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Ergonomics principles in the design of work systems

Principes ergonomiques de la conception des systèmes de travail

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

The committee responsible for this document is ISO/TC 159, *Ergonomics*, Subcommittee SC 1, *General ergonomic principles*.

This third edition cancels and replaces the second edition (ISO 6385:2004), which has been technically revised with the following changes:

— terms were aligned with the terms given in ISO 26000;

— 3.2, 3.7 and Clause 4 have been technically revised;

— life cycle of a work system was introduced in 3.2;

— principle of adjustment was added to 3.7 and validation replaced by verification;

— new subclause on conformity was added to Clause 4;

— examples were added in several clauses.

Introduction

Technological, economic, organizational and human factors affect the work behaviour and well-being of people as part of a work system. Applying ergonomic knowledge in the light of practical experience in the design of a work system is intended to satisfy human requirements.

This International Standard provides a basic ergonomic framework for professionals and other people who deal with the issues of ergonomics, work systems and working situations. The provisions of this International Standard will also apply to the design of products for use in work systems.

Following the principles and requirements described in this International Standard will support management in making better decisions, for instance related to the sustainability of investments in work system innovation.

In the design of work systems in accordance with this International Standard, the body of knowledge in the field of ergonomics is taken into account. Ergonomic evaluations of existing or new work systems will show the need for, and encourage attention to, the role of the worker within those systems.

ISO 26800 provides a general starting point for thought on ergonomics and determines the essential general principles and concepts. This International Standard presents these in the context of the design and evaluation of work systems.

This International Standard is also valuable in the application of management systems such as OHSAS 18001. Besides guidelines for processes, it also offers guidance for achieving good human performance.

Ergonomics principles in the design of work systems

1 Scope

This International Standard establishes the fundamental principles of ergonomics as basic guidelines for the design of work systems and defines relevant basic terms. It describes an integrated approach to the design of work systems, where ergonomists will cooperate with others involved in the design, with attention to the human, the social and the technical requirements in a balanced manner during the design process.

Users of this International Standard will include executives, managers, workers (and their representatives, when appropriate) and professionals, such as ergonomists, project managers and designers who are involved in the design or redesign of work systems. Those who use this International Standard can find a general knowledge of ergonomics (human factors), engineering, design, quality and project management helpful.

The term "work system" in this International Standard is used to indicate a large variety of working situations, including permanent and flexible work places. The intention of this International Standard is to assist in the improvement, (re)design or change of work systems. Work systems involve combinations of workers and equipment, within a given space and environment, and the interactions between these components within a work organization. Work systems vary in complexity and characteristics, for example, the use of temporary work systems. Some examples of work systems in different areas are the following:

— production, e.g. machine operator and machine, worker and assembly line;

— transportation, e.g. driver and car or lorry, personnel in an airport;

— support, e.g. maintenance technician with work equipment;

— commercial, e.g. office worker with workstation, mobile worker with a tablet computer, cook in a restaurant kitchen;

— other areas like health care, teaching and training.

The observance of ergonomic principles applies to all phases throughout the life cycle of the work system from conception through development, realization and implementation, utilization, maintenance and support to decommissioning.

The systems approach in this International Standard gives guidance to the users of this International Standard in existing and new situations.

The definitions and ergonomic principles specified in this International Standard apply to the design of optimal working conditions with regard to human well-being, safety and health, including the development of existing skills and the acquisition of new ones, while taking into account technological and economic effectiveness and efficiency.

The principles in this International Standard are applicable to many other human activities, e.g. in the design of products for domestic and leisure activities. A more general description of the principles in this International Standard can be found in ISO 26800.

NOTE 1 This International Standard is considered to be the core ergonomic standard for work systems from which many others on specific issues are derived.

Note 2 Although elements of the system can be the same, this International Standard is not intended to be applied to systems used in a non-work context (e.g. the use of a vehicle for private purposes).

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
well-being
<work system> sustainable internal state resulting from satisfaction of the physical and cognitive needs of the *worker* (2.4) during his/her activity

Note 1 to entry: Well-being can contribute to the quality of working life.

