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# Ergonomics — General approach, principles and concepts (ISO 26800:2011)

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**National foreword**

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## Ergonomics - General approach, principles and concepts (ISO 26800:2011)

Ergonomie - Approche générale, principes et concepts (ISO 26800:2011)

Ergonomie - Genereller Ansatz, Prinzipien und Konzepte (ISO 26800:2011)

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# Foreword

This document (EN ISO 26800:2011) has been prepared by Technical Committee ISO/TC 159 "Ergonomics" in collaboration with 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of an identical text or by endorsement, at the latest by February 2012, and conflicting national standards shall be withdrawn at the latest by February 2012.

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**Endorsement notice**

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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.

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ISO 26800 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 1, *General ergonomics principles*.

# Introduction

Human, technological, economic, environmental and organizational factors all affect the behaviour, activities and well-being of people in work, domestic and leisure contexts. The science of ergonomics has evolved from its origins in the context of work to embrace many other fields of application, such as home and leisure. However, whatever the context, the underlying principles of ergonomics remain the same, although the relative emphasis placed on them will vary. These principles are fundamental to the design process wherever human involvement is expected, in order to ensure the optimum integration of human requirements and characteristics into a design. This International Standard considers systems, users, workers, tasks, activities, equipment and the environment as the basis for optimizing the match between them. These principles and concepts serve to improve safety, performance and usability (effectiveness, efficiency and satisfaction), while safeguarding and enhancing human health and well-being, and improving accessibility (e.g. for elderly persons and persons with disabilities).

Ergonomics covers a wide range of issues, including physical, cognitive, social and organizational. These are ideally addressed within an integrated framework. A substantial number of ergonomics standards have been developed to cover specific issues and different application domains. All depend upon the basic principles and concepts that are fundamental to the ergonomics approach to design. This International Standard has been developed in order to provide an integrated framework, bringing together the basic principles and concepts of ergonomics in one document, and thus providing a high-level view of the way in which ergonomics is applied.

NOTE 1 ISO 6385[2] remains a high-level International Standard for work systems.

NOTE 2 A complete list of current published ergonomics International Standards can be accessed via http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_tc_browse.htm?commid=53348&published=on&includesc=true.

# Ergonomics — General approach, principles and concepts

## 1 Scope

This International Standard presents the general ergonomics approach and specifies basic ergonomics principles and concepts. These are applicable to the design and evaluation of tasks, jobs, products, tools, equipment, systems, organizations, services, facilities and environments, in order to make them compatible with the characteristics, the needs and values, and the abilities and limitations of people.

The provisions and guidance given by this International Standard are intended to improve the safety, performance, effectiveness, efficiency, reliability, availability and maintainability of the design outcome throughout its life cycle, while safeguarding and enhancing the health, well-being and satisfaction of those involved or affected.

The intended users of this International Standard are designers, ergonomists and project managers, as well as managers, workers, consumers (or their representatives) and procurers. It also serves as a reference standard for standards developers dealing with ergonomics aspects.

This International Standard provides the basis for other, more detailed, context-specific ergonomics International Standards.

## 2 Terms and definitions

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

**2.1**
**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

NOTE 1 Context of use includes direct use or use supported by assistive technologies.

NOTE 2 Adapted from ISO/TR 22411:2008, definition 3.6.

**2.2**
**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 and overall system performance

NOTE This definition is consistent with that given by the International Ergonomics Association[21].

**2.3**
**environment**
physical, chemical, biological, organizational, social and cultural factors surrounding one or more persons

**2.4**
**external load**
external conditions and demands in a system which influence a person's physical and/or mental internal load

NOTE 1 In ISO 6385:2004, “external load” is called “work stress”.

NOTE 2 External load is a neutral term. Its effects can be positive, neutral or negative.

**2.5**
**fatigue**
impairing non-pathological manifestation of internal load, completely reversible with rest

NOTE Fatigue can be mental, physical, local and/or general.

**2.6**
**internal load**
internal response of a person to being exposed to the external load, depending on his/her individual characteristics (e.g. body size, age, capacities, abilities, skills, etc.)

NOTE 1 In ISO 6385:2004, “internal load” is called “work strain”.

NOTE 2 Internal load is a neutral term. Its effects can be positive, neutral or negative.

**2.7**
**system**
combination of interacting elements organized to achieve one or more stated purposes

NOTE 1 In ergonomics, the “elements” of a system are often called “components”.

NOTE 2 A system can consist of products, equipment, services and people.

NOTE 3 The word “system” can be qualified by adding a context-dependent term (e.g. aircraft system).

NOTE 4 Adapted from ISO/IEC 15288:2008, definition 4.31.

**2.8**
**target population**
people for whom the design is intended, specified according to relevant characteristics

NOTE 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.

**2.9**
**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

[ISO 9241-210:2009, 2.13]

NOTE This definition is usually applied to systems, products or services, but not to work systems. It could, however, relate to the design and evaluation of work equipment within a work system.

**2.10**
**user**
person who interacts with a system, product or service

NOTE 1 Adapted from ISO 9241-110:2008, definition 3.8, and ISO 9241-11:1998, definition 3.7.

NOTE 2 The person who uses a service provided by a work system, such as a customer in a shop or passenger on a train, can be considered a user.

NOTE 3 A user who is using a system is not a component of that system. However, both the user and the system used can be considered as components of a higher-level system.

