SLOVENSKI STANDARD
SIST EN 614-2:2001+A1:2008

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Varnost strojev - Naļ ela ergonomskega naļ rtovanja - 2. del: Medsebojni vplivi med oblikovanjem strojev in delovnimi nalogami

Safety of machinery - Ergonomic design principles - Part 2: Interactions between the design of machinery and work tasks

Sicherheit von Maschinen - Ergonomische Gestaltungsgrundsätze - Teil 2: Wechselwirkungen zwischen der Gestaltung von Maschinen und den Arbeitsaufgaben

Sécurité des machines - Principes ergonomiques de conception - Partie 2: Interactions entre la conception des machines et les tâches du travail

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13.110	Varnost strojev	Safety of machinery
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Foreword

This document (EN 614-2:2000+A1:2008) has been prepared by Technical Committee CEN/TC 122 "Ergonomics", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.

This document includes Amendment 1, approved by CEN on 2008-08-14.

This document supersedes EN 614-2:2000.

The start and finish of text introduced or altered by amendment is indicated in the text by tags ⟩A1⟨ ⟩A1⟨.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

⟩A1⟨ For relationship with EU Directive(s), see informative Annexes ZA and ZB, which are integral parts of this document. ⟩A1⟨

EN 614 consists of the following Parts, under the general title Safety of machinery – Ergonomic design principles:

— Part 1: Terminology and general principles

— Part 2: Interactions between the design of machinery and work tasks.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

This European Standard helps the designer in applying ergonomics principles to the design of machinery, focusing especially on the interaction between the design of machinery and work tasks.

This is essential since the quality of design and safety of machinery depends on the prospective operators being able to perform their tasks with the machinery in a safe and competent manner. Applying ergonomics principles to the design of machinery and work tasks aims at minimizing the discomfort, fatigue and other impairing effects faced by the operator and thus contributes to the optimal functioning of the work system (EN 292-2:1991, Annex A.1, 1.1.2 (d)) and reduces the risks of negative health effects. Therefore, good design follows ergonomics principles, starts with the specification of system functions and anticipates how the prospective operator will interact with the machinery and other work equipment.

In the design of machinery and work tasks, the physical aspects of the operator's activities are not the only design parameters to be dealt with. Operator activities also include the perception and processing of information, determination of strategies, decision making and communication.

1 Scope

This European Standard establishes the ergonomics principles and procedures to be followed during the design process of machinery and operator work tasks.

This European Standard deals specifically with task design in the context of machinery design, but the principles and methods may also be applied to job design.

This European Standard is directed to designers and manufacturers of machinery and other work equipment. It will also be helpful to those who are concerned with the use of machinery and work equipment, e.g. to managers, organizers, operators and supervisors.

In this European Standard the designer refers to the person or group of persons responsible for the design.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated reference subsequent amendments to, or revisions of, any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 614-1:1995, *Safety of machinery – Ergonomic design principles – Part 1: Terminology and general principles.*

EN 894-1, *Safety of machinery – Ergonomics requirements for the design of displays and control actuators – Part 1: General principles for human interactions with displays and control actuators.*

EN 292-1, *Safety of machinery - Basic concepts, general principles for design - Part 1: Basic terminology, methodology.*

EN 292-2:1991/A1:1995, *Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles and specifications.*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 614-1 apply.

4 Principles of work task design

Work task design covers the analysis and specification of functions and their allocation to the machine or the operator as part of the design process, and aims at contributing to the optimal functioning of work systems. Therefore, good design follows ergonomics principles and gives special attention to the intended operator population. Principles of good ergonomic design are given in EN 614-1. The aim shall be achieved by approaching the characteristics of well designed operator work tasks given in 4.1 by following the methodology for work task design given in 4.2 and by performing an evaluation of work task design according to 4.3.

4.1 Characteristics of well-designed operator work tasks

When designing machinery and work tasks, the designer shall ensure that the following ergonomics characteristics of well-designed work tasks are fulfilled. These characteristics take into account the differences and dynamic characteristics of the intended operator population, and shall be pursued by designing machinery and work tasks in interaction.

