International Standard

ISO 11228-3

Ergonomics — Manual handling —

Part 3: Repetitive movements and exertions of the upper limbs

Ergonomie — Manutention manuelle —

Partie 3: Mouvements répétitifs et efforts des membres supérieurs

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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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 11228-3:2007), which has been technically revised.

The main changes are as follows:

— addition of an assessment method in Annex B (see Clause B.3 and Figure B.1);

— addition of different methods presented in Table C.1, providing guidance to the user for application;

— addition of inclusion and validation criteria for the different methods in Table C.2.

A list of all sections in the ISO 11228 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Repetitive movements and forceful exertions of the upper limbs (repetitive work) can cause pain and fatigue, which can lead to musculoskeletal disorders, and deteriorated posture and movement co-ordination. These outcomes can increase the risk of errors and can result in hazardous situations and reduced productivity and quality. Repetitive work, and its consequences, can be prevented through the use of ergonomic design and organization of work.

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), psychosocial factors and level of training or skill. Additional factors can include environmental factors, such as climate, noise, vibration and illumination.

The recommendations provided by this document are based on current scientific evidence concerning the physiology, biomechanics and epidemiology of manual work. The knowledge is, however, limited, and the suggested guidelines are subject to change as evidence emerges. Those recommendations concerning health risks and control measures are mainly based on research involving in North American and European populations and how work methods affect musculoskeletal loading, discomfort or pain and endurance or fatigue. These recommendations can be used for guidance purposes. Countries can generate their own recommendations based on studies of national populations. For the evaluation of working postures, refer to ISO 11226.

The changes in this edition of this document include the introduction of a general assessment method, the presentation of several different risk assessment tools along with inclusion, validation and application criteria. A set of criteria have been defined regarding the selection and validation status of the tools and methods presented. The tools are presented in Annex C. This document does not have a mass threshold or limit. However, if the masses handled are 3 kg or more, the user is directed to also consult ISO 11228-1.

This document is intended to provide information for all those involved in the design or redesign of work, jobs and products (e.g. machinery).

For more detailed background information on the methods for assessment, a list of secondary references can be purchased at each National Standards Body.

Ergonomics — Manual handling —

Part 3: Repetitive movements and exertions of the upper limbs

1 Scope

This document specifies requirements and provides recommendations for repetitive work tasks involving repetitive movements and exertions of the upper extremity. It provides guidance on the identification and assessment of risk factors commonly associated with repetitive movements and exertions of the upper limbs, 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.

This document does not address the manual handling of objects while using lift-assistive devices such as exoskeletons and does not address the needs of pregnant women or persons with disabilities.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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, *Ergonomics principles in the design of work systems*

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

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

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

3 Terms and definitions

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

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

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

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

3.1
repetitive manual task
task executed by the upper limbs and characterized by repeated, relatively short work cycle times (up to several minutes) or a task during which the same, or very similar, working actions are repeated for more than 30 % of the task time

Note 1 to entry: Different tools can define different duration and other operative factors in assessing repetitive manual tasks.

Note 2 to entry: Manual handling consists of a variety of actions and can require the use of force to manoeuvre, manipulate, move or restrain an object.

3.2
key enter
type of hazard identification in the form of a specific question in the quick assessment tool for the purpose of deciding whether further risk evaluation is required

Note 1 to entry: For the purpose of this document, the possible hazard can lead to biomechanical overload of the upper limbs.

3.3
quick assessment
simple risk evaluation method used to quickly assess the presence of acceptable or critical conditions that can cause, aggravate, accelerate or exacerbate musculoskeletal injuries

3.4
work cycle
sequence of work actions that are repeated in the same or very similar way to complete a specified work task

Note 1 to entry: Work cycles are usually defined by industrial engineers when the same sequence of actions must be repeated on a regular basis in an organized workstation.

3.5
cycle time
total time it takes to complete a single work cycle, from the beginning of a work cycle to the same work cycle recurring, expressed in seconds or minutes

Note 1 to entry: Time units may be in seconds, minutes, etc.

Note 2 to entry: Cycle time begins from the moment one operator begins a work cycle to the moment that the same work cycle is repeated.

3.6
work action
elementary manual movements or exertions required to complete the operations within the cycle

EXAMPLE Holding, turning, pushing, cutting.

3.7
frequency of actions
number of actions per unit of time

3.8
force
intensity magnitude of a physical action to execute working actions

3.9
postures and movements
positions and movements of body segment(s) or joint(s) performed to execute the task

3.10
exertions
static or dynamic movements or efforts of body segments to exert force

3.11
recovery time
period, typically of rest, which allows restoration of musculoskeletal function or recovery from fatigue

3.12
risk factors
type of hazard, exposure to which could cause or aggravate work-related musculoskeletal disorders of the upper limb (UL WMSD)

Note 1 to entry: The main contributing risk factors to UL WMSD are: frequency of actions, exposure duration, postures and movement of body segments and forces exerted.

