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Ergonomics — Manual handling —

Part 3: Handling of low loads at high frequency

Ergonomie — Manutention manuelle —

Partie 3: Manipulation de charges faibles à fréquence de répétition élevée

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 11228-3 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 3, *Anthropometry and biomechanics*.

ISO 11228 consists of the following parts, under the general title *Ergonomics — Manual handling*:

— *Part 1: Lifting and carrying*

— *Part 2: Pushing and pulling*

— *Part 3: Handling of low loads at high frequency*

This corrected version of ISO 11228-3:2007 incorporates the following corrections:

— the error message substituted for Equation (C.9) has been replaced by the missing equation;

— the hyperlink previously referenced as [65] in the Bibliography, no longer active, has been deleted, together with its mention in the main body of the document, and the numbers of the other bibliographical references following it have been adjusted accordingly.

Introduction

Handling of low loads at high frequency (repetitive work) can cause pain and fatigue, which could lead to musculoskeletal disorders, reduced productivity, and deteriorated posture and movement co-ordination. The latter can increase the risk of errors and may result in reduced quality and hazardous situations. Good ergonomic design and proper organization of work are basic requirements for the avoidance of the adverse effects mentioned.

Risk factors in repetitive work include the frequency of actions, exposure duration, postures and movement of body segments, forces associated with the work, work organization, job control, demands on work output (e.g. quality, task precision) and level of training/skill. Additional factors can include environmental factors, such as climate, noise, vibration and illumination.

The recommendations provided by this part of ISO 11228 are based on available scientific evidence concerning the physiology and epidemiology of manual work. The knowledge is, however, limited, and the suggested guidelines are subject to change according to future research.

Ergonomics — Manual handling —

Part 3:
Handling of low loads at high frequency

1 Scope

This part of ISO 11228 establishes ergonomic recommendations for repetitive work tasks involving the manual handling of low loads at high frequency. It provides guidance on the identification and assessment of risk factors commonly associated with handling low loads at high frequency, thereby allowing evaluation of the related health risks to the working population. The recommendations apply to the adult working population and are intended to give reasonable protection for nearly all healthy adults. Those recommendations concerning health risks and control measures are mainly based on experimental studies regarding musculoskeletal loading, discomfort/pain and endurance/fatigue related to methods of working. For the evaluation of working postures, refer to ISO 11226.

This part of ISO 11228 is intended to provide information for all those involved in the design or redesign of work, jobs and products.

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.

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

ISO 11226, *Ergonomics — Evaluation of static working postures*

ISO 11228-1, *Ergonomics — Manual handling — Part 1: Lifting and carrying*

ISO 11228-2, *Ergonomics — Manual handling — Part 2: Pushing and pulling*

ISO 14738, *Safety of machinery — Anthropometric requirements for the design of workstations at machinery*

ISO 15534 (all parts), *Ergonomic design for the safety of machinery*

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the terms and definitions given in ISO 6385, ISO 11228-1, ISO 11228-2, ISO 11226 and the following terms, definitions, symbols and abbreviated terms apply.

NOTE In the definitions involving frequency, a unit of time is mentioned because more than one method is involved, each using a different unit, e.g. seconds in HAL (see Annex D), minutes in the OCRA Index (see Annex C) and Strain Index (see Annex D).

3.1 Terms and definitions

3.1.1
repetitive task
task characterized by repeated work cycles

3.1.2
work cycle
sequence of (technical) actions that are repeated always the same way

3.1.3
cycle time
t_C
time, in seconds, elapsing from the moment when one operator begins a work cycle to the moment that the same work cycle is repeated

3.1.4
technical action
elementary manual actions required to complete the operations within the cycle

EXAMPLE Holding, turning, pushing or cutting.

3.1.5
repetitiveness
characteristic of a task when a person is continuously repeating the same work cycle, technical actions and movements

3.1.6
frequency of actions
number of technical actions per unit of time

3.1.7
force
F
physical effort of the operator required to execute the task

3.1.8
postures and movements
positions and movements of body segment(s) or joint(s) required to execute the task

3.1.9
recovery time
period of rest following a period of activity which allows restoration of musculoskeletal function (in minutes)

3.1.10
additional risk factor
object and environmental factors for which there is evidence of causal or aggravating relationship with work-related musculoskeletal disorders of the upper limb

EXAMPLE Vibration, local pressure, cold environment or cold surfaces.

