SLOVENSKI PREDSTANDARD

oSIST prEN 1005-5:2005

maj 2005

Varnost strojev - Človeške fizične zmogljivosti - 5. del: Ocena tveganja rokovanja z veliko pogostostjo ponavljanja

Safety of machinery - Human physical performance - Part 5: Risk assessment for repetitive handling at high frequency

ICS 13.110; 13.180

Referenčna številka
oSIST prEN 1005-5:2005(en)

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

DRAFT
prEN 1005-5

February 2005

ICS

English version

Safety of machinery - Human physical performance - Part 5: Risk assessment for repetitive handling at high frequency

Sicherheit von Maschinen - Menschliche körperliche Leistung - Teil 5: Risikobewertung für kurzzyklische Tätigkeiten bei hohen Handhabungsfrequenzen

This draft European Standard is submitted to CEN members for second enquiry. It has been drawn up by the Technical Committee CEN/TC 122.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN 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 Management Centre has the same status as the official versions.

CEN members are the national standards bodies of 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.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. prEN 1005-5:2005: E

Contents

Foreword

This document (prEN 1005-5:2005) has been prepared by Technical Committee CEN/TC 122 “Ergonomics”, the secretariat of which is held by DIN.

This document is currently submitted to the second CEN Enquiry.

This document 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 document.

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[1)]: Evaluation of working postures and movements in relation to machinery;

— Part 5: Risk assessment for repetitive handling at high frequency.

1) Under preparation

Introduction

Within the life cycle of a machine from construction to dismantling, various machine-related actions require repetitive handling at high frequency, which causes musculoskeletal strain and the risk of fatigue, discomfort and musculoskeletal disorders. The designer of a machine should seek to minimise these health risks by taking into account a variety of risk factors including the frequency of actions, the force, postures, durations, lack of recovery and other additional factors.

The risk assessment method in this standard gives guidance to the designer how to reduce health risks for the operator.

This standard is written in conformity with EN 1050 and gives the user a guidance for hazard identification for harm through musculoskeletal overload and tools for qualitative and, to an extent, a quantitative risk assessment. The risk assessment tools also indicate how to achieve risk reduction. This standard does not deal with risks related to accidents.

The recommendations provided by this standard are based on available scientific evidence concerning the physiology and epidemiology of manual work. The knowledge is, however, scarce and the suggested guidelines are subject to changes according to future research. In accordance with the rules for CEN/CENELEC-standards Part 2 clause 4.9.3.

This European Standard is a type B standard as stated in EN 1070.

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

This standard is not applicable to machinery, manufactured before the date of publication of this document by CEN.

NOTE 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 to the designer of machinery or its component parts and the writer of C-standards in assessing and controlling health and safety risks due to machine-related repetitive handling at high frequency.

This standard specifies reference data for action frequency of the upper limbs during machinery operation, and it presents a risk assessment method intended for risk reduction option analysis.

This standard applies to machinery for professional operation by the healthy adult working population. This standard is not applicable for upper arm elevation above shoulder height.

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

EN 614-2, *Safety of machinery - Ergonomic design principles – Part 2: Interactions between the design of machinery and work tasks*.

EN 1005-1, *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 1005-4[2)], *Safety of machinery - Human physical performance – Part 4: Evaluation of working postures in relation to machinery*.

EN 1050, *Safety of machinery - Risk assessment*.

EN 1070, *Safety of machinery - Terms and definitions*.

EN ISO 6385, *Ergonomic principles in the design of work systems.*

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

EN ISO 12100-2, *Safety of machinery - Basic concepts, general principles for design – Part 2: Technical principles and specifications*.

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

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

2) Under preparation

3 Terms and definitions

Definitions used in EN and ISO standards referred to in this European standard are also valid for this standard. Additional definitions specifically needed for this European standard are added below.