**2.11**
**worker**
person performing one or more activities to achieve a goal within a work system

[ISO 6385:2004, 2.8]

**2.12**
**work system**
system comprising one or more workers and work equipment acting together to perform the system function, in the workspace, in the work environment, under the conditions imposed by the work tasks

[ISO 6385:2004, 2.16]

# 3 The ergonomics approach

Ergonomics (or human factors) has been defined by the International Ergonomics Association (IEA), the federation of ergonomics and human factors societies from around the world, as "the scientific discipline concerned with the understanding of the 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 and overall system performance"[21]. This includes the specific goals of facilitating task performance, safeguarding and enhancing the safety, health and well-being of the worker, or the user/operator of products/equipment, by optimizing tasks, equipment, services, the environment or, generally speaking, all elements of a system and their interactions. Achieving these goals potentially contributes to sustainability and to social responsibility (see Annex A).

NOTE 1 Throughout this International Standard, the use of singular terms to refer to a human in different roles (e.g. worker, operator, user, consumer) in different domains (e.g. the private and work domains) is intended to include multiples of humans as well as higher aggregation levels such as groups, teams or organizations.

Ergonomics addresses the interactions between the humans and other components of a system, such as other humans, machines, products, services, environments and tools, as appropriate. This includes taking into account the following factors:

— purpose of the system, product or service (see 4.2);

— characteristics of the intended target population (see 4.2.2);

— goals to be achieved and tasks to be performed (see 4.2.3);

— existing constraints (e.g. legacy equipment or processes, economic or legal issues);

— factors of the physical, organizational and social environment (see 4.2.4);

— life cycle and any dynamic changes within it (see Clause 6).

In order to achieve optimized system performance, all these factors shall be taken into account. Figure 1 provides an example of factors to be taken into account in an ergonomics approach. It shows the activity of a person as central to the functionality of the system. Additional factors might be identified for a particular context.

NOTE 2 A textual description of Figure 1 is given in B.2.

NOTE 3 The analysis of variations in activities in the context of use helps in the understanding of potential effects on health and safety and, on the other hand, quantitative and qualitative results.

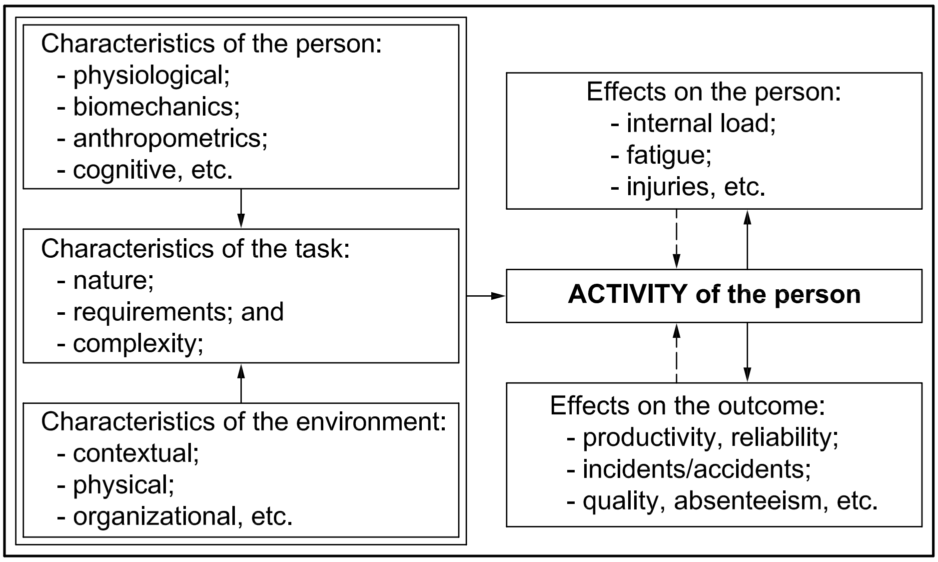


**Figure 1 — Example of factors to be taken into account in optimizing system performance**

In its simplest form, the system consists of a human and at least one other element (human, machine or environment) interacting within a specific context. More complex systems involve further elements (e.g. humans, machines or equipment). All such systems can be found in different contexts such as work, public life, leisure, etc. In the context of work, these systems are called *work systems*.

NOTE 4 An example of a simple system is given in 5.2 and Figure 2 (see also Annex B).

NOTE 5 A more detailed account of designing work systems can be found in ISO 6385[2].

This International Standard includes both principles (see Clause 4) and concepts (see Clause 5). The principles are fundamental to an ergonomics-oriented design process (see Clause 6) and serve to distinguish an ergonomics approach from other approaches that do not observe these principles.

To meet the main goal of ergonomics, i.e. optimizing system performance, the principles presented in Clause 4 shall be applied.

Concepts provide the means for interpreting, addressing and evaluating design from an ergonomics perspective. Those presented in this International Standard have previously been successfully applied in specific contexts to achieve an ergonomic design outcome that meets ergonomics goals and can be helpful in other contexts, although they are not necessarily universally applicable.

The concepts described in Clause 5 shall be applied where appropriate.

## 4 Principles of ergonomics

### 4.1 General

This clause presents the principles which are fundamental to an ergonomics approach. These place the human at the centre of the ergonomics approach to design (human-centred, see 4.2), taking into account the diversity of the human population (target population, see 4.2.2) and the implications of the task for the human (task oriented, see 4.2.3), as well as the environment in which the outcome of the design is to be used (environmental context, see 4.2.4). Finally, it emphasises the basic ergonomics criteria which need to be applied in evaluating the design (criteria-based evaluation, see 4.3).

