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# Ergonomics of human-system interaction —

## Part 920: Guidance on tactile and haptic interactions

*Ergonomie de l'interaction homme-système —*

*Partie 920: Lignes directrices relatives aux interactions tactiles et haptiques*



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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 9241-920 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 4: Keyboard requirements*
- *Part 5: Workstation layout and postural requirements*
- *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*

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 210: Human-centred design for interactive systems*

— *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 for electronic visual displays*

— *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 309: Organic light-emitting diode (OLED) displays* [Technical Report]

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

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

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

The following parts are under preparation:

— *Part 100: Introduction to standards related to software ergonomics*

— *Part 129: Guidance on software individualization*

— *Part 420: Selection procedures for physical input devices*

— *Part 910: Framework for tactile and haptic interaction*

Forms-based dialogues and design guidance for interactive voice response (IVR) applications are to form the subjects of future parts 143 and 154.



## Introduction

Tactile and haptic interactions are becoming increasingly important as candidate interaction modalities in computer systems such as special-purpose computing environments (e.g. simulation) and in assistive technologies. While considerable research exists, a lack of ergonomic standards in this area could result in systems being developed without sufficient concern for either ergonomics or interoperability, leading to serious ergonomic difficulties for users of multiple, incompatible or conflicting tactile/haptic devices/applications. This part of ISO 9241 provides ergonomics recommendations for tactile and haptic hardware and software interactions, including guidance related to the design and evaluation of hardware, software, and combinations of hardware and software interactions. The guidelines are not technology-dependent and will also be applicable to future technologies.



# Ergonomics of human-system interaction —

# Part 920: Guidance on tactile and haptic interactions



## 1 Scope

This part of ISO 9241 gives recommendations for tactile and haptic hardware and software interactions. It provides guidance on the design and evaluation of hardware, software, and combinations of hardware and software interactions, including

— the design/use of tactile/haptic inputs, outputs, and/or combinations of inputs and outputs, with general guidance on their design/use as well as on designing/using combinations of tactile and haptic interactions for use in combination with other modalities or as the exclusive mode of interaction,

— the tactile/haptic encoding of information, including textual data, graphical data and controls,

— the design of tactile/haptic objects,

— the layout of tactile/haptic space, and

— interaction techniques.

It does not provide recommendations specific to Braille, but can apply to interactions that make use of Braille.

The recommendations given in this part of ISO 9241 are applicable to at least the controls of a virtual workspace, but they can also be applied to an entire virtual environment — consistent, in as far as possible, with the simulation requirements.

NOTE It is recognized that some interactive scenarios might be constrained by the limitation that a real workspace is to be modelled in a virtual environment. Objects can be in suboptimal positions or conditions for haptic interaction by virtue of the situation being modelled.

## 2 Applying ISO 9241-920

### 2.1 Recommendations

Individual recommendations given in Clauses 5 to 7 should be evaluated for their applicability. The applicable recommendations should be implemented unless there is evidence that to do so would cause deviation from the design objectives.

### 2.2 Evaluation of products

If a product is claimed to have met the applicable recommendations in this part of ISO 9241 then the procedures used to establish the product's requirements, and to evaluate the product, shall be specified. The level of detail of the specification is a matter of negotiation between the involved parties.

# 3 Tactile/haptic inputs, outputs, and/or combinations

## 3.1 General guidance on tactile/haptic inputs, outputs and/or combinations

### 3.1.1 Optimizing performance

The system should be optimized to take account of the following.

a) The accuracy of available devices, the accuracy of the user, and the required accuracy of the task.

b) The ability of a user to control the speed and the force involved in operations.

NOTE 1 High speed of user actions is inconsistent with accurate control of force, and vice versa.

c) Active exploration over passive exploration, when appropriate.

NOTE 2 This can increase kinaesthetic perception.

d) Multiple point-of-contact operation, when possible and appropriate.

NOTE 3 This can reduce errors and improve tactile perception.

EXAMPLE The use of two hands in reading Braille can improve efficiency.

e) The overall amount and distributed nature of cognitive and sensory task demands.

NOTE 4 Effectiveness of tactile and haptic inputs is affected by overall workload, conflict among multi-task demands, and/or overload or decrement of particular sensory information channels.

### 3.1.2 Providing accessible information on tactile/haptic elements

The system should provide accessible descriptions of all tactile/haptic user interface elements, whether those descriptions are automatically presented or not.