3.1.11
move
transport of an object to a given destination using the upper limbs and without walking

3.1.12
reach
shift the hand towards a prefixed destination

3.1.13
carry
transport of an object to a given destination by walking

3.2 Symbols and abbreviated terms

A_M	additional multiplier
ATA	actual technical action
f	frequency of actions per minute
F	force (N)
F_B	basic force limit
F_L	force limit
F_M	force multiplier
j	generic repetitive tasks
k_f	constant of frequency of technical actions per minute
L	actual load
MODA PTS	modular analysis predetermined time system
MSD	musculoskeletal disorders
MTA	motion time analysis
MTM	methods/time measurement
MVC	maximum voluntary contraction
n_{ATA}	overall number of actual technical actions within a shift
n_{ep}	number of exposed individuals
n_{pa}	number of persons affected by one or more UL-WMSD
n_{RPA}	partial reference number of technical actions within a shift
n_{rt}	number of repetitive task(s) performed during a shift
n_{RTA}	overall number of reference technical actions within a shift

n_{TC}	number of technical actions in a cycle
OCRA	occupational repetitive action
PA	prevalence (%) of persons affected
P_M	posture multiplier
PTS	predetermined time system
RTA	reference technical action
R_{eM}	repetitiveness multiplier
R_{cM}	recovery multiplier
SE	standard error
t	net duration of each repetitive task, in minutes
t_C	cycle time, in seconds
TA	technical action
t_M	duration multiplier
UL-WMSD	upper limb work-related musculoskeletal disorders
WF	work factor

4 Recommendations

4.1 Avoiding repetitive handling tasks

Hazardous manual handling tasks should be avoided wherever possible. This can be achieved through work enlargements, job rotation and/or mechanization/automation within the framework of a participative ergonomics approach. In the case of repetitive handling of low loads at high frequency, many tasks can be modified through the use of robotics or automated production systems.

NOTE A "participative ergonomics approach" signifies the practical involvement of workers, supported by suitable communication, in planning and managing a significant amount of their work activities, with sufficient knowledge and ability to influence both processes and outcomes in order to achieve desirable goals.

4.2 Risk assessment

4.2.1 General

When repetitive handling is unavoidable, a four-step approach in accordance with ISO Guide 51 and ISO 14121, and involving both risk assessment and risk reduction, should be adopted. The four steps are hazard identification, risk estimation, risk evaluation and risk reduction.

The procedure shown in Figure 1 should be adopted when carrying out a risk assessment of jobs involving the manual handling of low loads at high frequency.