## 4.2 Human-centred

### 4.2.1 General

An ergonomics approach to design shall be human-centred.

This means that all designable components of a system, product or service are fitted to the characteristics of the intended users, operators or workers, rather than selecting and/or adapting humans to fit the system, product or service. This should be done by consideration of

— the intended target population,

— the task, goal or intended outcome of the system, product or service, and

— the environment in which the design is to function.

From an ergonomics point of view, selection and training strategies are no substitute for an appropriate design of systems, products or services, although some selection and training can still be required.

Those affected by the design (e.g. workers or users) should be involved throughout the whole design process, including evaluation. This will help to optimize solutions (e.g. by providing specific experience and requirements). Their early and continued participation and involvement is regarded as an efficient design strategy within ergonomics.

NOTE For a more detailed description of the human-centred approach for interactive systems, see, for example, ISO 9241-210[8].

### 4.2.2 Target population

The target population shall be identified and described.

The human population is very diverse. Humans vary in their physical dimensions and in their biomechanical, sensory and cognitive capabilities. This is why ergonomics design is usually orientated towards a specified target population, not towards one individual or the entire population. Discrimination leading to unfair treatment (e.g. on the basis of gender, age or disability) shall be avoided in identifying and specifying the target population (see ILO Convention No.111[22]).

NOTE 1 In particular circumstances (e.g. rehabilitation), the target population might be one person.

NOTE 2 Target populations may change over time and any such trends need to be considered.

NOTE 3 The inclusion of older persons and people with disabilities in the target population and designing accordingly can help to improve the accessibility of a system, product or service (see ISO/IEC Guide 71[20] and ISO/TR 22411[17]).

The characteristics of the target population relevant to the design shall be identified and their range of variation within the intended target population specified (e.g. body size, visual abilities, literacy, skills, knowledge).

NOTE 4 For more detailed descriptions of sources of variability, see, for example, ISO 14738[12] for anthropometric requirements of workers and ISO/TR 22411[17] for ergonomics data of elderly or disabled persons.

In ergonomics, the variation within the target population is commonly accounted for by using the 5th and/or 95th percentiles of important design characteristics (e.g. body size, visual abilities, literacy), with the intention of accommodating at least 90 % of the target population. In some circumstances, a different percentile range is used. For example, in many safety-related applications, the 1st and 99th percentiles are used.

NOTE 5 In most instances, the use of average values is not an adequate way of accommodating the range of values to be found associated with a particular characteristic.

NOTE 6 It is important to recognize that uncritical use of univariate percentiles, where simultaneous accommodation of multiple characteristics is necessary, might lead to a smaller range of the population being included than had been intended. The degree to which an ergonomic solution is compromised by using univariate percentiles depends upon the correlations between these characteristics. When correlations are low, it can be advisable to use wider percentile ranges or multivariate models of population variation to establish design criteria.

### 4.2.3 Task oriented

Design shall take full account of the nature of the task and its implications for the human.

Task-oriented design is used to ensure that the tasks are appropriate to the human. This includes the allocation of functions and tasks to the human or to technology. Deficits in task design will lead to adverse effects, both for the human and the system as a whole. These cannot be compensated for by the design of the technical components of the system. The possible consequences of the task design, both for people affected by it and for the system as a whole, shall be taken into account.

Task-oriented design also takes account of differences that can be observed between the designed task and the way the task is actually performed. Activities in performing a task are affected by variations and changes in, for example, context, procedures, equipment, products or materials.

NOTE 1 In order to be able to consider the effects of the task on the human, it is important to refer to knowledge about existing similar or related tasks.

NOTE 2 An example of this approach in the context of interactive systems can be found in ISO 9241-2[4].

Appropriately designed tasks

— can be performed safely and effectively by the target population, in both the short and the long term,

— do not lead to short- or long-term impairment in members of this population,

— can be used to develop the operators'/users' capabilities and skills.

Tasks and their associated activities shall be identified and described in sufficient detail so that the human capabilities, skills and knowledge requirements can be specified. This description should include task inputs and outputs.

NOTE 3 It is also important to identify the relationships among different tasks.

In human-centred design, the goal is differentiated from the task. Goals can be regarded as the intended outcomes, whereas tasks comprise a series of activities required to achieve a goal or goals. Hierarchically, a goal can be subdivided into a series of sub-goals and a task into corresponding sub-tasks.

NOTE 4 In simple systems, all tasks might be performed by the same individual in achieving the eventual goal. In more complex systems, the goal is likely to be achieved by a number of individuals performing different but connected tasks.

Activities are based on individual actions, comprising a single event such as pushing a button, identifying a signal or generating an idea.

NOTE 5 In some ergonomics domains, the term “step” is used to describe a specific level of “activity”.

### 4.2.4 Environmental context

The physical, organizational, social and legal environments in which a system, product, service or facility is intended to be used shall be identified and described, and their range defined.

These environments provide important elements of the context of a design and can have a significant effect on the effectiveness of the resulting design. The physical attributes include issues such as thermal conditions, lighting, noise, spatial layout and furniture. The organizational and social aspects of the environment include factors such as work practices, organizational structure and attitudes.

