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Ergonomics of human-system interaction —

Part 410: Design criteria for physical input devices

Ergonomie de l'interaction homme-système —

Partie 410: Critères de conception des dispositifs d'entrée physiques

Reference number
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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 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 9241-410 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*.

This first edition of ISO 9241-410, together with ISO 9241-400, ISO 9241-411[1)], ISO 9241-420[1)] and ISO 9241-421[1)], partially replaces ISO 9241-4:1998 and ISO 9241-9:2000, technically revised as follows:

— terms and definitions from ISO 9241-4 and ISO 9241-9 have been transferred to ISO 9241-400;

— all guiding principles have been incorporated into ISO 9241-400 and unified so that they correspond to the scope of the new ISO 9241 series;

— these principles are applied in ISO 9241-410 in order to generate provisions for product design.

— an application procedure has been specified in ISO 9241-410, for reasons related to the structure of the "400" subseries of ISO 9241 and its *usability*- rather than property-based nature;

— for greater convenience, a separate normative annex covering each of the different devices, as well as an informative annex addressing issues related to accessibility, have been included in ISO 9241-410.

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*

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1) Planned or under preparation. (See Annex A)

— *Part 6: Guidance on the work environment*

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

— *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*

The following part is under preparation:

— *Part 129: Guidance on software individualization*

ISO 9241 also consists of the following parts, under the general title *Ergonomics of human-system interaction*:

— *Part 20: Accessibility guidelines for information/communication technology* (*ICT*) *equipment and services*

— *Part 110: Dialogue principles*

— *Part 151: Guidance on World Wide Web user interfaces*

— *Part 171: Guidance on software accessibility*

— *Part 300: Introduction to electronic visual display requirements*

— *Part 302: Terminology for electronic visual displays*

— *Part 303: Requirements for electronic visual displays*

— *Part 304: User performance test methods*

— *Part 305: Optical laboratory test methods for electronic visual displays*

— *Part 306: Field assessment methods for electronic visual displays*

— *Part 307: Analysis and compliance test methods for electronic visual displays*

— *Part 308: Surface-conduction electron-emitter displays* (*SED*) [Technical Report]

— *Part 400: Principles and requirements for physical input devices*

— *Part 410: Design criteria for physical input devices*

— *Part 920: Guidance on tactile and haptic interactions*

Framework for tactile and haptic interaction is to form the subject of a future part 910.

Introduction

Input devices are a means for users to enter data into interactive systems. Generally speaking, an input device is a sensor that can detect changes in user behaviour (gestures, moving fingers, etc.) and transform it into signals to be interpreted by the interactive system. An *input device* is regarded as the combination of hardware with the software designed to use it (e.g. a driver).

This part of ISO 9241 defines design criteria for products on the basis of relevant properties of physical input devices as laid down in ISO 9241-400:2007. It is intended to cover assessment methods for laboratory use (in order to accelerate future development of test and evaluation methods) and user organizations in future parts of ISO 9241.

Most of the principles presented in this part of ISO 9241 have previously been defined or outlined in International Standards for keyboards and other input devices (ISO 9241-4 and ISO 9241-9). Where necessary, definitions of terms have been reformulated so that they are applicable for all input devices.

ISO 9241 was originally developed as a seventeen-part International Standard on the ergonomics requirements for office work with visual display terminals. As part of the standards review process, a major restructuring of ISO 9241 was agreed to broaden its scope, to incorporate other relevant standards and to make it more usable. The general title of the revised ISO 9241, “Ergonomics of human-system interaction”, reflects these changes and aligns the standard with the overall title and scope of Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*. The revised multipart standard is structured as a series of standards numbered in the “hundreds”: the 100 series deals with software interfaces, the 200 series with human centred design, the 300 series with visual displays, the 400 series with physical input devices and so on.

See Annex A for an overview of the entire ISO 9241 series.

