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Review of ISO Standards on Human-System Interaction Published during 2008-2013

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Objective: The aim of this study is to give ergonomists the brief summary of the recently published ISO standards on human-system interaction and tips for application of the standards.

Background: Standard developers did hard work on developing a standard in a concise manner. But most of standards are often bulky in volume. Readers of the standards are difficult to catch key points from the voluminous contents of standards and intermingle among them.

Method: Focused on newly developed display/control technology, this study reviewed the 14 ISO standards on human-system interaction published during 2008-2013 and summarized key points from them.

Results: Schematic diagrams and tables concisely illustrated the processes, procedures, dimensions, or best practices recommended by the standards concerning conception, design, and usability testing for consumer products.

Conclusion: The standards provided the minimum level of requirements on design and evaluation on the physical input devices, electronic displays, and control interfaces based on the current state of technology. But the minimum requirements specified in the standards nowadays become mandatory ergonomic requirements in global trade world.

Application: Ergonomists can take a quick and broad view on international standardization activities on newly developed display/control technology from this summary study.

Keywords: ISO, TC 159, Standards, Ergonomics, Usability, Display, Control, Tactile, Haptics, SED, OLED, Autostereoscopic display

1. Introduction

Since Lee (2009) reviewed the standards published by International Standard Organization Technical Committee 159 (ISO/TC 159) on ergonomics, fourteen standards have been add to the published list of the standard catalogue on the ergonomics of human-system interaction. Subcommittee 4 (SC4) is in charge of publishing the standards on this area. The newly published standards mainly deal with usability evaluation, performance enhancing method and conformance testing method for interactions involving visual electronic displays, physical input devices, control center, and consumer products (Figure 1). The purpose of this study is to give ergonomists a quick and broad view on the standard practices and how to apply the standards to the human-system interaction design issues.

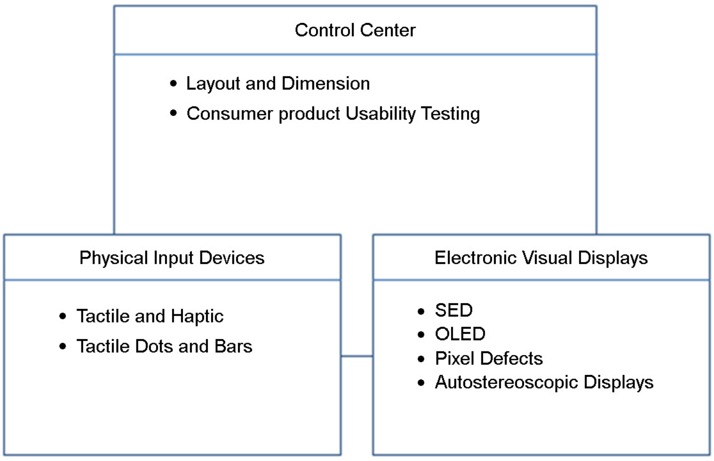

Figure 1. The area of the standards published by ISO/TC159 SC4 during the year 2008-2013 and summarized in this study

2. Summary of the ISO Standards on Human-System Interaction Published during 2008-2013

2.1 ISO 9241-307:2008 Ergonomics of human-system interaction-Part 307: Analysis and compliance test methods for electronic visual displays

ISO 9241-307:2008 provides test methods for CRT, LCD, PDP, front screen projection display, and hand held LCD. The ergonomist who want to do a compliance test for a CRT, for example, with this part of ISO 9241 at first should establish context of use. Context of use includes specification on user, environment, task, and technology. The context of use should be included in a part of compliance test report. Table 1 shows the procedure for compliance testing based on ISO 9247-307:2008. The test method summarized in Table 1 is intended to be applied to a testing a CRT for indoor use.

Table 1. Procedure of compliance test for a CRT (ISO 9241-307:2008)

Process	Practice	Example
Describe intended context of use	Specify the user	User with normal vision
	Specify the environment	Screen luminance
		Ambient temperature
	Specify the task	Contents of perception such as simple text or simple graphics
		Amount of information without scrolling such as 1 character or n character
		Viewing condition such as viewing distance, viewing direction, and eye/head position

Table 1. Procedure of compliance test for a CRT (ISO 9241-307:2008) (Continued)

Process	Practice	Example
Describe intended context of use	Specify the use of technology	Optical mode of operation in CRT Diagonal of the active display area Resolution Equipment is used stationary Equipment is used indoor
Specify compliance assessment method	Specify attributes to test	Design viewing distance Design viewing direction
	Establish pass/fail criteria	For viewing condition: the workplace and the visual display should permit the user to view the screen with a gaze angle from 0 to 40 degrees and a head tilt angle 0 to 25 degrees
	Specify measuring method	Supplier specification
Assess and report	Report assessment data	Refer to ISO/IEC 17025

2.2 ISO 9241-308:2008 Ergonomics of human-system interaction-Part 308: Surface-conduction electron-emitter displays (SED)

ISO 9241-308:2008 deals with surface conduction electron-emitter display (SED) technology. SEDs use nanoscopic-scale electron emitters to energize colored phosphors and produce an image. In a general sense, a SED consists of a matrix of tiny cathode ray tubes, each "tube" forming a single sub-pixel on the screen, grouped in threes to form red-green-blue (RGB) pixels.