2.2
work system
system comprising one or more *workers* (2.4) and *work equipment* (2.6) acting together to perform the *system function* (2.21), in the *workspace* (2.9), in the *work environment* (2.8), under the conditions imposed by the *work tasks* (2.17)

2.3
ergonomics
human factors
scientific discipline concerned with the understanding of interactions among human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human *well-being* (2.1) and overall system performance

[SOURCE: ISO 26800:2011, 2.2]

2.4
worker
person performing one or more activities to achieve a goal within a *work system* (2.2)

[SOURCE: ISO 26800:2011, 2.11, modified — synonym "operator" omitted]

2.5
work organization
interacting *work systems* (2.2) acting to produce a specific overall outcome

Note 1 to entry: The process of work organization includes coherent actions in relation to establishing the form and mode of organization to be adopted (e.g. individual or collective work, teams working separately or interdependently, etc.). It is also necessary to define and allocate resources and determine the means and channels of communication. All these actions lead to the definition and assignment of prescribed tasks to the operators involved.

2.6
work equipment
tools, including hardware and software, machines, vehicles, devices, furniture, installations and other components used in the *work system* (2.2)

2.7
work process
sequence in time and space of the interaction of *workers* (2.4), *work equipment* (2.6), materials, energy and information within a *work system* (2.2)

2.8
work environment
physical, chemical, biological, organizational, social and cultural factors surrounding a *worker* (2.4)

2.9
workspace
volume allocated to one or more persons in the *work system* (2.2) to complete the *work task* (2.17)

2.10
external work load
work stress
external conditions and demands in a *work system* (2.2) which influence a person's physical and/or mental internal load

Note 1 to entry: In some countries, "external work load" is referred to as "work stress".

Note 2 to entry: Compare ISO 26800:2011, 2.4.

2.11
work strain
internal response of a *worker* (2.4) to being exposed to *external work load* (2.10) depending on his/her individual characteristics (e.g. body size, age, capacities, abilities, skills, etc.)

Note 1 to entry: In ISO 26800, "work strain" is called "internal load".

Note 2 to entry: Compare ISO 26800:2011, 2.6.

2.12
usability
extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use

Note 1 to entry: Systems, products or services are part of *work systems* (2.2) and used by *workers* (2.4) within those systems.

Note 2 to entry: In this International Standard, the context of use is within a work system.

[SOURCE: ISO 9241-210:2010, 2.13]

2.13
human-centred design
approach to systems design and development that aims to make interactive systems more usable by focusing on the use of the system and applying *human factors/ergonomics* (2.3) and *usability* (2.12) knowledge and techniques

[SOURCE: ISO 9241-210:2010, 2.7, modified — Notes 1 and 2 to entry omitted]

2.14
accessibility
extent to which products, systems, services, environments and facilities can be used by people from a population with the widest range of characteristics and capabilities to achieve a specified goal in a specified context of use

[SOURCE: ISO 26800:2011, 2.1, modified — Notes 1 and 2 to entry omitted]

Note 1 to entry: Products, systems, services and facilities are part of *work systems* (2.2) and used by *workers* (2.4) within those systems.

Note 2 to entry: In this International Standard, the context of use is within a work system.

2.15
allocation of functions
process of deciding whether *system functions* (2.21) will be implemented by humans, by equipment and/or hardware and/or software

2.16
job
organization and sequence in time and space of an individual's *work tasks* (2.17) or the combination of all human performance by one *worker* (2.4) within a *work system* (2.2)

2.17
work task
activity or set of activities required of the *worker* (2.4) to achieve an intended outcome

2.18
workstation
combination and spatial arrangement of *work equipment* (2.6), surrounded by the *work environment* (2.8) under the conditions imposed by the *work tasks* (2.17)

2.19
work fatigue
impairing non-pathological manifestation of *work strain* (2.11), completely reversible with rest

Note 1 to entry: Work fatigue can be mental, physical, local and/or general.

Note 2 to entry: Compare ISO 26800:2011, 2.5.

2.20
target population
people for whom the design is intended, specified according to the relevant characteristics

Note 1 to entry: Relevant characteristics include, for example, the skill level, intelligence or physical characteristics, such as anthropometric dimensions, of these people. Gender and age can be related to variations in these characteristics. In addition to these intrinsic characteristics, extrinsic factors (e.g. cultural differences) could also be relevant.