3.1
repetitive task
task characterized by repeated work cycles

3.2
non-repetitive task
task characterized by the presence of non-repeated work cycle

3.3
work cycle
sequence of technical actions that are repeated always the same way

3.4
cycle time
the time elapsing from the moment when one operator begins a work cycle to the moment that the same work cycle is repeated (in seconds)

3.5
technical action
elementary manual actions required to complete the operations within the cycle, such as holding, turning, pushing, cutting

3.6
repetitiveness
quality of task when a person is continuously repeating the same cycle, technical actions and movements in a significant part of a normal workday

3.7
frequency
number of (technical actions) per minute

3.8
force
physical effort of the operator required to execute the operations related to the machinery

3.9
posture and movements
positions and movements of body segment(s) or joint(s) required to execute the operations related to the machinery

3.10
recovery time
period of rest following a period of activity in which restoration of a muscle can occur (in minutes)

3.11
additional risk factors
risk factors which include other factors for which there is evidence of causal or aggravating relationship with work-related musculoskeletal disorders of the upper limb, e.g. vibrations, local pressure, cold

4 Abbreviations

For the purposes of this European Standards the following abbreviations apply.

Acronyms	Legenda for abbreviations
NTC	Number of technical actions in the cycle
FCT	Foreseeable duration of the Cycle Time (in seconds)
FF	Foreseeable Frequency of actions per minute
RF	Reference Frequency of technical actions
CF	"Constant of Frequency" of technical actions per minute
Po_M	Posture Multiplier
Re_M	Repetitiveness Multiplier
Ad_M	Additional Multiplier
Fo_M	Force Multiplier
Rc_M	Recovery Multiplier
Du_M	Duration Multiplier
ATA	Number of Actual Technical Actions within a shift
RTA	Number of Reference Technical Actions within a shift
n	Number of repetitive task/s performed during shift
j	generic repetitive tasks
D	net Duration in minutes of each repetitive task
OCRA	OCcupational Repetitive Action
NPA	Number of Persons Affected by one or more UL-WMSDs
PA	Prevalence (%) of persons Affected
NEP	Number of Exposed Persons
MSDs	Musculo-Skeletal Disorders
UL-WMSDs	Upper Limb Work-related Musculo-Skeletal Disorders
S.E.	Standard Error

5 Requirements

5.1 The application of standards relevant to this document

The designer shall first consider EN 614 (Part 1 and 2), EN 1005-3, prEN 1005-4, EN ISO 12100 (Part 1 and 2) and EN ISO 14738.

5.2 General aspects

Machines and related tasks shall be designed in a way so that activities demanding high frequency can be performed adequately with respect to the force required, the posture of the limbs and the foreseeable presence of recovery periods. In addition machines and related tasks shall be designed to allow for variations in movements. Additional factors (vibration, cold, etc.) have to be considered.

The technical action is identified as the specific characteristic relevant to repetitive movements of the upper extremities. The technical action is factored by its relative frequency during a certain time period.

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

Thus, in design process the designer shall also (see EN 614-2):

a) avoid overload as well as under load of the operator, which may lead to unnecessary or excessive strain, fatigue or to errors. Frequency, duration and intensity of perceptual, cognitive and motor activities shall be designed so as to avoid these consequences

b) avoid repetitiveness for the operator, which may lead to unbalanced work strain and thus to physical disorders as well as to sensations of monotony, satiation, boredom or to dissatisfaction.

Short work cycles should therefore be avoided. The operator shall be provided with an appropriate variety of tasks or activities. If repetitive task cannot be avoided:

1) cycle time shall not be determined solely on the basis of average time measures or estimated under normal conditions;

2) allowances shall be given for deviations from normal conditions;

3) very short cycle times shall be avoided;

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

5) working on moving objects shall be avoided.

In this standard risk assessment in relation to physical overload during repetitive handling is described.

5.3 Risk assessment

The “frequency of upper limbs action“ is related to other risk factors such as force (the greater the force, the lower the frequency), posture (the greater the joint excursion, the longer the time necessary to carry out an action) and recovery periods (if well distributed during the shift, they increase the recovery of muscular function).

Some additional factors can increase the need for force (awkward tools or gloves) or cause damage to muscles, tendons and vessels (vibration, compression, cold surfaces).

Data from recent epidemiological studies on workers exposed to repetitive movements of upper limbs allow, among others, designers to forecast from exposure indexes the occurrence of the consequences for Upper Limbs Work-related Musculoskeletal Disorders (UL-WMSDs) [10, 31, 32, 33]. Annex D describes a method of determination [5]. The acceptable situation occurs when the exposure index (*OCRA*) corresponds to a forecast of occurrence of MSDs as observed in a working population not exposed to occupational risks for the upper limbs [4, 11, 15].