Ergonomic advantage of SED is no curvature, fast response time, and a uniform and sharp focus on the screen while SED has disadvantage of limited display size and fixed resolution.

ISO 9241-308:2008 gives the ergonomists information on panel and face plate structures, resolution, and display size with comparison with other types of display such as CRT, LCD and PDP.

An example of intended context of use of SED include:
- Design screen illuminance is up to 600lux at indoor use.
- Design viewing distance is three times of vertical display height.
- Design viewing direction is perpendicular to the screen.

For visual quality assessment of SED, ISO 9241-307:2008 for CRT display for indoor use can reasonably be applied (Table 1).

2.3 ISO 9241-309:2008 Ergonomics of human-system interaction-Part 309: Organic light-emitting diode (OLED) displays

ISO 9241-309:2008 deals with organic light-emitting diode (OLED) displays. An OLED is a kind of light-emitting diode (LED) in which the emissive electroluminescent layer is a film of organic compound which emits light in response to an electric current.

An OLED display works without a backlight; thus, it can display deep black levels and can be thinner and lighter than a liquid crystal display (LCD). In a dark room, an OLED screen can achieve a higher contrast ratio than an LCD. This part of ISO 9241 gives the ergonomists understanding of OLED structure and operating principles and compares display features for example, emitting principle, optical performance, thickness of face plate, or pixel type of OLED with other type of displays such as CRT, LCD or PDP.

Because up to now there are no specific assessment method available for an OLED display, the assessment method for PDP for indoor specified in ISO 9241-307:2008 may be used considering the following OLED attributes of optically isotropic behavior:
- No geometrical distortion,
- Uniform and sharp focus on the entire screen,
- Quick response time less than 1 msec.

As a compliance test for an OLED, the same procedure shown in Table 1 can be applied.

2.4 ISO 9241-310:2010 Ergonomics of human-system interaction-Part 310: Visibility, aesthetics and ergonomics of pixel defects

ISO 9241-310:2010 deals with ergonomic and aesthetic requirement, specification, and visibility threshold of pixel defects in electronic displays.

Detection of pixel defect is definitely influenced by size of the spot, contrast of spot, and adaptation of luminance. As for spot size of pixel defect, the special width of the summation (a function of target size and adaptation level) will be at least 0.5' for fovea vision. Blue-Yellow contrast is as not good as luminance contrast in detecting pixel defects appearing as small spots.

Visibility of pixel defect can be influenced by display factor such as color, viewing angle, background luminance, reflectance, amount of area producing luminance and test subject factor such as visual acuity and environmental factor.

The subtended visual angle of the display, the display resolution, and the content of the display affects aesthetical acceptance limit of pixel defects.

This part of ISO 9241 provides information on pixel defects classification from the review of ISO 13406-2:2001 and ISO 9241-307:2008, and IEC 61747 series on liquid crystal display devices, and VESA (Video Electronics Standards Association) FPDM (Flat Panel Display Measurements) and industry practice. In case of high end purpose display such as medical displays where a pixel defects is critical, the industry practice recommends the manufacture should screen every display and give a map of pixel defect locations to the end user. This part of ISO 9241 also illustrates some examples of the map of pixel defect locations.

2.5 ISO 9241-331:2012 Ergonomics of human-system interaction-Part 331: Optical characteristics of autostereoscopic displays

The purpose of ISO 9241-331:2012 standardizes the methodology which characterizes and validates the 3D technology to ensure visual quality of autostereoscopic display (ASD) and to reduce the undesirable visual fatigue caused by imperfection of the technology.

In this part of ISO 9241 ASD means 3D display where depth perception is made by binocular parallax without any viewing aids such as 3D glasses or head-mount gears. Three different 3D technologies are presented based on principles, structures and features:

• two-view ASD,
• multi-view ASD,
• integral ASD.

Table 2 compares three kinds of ASD with each own advantages and disadvantages.