NOTE Information can be presented by text, sound labels, synthetic speech, sign language or as Braille text.

EXAMPLE Ability to determine file size or file location.

### 3.1.3 Providing contextual information

The system should provide a context to help the user to understand the meaning of the tactile/haptic perception and the environment or program.

NOTE 1 Contextual information that is helpful includes information about the purpose of the program, and information about possibilities and pitfalls in the environment.

NOTE 2 Contextual information can be in the form of a short text message, such as a caption under an image or model, provided as speech, sign language or Braille.

### 3.1.4 Using consistent labels

Labels of user interface elements that are presented in a tactile/haptic modality should

a) be consistent in size and distances from other tactile objects,

b) be located according to a consistent rule,

c) be uniformly oriented.

NOTE Labels that contain the same information or function need to be equal in form, symbol usage and/or text.



### 3.1.5 Identifying system state

The system should provide information that allows the user to know which task or function is active.

### 3.1.6 Minimizing fatigue

The system should

a) ensure user comfort over extended periods of time, and

b) avoid or minimize user fatigue.

NOTE Minimization of tactile fatigue can be achieved by

— careful choice of body location for stimulation,

— careful choice of method of contact with the body,

— careful choice of stimulus frequency,

— choosing the lowest effective magnitude of the stimulus,

— reducing minute, precise joint rotations, particularly at proximal segments,

— not using static positions at or near the end of the range of motion, and/or

— not expecting users to overreach to discover the full extent of the display.

### 3.1.7 Providing alternative input methods

The system should enable users to accomplish the same function in a number of ways, with at least one of these not requiring fine manipulation skills on the part of the user.

NOTE The most efficient, logical or effective input/control mechanism for a majority of users might be difficult, if not impossible, to use by individual users with disabilities.

EXAMPLE One-handed (either left or right) operation is used.

### 3.1.8 Maintaining coherence between modalities

The system should maintain coherence, where appropriate, between the tactile/haptic modality and other modalities, including the descriptions of actions.

NOTE 1 The visual perception of objects can bias, and be biased by, the tactile/haptic perception of objects. This can also occur between the tactile/haptic modality and other modalities.

NOTE 2 Aspects of coherence (amodal attributes) can include

— size,

— orientation,

— shape,

— mapping,

— separation of objects, and

— temporal presentation.

NOTE 3 Coherence also includes relative location of on-screen controls, including the directions in which they can be moved.

NOTE 4 Incoherence can cause confusion and control instabilities in multimodal systems.

### 3.1.9 Combining modalities

The combining of modalities is recommended, as it can have the following effects.

a) Reinforcement of information obtained from purely tactile/haptic interactions.

EXAMPLE A sound when an object is struck.

b) Provision of additional information not presented via tactile/haptic interactions.

NOTE 1 The resulting combinations can enhance spatial memory and the identification and exploration of objects and their attributes.

NOTE 2 Combination of modalities can contradict information obtained from purely tactile/haptic interactions. (See 3.1.8.)

EXAMPLE Information on the colour of an object.

c) Compensation for sensory channels that are diminished or overloaded.

NOTE 3 Tactile cues can be particularly effective when audio or visual cues are less effective (e.g. high noise, low visibility).

### 3.1.10 Presenting realistic experiences

While the use of real world experiences (e.g. following the laws of physics) can enhance the user's understanding, deviating from real world experiences may be used to

a) simplify and focus on important features, and/or

b) explore new experiences.

NOTE There are several cases — especially in designing interface widgets — where the slightly unreal, yet well-designed, behaviour of a virtual object makes it easier to use.

EXAMPLE Properties of an object (e.g. size, frequency of its vibration) are changed as it is approached by the user, even though these properties would not change in the real world.

### 3.1.11 Isolation of individual interface elements

The system should prevent unintended effects on non-activated interface elements due to the activation of a nearby interface element.

EXAMPLE 1 Because there is a high risk of unintentional vibration where the nearby actuator vibrates at the same resonant frequency, a rigid surround is installed to reduce the spreading of vibration.

EXAMPLE 2 Mechanical or electrical crosstalk between different tactile/haptic channels is reduced in order to minimize any unintentional perceptual illusion.



## 3.2 Intentional individualization

### 3.2.1 Enabling users to change modalities

The system should enable the user both to disable tactile output and/or have output presented in another modality.

NOTE 1 Tactile stimuli can annoy the user who does not want to use them, as they are difficult to ignore.

