SLOVENSKI STANDARD
SIST EN 1005-4:2005

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Varnost strojev ï Ļloveģke fiziļne zmogljivosti ï 4. del: Vrednotenje delovnih poloģajev in gibov pri delu s stroji

Safety of machinery - Human physical performance - Part 4: Evaluation of working postures and movements in relation to machinery

Sicherheit von Maschinen - Menschliche körperliche Leistung - Teil 4: Bewertung von Körperhaltungen und Bewegungen bei der Arbeit an Maschinen

Sécurité des machines - Performance physique humaine - Partie 4: Evaluation des postures et mouvements lors du travail en relation avec les machines

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ICS:

13.110	Varnost strojev	Safety of machinery
13.180	Ergonomija	Ergonomics

SIST EN 1005-4:2005 **en**

EUROPEAN STANDARD

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Safety of machinery - Human physical performance - Part 4: Evaluation of working postures and movements in relation to machinery

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Sicherheit von Maschinen - Menschliche körperliche Leistung - Teil 4: Bewertung von Körperhaltungen und Bewegungen bei der Arbeit an Maschinen

This European Standard was approved by CEN on 17 February 2005.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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Foreword

This European Standard (EN 1005-4:2005) 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of an identical text or by endorsement, at the latest by November 2005, and conflicting national standards shall be withdrawn at the latest by November 2005.

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).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this European Standard.

EN 1005 consists of the following Parts, under the general title *Safety of machinery - Human physical performance*:

— *Part 1: Terms and definitions*;

— *Part 2: Manual handling of machinery and component parts of machinery*;

— *Part 3: Recommended force limits for machinery operation*;

— *Part 4: Evaluation of working postures and movements in relation to machinery*;

— *Part 5*[1]*: Risk assessment for repetitive handling at high frequency*.

This European Standard includes a Bibliography.

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

1 This European Standard is under preparation by CEN/TC 122/WG 4 "Biomechanics".

Introduction

About one third of all workers in the European Union are involved in painful or tiring postures for more than half of their working day, and close to 50 % of all workers are exposed to short repetitive tasks, which are mostly accompanied by painful and tiring movements [2]. Pain and fatigue may lead to musculoskeletal disorder, reduced productivity, and deteriorated posture and movement control. The latter can increase the risk of errors and may result in reduced quality and hazardous situations. Within the life cycle of a machine, from construction to dismantling, all machine-related actions require certain postures and movements. The role of the machinery designer should be to avoid painful and tiring postures and movements.

The requirements in this European Standard aim to reduce the health risks associated with machine-related actions and could also have a positive effect on the quality, efficiency and profitability of those actions.

The requirements in this European Standard are based on current ergonomic knowledge and expert opinions, and will be subject to changes in accordance with future research [1].

This document is a type B standard as stated in EN ISO 12100-1.

The provisions of this European Standard can be supplemented or modified by a type C standard.

For machines which are covered by the scope of a type C standard and which have been designed and built according to the provisions of that standard, the provisions of that type C standard take precedence over the provisions of this type B standard.

1 Scope

This European Standard presents guidance when designing machinery or its component parts in assessing and affecting health risks due only to machine-related postures and movements, i.e. during assembly, installation, operation, adjustment, maintenance, cleaning, repair, transport, and dismantlement. This European Standard specifies requirements for postures and movements without any or with only minimal external force exertion. The requirements are intended to reduce the health risks for nearly all healthy adults.

This European Standard is not applicable to the machinery, which is manufactured before the date of publication of this European Standard by CEN.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 547-1, *Safety of machinery - Human body measurements - Part 1: Principles for determining the dimensions required for openings for whole body access into machinery.*

EN 547-2, *Safety of machinery - Human body measurements - Part 2: Principles for determining the dimensions required for access openings.*

EN 547-3, *Safety of machinery - Human body measurements - Part 3: Anthropometric data.*

EN 614-1, *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 894-2, *Safety of machinery - Ergonomics requirements for the design of displays and control actuators - Part 2: Displays.*

EN 894-3, *Safety of machinery - Ergonomics requirements for the design of displays and control actuators - Part 3: Control actuators.*

EN 1005-1:2001, *Safety of machinery - Human physical performance - Part 1: Terms and definitions.*

EN 1005-2, *Safety of machinery - Human physical performance - Part 2: Manual handling of machinery and component parts of machinery.*

EN 1005-3, *Safety of machinery - Human physical performance - Part 3: Recommended force limits for machinery operation.*

prEN 1005-5[2], *Safety of machinery - Human physical performance - Part 5: Risk assessment for repetitive handling at high frequency.*

EN 1050, *Safety of machinery – Principles for risk assessment.*

EN ISO 12100-1:2003, *Safety of machinery - Basic concepts, general principles for design - Part 1: Basic terminology, methodology (ISO 12100-1:2003).*

EN ISO 12100-2, *Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles (ISO 12100-2:2003).*

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2 This European Standard is under preparation by CEN/TC 122/WG 4 "Biomechanics".