Table 2. Summary of technical features of autostereoscopic displays presented in ISO 9241-331:2012

ASD	Technology	Advantage	Disadvantage
Two-view ASD	Two monocular views	Simple implementation methods with high resolution	Viewing space is small
Multi-view ASD	More than two monocular views	Wide viewing spaces	Degraded image quality at other viewpoint area Decreased resolution with increased number of view
Integral ASD	Integrated images Dependent on the number of rays through lenslets and the pitch of lenslets	Clear images Smooth simulated motion parallax	Image quality is lower than at the viewpoint of multi-view ASD

Two-view ASD creates two monocular views with which left and right stereoscopic images are coupled while multi-view ASD creates more than two monocular views. An integral ASD, a kind of display with integral imaging method reproduces many integrated images via lenslets (arrays of small lens) in the screen inducing 3D objects in space optically.

Two-view ASD satisfies minimum technical requirement for ASD and has simple implementation methods with high resolution resulting in clear 3D view. Two-view ASD technology does not support simulation of motion parallax and viewing space is small.

Multi-view ASD technology can provide wide viewing spaces for 3D images while pseudoscopic image giving reversed depth perception is small compared with two-view ASD. Resolution of multi-view ASD decreases as number of view increases.

The fidelity of special image reproduction in integral ASD depends on the number of rays through lenslets, the pitch of lenslets and the distance between the screen and reproduced objects. Integral ASD produces clear images and smooth simulated motion parallax.

Multi-view display has a so-called viewpoint condensing light rays from all locations on screen. At the viewpoint 3D images can be viewed clearly while at other places the image quality gets degraded. Integral display has no viewpoint. Image quality of integrated display is lower than at the viewpoint of multi-view display and higher than at other places of multi-view display.

A 3D display is different from conventional 2D displays in optical characteristics: A 3D display shows a different image for each eye while a 2D display does not; A 3D display gives different images in different angular directions while in a 2D display angular uniformity is maintained; In 3D display all spatial locations do not have the same characteristics.

A typical ASD consists of 2D display panel and additional parallax barrier which give depth perception to the two eyes of the user by inducing binocular parallax.

Human performance using ASD is influenced by visual fatigue caused by excessive amount of binocular disparity, difference in retinal images between the two eyes such as luminance difference, and the conflict information inducing depth cue. Some conditions in ASD inducing excessive eye movement or conditions disturbing the consistent coordination between convergence and accommodation are also main cause of visual fatigue.

There are three kinds of visual performance measure in ASD: 3D crosstalk, interocular crosstalk, and interocular 3D purity.

3D crosstalk is the leakage of left eye data to the right eye and vice versa. 3D crosstalk makes images as blur or double images resulting in visual discomfort. For a multi-view ASD with discrete views, 3D crosstalk for one view is measured from luminance profile of each view.

Interocular crosstalk is the extent to which one eye sees the image of the other eye, which can disturb and cause visual fatigue. In two-view ASD interocular crosstalk is equivalent to 3D crosstalk.

Interocular 3D purity is the average of both eyes' degree of how much the image is free from unwanted light. Small values of the measured interocular 3D purity causes double images or blurred images resulting in visual fatigue.

Qualified visual space (QVS) is one of important measures for visual performance defined as a space where ASD is observed at an acceptable level of visual fatigue. ISO 9241-331:2012 proposes two types of QVS: the one is qualified binocular visual space (QBVS) a space for the mid-point of eyes where images on ASD is observed by both eyes at an acceptable visual fatigue; the other is qualified stereoscopic visual space (QSVS); a space where images on ASD induce stereopsis at an acceptable visual fatigue. This part of ISO 9241 also presents analysis and measurement methods for QBVS and QSVS.

Table 3 shows the excerpted examples of measuring methods for each visual performance parameter of ASD.

Table 3. Conformance test method for visual performance parameter of ASD (ISO 9241-331:2012)

Parameter	Measuring method
Alignment of screen	The screen should be aligned such that a plane tangential to the screen center is parallel to the axis of the measurement system
Image size	Factory setting or default mode
Standard nine point measurement locations	Those defined in ISO9241-305
Measurement field	A minimum of 500 pixels
Angular aperture	5 degrees or less
Test illumination	Illuminance on the screen less than 1 lx

2.6 ISO 9241-410:2008 Ergonomics of human-system interaction-Part 410: Design criteria for physical input devices

ISO 9241-410:2008 deals with properties of physical input devices such as keyboard, computer mice, pucks, joysticks, trackballs, trackpads, tablets, overlays, touch screen, styli, light pens, and voice- or gesture-controlled devices in relation to usability and design requirements for these input devices.

In this part of the standard input devices is regarded as a kind of a sensor for user behavior and a transmitter of user behavior signal to user interface system.

The most important requirement for the input devices is about performance related requirement. Input devices are acceptable in terms of performance if user can obtain a satisfactory performance on a given task with an acceptable effort and satisfaction. This is the performance criterion for input devices selection.