NOTE 2 Individuals differ with regard to effectiveness of visual, audio, and/or tactile/haptic cues. Allowing them the capability to select among alternatives, or combine several modalities when appropriate, needs to be considered.

NOTE 3 Tactile cues might be preferred when other sensory channels are diminished or overloaded (e.g. high noise, low visibility, high need for stealth).

### 3.2.2 Enabling force feedback override

The system should allow any force feedback to be overridden by the user.

NOTE The maximum force that a user can exert will limit the maximum possible force for force feedback.

### 3.2.3 Enabling users to individualise tactile parameters

Options to adjust tactile/haptic parameters should be provided to prevent discomfort, pain or injury to users of interactive systems.

NOTE 1 Different users have different levels of thresholds of sensation and pain. Furthermore, over a user's lifespan, thresholds of sensation and pain will change (e.g. spatial and temporal acuity degrade with age).

NOTE 2 Users vary in the amount of force that can overpower or be “too strong” for them.

EXAMPLE Tactile signals are made stronger to overcome distractions and physical exertion.

## 3.3 Unintentional user perceptions

### 3.3.1 Limiting acoustic output of tactile/haptic display

Acoustic energy emissions created by a tactile/haptic display should not interfere with

a) the user perceiving presented auditory information,

b) nearby equipment and/or persons,

c) security requirements.

### 3.3.2 Limiting heat gain of contact surface

The heat gain of the contact surface (not intentionally generated) should not

a) deform the contact surface,

b) disturb the user’s haptic perception,

c) injure the user’s skin,

d) damage the haptic interface.

NOTE A sudden unintentional temperature increase/decrease of the contact surface of a haptic interface can occur from various intentional haptic actions (such as vibration, friction).

### 3.3.3 Avoiding sensory adaptation

The system should minimize the effects of sensory adaptation to vibration.

NOTE 1 Sensory adaptation effects occur only for vibration stimuli within the same frequency range. One approach to preventing sensory adaptation is to switch between a frequency below 80 Hz and one above 100 Hz. Changes in frequency can change sensation levels. Keeping sensation levels similar can involve adjustments to amplitude in correspondence with adjustments in frequency.

NOTE 2 Sensory adaptation to vibration can decrease a user’s absolute threshold and change their experience of subjective magnitude. This is a gradual process caused by prolonged stimulation and can take up to 25 minutes to occur.

### 3.3.4 Recovering from sensory adaptation

The system should enable the user to recover from sensory adaptation to stimuli.

NOTE A user's recovery time from sensory adaptation to vibration is about half as long as the adaptation time.

### 3.3.5 Avoiding unintended perceptual illusions

The system should minimize the occurrence of unintended perceptual illusions.

NOTE If stimuli are presented too closely in time and space, the percept might be altered or changed completely.

### 3.3.6 Preventing temporal masking

The system should prevent the occurrence of temporal masking.

NOTE 1 Masking can occur when two stimuli are presented at the same location asynchronously.

NOTE 2 Temporal masking can distort the perception of multiple stimuli.

NOTE 3 Presenting stimuli at different locations can prevent temporal masking.

NOTE 4 Presenting stimuli at different frequencies in the same location does not necessarily reduce temporal masking.

## 4 Attributes of tactile and haptic encoding of information

### 4.1 High level guidance on tactile/haptic encoding of information

#### 4.1.1 Using familiar tactile/haptic patterns

Where available, well known tactile/haptic patterns, which are familiar in daily life, should be used for presenting information.

NOTE 1 A person without special knowledge of specialized tactile coding (e.g. Braille code, Morse code) will probably be familiar with tactile patterns experienced in daily life.

NOTE 2 Most users are more familiar with patterns that represent two dimensions rather than patterns involving three dimensions.

#### 4.1.2 Making tactile/haptic encoding obvious

Where possible, tactile/haptic encodings should be made obvious to the users by ensuring cues are

a) simple and intuitive,

b) easy to learn and discriminate between.

EXAMPLE An array of torso-mounted tactors (small transducers designed to optimize skin response to vibration) is used to provide direction cues.



### 4.1.3 Conformity to user expectations

System behaviour should conform to user expectations.

NOTE An orientation that does not correspond to that of the user's mental image can make the object difficult to understand.

EXAMPLE Predictable behaviour that mimics nature, like that experienced from gravity, makes control of objects easier.

### 4.1.4 Using sensory substitution

The system should use the most appropriate sensory substitutions for presenting/receiving the information to/from the user.

