direct observation typically results in a binary decision (such as Yes or No). This decision depends on observation of the presence or absence of a feature.

7.2.3 Performance test

A performance test is a method for determining the match between specified requirements and the corresponding features of an input device.

If a performance test is used, the relevant information on the experiment design methodology, analysis and results shall be provided.

7.3 Required measurements

7.3.1 Anchoring

Test method for fine-positioning accuracy tasks: Direct observation

Determine if it is possible to anchor some part of the fingers, hand, wrist or arm on the device, work or support surface as a reference.

If the answer is yes, then the input device has passed. If the answer is no, then the input device has failed.

7.3.2 Repositioning

Test method: Direct observation

Determine whether the input device can be repositioned without tools.

If the answer is yes, then the input device has passed. If the answer is no, then the input device has failed.

7.3.3 Button lock

Test method: Direct observation

Determine whether a hardware or software button lock is provided.

If the answer is yes, then the input device has passed. If the answer is no, then the input device has failed.

7.3.4 Pointer movements

Test method: Direct observation

Determine whether the direction of the pointer movement conforms to the user-stated expectations in the cardinal directions: left, right, forward/upward, and backward/downward.

If the answer is yes, then the input device has passed. If the answer is no, then the input device has failed.

7.3.5 Event feedback

Test method: Direct observation

Determine whether feedback is present when input device button(s) are actuated.

If the answer is yes, then the input device has passed. If the answer is no, then the input device has failed.

7.3.6 Maintainability

Test method: Direct observation

Determine whether it is possible to perform the manufacturer's specified maintenance tasks on the device without the use of special tools.

If the answer is yes, then the input device has passed. If the answer is no, then the input device has failed.

7.4 Legibility of legends and identification of graphic symbols

Test method: Direct observation or performance test

Determine whether it is possible to read all legends and distinguish all symbols from the design viewing distance.

For performance testing, see ISO 9241-3:1992, Amendment 1.

If the answer is yes, then the input device has passed. If the answer is no, then the input device has failed.

7.4.1 Legends and graphic symbols size

Test method: Direct measurement, observation or performance test

Calculate or determine if the size of the character height legends and graphic symbols are appropriate for the design viewing distance.

7.4.2 Width to height ratio of legends

Test method: Direct measurement

Measure the width and height of a capital letter (other than “I”) from its edges and calculate their ratio.

7.4.3 Height to stroke width ratio of legends

Test method: Direct measurement

Measure the stroke width and height of a capital letter from its edges and calculate their ratio.

7.4.4 Contrast of legends and graphic symbols

Test method: Direct measurement

Measure the contrast of the legends and graphic symbols and their background and calculate the contrast ratio.

7.4.5 Touch-sensitive screen: target location

Test method: Direct measurement

For *vertically oriented* touch-sensitive screens, determine whether the target location accommodates anthropometric data of the intended user population for shoulder height.

If the answer is yes, then the input device has passed. If the answer is no, then the input device has failed.

For *horizontally oriented* touch- sensitive screens, determine whether targets are at or below elbow height of a sample of the intended user population.

If the answer is yes, then the input device has passed. If the answer is no, then the input device has failed.

7.4.6 Character size and contrast

Test method: Direct observation

Using a workstation installation in conformance with ISO 9241-5, determine whether the character size and contrast conforms to the requirements in ISO 9241-3, ISO 9241-7, ISO 9241-8 or ISO 13406-2.

If the answer is yes, then the input device has passed. If the answer is no, then the input device has failed.

8 Conformance

Conformance with this part of ISO 9241 can be achieved by meeting all the requirements of clause 6. Normative requirements are identified by the presence of the word "shall".

Annex A
(informative)

Input device selection, usability testing and analysis

A.1 Introduction

This annex provides more information on task primitives than is addressed in the normative part of this part of ISO 9241. It is included to provide information on potential methods of testing input devices and to encourage institutions or individuals to conduct research on these methods such that further validation can be supplied.