Note 2 to entry: Additional risk factors include, but are not limited to: vibration, local pressure, cold environment or cold surfaces and psychosocial factors.

3.13
work-related musculoskeletal disorder
WMSD
injuries and illnesses of the locomotor apparatus that can be caused by, aggravated, accelerated, or exacerbated by interaction with known or unknown risk factors in the workplace, and can impair work capacity

Note 1 to entry: The locomotor apparatus includes tendons, ligaments, joints, cartilage, nerves, vessels and supporting structures that are involved in locomotion.

3.14
hazard
potential source of harm

3.15
hazard identification
systematic identification of hazards

3.16
risk
combination of the probability of occurrence of harm and the severity of that harm

3.17
risk estimation
defining the likely severity of harm and the probability of its occurrence

3.18
risk analysis
combination of the specification of the limits of the machine, hazard identification and risk estimation

3.19
risk evaluation
procedure based on the risk analysis to determine whether further risk reduction is required

3.20
risk assessment
overall process comprising a risk analysis and a risk evaluation

4 Repetitive manual tasks

4.1 Avoiding repetitive manual tasks

Repetitive manual tasks should be avoided wherever possible. The employer should take appropriate organizational measures or use the appropriate means — in particular, mechanical equipment — in order to avoid repetitive manual tasks by workers. Where it cannot be avoided, the employer should take appropriate organizational measures, use the appropriate means or provide workers with the means to reduce the risk involved in repetitive manual tasks.

Avoiding or reducing repetitive manual tasks can be achieved through mechanization or automation, work enlargement, and properly designed job rotation within the framework of a participative ergonomics approach as described in ISO 6385.

In the case of repetitive movements and exertions of the upper limbs, many tasks can be modified through the use of robotics or automated production systems. See Annex E for details.

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 one or more repetitive handling tasks are present, the degree of risk must be assessed and, where appropriate, reduced. The recommended steps are outlined in Figure 1:

a) entering the risk assessment by key enter (see B.3 for information on the key enter), or performing a qualitative hazard identification;

b) assessing the risk using the quick assessment (see Annex B) and performing a risk evaluation using simple or detailed methods and finally, reducing the risk.

The procedure shown in Figure 1 should be used when carrying out a risk assessment of jobs involving repetitive movements and exertions of the upper limbs.

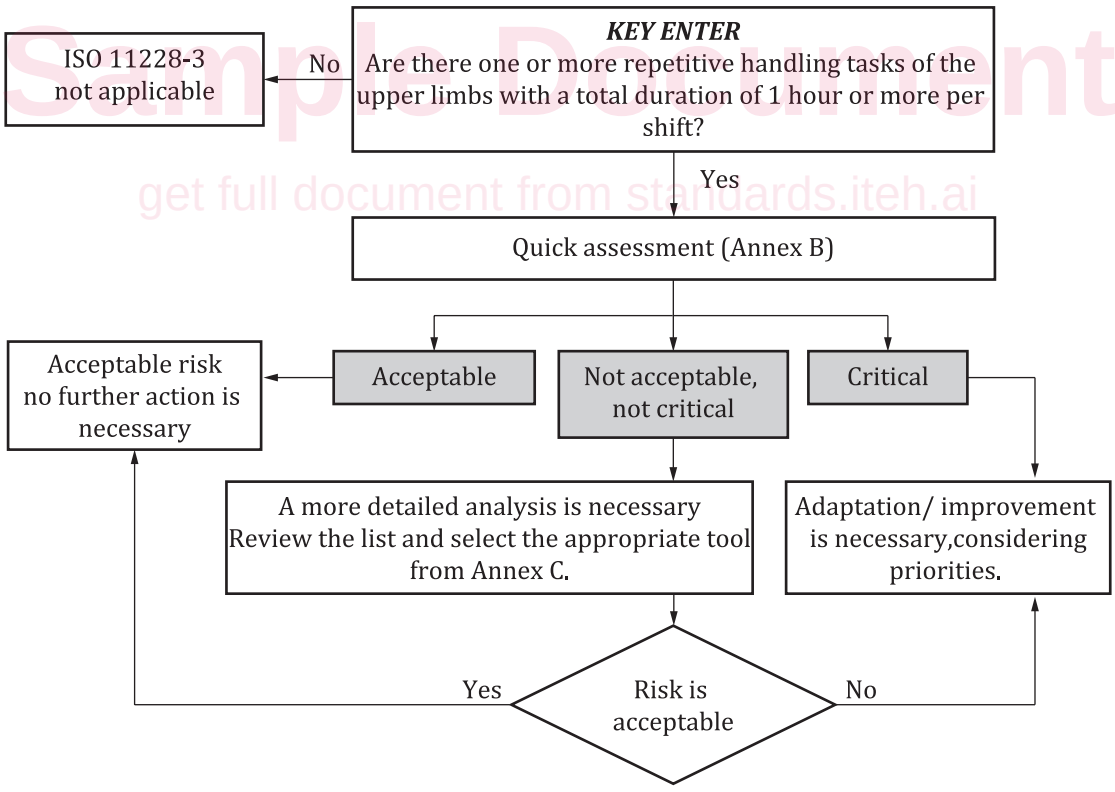

Figure 1 — Risk assessment procedure

The first step of the risk assessment procedure is to establish if a repetitive manual task is required to be further evaluated by means of a specific key enter.