When repetitive handling is unavoidable then a risk assessment and risk reduction approach should be adopted. In accordance with ISO Guide 51 and EN 1050, this should follow a four-step approach: hazard identification, risk estimation, risk evaluation and risk reduction.

It is required to simulate tasks at least once by actual users with a full-size model/prototype of the machinery or the machinery itself (refer to EN 614-1, ergonomic task 'evaluate with users'; see also prEN 1005-4 clause 4.2 ‘Guidance towards risk assessment’).

The following procedure should be adopted when conducting a risk assessment of machinery design involving repetitive handling (Figure 1).

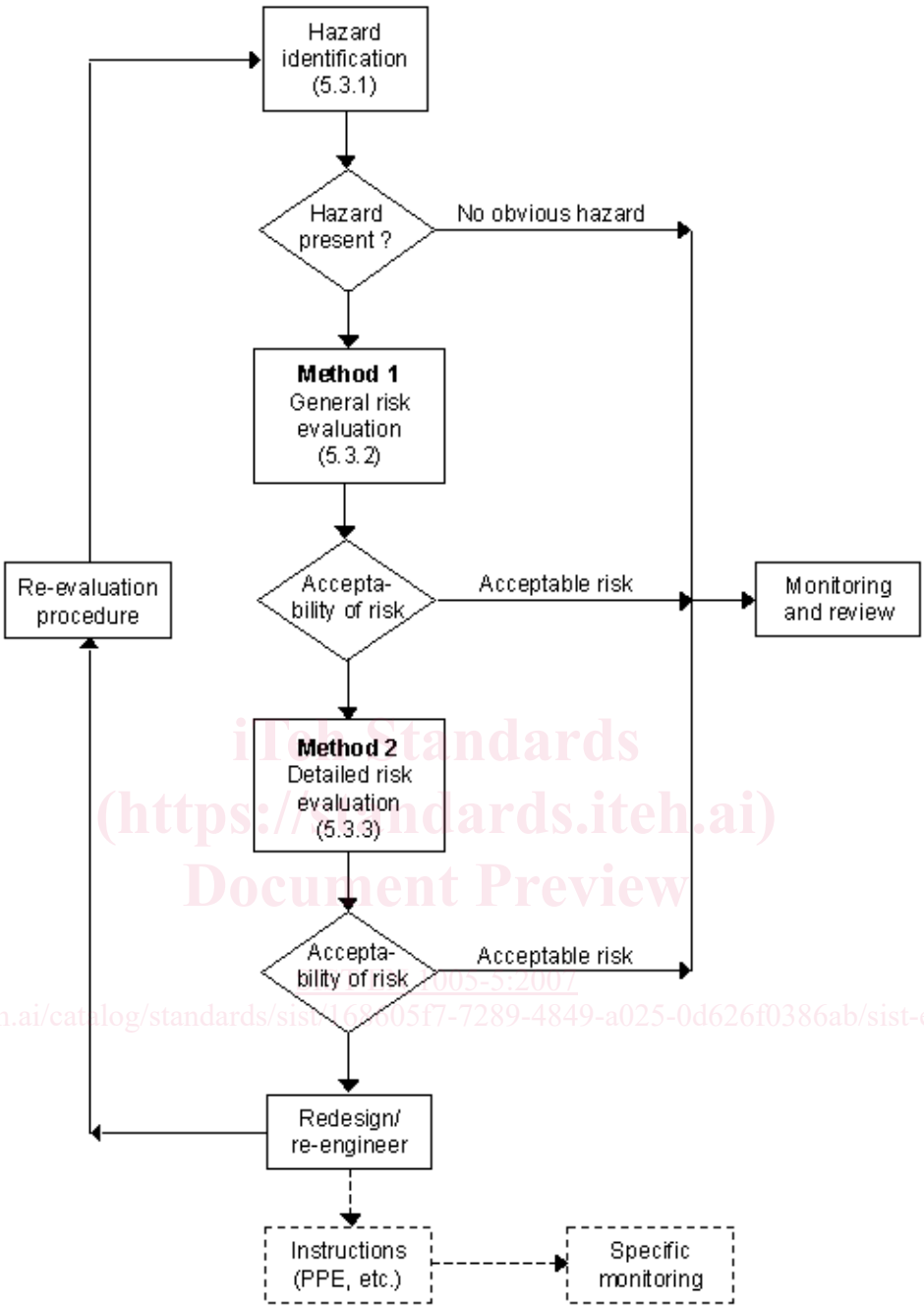

Figure 1 — Risk assessment model

The first stage of the risk assessment is to identify whether hazards exist which may expose individuals to a risk of injury. If such hazards are present, then a more detailed risk assessment may be necessary. When determining a risk assessment, consideration should be given to the following risk factors:

a) Repetitiveness:
Repetitive movements should be avoided within a task. As the movement frequency increases and/or the cycle duration decreases, the risk of injury increases. Frequent repetitive movements giving rise to a risk of injury may vary depending on the context of the movement pattern and the individual.

b) Force:
Tasks should involve smooth force exertions, avoiding sudden or jerky movements. Handling precision (accurate picking and placement), the type and nature of the grip may introduce additional muscular effort.

c) Posture and movement:
Work tasks and operations should provide variations to the working posture; both whole body postures and movement of specific limbs. The work tasks should avoid extreme ranges of joint movement and there is a need to avoid prolonged static postures. Complex postures involving combined movements (e.g. flexed and twisted) may present greater risk.

d) Sitting restricts overall movement of the body, particularly those of the lower leg and back. This may lead to increased and complex loading of the back and upper extremities. Standing for prolonged periods of time often results in pain/discomfort in the legs and lower back, and may lead to venous pooling in the legs. Whenever possible, workers should be given the option to vary between sitting and standing.

e) Duration and insufficient recovery:
Duration can be broken down in a number of ways, i.e. task duration, job duration, and work shift duration. The opportunity for recovery or rest can fall within each of these work periods. Insufficient time for the body to recover between repetitive movements (i.e. lack of recovery time) increases the risk of injury.

f) Additional risk factors:
The following list should be considered to find out if the risk related to repetitive handling is increased due to additional risk factors:

1) Object characteristics (e.g. contact forces, shape, dimensions, coupling, object temperature)

2) Vibration and impact forces

3) Environmental conditions (e.g. lighting, climate, noise)

4) Individual and organisational factors (e.g. skills, the level of training, age, gender, health problems, pregnancy)

5.3.1 Hazard identification

If the following conditions are satisfied there is no hazard:

— The task is not characterized by cycles

— The task is characterized by cycles, but perceptual or cognitive activities are clear prevalent and upper limb movements are residual.

For all the machinery/task combinations in which cyclic manual activities are foreseen, risk estimation shall be applied.

For each manual task to be performed on machinery the designer shall:

— identify and count the technical actions (for each upper limb) needed to carry out the task (NTC);

— define the foreseeable duration of the cycle time (FCT);

— consider the foreseeable duration and frequency of recovery periods;

— consider the possibility of rotation on different tasks, when designing a machinery e.g. in the context of an assembly line.

An evaluation model will be presented in 5.3.2 (Method 1) and 5.3.3 (Method 2).

When the characteristics described in Method 1 are fully and simultaneously present, it is possible to affirm that risk exposure to repetitive movements at high frequency is acceptable.

Where one or more of the listed characteristics for the different risk factors are not satisfied, the designer shall use a more detailed evaluation (Method 2, 5.3.3).

5.3.2 Risk estimation and simple evaluation of machinery related repetitive handling at high frequency (Method 1)

5.3.2.1 Check of the risk factors

The designer shall check if, considering the main risk factors (force, awkward postures and movements, repetitiveness, frequency of technical actions, additional factors), for each upper limb, the following conditions are satisfied:

a) Absence of force, or use of force in accordance with the criteria regarding the recommended force limits as reported in EN 1005-3.

b) Absence of awkward postures and movements considering the same conditions exposed in prEN 1005-4 as summarized below:

   1) The upper arm postures and movements are in the range between 0° and 20° (Zone 1 in Figure 6, prEN 1005-4);

   2) The articular movements of the elbow and wrist do not exceed 50 % of the maximum articular range [9], (Table 1 and Annex B);

   3) The kinds of grasp are “power grip”, or “pinch lasting no more than 1/3 of the cycle time”, (Table 1 and Annex B). [4, 7, 10].

c) Low repetitiveness.