A.2 Selection criteria for input device

Selection of an input device depends on the task for which it is to be used and the operating environment in which it is to be used. Examples of the appropriateness of input devices for basic and specific task primitives are shown in Table A.1. As input devices become more flexible and configurable, the appropriateness of an input device for a task primitive may change. In addition, a given level of performance can be improved by using appropriate software (such as a device driver and software functions).

Table A.1 — Examples of input devices appropriate for tasks

Task primitive	Device
Pointing	Mouse, puck, trackball, tablet, stylus, light-pen, touch-sensitive screen
Selecting	Mouse, puck, joystick, tablet, stylus, light-pen, touch-sensitive screen
Dragging	Mouse, puck, tablet,
Free-hand input	Tablet
Tracing	Puck, tablet, stylus, light-pen

A.3 Usability testing and assessment

A.3.1 General

Usability testing is utilized to evaluate efficiency, effectiveness, and satisfaction in a specific context.

Since all these measures indicate different aspects of usability, they could all be considered and evaluated simultaneously.

Examples of methods to evaluate efficiency, effectiveness and satisfaction are included in annexes B, C, and D. Annex B includes a series of test methods to evaluate efficiency and effectiveness. Annex C includes methods to assess satisfaction. Annex D is a discussion of measures for biomechanics.

Annexes B to D are intended to help designers, manufacturers and system integrators assess the usability and ergonomic aspects of current and newly designed input devices. The assessment methodologies can also be used by organizations that need to determine whether a particular input device meets usability requirements.

Usability testing of input devices should be conducted by individuals who have appropriate knowledge of usability test techniques, statistical analysis and instrumentation. Rules governing the ethical conduct of human experimental testing should be followed.

A.3.2 Environment

The test area should be quiet and free from distractions. Ideally, it should be located in a dedicated test area such as a usability laboratory.

Test subjects should be adapted to the test environment for at least 15 min prior to the test. The test subjects should be kept at this level of adaptation throughout the test.

A.3.3 Thermal conditions

Ambient temperature should be between 20° C and 24° C and should not vary by more than 2° C during the test. The relative humidity should be between 30 % and 70 %. The air velocity should be less than 0,15 m/s.

A.3.4 Lighting

The ambient illumination should be a maximum of 250 + 250 cos(A), where A is the angle formed by the intersection of the plane tangent to the centre of the display and the horizontal plane. Recommended values for surface reflectance are given in Table A.2.

Table A.2 — Surface reflectance

Object	Reflectance
Ceiling	70 % to 80 %
Walls	30 % to 50 %
Floor	20 % to 30 %
Furniture	20 % to 50 %

The character or background luminance (whichever is higher) of an emissive display [such as a cathode ray tube (CRT)] should be about 100 cd/m^2 and not be below 35 cd/m^2 while maintaining a contrast of at least 3:1. The character or background luminance (whichever is higher) of a passive display [such as a liquid crystal display (LCD) or an electroluminescent display (ELD)] should be a minimum of 35 cd/m^2 while maintaining a contrast of at least 3:1. There should not be any obvious glare on the display from lighting fixtures or windows.

A.3.5 Test workstation

The workstation should meet all the requirements in ISO 9241-5. The following should be included as part of the test workstation:

a) chair with adjustable seat height and back angle;

b) work surface with adjustable height;

c) adjustable display such that the centre of the display is located between 20° and 50° below the test subject's horizontal line of sight;

d) document holder, if needed;

e) foot rest;

f) sufficient work space.

A.3.6 Subjects

A profile of the intended user population should be provided to the test developer. Test subjects should represent as closely as possible the intended user population(s) of the input device. User variables such as gender, age range, visual characteristics (use of corrective lenses), handedness, hand-size category, and previous input device experience should be considered when selecting the subject sample.

A.3.7 Test equipment

The test system should be capable of

a) displaying visual stimuli,

b) capturing and storing input actions,

c) timing sessions, and

d) characterizing, printing or displaying input actions and errors.