The second most important requirements for input devices are generic design requirements. Table 4 shows the generic design requirements for input devices.

Table 4. Summary of generic design requirements for physical input devices specified in ISO 9241-410:2008

Design requirement	Detailed requirement
Appropriateness	Appropriate for the intended tasks Compatible with anthropometric dimensioning of the part of the body Performance enhancement by software
Operability	Obvious intended use by appearance, trial and error, instructions or training Predictable input movement Operating in a consistent manner Accommodation of the intended user's anthropometry and force Effective feedback
Controllability	Consistent and sufficient response to actuation Non-interference with its own use Reliable, quick and easy access to the input devices
Biomechanical loads	Operable without undue posture or excessive effort

Besides performance related requirements and generic design requirements, it is valuable to evaluate physical input device-specific design requirements. Device-specific design requirements include functional, mechanical and electrical properties, maintainability-, health- and safety-related properties, and interdependency with software and user environment.

For example keyboard has the design-specific requirements as shown in Table 5.

Table 5. Keyboard design-specific requirements illustrated in ISO 9241-410:2008

Design-specific requirement		Detailed dimension
Functional properties	Design of keys	Size Keytop shape Strike surface

Table 5. Keyboard design-specific requirements illustrated in ISO 9241-410:200 (Continued)

Design-specific requirement		Detailed dimension
Functional properties	Design of keys	Displacement Force
	Keypad sections and zones	Alphanumeric section Numeric section Editing section Function section
Mechanical properties		Centerline spacing Height Width Slope Profile
Electrical properties for keyboards with external power supply		Influence of cabling Electromagnetic influence on other equipment
Maintainability-related properties		Surface of key tops Surface of cover
Health- and safety-related properties		Weight Sanitation for keyboard Sharp edge
Interdependency with software		Slowing down of data transfer speed by an application software
Interdependency with user environment		Noise Occupying free space Environmental vibration Lighting

Ergonomists who want to do a usability testing for physical input devices should set up the procedure by following Figure 2.

2.7 ISO 9241-411:2012 Ergonomics of human-system interaction-Part 411: Evaluation methods for the design of physical input devices

ISO 9241-411:2012 provides methods for evaluating conformance with the requirements of ISO 9241-410:2008 for physical input devices including keyboards, mice, pucks, joysticks, trackballs, touchpads, tablets, overlays, styli, light-pens and touch screens. As an example, the evaluating methods for requirements of computer mice specified in ISO 9241-411:2012 are shown in Table 6.

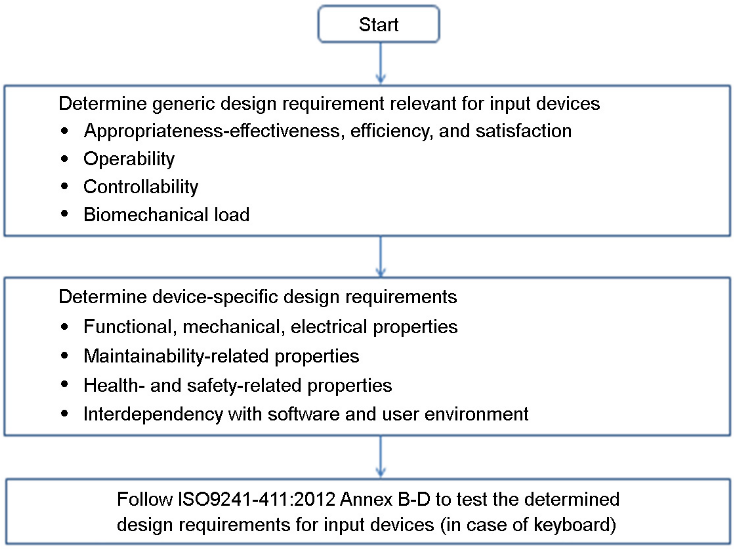

Figure 2. A procedure of setting up usability testing for a physical input device (keyboard in this case) summarized from ISO 9241-410:2008

Table 6. Evaluating methods for computer mice requirements excerpted from ISO 9241-411:2012

Design requirement	Pass/fail criterion for the requirement	Measuring method
Appropriateness: effectiveness of pointing, selecting, etc.	Index of difficulty>6 for class1 equipment	Measurement of index of difficulty defined in ISO 9241-441 during multi-directional tapping task, dragging task, or tracing task
Functional property: button displacement	Maximum button displacement on a mouse <= 6mm	Measurement of button displacement on a mouse
Maintainability related property: maintainability	User shall gain access to maintainable part of the mouse (eg. mouse ball) and surface for cleaning without any tools	Verify that user can clean the part without any tools
Health- and safety-related property: contacting with edges of a mouse during use	Edges on a mouse shall not cause discomfort or injury	Verify that edges do not cause any discomfort or injury even for prolonged use

2.8 ISO 9241-420:2011 Ergonomics of human-system interaction-Part 420: Selection of physical input devices

ISO 9241-420:2011 provides guidance on proper selection based on ergonomics factors of devices, limitation and capability of users, task characteristics and context of use. Objectives of selection using this part of ISO 9241 includes comparing the devices of the same kinds for a given context of use (for example, comparing mice with brand A vs. brand B), testing acceptability of a device used in an unintended context of use (for example, keyboard as a pointing device), and determining minimum quality of an input device (for example, optimum size of a tablet for a given resolution).