To this end, the following specific key enter is adopted:

Are there one or more repetitive handling tasks of the upper limbs with a total duration of one[2] hour or more per shift?

If the answer is Yes then proceed with risk assessment; otherwise ignore this part of ISO 11228.

4.2.2 Quick assessment

A risk assessment (quick assessment) shall be performed when one (or more) repetitive task(s) involving the upper limbs is performed for one[2] hour or more in the shift or when a qualitative hazard identification identifies hazards which can expose individuals to a risk of injury (see A.1). It is intended to analyse a task in a given workstation.

The quick assessment is provided in Annex B (normative) and involves quickly evaluating the extent of the risk by asking simple qualitative and quantitative questions. The quick assessment identifies one of three possible risk conditions.

a) Acceptable: no further actions are required.

b) Critical: the work or process must be immediately redesigned based upon a risk assessment.

c) Not acceptable/not critical: a more detailed analysis is required, and a proper risk assessment must be carried out using more specific analytical tools for simple or detailed risk evaluation.

When conditions are found to be acceptable or critical, it is not always necessary to conduct a more in-depth analysis of the exposure level, especially in the case of critical conditions, since risk reduction should be considered at that point.

In Annex B, a specific part of Figure B.1 lists the conditions that must all be present simultaneously to classify a repetitive manual handling task as acceptable. A repetitive task which is assessed as being acceptable using the quick assessment, can also be considered to have been classified as acceptable using the detailed methods indicated in this document. Conversely, Figure B.1 also lists situations which represent a critical condition, if any one of them is present. If a task is deemed critical, immediate corrective action (i.e., risk reduction) is recommended. Further analyses can help to quantify the risk and guide corrective actions. More in-depth investigations should be undertaken to monitor the potential effectiveness of the corrective actions.

4.2.3 Detailed risk assessment

If the result of the quick assessment is neither acceptable nor critical, the next step (depending on the identified condition of the risk) is to perform a more detailed risk assessment. This is particularly helpful in industrial manufacturing sectors or in selected, non-industrial sectors [e.g., logistics (includes warehousing, supply chain, transportation), food preparation, industrial cleaning, etc.]. Other reasons for completing a more detailed risk assessment can be if the risk estimated is still uncertain or where tasks and jobs are being redesigned. A more detailed risk assessment is required, especially when jobs are composed of two or more repetitive tasks (multitask job). Annex D provides suggested approaches to use in these circumstances. A more detailed risk assessment will also allow a better determination of the corrective actions to be implemented. The methods listed in Annex C and Table C.1 have been identified as providing more detailed risk assessments. and have met to varying degrees, the validation criteria given in Annex A.

4.2.4 Risk assessment validation criteria

For the purposes of this document, the criteria for selection and the criteria for validation of risk assessment tools are presented in Annex A. Table C.2 presents which criteria each method meets.

For each method given in Table C.2, an indication of the criteria met is provided.

4.3 Risk reduction

A proper risk assessment is the basis for appropriate choices in risk reduction. Risk reduction can be achieved by making, improvements to one or most risk factors and should consider the following:

a) the avoidance and limitation of repetitive handling by design of the task, especially for long daily durations without proper recovery time or at high frequencies;

b) optimal design of the task, workplaces and work organization, also using existing International Standards and introducing adequate task variation;

c) proper design of the objects, tools and materials handled;

d) proper design of the work environment;

e) individual workers' capacities and level of skill for the specific task.

See Annex E for more detailed information about risk reduction options.

Annex A
(informative)

Risk assessment — Risk factors, general framework and criteria for the selection of tools

A.1 Background on work related risk factors

A.1.1 General

Many hazards or work-related risk factors are associated with an increased probability (risk) of UL WMSDs. Some of them have been defined as main contributing factors (repetition, force, awkward postures and movements, lack of recovery periods, duration) whilst for additional hazards there is some evidence that they can contribute to increasing the overall level of risk for UL WMSDs.

In Clause A.1, the main hazards (and risk factors) as identified in the quick assessment (see 4.2.2), as well as additional hazards to be assessed in a preliminary qualitative assessment are each briefly described. Clause A.2 provides guidance regarding the evaluation of the overall risk of contracting UL WMSDs.