The subject's display(s) should meet all the requirements in ISO 9241-3. The same display should be used for displaying images for all the input devices. If different displays need to be used, they should have the same polarity and the same font appearance. The software drivers (velocity scaling) for each device tested should be the same.

A.3.8 Test procedures

A.3.8.1 Device assignment

Novel input devices should be tested comparatively to commercially available devices, which are generally accepted by the user population.

It may be desirable to compare two devices of the same type but of different design (such as two different sizes or shapes of mice) or two different types of devices (such as a mouse and a trackball). Alternatively, it may be necessary to compare devices across a variety of task primitives.

If a comparative test between two or more devices is being conducted, each test subject should be tested using each device. The input devices should be labelled anonymously (for example, "A" and "B") and all identifying logos and labels should be covered. The order of presentation should be counterbalanced to eliminate any effects due to test order.

A.3.8.2 Length of sessions

The test should not exceed 4 h per subject per day including breaks. A 5 min break should be given every hour. Sessions should be of sufficient length to obtain statistically valid performance samples.

A.3.8.3 Statistical treatment

Normal statistical protocol should be used to ensure the appropriate power and confidence level of the test. All test results should be evaluated using an alpha level of 0,05.

A.3.8.4 Confidentiality

Confidentiality of an individual's performance should be assured. Data, which reveal an individual subject's identity, should not be released by the testing organization.

Annex B
(informative)

Testing of efficiency and effectiveness

B.1 Introduction

The purpose of this annex is to describe a performance test method for evaluating the efficiency and effectiveness of existing or new input devices. It is included to provide information on potential methods of testing input devices and to encourage institutions or individuals to conduct research on these methods such that further validation can be supplied.

The tests provide a measure of throughput. Because it is not possible to define a single performance test procedure that will encompass all input devices and situations of input device use, several test procedures are included in this annex.

B.2 Procedure overview

Input devices should be tested for the tasks for which they are intended to be used. The tests included in this annex are designed to evaluate the following task primitives:

- pointing;
- selecting;
- dragging;
- tracing;
- free-hand input.

It is not necessary for an input device to be tested on all task primitives (see Table A.1) unless they are all considered essential components of the job. However, valid comparisons between two or more different input devices can only be achieved if the same test method is used on each device.

Any software used in the test system should not interfere with a subject's performance. For example, if the system is connected to a network, notification of incoming mail should be disabled.

B.3 Special training

Due to the potential lack of familiarity with a novel input device design, subjects may require training before performance testing can be reliably conducted. In cases where training is needed, each subject should be allowed to learn the use of the input device until speed and accuracy do not show any significant improvements. Subjects should be given sufficient practice sessions to ensure that learning effects are stabilised. Thus, this should be verified by a procedure like the Duncan's Range test.

A standard set of instructions should be given to each subject prior to starting the test. The instructions should inform subjects to work as quickly and accurately as possible and to leave errors uncorrected.

B.4 Task primitive identification and selection

Appropriate task primitive(s) (see clause A.2) should be identified for the intended use of the input device(s) being tested. Task-primitive variations and conditions should then be selected (see Table B.1).

Table B.1 — Task and condition variations

Task	Condition
Movement	1) One direction (x or y direction only) 2) Two directions (x or y directions only) 3) Any direction (all angles)
Feedback and prompting	1) Presence/absence of positional visual feedback 2) Presence/absence of visual prompting 3) Presence/absence of feedback for target acquisition
Target acquisition	1) Manual when the user signals acquisition to the system 2) Automatic when the user's pointing is within a present range

B.5 Calculations for input device throughput

B.5.1 Target widths (w)

The target width is the width of a target presented on a display.

NOTE For a selection, pointing or dragging task, the target width is measured along the direction of movement. For a tracing task, the target width is measured perpendicular to the direction of movement.

B.5.1.1 Effective target widths (w_e)

The effective target width is the width of the distribution of selection coordinates made by a subject during a pointing/tapping test.

It is calculated as

$$w_{\mathrm{e}} = 4{,}133\, s_x$$

where s_x is the standard deviation of the selection coordinates in the direction where movement proceeds (x-axis in a horizontal tapping test).