   This is true if [38, 39]:

   1) The cycle time is more than 30 seconds [19].

   1) The same kinds of action are not repeated for more than 50 % of the cycle time [19].

d) Frequency of technical actions for both upper limbs is less than 40 actions per minute. If the frequency is greater than 40 actions per minute for at least one upper limb then move on to Method 2.

   In order to compute the frequency of actions/min (see annex A for identification of technical action), use the following formula:

$$FF = \frac{NTC \cdot 60}{FCT} \qquad \textbf{(1)}$$

   where:

   FF is the foreseeable frequency of actions per minute;

   FCT is foreseeable duration of the cycle time in seconds;

   NTC is the number of technical actions (for each upper limb) needed to carry out the task.

e) Absence of additional factors (physical and mechanical factors).

   The task should not include hand/arm vibration, shock (such as hammering), localized compression on anatomical structures due to tools, exposure to cold, use of inadequate gloves for grasping etc. [4, 7] (Annex G).

5.3.2.2 Final estimation and evaluation of machinery design by Method 1

When every condition shown in 5.3.2.1, points a, b, c, d, e are satisfied for each upper limb, the exposure is acceptable. If one or more conditions mentioned in Method 1 are not met, the designer shall analyse in more detail each risk factor that interferes with the frequency of actions by Method 2.

5.3.3 Detailed risk assessment of machinery related repetitive handling at high frequency: risk reduction and risk reduction option analysis (Method 2)

5.3.3.1 Evaluation of acceptable frequency of actions when one or more risk factors are present

If one or more conditions defined in Method 1 are not satisfied, the designer shall analyse in more detail each risk factor that has an impact upon the frequency of actions. Since different risk factors can be present to a greater or lesser extent, and in a variety of combinations, then different levels of risk can be expected.

The level of risk is assessed with reference to the *OCRA* method [8, 10, 30]. The *OCRA* index, when assessing a single repetitive task in a shift (mono task job), is given by the ratio between the foreseeable frequency (*FF*) of technical actions needed to carry out the task, and the reference frequency (*RF*) of technical actions, for each upper limb (see Annex A for identification of technical action). This is a particular procedure for mono task jobs. For multitask jobs see Annex H.

In this context:

$$OCRA\ index = \frac{FF}{RF}$$

The foreseeable frequency (number per minute) of technical actions needed to carry out the task (*FF*) is given by the following formula:

$$FF = \frac{NTC \cdot 60}{FCT}$$

where:

FCT is foreseeable duration of the cycle time in seconds;

NTC is the number of technical actions (for each upper limb) needed to carry out the task during one cycle.

The following formula calculates the reference frequency (number per minute) of technical actions (*RF*) on a work cycle base:

$$RF = CF \times Po_M \times Re_M \times Ad_M \times Fo_M \times \left(Rc_M \times Du_M\right)$$

where:

CF = “constant of frequency” of technical actions per minute = 30

Po_M; Re_M; Ad_M; Fo_M = multipliers for the risk factors postures, repetitiveness, additional, force.

Rc_M = multiplier for the risk factor “lack of recovery period”

Du_M = multiplier for the overall duration of repetitive task (s) during a shift.

When designing a machinery related task, evaluate reference frequency of the technical actions within a work cycle that is representative of the task under examination. The analyses shall include the main risk factors that the designer can influence with the consequent choice of a specific multiplier for each risk factor. These multipliers will decrease from 1 to 0 as the risk level increases. The risk factors and the corresponding multiplier, influenced by the designer, are:

Awkward or uncomfortable postures or movements (posture multiplier) (Po_M), see 5.3.3.1.1

High repetition of the same movements (repetitiveness multiplier) (Re_M), see 5.3.3.1.2

Presence of additional factors (additional multiplier) (Ad_M), see 5.3.3.1.3