A.1.2 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 either the frequency of actions and movements increases or the cycle time decreases, or both, the risk of injury increases. Extremely repetitive movements should be avoided within a task or job.

A.1.3 Posture and movement

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

A.1.4 Force

Forceful exertions can be harmful. Tasks should involve smooth force exertions, with the avoidance of sudden or jerky movements or any condition that can present an unanticipated significant increase in force to the worker. Handling precision (accurate picking and placement), and the type and nature of the grip can introduce additional muscular activation.

A.1.5 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. Refer to Annex E for more information on duration and recovery.

A.1.6 Object characteristics

Inappropriately designed objects can have characteristics that cause harm (e.g., contact forces, shape, dimensions, coupling, object temperature). Inappropriately placed handholds can lead to awkward hand or arm postures. Un-cushioned handholds and flat objects laying on a hard surface increase the difficulty of grasping the object and augment force requirements. The size and shape of the object being handled and the nature of the coupling between it and the operator's hands will determine the grip type and the force that the operator must exert.

A.1.7 Vibration and impact forces

Exposure to hand or 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.

A.1.8 Environmental conditions (climate, etc.)

Hot and, most of all, cold environments 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.

A.1.9 Work organization

Work organization (e.g., task duration, job duration, recovery time, shift patterns and the type of man-machine interaction) 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.

A.1.10 Psychosocial factors

Psychosocial factors include e.g., job complexity, job demands, and job content. The 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.

Important aspects of work design include the amount of control an individual has over their work, the level of work demands, the variety of tasks they are 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:

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

b) tasks require high levels of attention and concentration;

c) workers are unable to make full use of their skills;

d) workers have little or no involvement in decision making;

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

f) work is machine or system-paced;

g) work demands are perceived as excessive;

h) payment systems encourage working too quickly or without breaks;

i) work systems limit opportunities for social interaction;

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

A.1.11 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.

A.2 General framework for risk assessment

The general framework for risk assessment is covered by ISO 12100. In relation to WMSD and ergonomics, the general model of description and assessment of tasks as mentioned in EN 614-2 must be considered. When the need for manual repetitive tasks cannot be avoided in a given situation different measures have to be taken by employers. Designers have the opportunity in the beginning of their product or process design phase to diminish risks for workers and consumers and users.

According to Reference [15], four main risk factors should be analysed: repetitiveness, forces, awkward postures and movements, and lack of proper recovery periods. Such factors should be assessed as functions of time (mainly considering their respective durations). In addition to these factors additional risk factors, should be considered; these are mechanical factors (e.g. vibrations, localized mechanical compressions), environmental factors (e.g. exposure to cold) and organizational factors (e.g. pace determined by machinery). For most of them there is evidence of association with UL-WMSD.

In a risk assessment, each identified risk factor should be properly described and classified. This allows, on the one hand, identification of possible requirements and preliminary preventive interventions for each factor and, on the other hand, the consideration of all the factors together contributing to the overall exposure within a general and mutually integrated framework. From this viewpoint, numerical or categorical classifications of results can be useful to make the management of results easier, even if it is important to avoid the feeling of an excessive objectiveness of methods whose classification criteria can still be empirical.

A.3 Tool selection: basic and risk assessment validation criteria

A.3.1 Introduction

Clause A.3 describes the criteria for inclusion of risk assessment tools for this document and the assessment of its validity. This is done by applying inclusion criteria and assessment criteria for validity based on consensus of the experts involved. The user should note the tools were selected and classified according to the criteria based on the latest published information available at the time that this document was developed.

The basic criteria listed below in A.3.2 were used to select all of the tools for inclusion in this document. Tools meeting these criteria, for the purposes of this document, can be described as job assessment or design tools. Depending upon the tool, they may assess force, repetition, exposure, or other risk factors for a job.

The risk assessment classification criteria indicate which of the tools have shown a relationship between the output metric of the tool and illness or injury outcomes.

A.3.2 Basic inclusion criteria

The tool is relevant for the assessment, design or re-design or surveillance of new or existing jobs, tasks or workstations of repetitive manual tasks of the upper limbs in relation to UL-WMSDs in a general adult working population.

The tool considers, directly or indirectly, the relevant risk factors for UL-WMSDs, including force, posture, repetition, frequency, recovery periods, movements, duration or derivatives thereof (e.g., duty cycle).

The tool applies to two or more body parts of the upper limbs, i.e., fingers, hands, wrists, arms, elbows and shoulders.

The basis of the tool should to the largest extent be based on findings from peer-reviewed scientific literature.

The possible application of the tool is not restricted to a single type of work task or occupation.

The time to perform an assessment using the tool for a skilled user of a single task is acceptable in relation to task complexity (i.e., 4 hours or less).