B.5.1.2 Index of difficulty

The index of difficulty is the measure, in bits, of the user precision required in a task.

For selection, pointing, or dragging tasks:

$$\mathrm{ID} = \log_2 \frac{d + w}{w}$$

For tracing tasks:

$$\mathrm{ID} = \frac{d}{w}$$

where

ID is the index of difficulty;

d is the distance of movement to the target;

w is the target width of the displayed target along the approach axis for selection, pointing or dragging tasks, and perpendicular for tracing tasks.

B.5.1.3 Effective index of difficulty

The effective index of difficulty is the measure, in bits, of the user precision achieved in accomplishing a task expressed as one of the following.

For selection, pointing or dragging tasks:

$$\mathrm{ID_e} = \log_2 \frac{d + w_\mathrm{e}}{w_\mathrm{e}}$$

For tracing tasks:

$$\mathrm{ID} = \frac{d}{w_\mathrm{e}}$$

where

$\mathrm{ID_e}$ is the effective index of difficulty;

d is the movement distance to the target;

w_e is the target width of the displayed target.

NOTE For selection, pointing or dragging tasks, the effective index of difficulty is logarithmically related to d and w_e. For tracing tasks, the effective index of difficulty is linearly related to d and w_e.

B.5.1.4 Task precision

Task precision is the measure of the accuracy required for a pointing, selecting or dragging task primitive and quantified by the index of difficulty.

NOTE Task precision can be classified into three precision levels:

a) low: an index of difficulty less than or equal to 4;

b) medium: an index of difficulty greater than 4 and less than or equal to 6;

c) high: an index of difficulty greater than 6.

B.5.2 Throughput calculations

The following calculations are for input throughput for selecting, pointing, dragging and tracing.

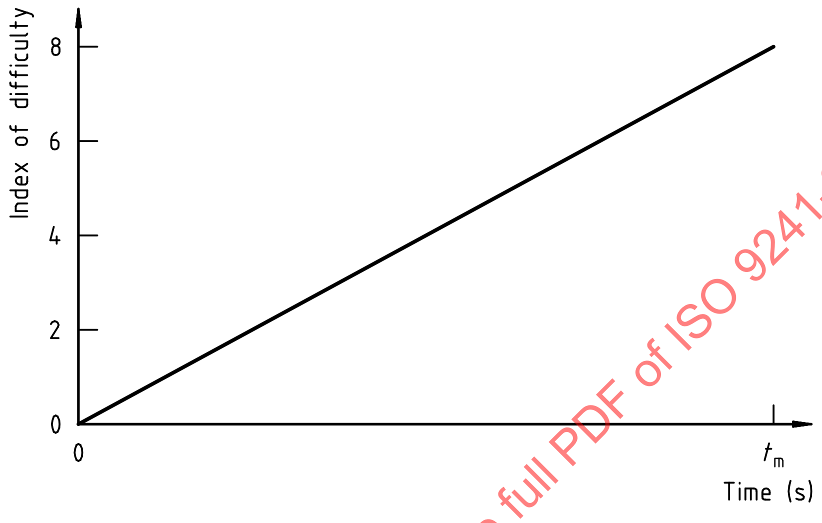
$$\text{Throughput} = \frac{\text{Effective index of difficulty}}{\text{Movement time}} = \frac{\mathrm{ID_e}}{t_\mathrm{m}}$$

where

ID_e is the effective index of difficulty for a movement task;

t_m is the movement time, calculated from the initiation of movement of the input device to target selection.

A graph of movement time is plotted against the effective index of difficulty and a linear relationship is obtained (see Figure B.1). The slope of the line represents the throughput of the device, in bits per second.



t_m Movement time

Figure B.1 — Relationship of index of difficulty to time

B.6 Tests

B.6.1 General

The use of the tests presented in this clause will depend on the task(s) for which the input device(s) is(are) intended to be used. In addition, the test selected will depend on the movement direction for the task, feedback and prompting, and the method of target acquisition. The test should include a range of difficulty that matches the expected use of the input device.