Ergonomics of human-system interaction —

Part 410: Design criteria for physical input devices

1 Scope

This part of ISO 9241 specifies criteria based on ergonomics factors for the design of physical input devices for interactive systems including keyboards, mice, pucks, joysticks, trackballs, trackpads, tablets and overlays, touch-sensitive screens, styli and light pens, and voice- and gesture-controlled devices. It gives guidance on the design of these devices, taking into consideration the capabilities and limitations of users, and specifies generic design criteria for physical input devices, as well as specific criteria for each type of device. Requirements for the design of products are given either as a result of context-free considerations, or else can be determined based on the specified design criteria for the intended use; such specified criteria generally having been subdivided into task-oriented categories, wherever applicable.

EXAMPLE The resolution of a pointing device is given in relation to four levels of index of difficulty for the Fitts test. The required category for the resolution can be determined on the basis of the task characteristics, user population and context of use for the intended application.

This part of ISO 9241 does not specify the categories that are appropriate for devices as, according to the concept of usability, a product has no *inherent* usability. Selecting the category to which a certain property of a device belongs is subject to the design of a product.

This part of ISO 9241 is expected to be used by the manufacturers of physical input devices, including product designers and test organizations, in determining the design characteristics of a device for its intended context of use (user population, task, software or environment, etc.). The data generated by the users of this part of ISO 9241 for the description of the properties of their products can be applied in the selection of a device adequate for the actual context of use on the basis of the task primitives relevant for the task of the specific user population, and for achieving the required level of efficiency and effectiveness for a given system.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7000, *Graphical symbols for use on equipment — Index and synopsis*

ISO 9241-400:2007, *Ergonomics of human-system interaction — Part 400: Principles and requirements for physical input devices*

ISO/IEC 9995 (all parts), *Information technology — Keyboard layouts for text and office systems*

IEC 60417-DB, *Graphical symbols for use on equipment* [2)]

2) Permanently updated database.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9241-400 and the following apply:

3.1
bounce-free switch
switch that generates a single and definite signal after actuation

3.2
category
part of a system into which properties of entities can be arranged

3.3
class
category of a property of a product with rank order

NOTE 1 Class 1 is the *most*, and class n the *least*, favourable category of a specific property of a product, where n is the number of classes.

NOTE 2 An example of a property is *durability of the legends* of a key. If a key belongs to the highest class, it will fulfil all requirements for the lower categories.

3.4
compact keyboard
keyboard that features most properties of a full-size keyboard, with the editing section integrated into the alphanumeric section

NOTE A compact keyboard can have a numeric section.

3.5
force feedback
application of physical force in response to user input

EXAMPLE In games, or in car and plane simulators.

3.6
full-size keyboard
keyboard that comprises all sections and zones as described in ISO/IEC 9995-1

3.7
group
category of a property of a product without rank order

NOTE Some properties such as the size of a key do not constitute a virtue without further considerations. For such properties, the categorization may help to differentiate objects without being able to determine a rank in consideration of the specific property.

EXAMPLE A particular size of key on a keyboard that is suited for continuous touch-typing, a smaller key size for hand-held devices or a larger size for use with gloves.

3.8
haptic, adj
of or relating to, or proceeding from, the sense of touch

3.9
haptic display
display presenting information accessible through the sense of touch, mainly by, but not limited to, use of hands and fingers

3.10
haptic interface
user interface based on touch, using the movements of the user as input and the sense of touch as output for tactile and kinaesthetic feedback

EXAMPLE Force feedback joysticks, Braille screen readers.

3.11
housing
protective cover designed to contain or support a mechanical component

NOTE An input device is either integrated into its own housing or into another unit that comprises other functional units (e.g. control desk, control panel, telephone).

3.12
index of difficulty
I_D
measure of the user precision required in a task

NOTE The index of difficulty, I_D, is measured in bits, and is calculated for selection, pointing, or dragging tasks by

$$I_D = \log_2 \frac{d + w}{w}$$

and for tracing tasks by

$$I_D = \frac{d}{w}$$

where

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.

3.13
key arrangement
spatial organization of keys of a keyboard following certain design rules or conventions

EXAMPLE Typewriter, calculator or telephone layout of keys for generating codes for numerals (numeric keys for digits 0 to 9) on office machines.