When we select an input device for a given task and context of use, the information should be collected from a task analysis

based on the following questions:
- What task elements are supported by the input device?
- What is the most important task in interaction way?
- Is there any restriction on the support surface?
- Is there any mutual intercept among the input devices when multiple devices are used?
- Is there any required level of effectiveness or efficiency?

We can select physical input devices by checking the design features of input devices listed in the checklist provided in ISO 9241-420:2011 Annex H. The design features and the measuring methods are specified in ISO 9241-410:2008 and ISO9241-411:2012 respectively. With this checklist, users or manufacturers can decide whether a device is usable for a task at hand under a given context of use.

This part of ISO9241 provides another selection method based on evaluating the importance of task primitives (tracing, free-hand input, rapid pointing, dragging, selecting, or text entry) as shown in Figure 3.

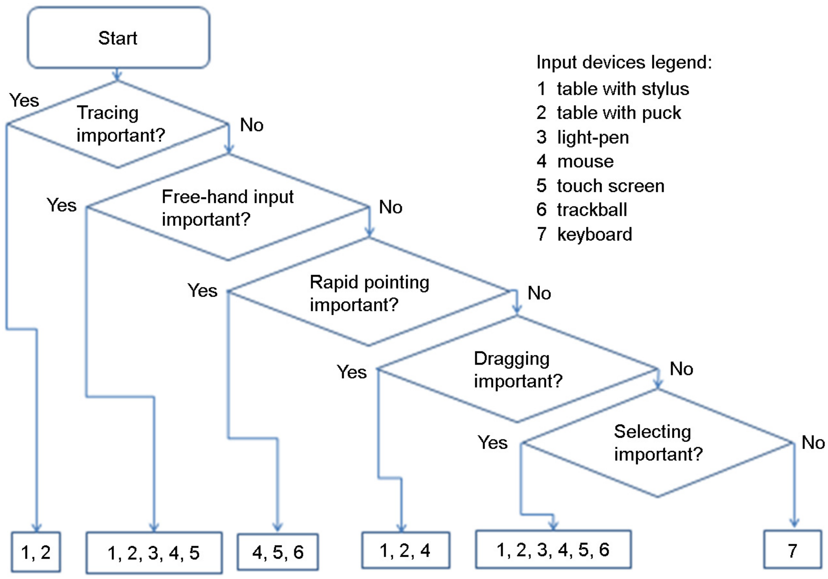

Figure 3. A procedure for selecting the proper physical input device based on importance of task primitives summarized from ISO 9241-420:2011

In most cases the main interaction task using input devices would be code entry (text input). This part of ISO 9241 adds a structogram for determining the best suitable keyboard type based on text entry task analysis.

When information on context of use, input devices, or task is insufficient, a direct field testing using the input devices is an alternative choice for selecting the proper input device. This part of ISO 9241 also presents direct field testing methods for input devices on tracing, dragging, tapping, and text entry tasks.

2.9 ISO 9241-910:2011 Ergonomics of human-system interaction-Part 920: Framework for tactile and haptic interaction

The main purpose of ISO 9241-910:2011 is to standardize the diversity of definitions and concepts involved in tactile/haptic interactions. Some important definitions include the following:
• Tactile means appertaining to sense based on receptors in the skin.
• Haptics means sensory and/or motor activity based in the skin, muscles, joints and tendons.

Haptics include touch and kinaesthesis. Kinaesthetic activity includes both sensing and action through force or torque on tactile/haptic devices. So haptics is a two-way exchange of information and action through devices.

Table 7 summarizes technical features of haptics in comparison with vision.

Table 7. Comparison of haptics with vision summarized from ISO 9241-910:2011

Interaction mode	Function	Advantage	Disadvantage
Haptics	To locate object within arm's reach To find edges separating surface To perceive size, form, or texture of object	To judge weight, hardness, texture, or temperature of object	Unable to get an overview Time lag in perception Unable to perceive 3D space beyond arm's reach
Vision	To locate object To find edges separating surface To perceive size and form or color of object	Quick perception of location, edges, size, form, or color of object	Unable to judge weight, hardness, or temperature of object

ISO 9241-910:2011 provides a concept of co-location of visual and haptic space. In virtual world visual object and haptic object may be located separately. Combining both visual and haptic object can facilitate rapid object targeting and perception of object form.