Thus, in the design process the designer shall

a) **recognise the experience, capabilities and skills of the existing or expected operator population.** This includes the levels of general education and vocational training, as well as knowledge acquired in other similar working situations. It should be kept in mind that levels of training and knowledge vary across operator populations and change over time. Therefore, e.g. speed and complexity requirements and information on task performance should be adaptable to all intended users.

b) **ensure that work tasks to be performed are identifiable as complete and meaningful whole units of work with a clearly identifiable beginning and end, rather than as isolated fragments of such tasks.** Therefore, each work task should in particular comprise not only performance components, but also preparatory (e.g. planning) and evaluative (e.g. inspection, checking) components.

c) **ensure that work tasks performed are identifiable as a significant contribution to the total output of the work system.** The operator should be able to understand how and to what extent task performance and its outcome will affect the whole work system and its outcomes. Thus, unnecessary fragmentation of the work process, leading to narrow operator work tasks shall be avoided.

d) **provide for the application of an appropriate variety of skills, capabilities and activities, and in particular provide for an appropriate combination of the following types of behaviour:**

- **skill based behaviour,** which consists of an immediate, simple conscious or non-conscious reaction to cues from the work process,
- **rule based behaviour,** which allows the operator to exert control of the work process by applying basic algorithmic rules (e.g. by making simple if-then decisions)
- **knowledge based behaviour,** which requires the operator to develop and maintain a complex set of knowledge about the interrelationships in the process, in order to diagnose system states and faults, and to develop solutions and perform adequate actions.

e) **provide an appropriate degree of freedom and autonomy to the operator.** The operator should be able to choose among alternative ways of task accomplishments and determine priority, pace and procedure of the work task. Rigidly fixed sequences, pace and working methods shall be avoided.

f) **provide sufficient feedback on task performance in terms meaningful to the operator.** Information on performance shall be made available enabling the operator to check whether goals are reached and performance is adequate. This includes also information on performance mistakes and correct alternatives.

In work tasks subject to frequent interruptions, the design of machinery shall provide for memory aids to remind the operator where he/she left off.

g) **provide opportunities to practise and develop existing skills and capabilities as well as to acquire new ones.** This should be achieved by providing for different ways of task accomplishment, sufficient degrees of autonomy and variety in connection with appropriate feedback on task performance. This allows the operator to choose the operation mode most suitable to the present state of expertise and to try to gain experience in different ways of task accomplishment, preferably combining different types of behaviour.

For monitoring and control tasks, especially in highly automated systems, the operator needs to be able to acquire the competence to control the process and develop a clear picture of the structure and interrelationships of the process. This will be especially crucial in emergency situations.

h) **avoid overload as well as underload of the operator, which may lead to unnecessary or excessive strain, fatigue or to errors.** Frequency, duration and intensity of perceptual, cognitive and motor activities shall be designed so as to avoid these consequences. Overload or underload shall not solely be determined under normal, but also under abnormal conditions (e.g. worst case situations). This is particularly relevant for monitoring and control tasks, especially in highly automated systems.

Occurrences of overload and underload vary across the population and will change with time. Therefore, it is necessary to provide for opportunities of adaptation to individual differences, stages of development and states of training.

i) **avoid repetitiveness, which may lead to unbalanced work strain and thus to physical disorders as well as to sensations of monotony, satiation, boredom or to dissatisfaction.** Short performance cycles should therefore be avoided. The operator shall be provided with an appropriate variety of tasks or activities. If repetitive tasks cannot be avoided,

— performance time shall not be determined solely on the basis of average times measured or estimated under normal conditions;

— allowances shall be given for deviations from normal conditions;

— very short cycle times shall be avoided;

— opportunities shall be given to the operator to work at his/her own pace, rather than at a set pace;

— working on moving objects shall be avoided.

j) **avoid working alone without opportunities for the operator for social and functional contacts.** Lines of sight, noise levels, distances between workplaces and workplace autonomy shall be taken into account when defining spacing, positioning and functions of machinery and other work equipment.