3.14
keypad
functional unit that comprises at least a group of keys dedicated and arranged for a given functionality and possibly additional keys supporting related functionality

EXAMPLE Numeric keys, “Enter” key of keypad.

3.15
multi-tap
alphanumeric input requiring several presses per character

3.16
section
⟨keyboard⟩ functional groups within computer keyboards for which different rules for layouts can apply

NOTE Some sections of existing keyboards are arranged according to more-than-century-old conventions.

3.17
task precision
measure of the accuracy required for a pointing, selecting or dragging task primitive, quantified by the index of difficulty

3.18
touchpad
touch-sensitive pad that senses the position of a finger on its surface

3.19
work surface
surface on which equipment and task materials are used

[ISO 9241-5:1998, definition 3.25]

3.20
zone
⟨keyboard⟩ smaller unit within a section of a keyboard representing different functionality

EXAMPLE The layout of the alphanumeric keys for entering graphic characters (alphanumeric zone) grouped with function and modifier keys such as “Ctrl”, “Alt”, “Tab” or “Backspace”.

4 Procedure for applying this part of ISO 9241

Generally speaking, the entirety of requirements for the overall design of a product is a result of considerations from a variety of origins, such as engineering, safety, environmental protection, economic efficiency, marketing or the concept of usability (see ISO 9241-400).

This part of ISO 9241 presents requirements related to product properties that are in turn related to usability of physical input devices. Its application requires following steps a) to d), below.

a) Identify properties of the device that are relevant for usability.

First, identify those properties relevant to usability, i.e. relevant for the effectiveness and efficiency of use and for the satisfaction of user needs. Some of the properties are known (e.g. key legends for keyboard) and requirements for them exist for certain areas of use (e.g. minimum size of key legends for full-size keyboards).

b) Apply generic design requirements

Identify other properties by applying the generic design principles on a specific device (e.g. controllability on keyboards or mice). The requirements for these properties can be different for different contexts of use. For these properties, the requirements are subdivided into categories — classes or groups. Specify the category to which a device belongs. The device will need to conform to the requirements that apply to that category.

c) Apply device specific design requirements

For each relevant property, apply the requirements for a specific device (see Annexes B to J). See Figure 1 for a summary of these requirements.

d) Evaluate the performance criterion

Ensure that the device fulfils the requirements derived from the provisions of this part of ISO 9241, while considering the product’s designated purpose.

NOTE A *product* is considered as being any combination of hardware and software utilized for a given task.

Relevant Properties			
Property			**Class/ Group/ Value**
Correspondence with generic design requirement	Appropriateness	Effectiveness	■■■□
		Efficiency	■■■□
		Dimensioning	■■■■
		Software dependency	✓
		Additional device	○
	Operability	Obviousness	■■■■
		Predictability	■■■■
		Correct order	■■■□
		Consistency	■■■□
		Compatibility	■■■□
	Controllability	Responsiveness	■■■■
		Non-interference	■■■■
		Reliability of device access	■■■■
		Adequacy of device access	■■■■
		Control access	■■■■
	Biomech. Load	Postures	■■□□
		Effort	■■■□
Functional Properties	Keys	Size	○○●○
		Roll-over	■■■□
		Durability of legends	■■□□
	Sections and zones	Alphanumeric	✓
		Numeric	○
		Editing	✓
		Function	✓
		Multimedia	--

1 2 3 4 5 6

Key

1 requirement derived from a generic design principle
2 not relevant
3 property with requirements in four groups
4 property with requirements in four classes
5 property with requirements
6 property without requirements in this document

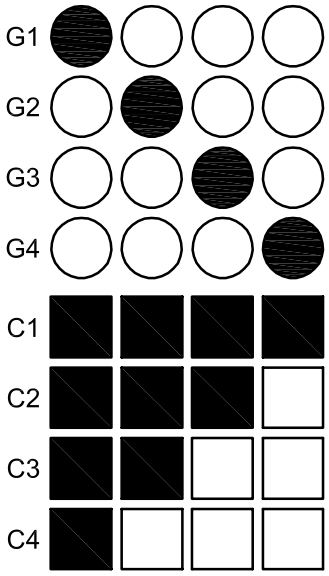

Figure 1 — Sample for a summarizing table

5 Performance criterion

The input device shall be usable for its designated purpose. It is considered *usable* if its user can achieve a satisfactory level of performance on a given task and maintain an acceptable level of effort and satisfaction. This objective is met when the design requirements and recommendations (see Annexes B to J) applicable to the device are satisfied.