NOTE 1 Sensory substitutions can be carried out between modalities that include visual, audio and tactile/haptic.

NOTE 2 When making substitutions, it is important to consider similarities and differences between the senses, utilizing similarities between them and avoiding replacements where the substituting sense is functionally different from the substituted one.

### 4.1.5 Using appropriate spatial addressability and resolution

The system's spatial addressability and resolution should be appropriate for the task and the user's perceptual capabilities.

NOTE Users will have different perceptual capabilities depending on the body part in contact with the tactile/haptic device.

### 4.1.6 Using tactile apparent location

Apparent location may be used to increase the spatial addressability of a vibrotactile display.

EXAMPLE Where the task requires access to a greater number of stimulus sites without increasing the number of actuators, the system utilizes apparent location.

### 4.1.7 Using distal body parts for high spatial resolution

Where high spatial resolution is needed, the user should interact with the system only with the distal body parts.

NOTE A refreshable Braille display uses spatial location as an important parameter in design.

### 4.1.8 Using higher addressability for trained users

Where the task allows, displays designed for trained or expert users may use a higher density of stimuli.

### 4.1.9 Using tactile apparent motion

Apparent motion may be used to simulate actual motion.

NOTE When using apparent motion, the most important parameters are the duration of bursts and the time intervals between the onsets of the consecutive stimuli.

EXAMPLE 1 In tracking displays, tracks are given apparent motion by displaying consecutive discrete positions.

EXAMPLE 2 Sequential activation of tactors from the back to the front, on a torso display, is a pattern that is used to indicate "move forward".

#### 4.1.10 Preventing spatial masking

The system should avoid spatial masking.

NOTE When presenting simultaneous stimuli in different locations, using stimuli with different frequencies (one below 80 Hz and one above 100 Hz) can prevent spatial masking.

### 4.2 Guidance on specific tactile/haptic attributes for encoding information

#### 4.2.1 Selecting dimensions for encoding information

Tactile/haptic dimensions that may be used for encoding information include the following.

a) Material properties:

   1) hardness;

   2) viscosity;

   3) elasticity;

   4) mass/weight;

   5) inertia;

   6) thermal conductivity.

b) Surface properties:

   1) texture;

   2) roughness;

   3) friction;

   4) temperature.

c) Geometrical properties:

   1) size;

   2) shape;

   3) location in environment;

   4) orientation within environment;

   5) spatial pattern;

   6) spatial grating amplitude;

   7) spatial grating frequency.

d) Temporal properties:

   1) temporal pattern;

   2) temporal vibration amplitude;

   3) vibration frequency.

NOTE These dimensions concern the coding of tactile/haptic information used for interaction. They do not concern the simulation of real tactile/haptic perceptions.



#### 4.2.2 Discriminating between attribute values

Attribute values should be discriminable.

NOTE Material properties, such as texture and hardness, are more salient than geometrical properties, such as size and shape.

#### 4.2.3 Limiting the number of attribute values

Unless it is proven that a user can discriminate between a larger number of values, the number of different values (as for vibration and thermal conductivity) used for encoding any single attribute should be limited to three that are significantly different from one another.

NOTE Although, typically, up to three attributes can be discriminated, a larger number of values can be discriminated for some attributes such as object shape, size, location, texture, temporal pattern and object mass/weight.

#### 4.2.4 Combining properties

Combinations of properties may be used to

a) encode different information dimensions,

b) encode the same information dimensions redundantly, and

c) encode information dimensions that are more complex than the number of allowable values of any of the individual attributes.

#### 4.2.5 Limiting complexity

All purposeful combinations of attribute values within a system should be discriminable.

NOTE When attributes are used in non-redundant combination, the number of discriminable values of an individual attribute can be diminished.

#### 4.2.6 Encoding by object shape

When encoding information by shape, the system should employ recognisable shapes.

EXAMPLE 1 A system uses square, circular, and triangular shapes for different types of controls.

EXAMPLE 2 A system with three-dimensional capabilities uses cubes, spheres and cones for different types of objects.

#### 4.2.7 Encoding information by temporal pattern

When encoding information in a temporal pattern, the time between signals should be perceivable and adjustable.

NOTE 1 The temporal sensitivity of the skin is very high: 10 ms pulses and 10 ms gaps can be detected.

NOTE 2 Rhythm, tempo, and duration can be combined to produce temporal patterns.