In some applications of ergonomics, the environment is a contextual factor and can not be changed. In others, environmental aspects can be designed. When the environmental factors are part of the system, product, service or facility, their design or redesign shall be included in the design process and its outcome. For those aspects of the environment that are not changeable, their characteristics shall be taken into account in the design of the system, product, service or facility.

 

The effects of the environment can be greater if people are already working to the limits of their ability. If design decisions are based on capability data measured only in a neutral environment, this can result in impairing effects.

EXAMPLE 1 Equipment for use in a cold store is designed to take account of the need for the workers to wear insulated protective gloves.

EXAMPLE 2 A properly designed ticket machine, which is to be installed for use in an outdoor car park, is designed to accommodate the range of varying environmental conditions in which it will be used (e.g. darkness to bright sunlight).

NOTE Information regarding taking environmental factors into account can, for example, be found in ISO 8995[3], ISO 15265[13] for workplaces and in ISO 24500[18] for elderly and disabled persons.

### 4.3 Criteria-based evaluation

Evaluation of the ergonomic design outcome of any system, product or service shall be based on established ergonomics criteria, regardless of whether or not it was designed following an ergonomics-based design process (see 6.2).

Ergonomics criteria can be related to the following:

— human performance;

— health, safety and well-being;

— satisfaction.

NOTE 1 Measurement of human performance might be used to assess changes in skills, abilities and knowledge arising from the design.

Iterative evaluation against ergonomics criteria shall be an integral part of any ergonomics-based design process. The relative importance of various criteria will depend upon the nature of the system, product or service.

EXAMPLE Besides safety-related criteria, user satisfaction might be accorded a high priority in the evaluation of consumer products, while in a work system, health-related and performance-related criteria will be dominant.

Evaluation shall take into account both short- and long-term effects, as appropriate.

NOTE 2 Examples for evaluation of interactive systems can be found in ISO 9241-11[5].

## 5 Concepts in ergonomics

### 5.1 General

This clause outlines a number of concepts which are helpful in understanding and applying the principles of ergonomics given in Clause 4. As explained in Clause 3, these concepts are important to the application of ergonomics in specific domains but not necessarily applicable to all domains.

NOTE 1 The load-effects concept is most commonly used in the design of work systems, while that of usability is most widely applied to the design of interactive systems.

NOTE 2 This International Standard does not present an exhaustive overview of all ergonomics concepts.

## 5.2 The system concept

One of the basic concepts of ergonomics in design and evaluation is the system concept, which deals with the interactions in the system between the human and other parts. As an example, a simple model of a human-machine system is shown in Figure 2. It shows the human and the machine as integral parts of the system. The human receives information about the status of the machine and the controlled process through sensors, then processes this information (perhaps considering it against targets or expectations) and then effects change to the system as appropriate through effectors (such as hands, feet or voice). Thus, humans are central to the system as described in 4.2. This model can also be used to illustrate human-human interaction by replacing the machine component by a second human. However, it is important to remember that systems are seldom designed for individuals, but rather for one or more target group or population (see 4.2.2).

NOTE 1 A textual description of Figure 2 is given in Annex B.

NOTE 2 Many models representing human-machine systems emphasising different aspects of the interactions between humans and machines have been developed over the years.

NOTE 3 Information concerning the design of controls and displays can be found, for example, in ISO 9355[9], ISO 1503[1] and, for elderly and disabled persons, in ISO/TR 22411[17].

As shown in Figure 2, there are inputs (e.g. information, energy, material, etc.) from sources outside the system, which are transformed by the system to outputs (e.g. products or information).

The human and machine exist within a spatial environment as indicated. The spatial environment in turn exists within a physical environment and an organizational environment. Outside this, the social, legal and cultural environments also potentially influence the functioning of the system. All these influences, represented by the blocks of Figure 2, are intended to represent figuratively how the various elements are influenced by each other. These influences are not necessarily open to design and, where not, should be considered in the design process as contextual constraints.

Similar reasoning can also be applied to different and often more complex types of systems — for example, those involving human-human interactions, or interactions between humans and multiple machines, products or services.

