INTERNATIONAL STANDARD

ISO 10075-1

First edition
2017-09

Ergonomic principles related to mental workload —

Part 1: General issues and concepts, terms and definitions

Principes ergonomiques concernant la charge de travail mental —
Partie 1: Questions et concepts généraux, termes et définitions

Reference number
ISO 10075-1:2017(E)

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

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

This first edition of ISO 10075-1, together with ISO 10075-2 and ISO 10075-3, cancels and replaces ISO 10075:1991, which has been technically revised.

The main changes compared to the previous edition are as follows:

— Clause 1 has been adjusted;

— Clause 2 and the terms 3.1.2, 3.2.1.2, 3.2.1.3, 3.2.2.1, 3.2.3.2, 3.2.3.2.1, 3.2.3.2.2 and 3.2.3.3 have been technically revised;

— the term 3.2.4.1 has been added;

— the term 3.2.3.2.3 has been corrected;

— Table A.1 has been updated;

— a linkage between ISO 10075-1 and ISO 6385 has been highlighted where applicable;

— Clause 3 has been restructured.

A list of all parts in the ISO 10075 series can be found on the ISO website.

Introduction

This document represents an extension of ISO 6385, with special respect to mental workload, describing general issues, concepts and terms in more detail because of the specific consequences that have to be taken into account in this domain.

These concepts from the field of mental workload include mental stress, mental strain and their effects.

Since there is a variety of different conceptions concerning mental workload, mental stress and mental strain, both in colloquial as well as in scientific usage, a standardization of the relevant concepts and terms in the field of ergonomics is required.

In this document, mental workload is considered as an umbrella term encompassing mental stress and mental strain. Mental stress is considered as a neutral term rather than the negative outcome from workload and other factors adopted in other approaches. In this way, it reflects a parallel with the engineering use of the terms stress and strain. Thus, mental stress refers to the causes of mental strain, and mental strain refers to the effects of that stress in the individual. This is consistent with the use of the terms in other ergonomics standards, e.g. on thermal stress (see ISO 7933).

Ergonomic principles related to mental workload —

Part 1:
General issues and concepts, terms and definitions

1 Scope

This document defines terms in the field of mental workload, covering mental stress and mental strain, and short- and long-term, positive and negative consequences of mental strain. It also specifies the relations between these concepts involved.

In this document, *mental workload* is regarded as an umbrella or generic term, referring to all the concepts and constructs mentioned in the document and does not have a specified or standardized meaning of its own within the document. This is consistent with the use of the term in ergonomics and its applications, where it can refer to mental stress, mental strain and their effects, i.e. both to the causes and the effects. In this document, the term mental workload will thus not be treated as a technical term but only as a reference to the domain of mental workload.

NOTE Annex A gives additional explanations of terms and concepts.

This document applies to the design of working conditions with respect to mental workload and is intended to promote a common usage of terminology between experts and practitioners in the field of ergonomics as well as in general.

This document does not address methods of measurement and principles of task design, which are dealt with in ISO 10075-2 and ISO 10075-3.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 Terms and definitions associated with mental workload

3.1.1
mental stress
total of all assessable influences impinging upon a human being from external sources and affecting that person mentally

Note 1 to entry: Since mental stress in this document refers to the total of all assessable factors impinging upon an individual mentally, the colloquial usage of the term mental stresses (plural) is inconsistent with the definition of mental stress in this document. The "total of all assessable influences" means that mental stress is usually comprised of different factors contributing to this total. The combination of all these factors is the resulting mental stress. Additional factors will change the resulting mental stress, but are not considered as new kinds of mental stress. It is the result of the coaction of all effects that is referenced by the term mental stress. For these reasons, a clear terminological differentiation between mental stress as the total of all impinging effects (as defined above) and single or multiple factors as components of this mental stress is required.

Note 2 to entry: The use of "mental stress" in this document is compatible with the use of the term "work stress" in ISO 6385, where it is synonymously used with the term "external workload".