#### 4.2.8 Encoding information using vibration amplitude

When encoding information using different discrete vibration amplitude levels, the system should allow the setting of a number of levels between the detection threshold and the comfort/pain threshold.

#### 4.2.9 Encoding information by vibration frequency

When encoding information by vibration frequency, the system should

a) use not more than seven different levels of frequency,

b) use a difference of at least 20 % of the lower frequency between levels,

c) use frequencies between 10 Hz and 600 Hz unless a lower frequency can be discriminated.

NOTE 1 If presented with the same amplitude, the different levels of frequency mentioned in b) can also lead to different subjective magnitudes.

NOTE 2 There is great variability in how different users experience the sensitivity of the human tactile channel. While the human tactile channel is typically only sensitive to frequencies between 10 Hz and 600 Hz, these thresholds are high, with some users experiencing their lowest threshold at 250 Hz. If at all possible, it is desirable that only frequencies between 50 Hz and 250 Hz be used.

NOTE 3 In the case of a small contactor, a frequency lower than 10 Hz can be used.

NOTE 4 When more than one vertically travelling vibrating stimulator operates together in order to transmit pattern information, a frequency lower than 10 Hz can be applied.

#### 4.2.10 Encoding by location

When encoding information by location, the system should take into account the spatial resolution of the body part that is intended to perceive the information.

NOTE 1 Distal body parts have a higher spatial resolution.

NOTE 2 Using a body joint can increase location identification accuracy.

#### 4.2.11 Encoding by temperature

When encoding information by temperature:

a) the range of temperature values to be used should be well within the comfort limits of the users;

b) the values of temperature used should remain discriminable over the duration of exposure.

#### 4.2.12 Encoding by thermal conductivity

The values of thermal conductivity used should

a) make due allowance for users' adaptation to them, and

b) be limited to four in number.

NOTE Thermal conductivity causes a different heat flow rate on the contact surface. Humans usually perceive the rate of heat flow rather than temperature itself.

EXAMPLE Humans feel differences between metal and plastic with the same surface temperature because their thermal conductivities are different.

#### 4.2.13 Identifying information values

The system should aid the user in identifying the values of individual attributes.

EXAMPLE 1 The system provides a set of reference values for identifying roughness.

EXAMPLE 2 The system provides a symbolic legend for identifying different object types.

# 5 Content-specific encoding

## 5.1 Encoding and text data

The speed of presentation of dynamic text information should be controllable.

## 5.2 Encoding and using graphical data

### 5.2.1 Displaying tactile/haptic graphics

**5.2.1.1** Tactile/haptic graphics should be sufficiently simple to be recognized without long exploration.

NOTE 1 Complex figures can be displayed as a set of interlinked figures, where the user is able to go back and forth between figures of low resolution and those of higher resolution that provide greater detail on some portion of the low resolution figure. An object that is portrayed in its entirety in a low addressability display can then become too large to portray in its entirety.

NOTE 2 Obtaining more detailed information is often handled by providing the figure with a “zoom” function.

EXAMPLE Tactile/haptic pictures portray only the elements necessary for accomplishing the task(s) for which they are used and avoid using unnecessary details.

**5.2.1.2** The important elements of a tactile/haptic graphic should be readily perceived by users of the tactile/haptic display.

NOTE 1 To users without sight, a clear and simple expression of meaning is more important than a high fidelity version of the presentation.

NOTE 2 Redundant information can be included in the encoding of tactile symbols of bar graphs to improve accuracy.

### 5.2.2 Using grids on tactile graphs

Grids on tactile graphs may be used when exact readings of values are required, but should not interfere with the information on the graph.

NOTE Grid lines can be confused with data lines when vision is not available.

### 5.2.3 Using landmarks in tactile maps

When appropriate to the use of the map, a tactile map should emphasize landmarks.

NOTE Landmarks can help the user to orient the map when vision is not present.

### 5.2.4 Providing scales for tactile maps

Where distance scales are provided on tactile maps they should

a) be presented in the orientation most relevant to the map contents, and

b) make use of units that are most accessible to the intended user group.

NOTE Units that are relevant to distances between landmarks can be helpful.

## 5.3 Encoding and using controls

### 5.3.1 Using tactile/haptic controls

When using tactile/haptic controls:

a) the tactile/haptic controls should be selectable without activating their associated functionality.

b) the system should provide the user with feedback that indicates the selection and the activation of a tactile/haptic control.

NOTE Using gravity wells or recess effects could improve control selection and setting.