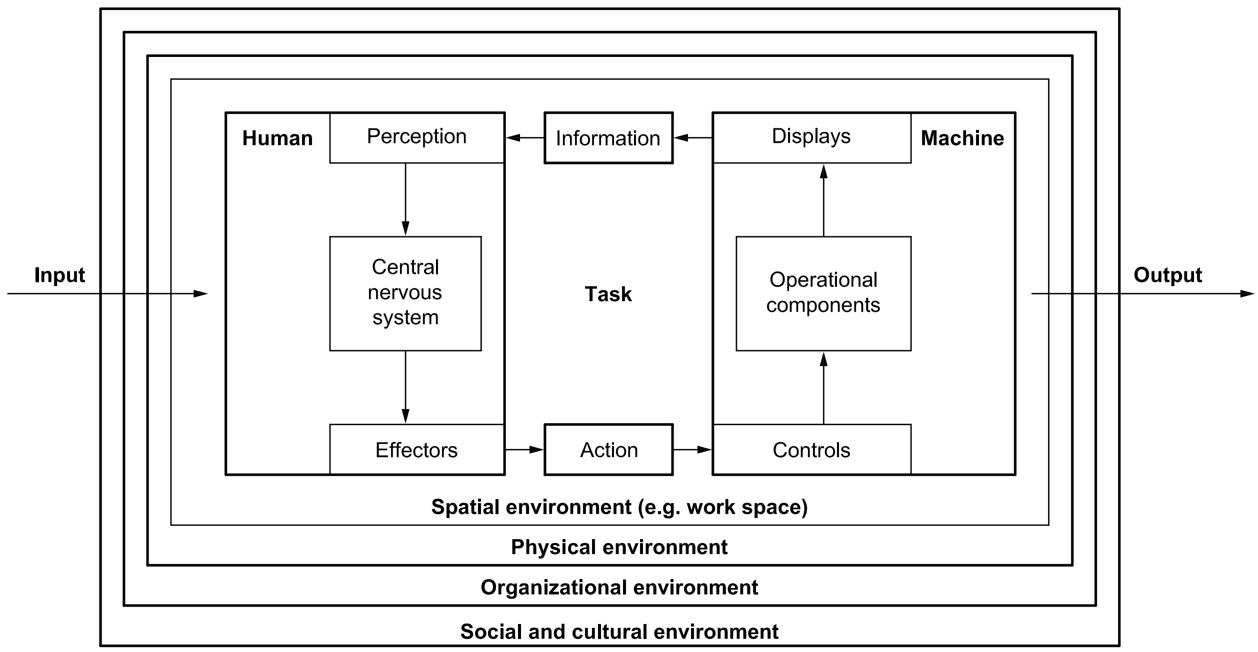


**Figure 2 — Example of human-machine-environment system model**

## 5.3 Load-effects concept

The load-effects concept applies to the assessment of human activities. In applying the load-effects concept, special attention is given to the relationships between the external load, the internal load this generates in the individual, and the effects this load has on the individual over both short and long time scales. This is fundamental to the population and task-based approaches (4.2.2 and 4.2.3 respectively). A key feature of this is that the effect which any external load (mental or physical) has on the individual is influenced not only by variations in that external load but also by short- and long-term variations within an individual. The effects of the external load on the internal load are also modified by variations between different individuals, such as in mental or physical capabilities.

Conceptually (see Figure 3), the individual is subjected to an external load. This is generated by factors outside the individual summarized in Figure 2 (see also Annex B). These factors are independent of the individual subjected to that load. The load, which can be physical (e.g. a manual handling task) or mental (e.g. an information-processing task), can be described with regard to its type, intensity and temporal characteristics. The temporal characteristics of the external load, such as duration or the pattern of activity and rest, are of particular importance because they modify the internal load and consequently the effects on the individual.

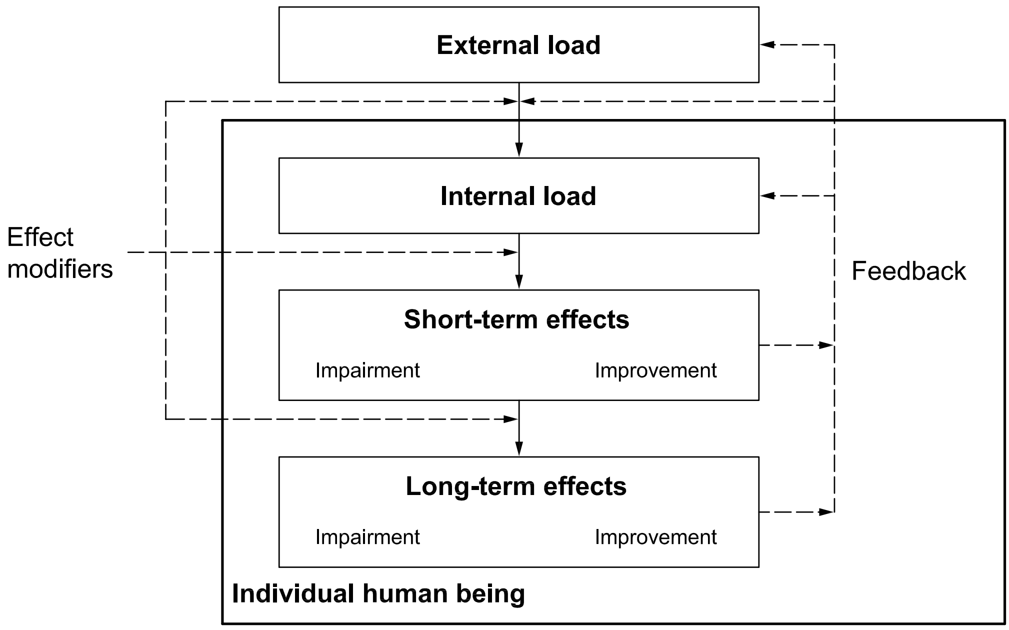


**Figure 3 — Model of load-effects concept**

NOTE 1 A textual description of Figure 3 is given in Annex B.

The effects that the external load has on the individual are modified by individual characteristics. These include characteristics such as physical and mental capabilities, skills, work techniques and behaviour, and the functional state, as well as the individual's performance of the task and his/her perception of the external and internal loads. Some of these might vary with time, in both the short-term and long-term for example, as part of the ongoing process of the acquisition and consolidation of skills associated with the development of expertise leading to increased efficiency and effectiveness. Alternatively, the individual might choose to change the external load (feedback), where feasible (e.g. taking a break or changing his/her work rate).

The external load gives rise to the internal load, again modified by individual characteristics. For example, lifting the same object to a specified height will result in a different internal load in different individuals, such as in the proportion of maximum muscle strength required.