3.1.2
mental strain
immediate effect of *mental stress* (3.1.1) within the individual depending on their current condition

EXAMPLE Examples of relevant conditions can be age, gender, skills, coping strategies, fatigue, mood.

Note 1 to entry: Considerations in 3.1.1, Note 1 to entry also apply to the concept of mental strain, which refers to the total, immediate impact within the individual resulting from mental stress.

3.2 Consequences of mental strain

NOTE The order of the following terms and definitions does not imply any functional relationships.

3.2.1 Facilitating effects resulting from short-term exposure

3.2.1.1
warming-up effect
frequent consequence of *mental strain* (3.1.2) which, soon after an activity has started, results in a reduction of the effort required to perform that activity relative to the effort initially required

3.2.1.2
activation
internal state resulting in increased mental and physical activity

Note 1 to entry: *Mental strain* (3.1.2) can lead to different degrees of activation, depending on its duration and intensity. There is a range in which the activation level is optimal, e.g. neither too low nor too high, ensuring best functional efficiency.

3.2.1.3
learning
process based on (work) experiences that leads to enduring changes in behaviour or behavioural potential, e.g. plans, attitudes and values

3.2.2 Facilitating effects resulting from long-term or repeated exposure

3.2.2.1
practice effect
enduring change in individual performance, associated with *learning* (3.2.1.3) processes, following from repeated experience of the same kind of *mental strain* (3.1.2)

3.2.2.2
competence development
complex form of learning involving the acquisition, consolidation, enhancement and/or differentiation of cognitive, emotional, social and motor skills and abilities, as strain-related consequence of an active engagement with a task

Note 1 to entry: Competence development can have different facets, e.g. factual, methodological and/or social ones.

Note 2 to entry: Competence development is a facilitating long-term effect of the exposure to mental stress (3.1.1).

3.2.3 Impairing effects resulting from short-term exposure

NOTE Impairing effects can be distinguished by the temporal pattern of their emergence and recovery, including the means necessary to achieve this recovery (which can require taking time for recuperation or variation in activity). They can also be distinguished by their symptoms which can be general or more specific.

3.2.3.1
mental fatigue
temporary impairment of mental and physical functional efficiency, depending on the intensity, duration, and temporal pattern of the preceding *mental strain* (3.1.2)

Note 1 to entry: In contrast to *fatigue-like states* (3.2.3.2) recovery from mental fatigue is achieved by rest rather than changes in activity.

Note 2 to entry: This reduced functional efficiency becomes apparent, e.g. in feelings of tiredness, less favourable relationships between performance and effort, type and frequency of errors. The extent of this impairment is also determined by individual preconditions.

3.2.3.2
fatigue-like states
states within the individual as effects of *mental strain* (3.1.2) resulting from situations offering little variety, which, in contrast to fatigue, quickly disappear after changes in the task and/or the environment/situation

Note 1 to entry: As a rule common with *mental fatigue* (3.2.3.2), feelings of tiredness also occur in fatigue-like states. However, they differ from mental fatigue by their transitoriness. Particularly marked interindividual differences can be found with these fatigue-like states.

3.2.3.2.1
monotony
slowly developing state of reduced *activation* (3.2.1.2) which is mainly associated with drowsiness, tiredness, decrease and fluctuations in performance, reductions in adaptability and responsiveness, as well as an increase in variability of heart rate often associated with/facilitated by long, uniform, repetitive task performance

EXAMPLE Monotony can be found in long, uniform, repetitive tasks or activities, e.g. assembly tasks, data input.

Note 1 to entry: Symptoms of monotony usually develop more slowly than in the development of *reduced vigilance* (3.2.3.2.2). Recovery from this state does not necessarily occur immediately after a change in the environment or the task.

Note 2 to entry: Monotony and *reduced vigilance* (3.2.3.2.2) can be differentiated with respect to the circumstances of their causal conditions, not with respect to their effects on performance and symptoms of alertness. Monotony can be found in uniform tasks with a high degree of repetitiveness.