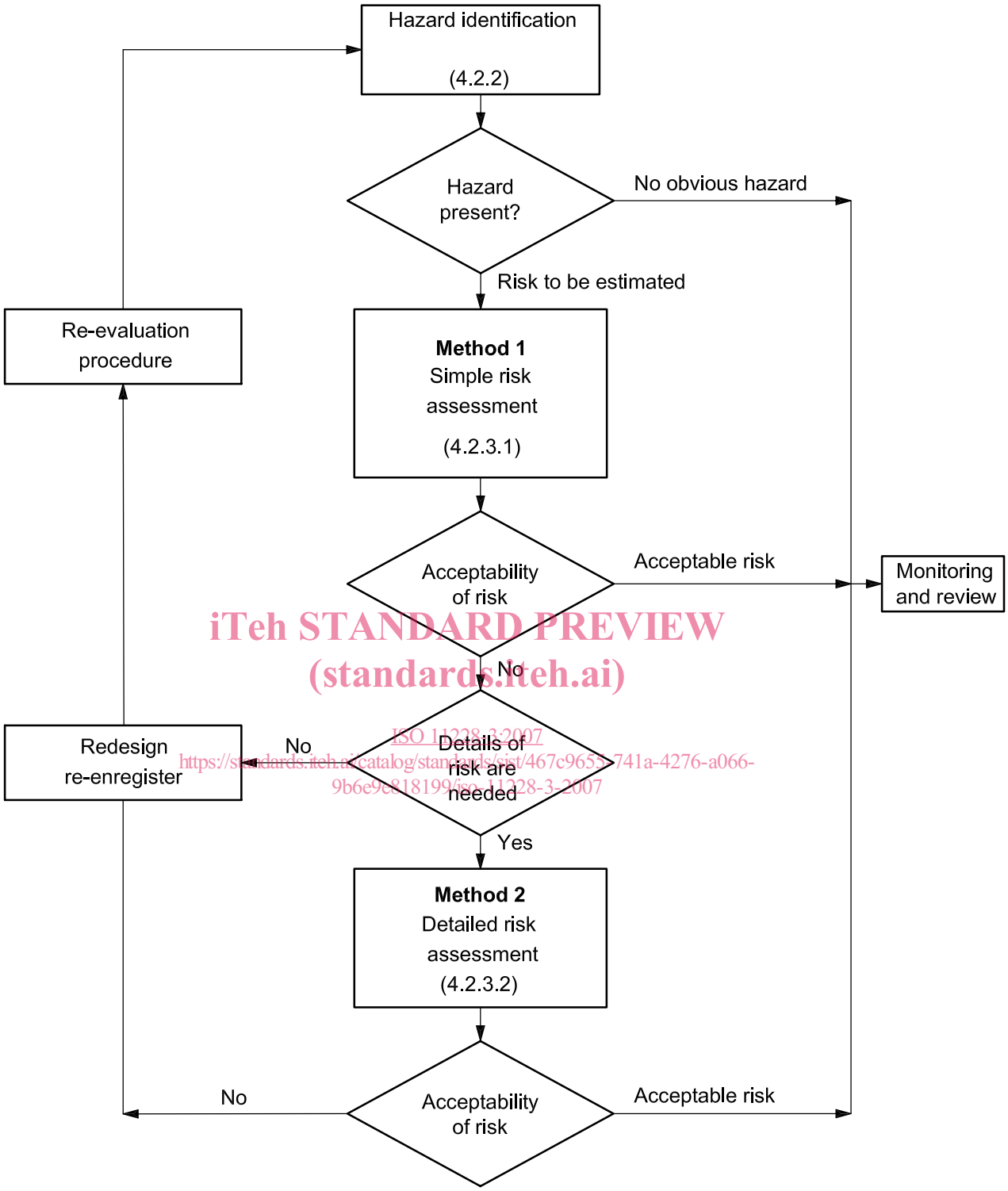

Figure 1 — Risk assessment procedure

4.2.2 Hazard identification

4.2.2.1 General

The first step 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 can be necessary. When determining if one or more of the following hazards is present, consideration should be given to the guidelines for avoiding them.

4.2.2.2 Repetition

Frequent repetitive movements give rise to a risk of injury that can vary depending on the context of the movement pattern and the individual. As the movement cycle increases and/or the cycle time decreases, the risk of injury increases. Repetitive movements should be avoided within a task or job.

4.2.2.3 Posture and movement

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 can lead to venous pooling in the legs. Complex postures involving combined movements (e.g. flexed and twisted) can present greater risk (see ISO 11226). Whenever possible, workers should be given the option to vary between sitting and standing.

Work tasks and operations should provide variations to the working posture: both whole-body postures and movement of specific limbs. In the work tasks, extreme ranges of joint movement should be avoided; there is also need to avoid prolonged static postures.

4.2.2.4 Force

Forceful exertions can be harmful. Tasks should involve smooth force exertions, with the avoidance of sudden or jerky movements. Handling precision (accurate picking and placement), and the type and nature of the grip can introduce additional muscular activation.

4.2.2.5 Duration and insufficient recovery

Insufficient time for the body to recover between repetitive movements (i.e. lack of recovery time) increases the risk of injury. Duration can be broken down into different levels, i.e. work shift duration, job duration, task duration. The opportunity for recovery or rest may fall within each of these work periods.

4.2.2.6 Object characteristics

Inappropriately designed objects could have characteristics that can cause harm (e.g. contact forces, shape, dimensions, coupling, object temperature). Inappropriately placed handholds may lead to awkward hand/arm postures. Non-cushioned handholds and objects constructed of a smooth material increase the difficulty of grasping the object and increase force requirements. The size and shape of the object being handled and the coupling between it and the operator's hands will determine the grip type and the force that the operator must exert.

4.2.2.7 Vibration and impact forces

Exposure to hand/arm vibration, shocks or impacts can lead to a desensitizing of the hand and increase the force necessary for gripping an object or tool. Prolonged exposure to these types of risk factors has also been linked to vascular and neurological disorders of the upper limbs.

4.2.2.8 Environmental conditions (lighting, climate, noise, etc.)

Inappropriate lighting, hot and cold environments and high levels of noise can impose additional hazards. Wet or contaminated surfaces are likely to inhibit the ability to exert forces and increase the risk of injury. The designer of products shall consider environmental conditions only within the limits of the foreseeable use of the product.

4.2.2.9 Work organization

Work organization (e.g. task duration, job duration, recovery time, shift patterns) has an important part to play in the exposure to musculoskeletal risk factors. This should be structured to facilitate rest periods and avoid the use of similar muscle groups over the duration of the work shift. Job rotation, job diversification and job enlargement are all methods of structuring the work to facilitate variation and recovery within the work period.

4.2.2.10 Psychosocial factors (e.g. job complexity, job demands, job content)

Psychological response to work and workplace conditions has an important influence on general health and, in particular, musculoskeletal health. These factors include the design, organization and management of work, the specific impact of workplace risk factors, such as work content, and the overall social environment (i.e. the context of work). Many of the effects of these psychosocial factors occur via stress-related processes, which can have a direct effect on biochemical and physiological responses.