ISO 9241-910:2011 presents motion pattern linked to object attributes perceived (Table 8). Motion can be used for exploring

Table 8. Mapping between motion of user and dimension of object perceived (ISO 9241-910:2011)

Body motion	Attribute of object
Lateral motion	Texture
Pressure	Hardness
Unsupported holding	Weight
Enclosure	Shape or volume
Contour following	Edge or shape

object in the virtual world.

2.10 ISO 9241-920:2009 Ergonomics of human-system interaction-Part 920: Guidance on tactile and haptic interactions

Nowadays tactile and haptic interactions using touch or movement of body parts are becoming popular in the area of simulation, game industry, and assistive technology. In this regard ISO 9241-920:2009 is getting more attention than ever. This part of ISO 9241 provides general guidance on the design of software, hardware or a combination of software and hardware for tactile and haptic input devices.

Tactile and haptic devices should be designed to minimize user fatigue by careful choice of body location for stimulation, reducing minute and precise joint rotations of the body, or avoiding static positions at or near the end of motion. Tactile and haptic devices should be designed to reduce confusion between modalities when multiple input device modalities are used by differentiating size, orientation, shape, mapping, or temporal presentation in input modalities.

The system using tactile/haptic devices should give the user option to enable/disable tactile/haptic modality. If tactile/haptic mode is disabled, alternative modality should be given. Different user have different threshold for sensation or pain from tactile input. So the system should enable users to individualize the tactile parameters. Where high spatial resolution is needed, the user should interact with the system only with the distal body parts.

The dimensions that can be used for encoding tactile/haptic information may be selected from Table 9. It is better to limit the number of different levels for any single attribute up to three. In general object using more values of attribute can be discriminated safely.

When using tactile/haptic controls, the system should provide the user with feedback indicating selection and activation of the

Table 9. Tactile/haptic properties for encoding information dimensions (ISO 9241-920:2009)

Properties	Attribute
Material properties	Hardness Viscosity Elasticity Mass/weight Inertia Thermal conductivity
Surface properties	Texture Roughness Friction Temperature
Geometric properties	Size Shape

Table 9. Tactile/haptic properties for encoding information dimensions (ISO 9241-920:2009) (Continued)

Properties	Attribute
Geometric properties	Location in environment Orientation in environment Spatial pattern Spatial grating amplitude & frequency
Temporal properties	Temporal pattern Temporal vibration amplitude & frequency

control. The system should avoid using the control actions that require difficult and fatigue inducing motion like rotation of the wrist, pinching, or twisting.

Where multiple tactile/haptic objects are adjacent, there should be enough space between objects.

This part of ISO 9241 provides interaction design principles and body motions manipulating tactile/haptic input devices as shown in Table 10. The design principles can be implemented by applying combinations of these body motions manipulating tactile/haptic devices.

Table 10. Tactile/haptic interaction design principles and body motions (ISO 9241-920:2009)

Design principles	Available motions to achieve the goal of design
Providing navigation information & strategy Supporting path planning Providing well-designed paths Making landmarks easy to identify Providing appropriate navigation techniques & aids	Moving, tracking, tracing, entering the object, pointing at an object, dragging, pulling, pushing, displacing the object, directing object motion, possessing the object, grabbing, grasping, holding, gripping, releasing, tapping, hitting, pressing, squeezing, stretching, rubbing, scratching, picking, or gesturing

2.11 ISO 11064-4:2013 Ergonomics design of control centers-Part 4: Layout and dimensions of workstations

ISO 11064-4:2013 provides ergonomic requirements, recommendations, and guidelines for the designs of workstations in control centers.

Displays for high-priority information source such as alarms or overview should be located centrally. The operator should preferably look at the primary information and towards frequently-used secondary equipment. The maximum number of displays that can be satisfactorily monitored and operated is dependent on the task analysis result but it is generally four. When we determine the number and arrangement of displays it is important to consider full range of operation scenario such as start-up, shut-down, disturbances, outage, etc.

Keyboards should be preferably located at the center of the operator's usual workspace. If movable keyboard is used, sufficient space should be given for moving the keyboard 30 degrees in a clockwise or anticlockwise direction from normal. There shall be a minimum of 150mm depth and the width of the keyboard space should support the operator's forearms and wrists in front of the keyboard. There shall be enough space and cabling facilities to place a mouse or trackball to the right or left hand users.

In case of mouse-only control workstation, a 200 x 240mm space shall be available for mouse movement. There shall be a minimum of 150 mm depth and the width of the mouse mat should support the operator's forearms and wrists in front of the mouse mat.