If completing the task requires the utilization of more than one physical device, all elements specified shall be treated as a unit for the purposes of determining usability.

6 Properties of physical input devices relevant for usability

Properties of physical input devices with relevance for usability can be broken down into groups of properties. Requirements can either be derived from a generic design principle to which various properties can contribute or the relevant property can be identified without applying a principle. Properties with requirements in groups serve to categorize products without the ability to assign them to classes, whereas other properties can be categorized into classes with rank order:

— functional properties;

— mechanical properties;

— electrical properties;

— maintainability-related properties;

— health- and safety-related properties;

— interdependency with software;

— interdependency with use environment.

For such properties, requirements or recommendations exist based on technical knowledge, scientific evidence or conventions. The relevance of additional (or sometimes the same) properties can be identified or established in consideration of the generic design principles presented in ISO 9241-400. This part of ISO 9241 specifies design requirements for each device derived from those principles. Other properties corresponding to a certain principle equally or even better suited may be used instead.

EXAMPLE 1 The form of the housing of a mouse is relevant if the user has no equivalent or better means to sense the orientation of the device (principle: controllability, reliability of device access).

EXAMPLE 2 The orientation of a button for minimizing finger extension is relevant if the button is located on a mouse where the button will be actuated without losing overall control of the device (principle: controllability, control access). For other buttons, the orientation might not be relevant.

7 Generic design requirements for physical input devices

7.1 General

The intended use of a physical input device shall be specified unless it is obvious or the product is designed for general-purpose use. The specification shall include technical conditions for the context of use to be realized for satisfactory use of the device (e.g. operating system, driver, support surface).

Each physical entity possesses a number of properties, of which only some are relevant for its usability. Since a device cannot have intrinsic usability, for each relevant property subject to a design requirement, wherever

possible four categories are given. If sufficient knowledge exists to recommend a certain category, this is indicated.

NOTE The category required for a given task, intended user population and/or context of use (e.g. stationary, portable, hand-held and in different environments) will be able to be determined using procedures given in a future part of ISO 9241.

7.2 Generic design requirements

7.2.1 General

This clause derives generic design requirements from the ergonomic principles that apply to all input devices as defined in ISO 9241-400:2007, 4.2. These are

— appropriateness,

— operability,

— controllability, and

— biomechanical load.

7.2.2 Appropriateness

The design of a device shall be appropriate for the intended tasks being performed and the intended use environment, including additional devices if required by the task. An appropriate input device enables the user to achieve the required effectiveness for the task and is efficient and satisfactory for the intended user population.

The dimensioning of an input device and its parts shall be compatible with the relevant anthropometric dimensions of the part of the body for the intended user population so that relevant design objectives can be met (intended level of effectiveness, intended level of efficiency).

If the design objectives cannot be met without the use of additional tools (e.g. stylus for input via small size keys) or if, in order to achieve the intended level of appropriateness, the design requires enhancement by software or the additional use of a device other than is delivered with the device under consideration, then this shall be specified.

7.2.3 Operability

7.2.3.1 General

An input device shall be operable, i.e. its intended use is obvious, predictable and consistent and the user receives adequate feedback.

7.2.3.2 Obviousness

The obviousness of the intended use can be categorized into four classes:

C1 known or visible without additional instructions and information;

C2 detectable by the user by trial and error;

C3 learnable by simple instructions;

C4 learnable by special training.

7.2.3.3 Predictability

The predictability of the input is achieved if the movement or other activation of the input device consistently produces a directly corresponding movement of the display or desired action by the system, e.g. movement of an input device in one of the cardinal directions (up, down, left, right), or if a voice command to the same effect consistently produces movement of the pointer in the same direction on the screen.