The internal load can have both short- and long-term effects. Some of these effects, such as fatigue, are transient, and the body returns quickly to its original state if sufficient rest opportunities are provided. Others are more persistent and have longer-lasting, sometimes permanent, effects. Both long- and short-term effects can be either positive or negative. They develop in a complex, time-dependent and sometimes iterative process. This applies to physical and mental activities in many domains, thus encompassing, for example, the operation of machinery, complex consumer products and public access systems, or giving care to a patient. A mismatch between external load and the resources of the individual could result in negative outcomes such as increased injuries and errors, and lower quality and productivity, etc.

NOTE 2 For a more detailed description in the field of mental work load, see ISO 10075[10].

EXAMPLE In carrying out a task involving heavy physical activity, the work may first induce a negative short-term effect (e.g. delayed onset of muscle soreness inducing an unpleasant sensation). However, this perceived effect will be accompanied by less apparent effects, such as physiological adaptation or psychological learning and habituation, so that, through internal feedback processes, the negative effect may be reduced and subsequently replaced by more positive responses (e.g. increased muscle strength). Similar processes can be observed in predominantly mental activities, with the learning process making the activity progressively easier to execute.

In general, extended exposure to excessive physical and/or mental external load will lead to impairing effects such as fatigue, monotony or reduced vigilance, depending on the intensity and temporal pattern of exposure to the external load and the resulting internal load, with a nonlinear increase of the effects over increasing time and/or intensity. All these effects are non-pathological manifestations of the internal load, completely reversible with rest or a change in activities/tasks. Breaks, or the limitation of the temporal exposure to external load, thus serve to reduce the increase in internal load and the resulting fatigue and to provide for the recovery from that fatigue to a state of full recuperation.

If temporary impairing effects cannot be avoided and a sufficient recovery from such impairing effects cannot be achieved, long-term effects, such as exhaustion, chronic fatigue or “burnout” can result. The control of the exposure to the external load, by modifying either its intensity or temporal pattern, is thus a means to avoid impairing short- and long-term effects in the individual.

Interrupting an activity/task, however, especially for longer periods than required for sufficient recuperation, can lead to a reduction in acquired capabilities (e.g. a reduction in the acquired skill level or a loss of problem-solving strategies). Learning or the acquisition of skills and the development of abilities, especially in the long term, is usually a consequence of the interaction between the external load and the individual. On the other hand, underload leading to “unlearning” or loss of capability through restricted use and a lack of feedback is an undesirable consequence.

Learning or the acquisition of skills can be enhanced by external modifiers such as training.

Long-term variations in capabilities, including skills, can result from experience, aging or illness.

The relations between external and internal load and their effects shall be considered in the design of systems, services, products and tasks in order to avoid impairing effects on the individual, by means of an appropriate design of the external load.

## 5.4 Usability

The effectiveness and efficiency of, and satisfaction with, a system, product or service with respect to a target population are important goals of ergonomics. One means for taking these goals into account is to apply the concept of usability and its associated criteria.

Usability is a concept which is used in the specification, design and evaluation of systems, products and services. It encompasses the dimensions of effectiveness, efficiency and satisfaction and serves as a framework for specifying design goals and measuring their achievement.

The concept of usability can be applied to the design and evaluation of the service provided by an organization.

In applying the concept within work systems, all relevant system components should be identified.

Designing (or re-designing) for usability includes the consideration of usability issues at all stages of the life cycle, including conception, detailed solution design, evaluation, implementation, long-term use, maintenance, disposal and recycling.

The specific design context (characteristics of the target population, goals, tasks, physical and technical environments, materials, etc.) determines which operational aspects of effectiveness, efficiency and satisfaction are important. In the concept of usability there is no standard set of metrics that is universally applicable when assessing usability or its dimensions. The metrics should be developed for the specific application.

NOTE For a more detailed description concerning usability, see ISO 9241-11[5].

## 5.5 Accessibility

Accessibility is the 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. It is usually multidimensional and continuous rather than unidimensional or discontinuous (e.g. “yes/no”). The aim in designing for accessibility is to widen the target population, thus making products, systems, services, environments and facilities more accessible to more people (see ISO/TR 22411[17]). The concept of accessibility can be applied to the design and evaluation of the service provided by an organization.

The extent concerns both the number of people who can use a product, system, service, environment or facility, as well as the quality of that use. In ergonomics design this aim can be met both by considering a potential widening of the scope of the intended target population as well as increasing accessibility for those within that population. Therefore, the characteristics of the target population that are taken into account shall be as diverse as possible, depending on the objectives of design. For example, taking a broader age span into account, in order to accommodate the increasing proportion of older people within the population, requires the designer to consider characteristics which are associated with increasing age. It might also include identifying specific subgroups that should be included, for example, people with impaired hearing, those with cognitive impairment, and people who are already using assistive technologies or who might require individualized solutions or alternative means of access.

The accessibility that can be achieved will be determined by the context in which the designed product, system, service, environment or facility is to be used. Explicit specification of the range and nature of characteristics within the intended target population will play a critical role in the identification of accessibility requirements.

EXAMPLE The target population for visual displays in aircraft cockpits is, by law, limited to individuals with high levels of visual acuity. However, the target population for a public information kiosk will have a wider range of capabilities and limitations, including (colour) blindness and low vision and are legally entitled to access. Taking such factors into account extends the population for which the kiosk is accessible.