EXAMPLE A tactile/haptic pushbutton control can avoid inadvertent activation by use of an initial springy region where the force increases linearly with displacement, followed by a sudden decrease in resistive force and transition to a deadband where the resistive force is constant, followed by a hard stop where the resistive force approximates that of a hard surface.

### 5.3.2 Using size and spacing of controls to avoid accidental activation

The system should use sizing and spacing to reduce the likelihood that a user will accidentally activate an adjacent control.

### 5.3.3 Avoiding difficult control actions

The system should avoid using very small controls or controls that require rotation of the wrist or pinching and twisting.

### 5.3.4 Using force to avoid accidental activation

Where avoidance of inadvertent operation is necessary, the operating force should not be less than 5 N.

### 5.3.5 Interacting with controls

The actuating force and torque of virtual controls should not be greater than the maximum values given in Table 1.

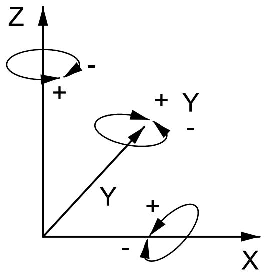
NOTE The maximum force and torque available for use by special populations (e.g. children) can be considerably lower.



**Table 1 — Maximum recommended operating forces/torques for manual control actuators**

| Type of grip | Part of hand applying force | Other factors | Max. recommended linear actuating force<br>N | Max. recommended linear actuating torque<br>N·m |
|---|---|---|---|---|
| Contact grip | Finger | Any direction | 10 | 0,5 |
| | Thumb | Any direction | 10 | 0,5 |
| | Hand | Any direction | 20 | 0,5 |
| Pinch grip | Finger/one hand | Any direction | 10 | 1 |
| | | X direction | 10 | 2 |
| | | Y direction | 20 | 2 |
| | | Z direction | 10 | 2 |
| Clench grip | One hand | X direction | 35 | — |
| | | Y direction | 55 | — |
| | | Z direction | 35 | — |
| | | 0,25 m radius | — | 20 |
| | Both hands | 0,25 m radius | — | 30 |




(Table and illustration taken from ISO 9355-3:2006, Table 4 and Figure 3.)

# 6 Design of tactile/haptic objects and space

## 6.1 Tactile/haptic display spaces

### 6.1.1 Ease of perceiving multiple tactile/haptic objects

The system should ensure an easily perceivable presentation of multiple tactile/haptic objects.

### 6.1.2 Ease of identifying adjacent tactile/haptic objects

Where multiple tactile/haptic objects are adjacent, it should be possible to identify them individually as well as together.

NOTE 1 Users might be confused when finding gaps between objects that are intended to be touching.

NOTE 2 When many haptically enabled objects are in close proximity, getting to a target can become difficult.

### 6.1.3 Maintaining separation between surfaces of objects

Individual objects should be sufficiently separated so that the user is able to perceive the boundaries between them.

NOTE If walls or edges are very close, there is a risk that a finger passing through a wall or edge will also unintentionally pass through an adjacent wall or edge.

#### 6.1.4 Separating tactile/haptic elements

Where not required to be contiguous, tactile/haptic elements should be separated by perceivable spaces.

NOTE Extra spaces between tactile/haptic elements make them more easily perceivable by people with poor tactual sensitivity.

#### 6.1.5 Avoiding empty spaces

The tactile/haptic space should avoid an excess of “empty space” as this is a significant source of confusion.

NOTE *Empty space* refers to areas on a display that do not communicate anything useful to the user.

#### 6.1.6 Avoiding volume limits

Restricting surfaces should be used in all directions in order to avoid tactile/haptic hardware volume limits being mistaken for an object.

NOTE Haptic clues, such as temporal vibration, can be used to indicate the physical limits of a device. In this way, the device limits will not be confused with objects in the virtual environment.

#### 6.1.7 Avoiding falling out of the tactile/haptic space

Users should not be able to involuntarily “fall out” of the tactile/haptic environment.

NOTE *Falling out* refers to a situation where the user finds him/herself outside the modelled space, experiences no feedback and is no longer able to navigate.

### 6.2 Objects

#### 6.2.1 Using appropriate object size

The size of a tactile/haptic object should be appropriate for the task and to the user's perceptual capabilities.

NOTE Objects requiring a large number of points of contact might not be capable of being fully perceived at once by a user in their entirety.