Input devices shall not compete for work surface space with other items such as telephones, manuals, and log books.

Frequently used controls should be within reach of the operator with an erect working posture; an approximation of 5th percentile arm reach minus 50mm.

Frequently used controls shall not be positioned above the shoulder height of the user population.

The height of the keyboard, mice, trackballs, and other input devices should be approximately at or below the elbow height of the seated operators.

Emergency controls such as shutdown button for power station shall be protected from accidental activation.

For seated or standing control workstations, the dimensions in Table 11 are recommended.

Table 11. Recommended dimensions of seated and standing control workstations excerpted from ISO 11064-4:2013

Type	Dimension	Recommendation
Seated	Vertical, horizontal, lateral clearance of leg, knees, and foot under the work surface	Sufficient for the user with 95th leg length
	Height of work surface	At or slightly below elbow height
	Characters on displays	Subtend the required minimum visual angle of the seated operator
	Adjustable foot rest	Minimum surface of 450 x 350mm Minimum height at front side 50mm, adjustable to at least 110mm Minimum slope 5 degrees, adjustable to at least 15 degrees
Standing	Work top surface	Not exceed 5th percentile elbow height of the user population
	Maximum vertical dimension of a view over the top	Not exceed 5th percentile standing eye-height of the user population
	Depth of work surface	Consider the 5th percentile arm reach of the user population

Appendix A of ISO 11064-4:2013 provides procedures for arrangement of singular or multiple displays at control workstations.

2.12 ISO/TS 18152:2010 Ergonomics of human-system interaction: Specification for the process assessment of human-system issues

ISO/TS 18152:2010 provides three processes to enumerate human-system issues:
• Human-system issues on system life cycle
• Human-system issues on integration of human factors
• Human-system issues on human centered design

Table 12 summarizes the process to enumerate human-system issues on system life cycle.

Table 12. Process for addressing human-system issues in system life cycle summarized from ISO/TS 18152:2010

System life cycle	Process for addressing human-system issues	Benefits of applying the process
Conception	Identify context of use	Consideration of human-system risk and impact on stakeholders
	Analyze system concept	Accurate definition of system requirements
	Describe objectives of system use	
	Identify roll of user in system	
Development	Generate design options in relation with use	Design is based on trial of potential users
	Produce user-centered design option	Identification of personal and training cost, human performance, and related risk
	Design for customization	Collection of user feedback
	Develop simulation and trial for use	
	Collect user feedback	
	Assess health and wellbeing risk of users and risk to the community and environment	
Production and use	Evolve system use strategy	New design of jobs and team working
	Maintain and contact user and user organization	Build new critical human-system criteria
	Build user training program	
	Test for system requirement for user	
	Analyze user feedback	
Use and support	Produce user strategy	Safe operational procedure
	Assess the effect of change in usability	Monitoring of long term use of system
	Review health and wellbeing risk of users and risk to the community and environment	
Retirement	Collect and analyze in-service report	Collection of user feedback and in-service data for next version of system
	Identify risk and health and safety issue related to removal of service and destruction of system	Identification of user requirement of replacement system
	Debriefing for replacement system	Monitoring of safety and health hazard after use of system

Table 13 summarizes best practices and benefits from applying human factors integration process and human-centered design process in system development.

Table 13. Human factors integration process and human-centered design process summarized from ISO/TS 18152:2010

Process	Practice	Benefit
Human factors integration	Consideration of system usability and health and safety risk in the organization's strategy plan	Human-system issues are addressed in the organization
	Establishment of infrastructure in the organization for human-system issues	Human-system life cycle process are enacted
	Consideration of system usability and health and safety risk in acquisition, supply and operation of system	
	Application of human factors data to mitigate human-system related risk	
	Facilitation of information exchange and communication regarding human-system issues	
Human-centered design	Establishment of context of use	System meets user needs in its context of use
	Establishment of user requirements	Consideration of possible health and safety hazard on use
	Design solution considering human factors data	User effectiveness, efficiency, and satisfaction with system are known
	Collection of feedback on evaluation of use	

2.13 ISO/TS 20282-2:2013 Usability of consumer product and products for public use-Part 2: Summative test methods

ISO/TS 20282-2:2013 provides a test procedure using summative test method for usability which can be applied to consumer products or products for public use. A summative test of a product is usually conducted at the end of product development stage. The purpose of summative test is to prove the goal of the product is achieved and to present conclusion about the