NOTE 1 Accessibility and usability are concepts which have previously been developed in different domains. As defined, usability primarily addresses the quality of use of the product, system, service, environment or facility within a population, while accessibility addresses the extent to which it can be used, especially by people with performance restrictions (although the distinction between the two concepts is not always clear).

NOTE 2 For a more detailed description concerning accessibility, see ISO/TR 22411[17] and ISO 9241-20[6]. See also web contents accessibility guidelines, e.g. Reference [23].

NOTE 3 Additional information relating to the importance of accessibility can be found in Reference [24].

# 6 The ergonomics-oriented design process

## 6.1 General

Design is carried out to a greater or lesser extent at all stages in the life cycle of systems, products, services, environments or facilities, i.e. in conceiving alternatives, developing and bringing the design into existence and correction of deficiencies based on evaluation. In all cases there are ergonomics considerations to be addressed. All aspects, including procedures, manuals and training and the relationship with users of services, have ergonomics considerations in their design.

NOTE 1 The life cycle typically consists of conception, solution design, evaluation, implementation, long-term use, maintenance, disposal and recycling.

All types of design projects shall address ergonomics issues throughout the life cycle. This process should be carried out in a structured manner.

NOTE 2 Examples of design projects are incorporating off-the-shelf components, tailoring an existing system and developing a new product or service.

In order to safeguard the safety, health and well-being of the worker or user, as appropriate, while optimizing system performance, effectiveness, efficiency, reliability and availability, the design process itself shall address the basic requirements listed in 6.2.

## 6.2 Basic requirements for an ergonomics-oriented design process

The basic requirements for an ergonomics-oriented design process are as follows.

- Ergonomics shall be considered early and continuously within the design process.
- Sufficient attention shall be given to the application of ergonomics principles, in order to prevent any negative effects (see 4.2 and 4.3).
- Ergonomics criteria shall be established for the design (see 4.3).
- Conceptual and detailed designs shall take account of these ergonomics criteria (see 4.3).
- The process shall take account of the human tasks and interactions (see 4.2.3).
- Workers or users, or potential workers or users, as appropriate, shall be involved in the process (see 4.2).
- Evaluation shall be carried out and the necessary adjustments and corrections made (see 4.3).

  NOTE 1 The ideal basis for evaluation is real use by real users carrying out representative tasks under realistic conditions.

  NOTE 2 All aspects of the design might be evaluated and revised (even requirements).

- The design process shall have sufficient flexibility to allow for iteration of the design solution.

  NOTE 3 The goal is to have sufficient flexibility in resources and procedures to support revision of the design solution so that it meets ergonomics principles and the requirements of the user or worker. It is not the intention to require unnecessary repetition within the design project.

Different management and design strategies place varying degrees of emphasis on these requirements. For example, participatory design emphasises the involvement of the users and others in the design process, and performance-centred design focuses on performance as the main outcome.

NOTE 4 ISO/TR 18529[16] provides an example of an ergonomics-oriented design approach as applied to computer-based interactive systems. ISO/TR 16982[15] provides an example of the methods and techniques used to implement ergonomics-oriented design for interactive systems. ISO 11064[11] provides an example of the application of an ergonomic approach to the design of control centres.

 

## 7 Conformity

Conformance with this International Standard shall be achieved by:

a) satisfying all the applicable requirements;

b) identifying applicable recommendations;

c) explaining why particular requirements and recommendations are not applicable;

d) stating whether or not the applicable recommendations have been followed.

If a system, product or service is claimed to have met the requirements, and if the applicable recommendations are considered to have been followed, the procedure used to determine how they have been met/followed should be specified. The detail to which the procedure is specified is a matter of negotiation between the involved parties.

# Annex A
(informative)

# Sustainability

In modern society, a key issue is to encourage socially responsible designs through consideration of sustainability, which can be defined as forms of progress that meet the needs of the present without compromising the ability of future generations to meet their needs. In terms of standardization, this involves considering the integration of, and balances between, economic, social and environmental considerations. Ergonomics can support all three of these considerations:

— **Economic**: matching a design's specification to people's needs and abilities will enhance its utilization and quality, and optimize efficiency, providing cost-effective solutions and reducing the likelihood that systems, products or services will be rejected by their users.

— **Social**: the application of ergonomics results in tasks, jobs, products, tools, equipment, systems, organizations, services, facilities and environments which are better for human health and well-being, including the needs of older people and those with disabilities. Consequent improvements in effectiveness, efficiency and satisfaction will also have implications for acceptable employment.

— **Environmental**: applying ergonomics in design reduces the risk that people will reject tasks, jobs, products, tools, equipment, systems, organizations, services and facilities, or that the design will result in errors causing damage to the natural environment or the waste of natural resources. Through this, it helps to minimize the overall environmental impact of any design. The process also encourages those involved to take a longer-term/whole life view of design.

Sustainability can be addressed at different levels — for example, at the level of the individual, the group, an organization or society as a whole or even an aggregation of societies.

Guidance on social responsibility is the subject of ISO 26000[19].

# Annex B
(informative)

# Textual descriptions of the figures for visually impaired readers

## B.1 General

This annex provides textual descriptions of Figures 1 to 3. This alternative format of the figures is intended to increase this International Standard's accessibility, especially for visually impaired readers.