3.2.3.2.2
reduced vigilance
state with reduced activation and detection performance mainly associated with monitoring tasks offering only little variation

EXAMPLE Reduced vigilance can be found in monitoring or inspection tasks, e.g. when monitoring radar screens or instrument panels.

Note 1 to entry: Performance decrements usually occur after 5 min to 20 min into task performance. The recovery from this decrement occurs immediately after a change in the environment or the task.

Note 2 to entry: *Monotony* (3.2.3.2.1) and reduced vigilance can be differentiated with respect to the circumstances of their causal conditions and the usual pattern of recovery, not with respect to their effects on performance and symptoms of alertness.

3.2.3.2.3
mental satiation
state of nervously unsettled, strongly emotional rejection of a repetitive task or situation in which the experience is of "marking time" or "not getting anywhere"

Note 1 to entry: Additional symptoms of mental satiation are anger, decreased performance and/or feelings of tiredness, and a tendency to withdraw. In contrast to monotony and reduced vigilance, mental satiation is characterized by an unchanged or even increased activation (3.2.1.2) level, coupled with a negative evaluation of the task leading to an adverse emotion or mood.

3.2.3.3
stress response
state within the individual characterized by increased mental (including both cognitive and emotional components) and/or physical activation (3.2.1.2) resulting from their negative interpretation of the *mental stress* (3.1.1) to which they are exposed as threatening their goals and/or values

EXAMPLE This state can be found in individuals working on a task or with tools and/or under time restrictions which from the perspective of the individual endanger task accomplishment or make it impossible, with expected negative consequences for the individual.

Note 1 to entry: According to this definition, the stress response is necessarily negative, arising from the individual's negative interpretation of the *mental stress* (3.1.1) relative to their available resources.

3.2.4 Impairing effects resulting from long-term or repeated exposure

3.2.4.1
burnout
state characterized by perceived mental, emotional and/or physical exhaustion, a distant attitude towards one's job, and perceived reduced performance capacities, resulting from prolonged exposure to specific kinds of *mental stress* (3.1.1)

Note 1 to entry: The perceived mental, emotional, and/or physical exhaustion expresses itself in an enduring feeling of overload, irritability, tension and lack of drive.

Note 2 to entry: Specific conditions leading to burnout are those which in the short term result in fatigue, satiation, and/or monotony.

Note 3 to entry: A distant attitude towards one's job and job content within service-oriented tasks (e.g. nursing, jobs in call centres, gastronomy) is called *depersonalization* and expresses itself, for example, in reacting with an emotionless, blunted and cynical attitude towards others.

Note 4 to entry: "Perceived reduced performance capacity" is a tendency to evaluate one's own performance ability negatively and to have insufficient coping strategies. It is characterized by a lack of, or a reduced, job-related self-esteem.

Note 5 to entry: There might be other impairing effects with long-term potential which are not listed in this document because they are otherwise already defined and/or the causal relations to the eliciting conditions are not sufficiently well established.

4 Concepts

4.1 General

Any activity, even a predominantly physical one, imposes mental stress. “Mental stress” in this case is a term employed to designate any external influence impinging upon human beings and affecting them mentally.

Mental stress can have both positive and negative effects.

Mental stress induces either processes of increasing or decreasing mental strain within human beings. The immediate, direct consequences of mental strain are facilitating effects on the one hand and impairing effects, e.g. mental fatigue and/or fatigue-like states, on the other. Indirect consequences of mental strain may be practice and training effects. The consequences of mental strain mentioned here may differ in form and intensity, depending on individual and situational preconditions.

4.2 Mental stress

4.2.1 Components of mental stress

In this document, the term "mental" is used for processes of human experience and behaviour. Accordingly, the term is related to cognitive and emotional processes. The term "mental stress" is used because cognitive and emotional processes are related to each other. Hence, it is not possible and not reasonable to analyse these processes separately. In total, mental stress is a term for all external influences affecting the human being mentally.