4.2.2.11 Individuals

Individual skills, training, age, gender, health problems and pregnancy are personal characteristics that can influence performance and should be considered in the risk assessment. Skill and experience are likely to benefit the individual when performing the task and reduce the risk of injury. Training can increase the level of skill.

Important aspects of work design include the amount of control an individual has over his/her work, the level of work demands, the variety of tasks he/she is required to perform and the level of support provided by managers, supervisors and/or co-workers. Undesirable psychosocial aspects of a job contributing to a risk of musculoskeletal disorders include the following:

— workers have little or no control over their work and work methods or organization;

— tasks require high levels of attention and concentration;

— workers are unable to make full use of their skills;

— workers have little or no involvement in decision making;

— workers are expected to carry out repetitive, monotonous tasks exclusively;

— work is machine- or system-paced;

— work demands are perceived as excessive;

— payment systems encourage working too quickly or without breaks;

— work systems limit opportunities for social interaction;

— high levels of effort are not balanced by sufficient reward (resources, remuneration, self-esteem, status, etc.).

4.2.3 Risk estimation

4.2.3.1 Method 1 — Simple risk assessment

Risk estimation is performed by a simple risk assessment of jobs composed by a single repetitive task (monotask jobs).

The procedure and checklist model presented in Annex B is preferred for the carrying out of the simple risk assessment. There are four parts to this assessment procedure:

— preliminary information describing the job task;

— hazard identification and risk estimation procedure and checklist;

— overall evaluation of the risk;

— remedial action to be taken.

NOTE As a second choice, other simple methods and checklists given in Annex A can be used, taking into consideration the specific characteristics of the repetitive task under examination.

Risk estimation using Method 1 should allow the classification of the risk by the three-zone approach (green, yellow and red) and determine the consequent action to be taken. The three risk zones are defined as follows.

a) Green zone (acceptable risk)

The risk of disease or injury is negligible or is at an acceptably low level for the entire working population. No action is required.

b) Yellow zone (conditionally acceptable risk)

There is a risk of disease or injury that cannot be neglected for the entire working population or part of it. The risk shall be further estimated (using the more detailed assessment of Method 2), analysed together with contributory risk factors and followed as soon as possible by redesign. Where redesign is not possible, other measures to control the risk shall be taken.

c) Red zone (not acceptable)

There is a considerable risk of disease or injury that cannot be neglected for the operator population. Immediate action to reduce the risk (e.g. redesign, work organization, worker instruction and training) is necessary (see 4.3 and Annex E).

4.2.3.2 Method 2 — Detailed risk assessment

4.2.3.2.1 General criteria

If the risk estimated using Method 1 is considered to be YELLOW or RED, or if the job is composed of two or more repetitive tasks (multitask job), the performing of a more detailed risk assessment is recommended. This will also allow a better determination of the remedial measures to be taken.

For detailed risk assessment, OCRA (occupational repetitive action) is the preferred method (see 4.2.3.2.2). It is recommended for the specific purposes of this part of ISO 11228 because, given the knowledge at the time of publication, it considers all the relevant risk factors, is also applicable to “multitask jobs”, and provides criteria — based on extensive epidemiological data — for forecasting the occurrence of UL-WMSD (upper limb work-related musculoskeletal disorders) in exposed working populations.

Other detailed risk assessment methods are available which can be used for a detailed risk assessment, depending on the kind of risk factors identified by Method 1, the nature of the job and the experience of the analyst.

Annex D gives basic information about other detailed risk assessment methods useful for the purposes of this part of ISO 11228, together with some remarks about their applicative limits at the time of publication.

Whichever method is used for detailed risk assessment, it should allow the classification of the risk by the three-zone model and determine the consequences to be acted upon in accordance with Table 1.

Table 1 — Method 2 — Final assessment criteria

Zone	Risk level	Consequences
Green	No risk	Acceptable: no consequences
Yellow	Very low risk	Improve structural risk factors (posture, force, technical actions, etc.) or take other organizational measures
Red	Risk	Redesign tasks and workplaces according to priorities

4.2.3.2.2 OCRA method for detailed risk assessment

The OCRA index is the ratio between the number of actual technical actions, ATA, carried out during a work shift and the number of reference technical actions, RTA, for each upper limb, specifically determined in the scenario under examination [11], [38].

The OCRA risk assessment procedure consists of three basic steps:

a) **Step 1**

Calculate the frequency of technical actions/min and the overall number of ATA carried out in the shift (by each upper limb).

b) **Step 2**

Calculate the overall number of RTA.

c) **Step 3**

Calculate the OCRA index and perform a risk evaluation.

Table 2 (ATA and RTA calculation in monotask jobs), Table 3 (ATA and RTA calculation in multitask jobs) and Table 4 (OCRA index calculation and risk evaluation) give an overview of the procedure detailed in Annex C.