EN ISO 14738, *Safety of machinery - Anthropometric requirements for the design of workstations at machinery. (ISO 14738:2002).*

ISO 11226:2000, *Ergonomics - Evaluation of static working postures.*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 1005-1:2001 and EN ISO 12100-1:2003 apply.

4 Requirements

4.1 General

It is recommended that those using this European Standard should first refer to EN 1050, EN ISO 12100-1, EN ISO 12100-2, and EN 614-1.

The requirements conveyed by this European Standard formally apply to all machine-related actions. Assessing each individual action may be impracticable, therefore those actions which are frequently undertaken or are infrequent but may give rise to risk of pain, fatigue or disorder shall be part of the risk assessment.

NOTE It is emphasised that the requirements in this European Standard should not be used to regulate work organisation.

Above all, machinery design shall allow for **variation** between and while sitting, standing, and walking. Awkward body postures and movements shall be avoided (e.g. kneeling, crouching). Good design shall encourage low frequency movements and avoid painful and tiring postures and high frequency movements (see 4.3).

This European Standard adopts a stepwise risk assessment approach for assessing postures and movements as part of the machinery design process (see Figure 1). The approach detailed in this European Standard makes a distinction between:

— Evaluation **without** operators: When there is no full-size model/prototype of the machinery or its parts currently available (see 4.2.5);

— Evaluation **with** operators: When a full-size model/prototype of the machinery or its parts is available (see 4.2.6).

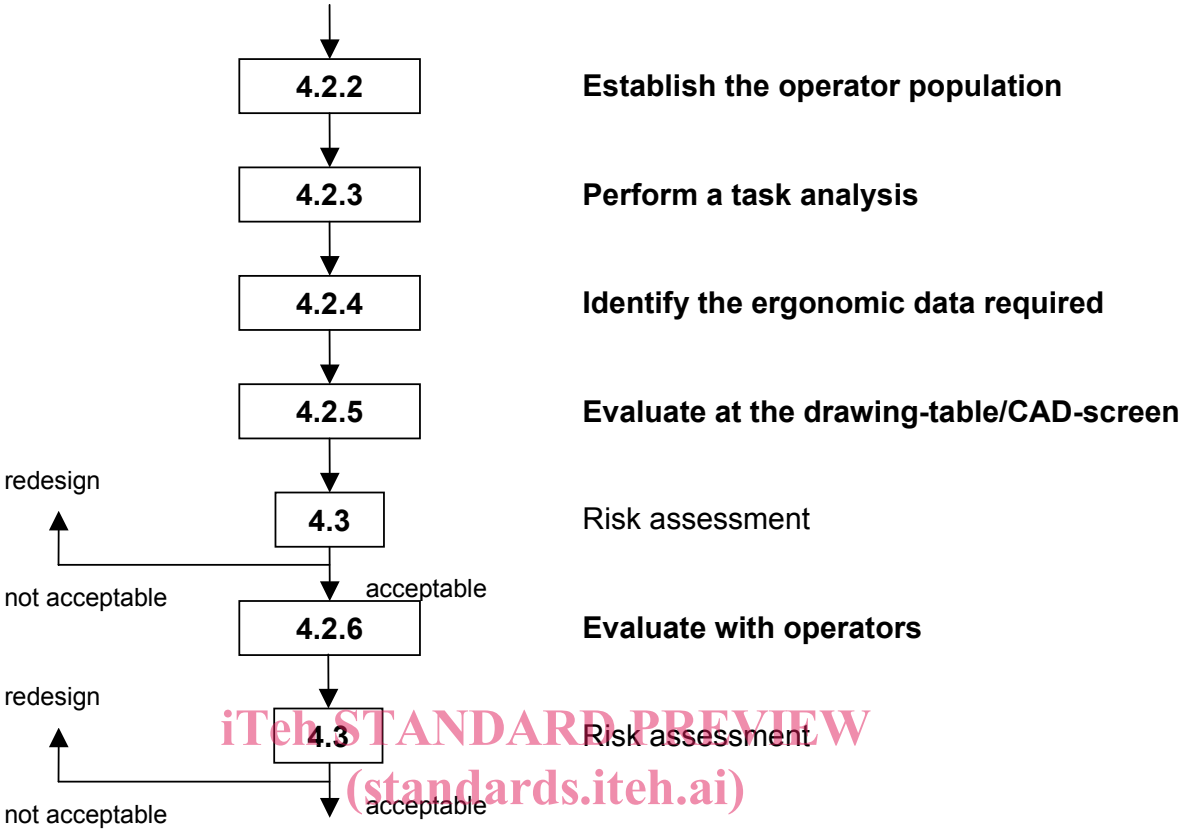
Clause 4.2 provides guidance during the various design stages. Clause 4.3 provides the risk assessment procedure for determining the acceptability of postures and movements.