These characteristics of well-designed operator work tasks shall not be violated by the design of machinery. However, taking into account applicability and the state of art, it may not be possible to meet all the objectives completely. In this case, machinery and operator work tasks shall be designed and constructed in accordance with these objectives as far as possible.

4.2 Methodology of work task design in relation to machinery design

The work task design in relation to machinery design can be described as a process, which includes the following stages:

— establishing design objectives;

— function analysis;

— function allocation;

— work task specification, and;

— assignment of work tasks to operators.

Figure 1 and Table 1 give an outline of this process, which is described in detail in 4.2.1 to 4.2.5.

NOTE Designing is usually an iterative process, and the division between the stages may not be distinct. The design solution of one function will often interact with the solutions of other functions within the system. Therefore, the designer may need to move back and forth in the process, e. g. proceed by making tentative solutions and come back to re-analyse the situation or revise the design specifications.

By following the stepwise procedure described in this European Standard, the designer can

— base the design decisions on the relevant information,

— make the decisions perceivable to all persons concerned in the design process,

— predict the consequences of the design decisions on human operations and activities, and

— check the adequacy of the decisions as early as possible.

As a general rule, in the design process the designer shall

— utilise existing experience at each stage of the process, e. g. by analysing existing design solutions and their influence on the operator's activities,

— consider human and basic engineering factors concurrently,

— use methods which can take into account the operator's interaction with the machinery and other work equipment,

— evaluate the design proposals at each stage of the process against the objectives, requirements and evaluation criteria established in earlier phases of the design process, and

— document the work task design process in order to be able to verify that compliance with the requirements of this European Standard and the established objectives have been achieved.