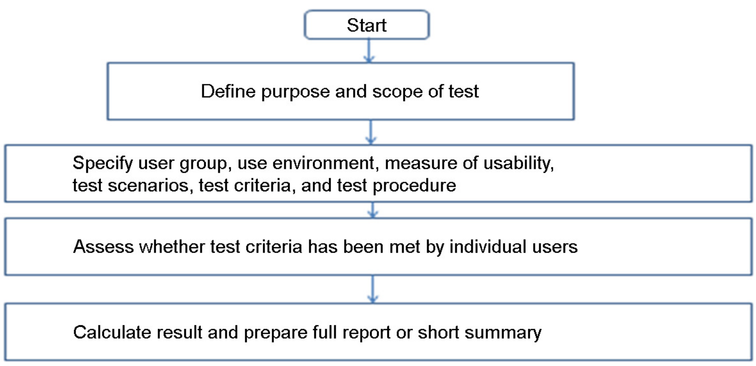

Figure 4. Procedure for summative usability test for consumer products or products for public use summarized from ISO/TS 20282-2:2013

merit or worth of development. Figure 4 summarizes the summative test procedure for usability of consumer products or products for public use based on ISO/TS 20282-2:2013.

It is noteworthy ISO/TS20282-2 emphasizes that the design and conduct of testing should protect human participants by conforming to the following ethical code:
(1) No test should demand excessive physiological and mental effort.
(2) Privacy of individual should be protected.
(3) The collected data should be kept confidentially.
(4) The vulnerable user group including children, aged persons or people with disability should be given special care to protect their rights.
(5) Participants should be given sufficient information about test.

2.14 ISO 24503:2011 Ergonomics-Accessible design-Tactile dots and bars on consumer products

ISO 24503:2011 presents a useful interface method using tactile dots and bars improving accessibility of consumer products used by people with visual disability. Tactile dots and bars are respectively dot-shaped and bar-shaped tactile symbols identifiable and recognizable by touch. They are served to identify a function of control or to locate arranged control. A tactile dot shall be placed on a control whose purpose is to start the function of a consumer product while a tactile bar is for stop/cancel of the control.

The dimensions of dots and bars which can be applied to controls of consumer products are summarized in Table 14.

Table 14. Sizes of tactile dots and bars on a control of consumer products (ISO 24503:2011)

Symbol	Dimension	Size (mm)
Dots	Diameter	0.8-2.0
	Height	0.4-0.8
Bars	Width	0.8-2.0
	Length	5 to 10 times width of bar
	Height	0.4-0.8

3. Conclusions

The standards dealt with in this study can be classified into four areas: ergonomic design principle/technology, ergonomic design

Table 15. Area of interest and application of the standards covered in this study

Area of standard		Design principle/technology	Design requirement	Usability test principle	Usability test method
Display	CRT				ISO 9241-307:2008
	LCD				
	PDP				

Table 15. Area of interest and application of the standards covered in this study (Continued)

Area of standard		Design principle/technology	Design requirement	Usability test principle	Usability test method
Display	SED	ISO 9241-308:2008			ISO 9241-308:2008
	OLED	ISO 9241-309:2008			ISO 9241-309:2008
	Pixel defects	ISO 9241-310:2010	ISO 9241-310:2010		
	ASD	ISO 9241-331:2012			ISO 9241-331:2012
Control	Keyboard Computer mice Pucks Joysticks Trackballs Trackpads Tablets Overlays Touch screen Styli pens Light pens Voice- or gesture-controlled devices	ISO 9241-410:2008	ISO 9241-410:2008	ISO 9241-411:2012	ISO 9241-411:2012
	Selection of input devices	ISO 9241-420:2011			
	Tactile/haptics	ISO 9241-910:2011	ISO 9241-920:2009		
	Tactile dots & bars		ISO 24503:2011		
Interactive system	Control center -dimension & layout	ISO 11064-4:2013	ISO 11064-4:2013		
	Human-system issue addressing	ISO/TS 18152:2010			
	Consumer products			ISO/TS 20282-2:2013	ISO/TS 20282-2:2013

requirements, usability test principles and usability test methods. Table 15 shows the main focus of each standard reviewed here.

The recently published standards from ISO/TC159 SC4 cover all the human-system interaction area: display, control and interactive system. Especially the standard developers introduced new technology like SED, OLED, and ASD in display area. They had a strong interest on tactile and haptics technology as an interactive method (Table 15).

The readers of the standards can use these standards as a way of getting information on state of the art technology and design requirements for interactive system or the usability test method to prove their products' conformance of a specific standard. It is the trend that the ergonomic design requirements specified in the standards becomes the minimum design requirements of consumer products in the global trade world. So it is important for developers of the product to be aware of those essential requirements.

This study tried to summarize the voluminous standards and extract key points from them. Schematic figures and tables may serve the reader of the standards to get a broad and quick view on the map of intermingled standards.

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ISO 9241-420:2011 Ergonomics of human-system interaction-Part 420: Selection of physical input devices, ISO, Geneva, 2011.

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