7.2.3.4 Consistency of operation

Consistency of operation is provided if the device operates and responds in the same manner in the specified context of use.

Operating in the same manner means that the same level of effectiveness is maintained under the intended context of use.

Responding in the same manner means that the user receives the same feedback through the same channels (e.g. tactile, visual or auditory).

7.2.3.5 User compatibility

7.2.3.5.1 General requirement

Physical input devices shall be user-compatible, i.e. their design accommodates the intended user anthropometric characteristics and biomechanical capabilities.

7.2.3.5.2 Throughput

The anthropometric characteristics of the intended user population can be accommodated in four classes:

C1 fully compatible, enables maximum throughput and accuracy;

C2 restricted (level 1), maximum achievable level for effectiveness 90 %, efficiency 90 %;

C3 restricted (level 2), maximum achievable level for effectiveness 80 %, efficiency 80 %;

C4 use requires additional aids.

7.2.3.5.3 Force and posture

The compatibility with biomechanical capabilities of the intended user population can be categorized by the degree to which a fraction of the maximum capability (e.g. angle of joint, contracting force of a muscle) is needed for the operation of the device.

NOTE Current scientific knowledge does not allow a setting up of such categories valid for all input devices. Therefore, this part of ISO 9241 does not include categories for the angle of joints and the contracting force of muscle.

7.2.3.6 Feedback

An input device shall provide effective feedback, i.e. the user is given immediately perceptible and understandable indication that the device is responding to user actuation (see ISO 9241-400). The feedback generated by the operation of an input device is only partly transmitted by that device to the users, e.g. by tactile feedback while actuating a button. Some input devices such as gesture-sensitive cameras do not provide any feedback except that generated by the system. Thus, the adequacy of feedback is highly software-dependent.

An input device shall either give adequate feedback by its own functionality or generate a signal enabling the system to provide feedback. The feedback is adequate if the user can detect the following without taking further action:

— current state of the device;

— outcome of the latest action (e.g. input accepted, required action initiated);

— any action required as consequence of the latest action.

Users with special needs or use conditions may require certain types of feedback. For example, feedback through the same channel (tactile feedback by the button that is being actuated) could be needed if visual or acoustic feedback are likely to fail. In other cases, feedback through a diverse channel may be beneficial if the channel that is being used for an action does not accept the response, e.g. the acceptance of a text that is being dictated cannot be confirmed continuously by sound, but by visual or tactile feedback.

7.2.4 Controllability

7.2.4.1 General

The operation of an input device shall be controllable. This means that

— the device shall be responsive, and its use shall not interfere with its functionality,

— the design of the device shall give the user adequate and reliable access, and

— the design shall prevent unintended loss of control during intended use, e.g. slipping by hand-operated devices.

NOTE See ISO 9241-110 for details concerning controllability in dialogue design in general.

7.2.4.2 Responsiveness

Responsiveness of an input device occurs if the feedback following its actuation is consistent and sufficient.

EXAMPLE Activating a graphic key on a keyboard is always accompanied by a generated character on the screen and by a tactile feedback that is the same for all keys on that keyboard.

7.2.4.3 Non-interference

An input device shall not interfere with its own use. This means that all functional elements belonging to that device can be accessed and operated without degrading the usability of the device. Functional elements needed to transport data from the device to the system and vice-versa (cables, infrared beams) shall not influence throughput and accuracy.

EXAMPLE 1 The user's hand or arm does not block an infrared beam.

EXAMPLE 2 A computer mouse is not pulled by its own stiffness and weight during intended use.

7.2.4.4 Reliability of device access

Adequate control of an input device is given when its design prevents unintended loss of control during intended use.

7.2.4.5 Adequacy of device access

The design of an input device shall enable the user to quickly and easily access it (e.g. grasp, position, manipulate) during intended use without adversely affecting performance.

NOTE Positioning of a device depends on its design and the design and adjustment of the workstation and position of the user.