## B.2 Textual description of Figure 1 — Example of factors to be taken into account in optimizing system performance

To the left in Figure 1, three medium-sized rectangles are placed vertically, one above the other. The topmost rectangle contains the text “Characteristics of the person”, with bullet points beneath this text with the terms “physiological”, “biomechanics” and “anthropometrics; cognitive; etc.”. The lowest of the three rectangles contains the text “Characteristics of the environment”, again with bullet points beneath the text with the terms “contextual”, “physical” and “organizational, etc.”.

From these two rectangles, arrows point to the third of the rectangles in the middle (pointing down from the “person” rectangle and up from the “environment” rectangle). This middle rectangle contains the text “Characteristics of the task”, with bullet points beneath this text with the terms “nature”, “requirements” and “complexity”.

These three rectangles are enclosed by a further rectangle indicating that they bear a common relationship. A horizontal arrow from this enclosing rectangle points to the right-hand half of the figure where, again, there are three vertically placed rectangles. The arrow head points directly at the middle of these three rectangles, which contains the text “ACTIVITY of the person”. Above this “activity” rectangle, a second rectangle contains the text “Effects on the person”, with bullet points beneath this text with the terms “internal load”, “fatigue” and “injuries, etc.”. Arrows point between these two rectangles, with a solid arrow pointing upwards indicating the main pathway of influence and a dotted arrow pointing downwards to indicate a feedback pathway through which the effects on the person might influence subsequent activity.

The lowest of these three rectangles on the right-hand side contains the text “Effects on the outcome”, again with bullet points, which in this case read “productivity, reliability”, “incidents/accidents” and “quality, absenteeism, etc.”. As before, arrows link this rectangle with the central activity rectangle. On this occasion, there is a solid arrow pointing down (“activity” to “outcome”) and a dotted arrow pointing back up (“outcome” to “activity”) again indicating the main effect and the feedback, potentially influencing subsequent activity.

Finally, the whole set of six rectangles is surrounded by a further large boundary rectangle with no further labelling or arrows.

As described in Clause 3, Figure 1 shows initially the significant central place of the human activity in a system. It points to the fact that this activity depends at the same time on the prescribed task characterized by their nature, requirements and complexity and the results which it generates on the person in the form of internal load, fatigue, injuries, etc., and simultaneously on the outcome of the system, expressed in productivity, reliability, incidents/accidents, quality, absenteeism, etc.

It underlines the significant and perpetual link between the prescribed task and the activity realized by the person and shows, through the column on the left-hand side, that the characteristics of the tasks are impacted by the characteristics of the person (physiological, biomechanics, anthropometrics, cognitive, etc.) and in addition, by the characteristics of the environment (contextual, physical, organizational, etc.).

## B.3 Textual description of Figure 2 — Example of human-machine-environment system model

Figure 2 has two medium-sized boxes arranged horizontally and side by side. These are separated by a space containing two smaller boxes arranged vertically: one of which is level with the top of the two larger boxes containing the legend “information” and the other level with the bottom of the two larger boxes containing the legend “Action”. Between these two smaller boxes is the legend “task”. Each of the smaller boxes are connected to the larger boxes by horizontal arrows, with those linking the top box running from right to left and those linking the bottom box running from left to right. The medium-sized box on the left has the label “human” while that on the right is labelled “machine”. Within the “human” box are three smaller boxes arranged vertically and linked by arrows from top to bottom. These include the legends “perception” “central nervous system” and “effectors”. Within the “machine” box there are also three smaller boxes, again arranged vertically and linked by arrows, in this case running from bottom to top. From the top, these include the legends “displays”, “operational components” and “controls”. All of the interconnecting arrows effectively form a loop linking all the smaller boxes in an anticlockwise circle.

This complex of two medium boxes (with small boxes inside) and two smaller boxes is enclosed by a rectangular box. The space inside this box (but outside the other boxes) has the legend “spatial environment (e.g. work space)”.

This rectangular box is again enclosed by a second rectangular box. In this instance, the space inside this box (but outside the inner rectangular box) has the legend “physical environment”.

In a similar fashion, a third rectangular box, enclosing the first two, has the legend “organizational environment” and a final (fourth) rectangular box encloses this and has the legend “social and cultural environment”.

Finally, two horizontal arrows cut horizontally across these concentric rectangles. The first starts from outside the left-hand side of the figure, running across the figure to point at the “human” box. The origin of this arrow has the legend “input”. Finally, in a similar manner, a horizontal arrow runs from the “machine” box to the right, ending outside the outermost rectangular box with the legend “output”.

## B.4 Textual description of Figure 3 — Model of the load-effects concept

Figure 3 shows a large box representing the individual human being. Above this box is a further, smaller, box labelled “External load”. From this box, an arrow points down into the larger box to the first of the three boxes inside this larger box. This first internal box is labelled “Internal load”. From this box an arrow runs down to a second internal box labelled “short-term effects”. Also within this box, in a smaller font, are the labels “impairment” and “improvement”, indicating that these short-term effects can be positive or negative. From this second internal box a further arrow runs down to the third (and last) internal box labelled “long-term effects”. As with the short-term effects box, this box also includes the words “impairment” and “improvement”.

In addition to these boxes and their linking arrows, the figure also includes two series of dashed lines with arrow heads. The first of these originate from the label “Effect modifiers” placed outside the large “human being” box. From this label, dashed lines point to the three transitions between the small boxes, indicating that these are influenced by the effect modifiers.

The second series of dashed lines, labelled “feedback”, run from the two effect boxes (short- and long-term) to point to the two load boxes (external and internal), indicating that the effects of the load can modulate the loads themselves.

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