It is emphasised that there may be information available or obtainable on the use and consequences of particular designs and tasks performed. Provision shall be made for the collection and use of this data. This data shall be analysed to determine whether current designs and practices are adequate or whether a redesign of the machine is needed. The use of inexperienced subjects to perform established tasks may sometimes identify problems that experienced operators have learned to avoid.

4.2 Guidance towards risk assessment

4.2.1 General

Five main stages of the design process based on ergonomic tasks, as outlined in EN 614-1, are discussed in more detail (see 4.2.2 to 4.2.6 and Figure 1 (texts printed in bold)).



NOTE The numbers in the boxes and the texts to the right refer to sections in this European Standard.

Figure 1 — Flow chart illustrating the risk assessment approach

4.2.2 Establish the operator population

A design shall accommodate the full range of intended operators. When considering the postures and movements of operators, it is important to determine the range of body dimensions of the operator population, the general principles of which are described in EN 614-1. The ergonomic tasks described in 4.2.4 to 4.2.6 rely on the selected body dimensions.

4.2.3 Perform a task analysis

Each task the operator is required to perform shall be identified and broken down into its individual components to produce a series of sequential events. All visual, control (hand/foot), stability, and force demands shall be determined for each of these events. The ergonomic tasks described in 4.2.4 to 4.2.6 are dependent upon this information. Furthermore, possible movement frequencies and work durations required with the machine shall be considered. The risk assessment described in 4.3.2 to 4.3.5 is dependent upon this information.

4.2.4 Identify the ergonomic data required

When considering the postures and movements of operators, EN ISO 14738 provides the ergonomic data required in any design process, i.e., with respect to:

— Selecting the main working posture
(sitting, standing, standing with a buttock rest);

— Machinery dimensions
(space/area demands, work surface height/slope).

This data alone will only establish the basic conditions for favourable postures and movements. Postures and movements may also be affected by the task demands listed below and these shall be considered early in the design process:

— Visual demands:
  Posture is adversely affected by an obstruction falling within the line of sight, low illumination levels, small-sized visual targets, and a small angle between the line of sight (gaze direction) and the surface of the visual target. Prolonged observation of a visual target to the side of the operator will lead to sustained head rotation and possible discomfort. In the vertical plane, the most favourable upward/downward direction of the line of sight depends upon the posture of the trunk, i.e., when leaning forwards the most favourable line of sight is in a more downwards, whereas when leaning backwards (i.e. against a backrest), it is in a more upwards direction;

— Control demands (operating a control device by hand/foot):
  Posture or movement may be adversely affected by the type and orientation of a hand grip/contact or pedal. For example, inappropriate orientation of the hand grip axis may create an unfavourable elevated upper arm;

— Stability demands:
  Posture may be affected by the need to support the body, or body parts, at the machinery. For example, when undertaking precision work, a low surface used to support the elbows can cause excessive forward bending of the trunk.

When there is a need to exert a force, reference shall be made to EN 1005-2, EN 1005-3, and prEN 1005-5. EN 894-1, EN 894-2, and EN 894-3 provide ergonomics requirements for the design of displays and control actuators.

4.2.5 Evaluate at the drawing-table/CAD-screen

Early in the design process a comparison shall be made between the body dimensions of the intended operator population (see 4.2.2) and the machinery dimensions. A number of methods may be used: standards (e.g. EN 547-1, EN 547-2, EN 547-3, EN ISO 14738), body templates or computer manikins.