B.6.2 Tapping tests

B.6.2.1 One-direction tapping test

This test can be used to evaluate: a pointing movement along one axis.

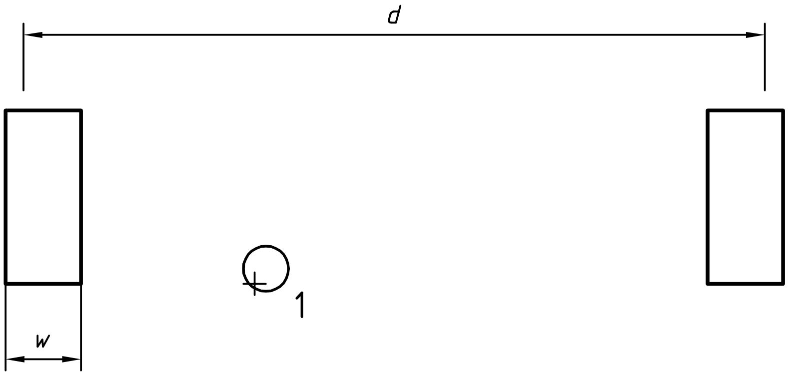
Its applications include

a) a horizontal or vertical rubber-banding,

b) an insert cursor at points along a character string, and

c) selecting information in columns or rows.

Test procedure: Two rectangles of width w and with a centre-to-centre distance d are presented to the user (see Figure B.2). The task is to point and click, along one axis, within each rectangle 25 times. Each test session starts when the user first moves the cursor into a rectangle and actuates a button[2)].



Key

1 Pointer object

d Target distance

w Target width

Figure B.2 — One direction tapping task

This test should be conducted with a range of difficulties, varying both the target distance (d) and the target width (w). These should be varied in equal proportions so that the effective index of difficulty ranges from about 1 bit to 6 bits. The results should be calculated according to the equation in clause B.5.

NOTE The effective index of difficulty (ID_e) for this test is given by $ID_e = \log_2 (d + w_e)/w_e$.

B.6.2.2 Multi-directional tapping test

This test can be used to evaluate: pointing movements in many different directions.

Its applications include

a) repositioning a cursor at different areas on the screen,

b) cell selection in a spreadsheet, and

c) selecting randomly located icons.

Test procedure: The subject is required to move the cursor across a circle to sequentially numbered targets (see Figure B.3). The targets (for example, squares) should be equally spaced around the circumference of the circle. The targets should be arranged so that the movements are nearly equal to the diameter of the circle. The targets to which the subject should advance should be highlighted. Each test session starts after the subject points to the topmost target and ends when the sequence is completed (at the topmost target).

This test should be conducted with a range of difficulties. That is, the size of the circle and thus the distance between the target squares should be varied between trials, as long as all subjects have the same test conditions. The results should be calculated according to the equation in clause B.5.

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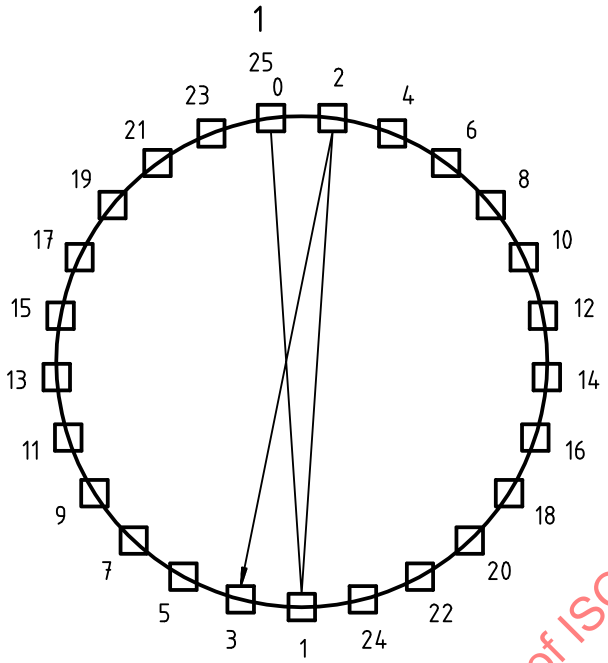
2) Target acquisition may be either manual (for example, depression of a button) or automatic (for example, system sensing the presence of the cursor within the target area).