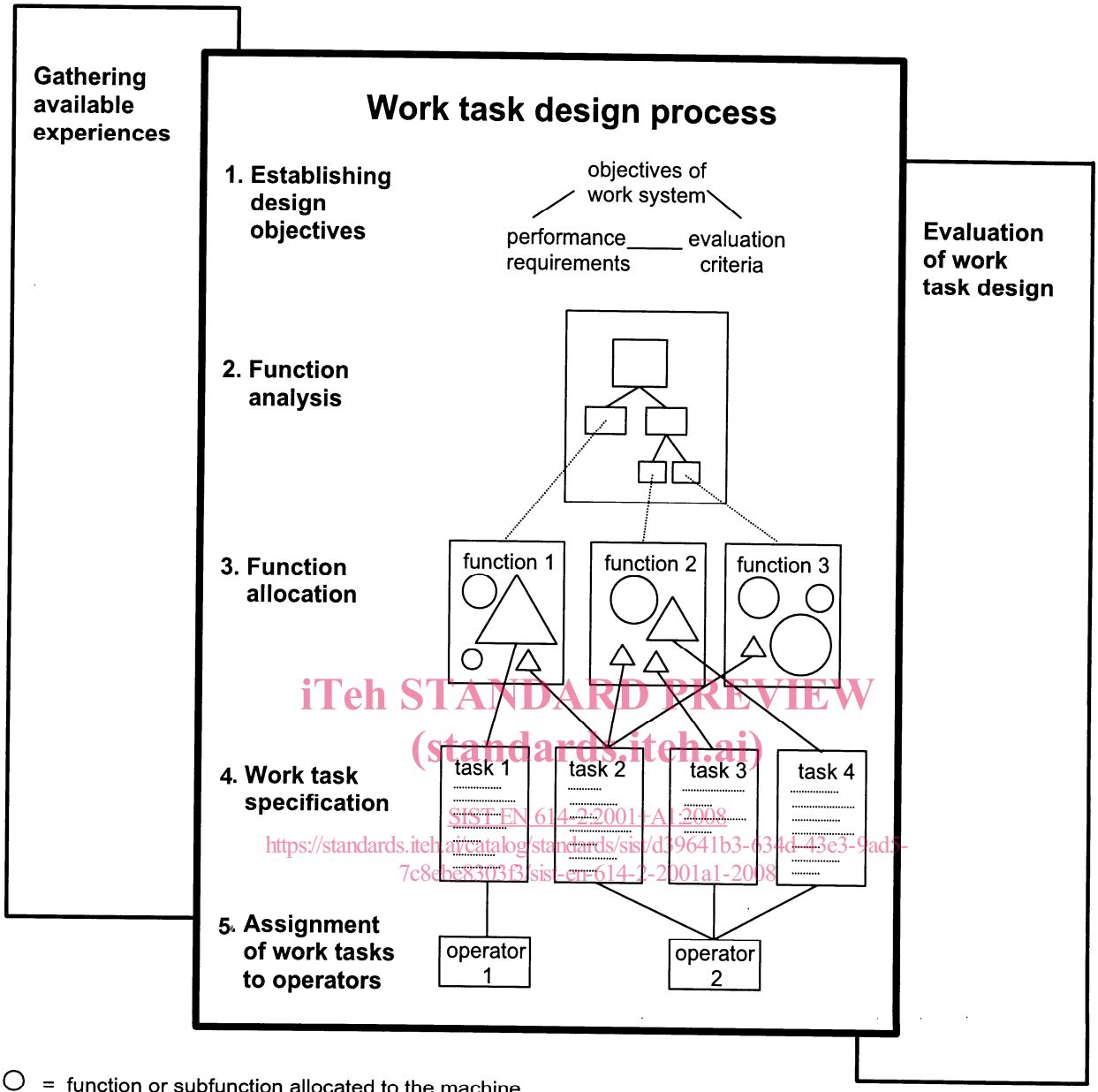

Figure 1 — Outline of the work task design process

Table 1 — Description of the work task design process

No	Design stage	Description of stages
1	Establishing the design objectives	— Gather information on comparable existing machinery — Work out the general design objectives and design specifications — Establish general performance requirements and evaluation criteria
2	Function analysis	— Identify functions and sub-functions and specify them in their hierarchy and functional relationships — Specify functions together with their performance criteria — Evaluate the specified functions against the design specifications
3	Function allocation	— Allocate functions and sub-functions to the operator or the machine, or, where appropriate, to both — Evaluate the suitability of the functions as human activity or machine operation — Outline alternative design solutions and analyse the benefits and drawbacks of them
4	Work task specification	— Gather information on comparable existing tasks — Specify the operator tasks in detail — Evaluate the workload each task imposes on the operator
5	Assignment of work tasks to operators	— Specify the number of operators required — Assign the tasks to the operators — Evaluate the total operator workload and fulfilment of the characteristics of well-designed operator work tasks

Decisions and actions taken in the design process have important consequences for the operator and for the functioning of the work system as a whole. Therefore, designers should not work on their own, but involve persons representative of all groups possibly affected by the work system, in the different design steps. This can efficiently be done e.g. by establishing a design project group, including system designers, management representatives, user representatives, supervisors, operators and customer groups.

4.2.1 Establishing the design objectives

At this stage the objectives of the work system have to be specified together with performance requirements and evaluation criteria. This stage of the task design process has to be carried out also when minor changes of an existing work system are being planned.

Thus, the designer shall

— gather information on similar or comparable systems, e.g. planning documents, system specifications, test and evaluation documents;

— work out general objectives of the work system regarding technical as well as human performance requirements;

— based on these objectives, specify and document the design specifications by taking into account the following items:

  — specific goals of the system;

  — any required inputs;

  — any required outputs;

  — any undesirable outputs;

  — capabilities and performance requirements of the system;

  — environmental factors that may affect the system;

  — environmental factors that may be affected by the system;

  — constraints on system performance;

  — risk and safety constraints;

  — the number and qualifications of persons employed in the system;

  — the kind of training necessary;

  — working conditions of the operators.

— based on these design specifications establish requirements on a general level concerning e.g. performance, reliability, usability, safety and maintainability. These requirements shall be ranked according to their relative importance and be used as evaluation criteria to evaluate design alternatives at later steps and to ensure design adequacy.

4.2.2 Function analysis

At this stage, the designer shall perform an analysis of the functions and sub-functions required to meet the design objectives, and specify the resulting functions together with their performance requirements.

NOTE Functions are logical units of activities or sets of activities that are necessary to accomplish the objectives of the work system. Functions are described strictly in terms of activities and not in terms of means of achievement.

Thus, the designer shall