[SOURCE: ISO 26800:2011, 2.8]

2.21
system function
broad category of activity performed by a system

3 Designing work systems

3.1 General principles

Work system design considers human beings as the main factor and an integral part of the system to be designed, including the work process, as well as the work environment.

In the design process of work systems, the major interactions between one or more people and the components of the work system, such as tasks, equipment, workspace and environment, shall be considered.

These interactions create demands on the worker that together constitute the external work load. This will result in reactions within the worker, depending on her/his individual characteristics (e.g. size, age, capacities, abilities, skills, etc.) called work strain. Work strain will result in impairing effects (e.g. fatigue generated by work), or facilitating effects (e.g. skill development), thus affecting the individual characteristics of the worker in a feedback loop.

Ergonomic work system design aims at optimizing work strain, avoiding impairing effects and promoting facilitating effects. Unimpaired human performance at the same time will often improve system effectiveness and efficiency, thus contributing to another important goal of ergonomic work system design.

Ergonomics shall be used in a preventive function by being employed from the beginning rather than being used to solve problems after the design of the work system is complete. However, ergonomics can be successfully employed in the redesign of an existing, unsatisfactory work system. Furthermore, in a risk assessment process, the interaction between work system design and the worker's foreseeable behaviour should be considered in order to secure their safety and health.

The most important decisions that have consequences in the design are made at the beginning of the design process. Therefore, particular attention should be paid to the application of ergonomics principles at this stage. Ergonomic contribution to the work system design shall continue throughout the design process. However, the level of input can vary from being fundamental and extensive during the analysis of the system needs ("formulation of goals") to fine-tuning when the completed system is being implemented ("realization, implementation and verification"). Sufficient attention shall continue to be given to the application of ergonomic principles until late in the design process in order to prevent negative effects such as delays in projects, extra costs for adaptation, a lower design quality, and reduced usability.

In accordance with a human-centred approach, workers should ideally be involved in and should participate in the design of work systems during the process in an effective and efficient manner. Workers include those responsible for constructing, maintaining, operating, and supervising, each of which requires different considerations. In work system design, a participatory approach is essential in order to avoid sub-optimal solutions, because the experience of workers provides an indispensable knowledge base. The design process shall therefore, wherever possible, involve workers in all stages.

NOTE 1 Detailed information about the human-centred approach can be found in ISO 9241-210.

It is recommended that a work system be designed for a broad range of the target population (see ISO 26800:2011, 4.2.2). In particular, the designer should consider the needs of people with special requirements and apply ergonomic principles to ensure that work systems are accessible to them. Thus, the need for the development of special solutions for individual workers can be minimized and the accessibility of the work system improved.

NOTE 2 Special requirements include limitations to sensory abilities such as vision, tactile and acoustic input, and physical abilities such as dexterity, manipulation, movement, voice, strength and endurance, cognitive abilities such as intellect, memory, language and literacy. For further guidance, see ISO/IEC Guide 71 and ISO/TR 22411.

In ergonomics, the variation within the target population is commonly accounted for by using the 5th and/or 95th percentiles of important design characteristics, with the intention of accommodating at least 90 % of the target population.

NOTE 3 In some circumstances, a different percentile range is used. For example, the 1st and 99th percentiles are used for many safety-related applications.

In designing the work system, a variety of conditions should be considered, e.g. normal, disturbed and degraded functioning.

The work system design process (3.2) can be divided into the following phases:

— formulation of goals (requirements analysis) (3.3);

— analysis and allocation of functions (3.4);

— design concept (3.5);

— detailed design (or development) (3.6);

— realization, implementation, adjustment, verification and validation (3.7);

— evaluation and monitoring (Clause 4).

These phases will be explained in the relevant clauses or subclauses.

3.2 Work system design process

"Designing" refers to an iterative and structured process of a number of design phases, which results in a new design or a redesign. The work system design process should include all phases throughout the life cycle of the work system from conception through development, realization and implementation, utilization, maintenance and support to decommissioning. Verification should be performed in each of