Key

1/2 Start/Finish

Figure B.3 — Multi-directional pointing task

B.6.3 Dragging test

This test can be used to evaluate: clicking and dragging objects to specific locations.

Its applications include

a) clicking and dragging the cursor down a pull-down menu, and

b) selecting and dragging an object from one window to another.

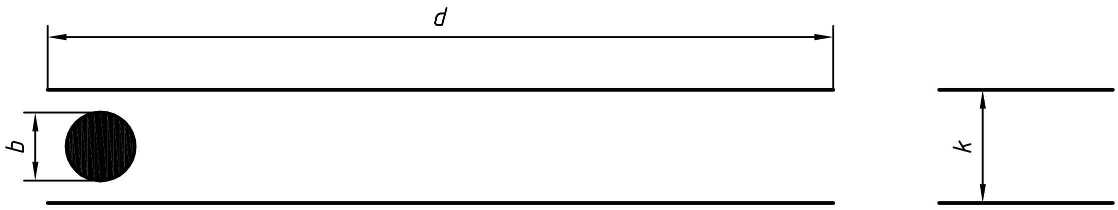
Test procedure: Either the one-direction test or the multi-direction test can be used with modifications of the feedback, prompting, and the method for signalling target acquisition. The results should be calculated according to the equation in clause B.5, using the equation for calculating the effective index of difficulty given in B.5.1.3.

B.6.4 Path-following test

This test can be used to evaluate: following a given path between two points.

Its applications include tracing an object.

Test procedure: The task is to move an object (such as a circle) of width b between the borders of two parallel lines, of length d separated by distance k, without touching the boundary lines (see Figure B.4). If the object touches a boundary line, the attempt is aborted and the subject is required to start again. The time taken for the subject to successfully move the object from one end of the track to the other is recorded.



Key

d Target distance

k Width of the track

b Width of the object

Figure B.4 — Path following task — one direction

This test should be conducted with a range of difficulties. That is, the width of the track (k) and width of the object (b) should be varied between trials, as long as all subjects have the same test conditions. The results should be calculated according to the equation in B.5.1.2.

The index of difficulty for this test is given by:

$$\mathrm{ID} = \frac{d}{w}$$

where width $w = k - b$

The effective index of difficulty for this test is given by:

$$\mathrm{ID_e} = \frac{d}{\text{Mean deviation from the centre-line}}$$

B.6.5 Tracing test (any direction)

This test can be used to evaluate: clicking and dragging objects to specific locations or to duplicate shapes.

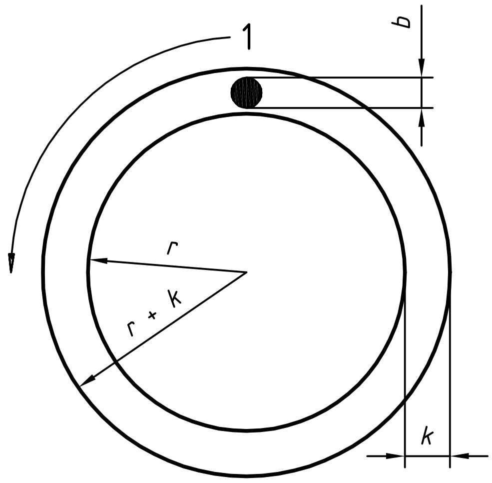
Its applications include

a) tracing an image (like a printed circuit board layout) on a tablet,

b) line or picture duplication, and

c) solid filling of objects.

Test procedure: Two concentric circles of radii r and ($r + k$) are presented to the subject (see Figure B.5). The task is to move an object of width b within the track of width k around the circle without touching the boundary line.