Mental stress usually comprises various external stress factors (see Table A.1) which affect an individual as combined, not as isolated stress factors, leading to cognitive and emotional processes. Correspondingly, mental stress has different quantitative and qualitative characteristics depending on the specific characteristics of the work task and the conditions in which they are executed. The analysis of mental stress for an existing or planned work system can identify a stress composition which has a different mixture of cognitive, emotional or social elements. Depending on the type and intensity of the mental stress and the temporal structure of its impact (i.e. duration, location and variation in time), different effects of mental stress will result.

Mental stress exceeding human information processing capacities will directly lead to errors in human performance. In such cases, mental stress attains a level making the required task accomplishment impossible in principle. Such dysfunctional requirements shall therefore be avoided by adequately designing tasks, tools and human machine/computer interfaces.

EXAMPLE Mental stress exceeding human information processing capacities can be initiated by the amount of information or the complexity of the information to be processed or need for parallel processing of information in incompatible channels or stages of processing (e.g. in an emergency situation in a process control system with non-prioritized alarms). Such situations/conditions can be avoided by, for example, prioritizing alarms and optimizing their displays.

Variations in mental stress, as mentioned above, can lead to an increase or decrease of mental strain. Short-term consequences of mental strain can lead to positive effects such as learning. On the other hand, negative consequences of mental strain can also occur, namely, fatigue and/or fatigue-like states.

Long-term positive consequences of mental strain encompass the development of competences. A long-term negative consequence of mental stress can be burnout. The characteristics and intensity of these consequences will depend on the given individual and situational preconditions. Mental stress is optimal if negative consequences of mental stress are avoided and beneficial effects are achieved. Accordingly, the optimal stress conditions aimed at can only be achieved by appropriate task design as well as design of the situational conditions, such as those described in Table A.1.

4.2.2 Short- vs. long-term effects of mental stress

When discussing short- or long-term effects of mental stress, care has to be given to what short-term or long-term effects mean, or to what these expressions of short- or long-term refer. They encompass three separate dimensions: (1) the duration of the exposure to mental stress (from minutes to a whole work life), (2) the onset of the effects (immediate to delayed), and (3) the duration (temporal persistence) of the effects (from transitory to chronic). Mental fatigue, for example, can result from a short-term exposure to mental stress (with a high intensity of stress in the area of minutes or hours). Fatigue starts after a short delay (given that the workload is high) or at the last part of a shift, but is usually transitory, i.e. can be reduced/compensated by adequate recuperation. The same, with regard to the onset of the effects, applies to monotony and satiation. All these short-term effects (where the effects appear after a short time of exposure) can be eliminated by a change in the task and not necessarily by rest only.

Repeated exposure to conditions leading to satiation, even where any short-term effects can be reduced or eliminated by rest periods after work periods (e.g. a working day), can eventually lead to alienation from one's work (one of the components of burnout), as a response to this continuing, repeated exposure over time. Such alienation is usually not transitory but persists for longer periods, at least for as long as the exposure to the adverse conditions persists. It can become a chronic state which persists even if the exposure to the adverse working conditions is terminated. In such cases, specific interventions (in some cases, person-oriented) are necessary to reduce the effects.

Other long-term effects with a delayed onset and persisting or chronic reactions based on a long-term exposition can be found in changes in individual characteristics, e.g. as a result of an exposure towards ergonomically unfavourable working conditions over a longer period of time.

EXAMPLE 1 Being exposed to a working time system which leads to a restriction of social activities can result in changes in the value structure, e.g. in a reduction in the value of social participation.

EXAMPLE 2 Immediate or at least short-term responses with long-lasting effects to very short-term exposure can be found in traumatic experiences, where some of the effects persist over the entire life span.

Long-term effects are not restricted to impairing or negative effects. Skill acquisition (e.g. via practice) and the development of competences require working conditions which allow for such an improvement in skills and capabilities and which are designed to match requirements and capabilities. For skills and competences of lower complexity, progress can be expected after a rather short time of exposure, whereas for the acquisition of more complex competences, long-term and repeated exposure will be required.