#### 6.2.2 Creating discriminable tactile/haptic symbols

Tactile/haptic symbols should be easily discriminable.

NOTE Examples of elements of symbols that make the symbols difficult to discriminate include

— lines with different amounts of incline,

— lines that cross,

— design elements that overlap or with narrow spacing between them,

— reliance on perspective (e.g. three-dimensional objects presented in two dimensions),

— thick lines,

— differing line lengths with different meanings,

— parallelism,

— large distances between objects, and

— small elements that vary slightly between symbols, e.g. broken lines with small breaks between the dashes, which could be mistaken for continuous lines or continuous straight versus continuously wavy lines, with small amplitude.



#### 6.2.3 Creating tactile/haptic symbols from visual symbols

Tactile symbols should be chosen for their tactual, rather than for their visual, discriminability.

NOTE 1 There are many symbols that are easy to discriminate visually, while equivalent tactile/haptic symbols can be difficult to discriminate.

NOTE 2 Direct translation from visual to tactile equivalent form (for use without vision) can be used for simple symbols. However, the more complex the symbol is, the less suitable direct translation can be.

#### 6.2.4 Tactile/haptic object angles

Tactile/haptic angles and perspectives should be close to those found naturally.

EXAMPLE Arrowheads can be misinterpreted if they are too wide or too narrow.

#### 6.2.5 Tactile/haptic object corners

When using a single-point interaction style, rounded corners should be used rather than sharp ones.



## 7 Interaction

### 7.1 Navigating tactile/haptic space

#### 7.1.1 Providing navigation information

Navigation information support should be available to assist users of tactile/haptic space.

NOTE Providing navigation information keeps users from becoming “lost” in tactile/haptic space.

#### 7.1.2 Supporting path planning

The display should enable the user to plan the shortest path to a target.

#### 7.1.3 Providing well-designed paths

The system should ensure that paths between objects have a clear structure, as well as clear start and end points.

EXAMPLE Easy-to-follow paths are implemented as a small groove or ridge.

#### 7.1.4 Making landmarks easy to identify and recognise

The system should provide well-defined and easy-to-find reference points or landmarks in the environment, and ensure that landmarks are easily identifiable and recognizable.

#### 7.1.5 Providing appropriate navigation techniques

The system should provide the most appropriate navigation technique (e.g. stylus, fingertip, multiple fingers, both hands), based on

a) the target users, domains, and task goals,

b) the size of the real or virtual space, the density of objects and their properties, and

c) the layout of the tactile/haptic space.

### 7.1.6 Providing navigational aids

Additional navigational aids can be required

a) where objects exist outside the currently displayed space,

b) where there are large open spaces between objects,

c) where objects are densely distributed,

d) where objects (that might be used as landmarks) are obscured.

NOTE 1 Types of navigation assistance include gravity wells, additional landmarks, grooves and ridges.

NOTE 2 Different representations can enhance different properties: negative relief emphasizes lines, whereas positive relief emphasizes the surface.

EXAMPLE 1 Height can help the user to easily “home-in on” certain features.

EXAMPLE 2 Positive relief is effective for spatial layouts that users explore with their hands.

EXAMPLE 3 Negative relief (grooves) hold the pointer, thereby making it easier to trace shapes when using a single point of contact haptic device.

### 7.1.7 Understanding the tactile/haptic space

The system should allow users to move about and explore the tactile/haptic space, acquiring an accurate understanding of the objects and their arrangement in the space.

### 7.1.8 Supporting exploratory strategies (procedures)

The system should

a) enable users to use their natural strategies for exploring the presented information, and

b) provide support for learning additional exploratory strategies appropriate to the user, application, and/or device.

NOTE Different kinds of exploratory strategies are more suitable for getting specific kinds of information, e.g. lateral motion for information about texture, pressure for information about hardness, unsupported holding for information about weight, and contour-following for information about shape.

## 7.2 Reconfiguration

### 7.2.1 Reconfiguring the tactile/haptic space

The system

a) may provide an option for reconfiguring the tactile/haptic space, and

b) should obtain user confirmation before changing the frame of reference of the tactile/haptic space.

EXAMPLE A system allows moving all of the controls for the product together to position them for optimal use by the individual.