Key

1 Start/Finish

k Width of track

b Width of object

r Radius of circle

Figure B.5 — Tracing task

This test should be conducted with a range of difficulties. That is, the width of the object (b), width of the track (k) and radius (r) of the circles should be varied between trials, as long as all subjects have the same test conditions.

The index of difficulty for this test is given by:

$$\mathrm{ID} = \frac{d}{w}$$

where width $w = k - b$

The effective index of difficulty for this test is given by:

$$\mathrm{ID_e} = \frac{d}{\text{Mean deviation from the centre - line}}$$

B.6.6 Free-hand input test

This test can be used to evaluate: quality of hand-drawn characters or symbols between devices and input modes.

Its applications include

a) graphics creation,

b) free-hand text entry, and

c) character recognition operations.

This test is intended to compare images created with an input device against those created with traditional input devices such as a pen onto paper.

Test procedure: The subject is presented with a horizontal line of boxes of specified dimensions that are the same for each input device. The subject should write a legible symbol (either alphanumeric or symbol character) in each box (see Figure B.6) as rapidly as possible. The time taken to complete the task is recorded and compared between input devices.

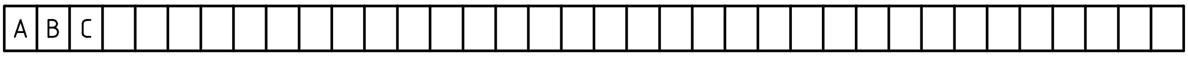


Figure B.6 — Free-hand symbol entry task

The subject should be instructed to make the same shape with each input device.

This test should be conducted with a range of difficulties. That is, the size of the rectangle and the distance between the rectangles should be varied between trials, as long as all subjects have the same test conditions. The results should be calculated according to the equation in clause B.5.

B.6.7 Grasp and park task

This test can be used to evaluate: combination of keyboard and input device actions.

Its applications include

a) text editing,

b) graphic design, and

c) numeric data entry in a spreadsheet.

In some applications, the important characteristic of the input task is the time required to grasp the device and then to park it when finishing the task. In these applications, the device is alternatively used with a primary input device (like a keyboard) but is less often used than the primary input device.

Test procedure: The subject performs a simple pointing task, and operates a key on the keyboard between each pointing with the same hand.

Grasp time is the time between stimuli presentation and grasping the input device; park time is the time from completing the task to releasing the input device (that is, including the time to place it in a holder). The time difference between this task and the equivalent pointing task is the grasp and park time.

Annex C
(informative)

Assessment of comfort

C.1 Introduction

This annex describes comfort-rating scales. It is included to provide information on potential methods of testing input devices and to encourage institutions or individuals to conduct research on these methods such that further validation can be supplied.

It includes rating scales that assess comfort and usability by asking subjects to rate input devices independently and comparatively. These scales are designed so that the devices with the highest scores represent those most preferred. Whichever scales are chosen for use, they should be formatted in a positive direction, with the highest values being associated with the most positive impressions.

C.2 Independent ratings

The independent rating scales (see Table C.1) can be used to assess impressions of each input device being tested. It is administered after the subject completes a series of tasks with an input device. Subjects draw a circle around the number that best describes their impression of each characteristic for the input device they used. Comparative evaluations are made by comparing significant differences between devices for each item rated.

C.3 Comparative ratings

The comparative scales (see Tables C.2 and C.3) are used to determine which input device is most preferred. Although they are designed to comparatively assess two devices, they can be expanded to be used for more than two input devices.

The response sheet is given to each subject after completing the tasks on one device (for example, device A) and again after completing the tasks on the other devise (for example, device B). Subjects complete the Phase 1 rating after using the first input device. Subjects check the letter associated with the input device they are rating (that is "A" or "B") and then place a mark under the column that best represents their feeling about the input device.

Subjects complete the Phase 2 rating after using the second input device. Subjects check the letter associated with the input device they are rating (that is "A" or "B") and then place a mark under the column that best represents their feelings about the second input device compared to the first.