It is recommended that a template or manikin be positioned in natural postures to simulate tasks, and that the risk assessment described in 4.3 of this European Standard be performed. If the design turns out to be ‘not acceptable', the user of this European Standard should go back to an earlier design stage and modify the design. This procedure should be repeated as many times as necessary, before going to 4.2.6.

4.2.6 Evaluate with operators

It is required to simulate tasks at least once by actual operators (selected test subjects representing the intended operator population) with a full-size model/prototype of the machinery or the machinery itself (see EN 614-1, ergonomic task 'evaluate with operators') and perform the risk assessment described in 4.3 of this European Standard. If the design turns out to be not acceptable, the user of this European Standard shall go back to an earlier design stage and modify the design.

4.3 Risk assessment

4.3.1 General

This European Standard uses a number of zones to evaluate postures and movements (see 4.3.2 to 4.3.5); three outcomes are possible:

— Acceptable:
  The health risk is considered low or negligible for nearly all healthy adults. No action is needed;

— Conditionally acceptable:
  There exists an increased health risk for the whole or part of the operator population. The risk shall be analysed together with contributing risk factors, followed as soon as possible by a reduction of the risks (i.e. redesign) or if that is not possible, other suitable measures shall be taken, for example the provision of operator guidelines to ensure that the use of the machine is acceptable;

— Not acceptable:

The health risk cannot be accepted for any part of the operator population. Redesign to improve the working posture is mandatory.

For the Tables 1 to 5 more than one posture and movement condition is considered acceptable. However, where acceptable appears in upper case, this is the recommended condition. ISO 11226 contains a detailed description of the procedure for determination of postures and movements (see Annex A).

NOTE 1 Current knowledge allows partially quantitative requirements, i.e., there may be non-acceptable combinations of otherwise acceptable postures or movements. For example, 10° bending forward of the trunk is acceptable according to the requirements (see 4.3.2.2). Not clearly visible twisting of the trunk (e.g. 5°) is acceptable according to the requirements (see 4.3.2.3). However, for a combination both positions quantitative requirements (i.e., is this acceptable or not) cannot yet be provided.

In 4.3.2 to 4.3.4 the above evaluation procedure constitutes only a first step if the postures or movements observed are assigned the outcome 'conditionally acceptable'. For this reason, Step 2 of the evaluation procedure is introduced. For particular postures, acceptability depends upon the nature and duration of the posture and period of recovery. Reference to ISO 11226 may be used as a guide. Furthermore, for other postures and movements acceptability may depend upon the frequency of the movement or the presence or absence of body support. It is emphasised that support of the arm or the trunk by machinery (directly or indirectly by the arm) may lead to different evaluation results for the upper arm, trunk and head. In this case, refer also to ISO 11226. Finally, it should be recognised that personal protective equipment (for instance, think about extra weight, increased body dimensions, and restricted range-of-motion) or tools (e.g. extra heavy) may affect the evaluation result.

Working periods of long duration and high movement frequencies are known to increase health risks due to machine-related working postures and movements. Current knowledge only allows partial quantitative evaluation of these risk factors (see Step 2 of the evaluation procedure in 4.3.2 to 4.3.4). Therefore, particularly if the machine may be used under the conditions mentioned above, it is strongly recommended that maximum improvement of the working posture be achieved, even if the working posture or movement is already assigned the outcome 'acceptable'. It is required that a text on this issue be incorporated in the user manual of the machine, e.g.: ‘If this machine or similar is used by the same operator for a considerable part of the working day as part of the daily work routine and requires static posture without adequate recovery time or body support being provided, or requires high frequency movements, it may cause pain, fatigue, musculoskeletal disorder, and hazardous situations. It is recommended that a health and safety professional and a production engineer work closely together to assess the status of the operator and the machine.’

The risk assessment procedure detailed below is based on the U-shaped model which proposes that health risks increase when the task approaches either end of the curve, i.e., if there is little or no movement (denoted static posture), or if movement frequencies are high. See Figure 2. It is emphasised that the term ‘movement frequency’ refers to the number of particular movements of a body segment per minute, and not to the number of work cycles per minute. That is, one work cycle may contain more than one particular movement of a body segment.

NOTE 2 Due to the fact that musculoskeletal fatigue is a main factor limiting the performance of work covered by this European Standard, different evaluation results for particular movement frequencies may come out as compared to EN 1005-2 (concerning manual handling), which is based on an energy expenditure criterion, amongst others.