## 7.3 Interaction techniques

### 7.3.1 Implementing interaction techniques

Systems may implement a variety of interaction techniques including some or all of the following:

a) moving relative to the object;

b) tracking (moving to/from/with/by the object);

c) tracing (moving across/around/along the surface of the object);

d) entering the object;

e) pointing at an object;

f) moving the object;

g) dragging;

h) pushing/pulling;

i) displacing the object (shaking/tilting/twisting/rotating);

j) directing object motion;

k) possessing the object;

l) grabbing/grasping;

m) holding/gripping;

n) releasing;

o) tapping/hitting;

p) pressing/squeezing/stretching;

q) rubbing/scratching/picking;

r) gesturing.

### 7.3.2 Avoiding unintended oscillation

The system should avoid oscillations related to control loop instability.

# Annex A
(informative)

# Overview of the ISO 9241 series

This annex presents an overview of ISO 9241: its structure, subject areas and the current status of both published and projected parts, at the time of publication of this part of ISO 9241. For the latest information on the series, see: http://isotc.iso.org/livelink/livelink?func=ll&objId=651393&objAction=browse&sort=name.

| Part no. | Subject/title | Current status |
|---|---|---|
| 1 | General introduction | International Standard (intended to be replaced by ISO/TR 9241-1 and ISO 9241-130) |
| 2 | Guidance on task requirements | International Standard |
| 3 | Visual display requirements | Replaced by the ISO 9241 "300" subseries |
| 4 | Keyboard requirements | International Standard (intended to be replaced by the ISO 9241 "400" subseries) |
| 5 | Workstation layout and postural requirements | International Standard (intended to be replaced by ISO 9241-500) |
| 6 | Guidance on the work environment | International Standard (intended to be replaced by ISO 9241-600) |
| 7 | Requirements for display with reflections | Replaced by the ISO 9241 "300" subseries |
| 8 | Requirements for displayed colours | Replaced by the ISO 9241 "300" subseries |
| 9 | Requirements for non-keyboard input devices | International Standard (intended to be replaced by the ISO 9241 "400" subseries) |
| 11 | Guidance on usability | International Standard |
| 12 | Presentation of information | International Standard (intended to be replaced by ISO 9241-111 and ISO 9241-141) |
| 13 | User guidance | International Standard (intended to be replaced by ISO 9241-124) |
| 14 | Menu dialogues | International Standard (intended to be replaced by ISO 9241-131) |
| 15 | Command dialogues | International Standard (intended to be replaced by ISO 9241-132) |
| 16 | Direct-manipulation dialogues | International Standard (intended to be replaced by ISO 9241-133) |
| 17 | Form filling dialogues | International Standard (intended to be replaced by ISO 9241-134) |
| 20 | Accessibility guidelines for information/communication technology (ICT) equipment and services | International Standard |

| Part no. | Subject/title | Current status |
|---|---|---|
| **Introduction** | | |
| 100 | Introduction to software ergonomics | Planned |
| | | |
| **General principles and framework** | | |
| 110 | Dialogue principles | International Standard |
| 111 | Presentation principles | Planned to partially revise and replace ISO 9241-12 |
| 112 | Multimedia principles | Planned to revise and replace ISO 14915-1 |
| 113 | GUI and controls principles | Planned |
| | | |
| **Presentation and support to users** | | |
| 121 | Presentation of information | Planned |
| 122 | Media selection and combination | Planned to revise and replace ISO 14915-3 |
| 123 | Navigation | Planned to partially revise and replace ISO 14915-2 |
| 124 | User guidance | Planned to revise and replace ISO 9241-13 |
| 129 | Individualization | Planned |
| | | |
| **Dialogue techniques** | | |
| 130 | Selection and combination of dialogue techniques | Planned to incorporate and replace ISO 9241-1:1997/Amd 1:2001 |
| 131 | Menu dialogues | Planned to replace ISO 9241-14 |
| 132 | Command dialogues | Planned to replace ISO 9241-15 |
| 133 | Direct-manipulation dialogues | Planned to replace ISO 9241-16 |
| 134 | Form-based dialogues | Planned to replace ISO 9241-17 |
| 135 | Natural language dialogues | Planned |
| | | |
| **Interface control components** | | |
| 141 | Controlling groups of information (including windows) | Planned to partially replace 9241-12 |
| 142 | Lists | Planned |
| 143 | Forms-based dialogues | Planned |
| | | |
| **Domain-specific guidance** | | |
| 151 | Guidance on World Wide Web user interfaces | International Standard |
| 152 | Interpersonal communication | Planned |
| 153 | Virtual reality | Planned |
| 154 | Design guidance for interactive voice response (IVR) applications | Planned |