BS ISO 11228-1:2021

BSI Standards Publication

Ergonomics - Manual handling

Part 1: Lifting, lowering and carrying

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National foreword

This British Standard is the UK implementation of ISO 11228-1:2021. It supersedes BS ISO 11228-1:2003, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PH/9/-/4, Ergonomics - Anthropometry and Biomechanics.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Published by BSI Standards Limited 2022

ISBN 978 0 539 03951 1

ICS 13.180

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2022.

Amendments/corrigenda issued since publication

Date	Text affected

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INTERNATIONAL STANDARD

ISO 11228-1

Second edition
2021-10

Ergonomics — Manual handling —

Part 1: Lifting, lowering and carrying

Ergonomie — Manutention manuelle —

Partie 1: Manutention verticale vers le haut, manutention verticale vers le bas et manutention horizontale

Reference number
ISO 11228-1:2021(E)

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Published in Switzerland

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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.

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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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 11228-1:2003), which has been technically revised.

The main changes to the previous edition are as follows:

— revision of the scope to include lowering;

— expansion of the risk estimation;

— expansion of Annexes A, B and C;

— addition of Annexes D to I to include updated information; expansions of the RNLE (revised NIOSH lifting equation); more examples for lifting and carrying; detailed information on the scientific background and recommended interpretation of the RNLE.

A list of all parts 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.

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Introduction

0.1 General

The ISO 11228 series establishes ergonomic recommendations for different dynamic manual handling tasks. It provides information for designers, employers, employees and others involved in work, job and product design. The ISO 11228 series provides information on the evaluation of static postures.

Disorders of the musculoskeletal system are common worldwide and one of the most frequent disorders in occupational health. The risk-assessment model in this document allows the estimation of the risk associated with a manual material handling task. It takes into consideration the hazards (unfavourable conditions) related to manual handling tasks and the time spent performing them. Unfavourable conditions can include factors such as the size and mass of the object being handled, working posture (e.g. twisting, bending, overreaching), quality of grip on items, and the frequency and duration of manual handling. Any of these can, alone or in combination, lead to a hazardous handling activity and increase the risk of musculoskeletal disorders. Accordingly, these factors are considered when determining a recommended safe limit of the mass of objects being handled.

The method of determination of safe recommended limits in this document is based on the integration of data derived from four major research approaches, namely the epidemiological, the biomechanical, the physiological and the psychophysical approach.

0.2 The ergonomic approach

0.2.1 General

Ergonomics pursues the specific goals of optimizing human well-being and overall system performance. This is achieved through contributions to the design and evaluation of tasks, jobs, production, environment and systems in order to make them compatible with the needs, abilities and limitations of people. It strives to design or to modify a work system to accommodate, as far as possible, a broad range of people in order to meet the needs of workers with various characteristics, including people with special requirements. Thus, the development of special solutions for individuals can be minimized. Achieving these goals also contributes to organizational sustainability and social responsibility.

Manual handling tasks in the workplace occur within the context of work systems. Interactions of humans with items, information, environment and other people must be taken into consideration when designing or modifying tasks and work areas. The ergonomics approach can be used to prevent manual-handling-related injuries from occurring by being used proactively in the design of processes, systems or work organization, in addition to when modifications to existing systems are being considered.

The ergonomic approach considers tasks in their entirety, taking into account a range of relevant factors including the nature of the task, the characteristics of objects handled, the working environment and the individuals performing the task. It considers environmental conditions (e.g. lighting, noise, temperature), as well as an individual's characteristics and experiences. An individual's characteristics include physical and mental capabilities, skills, work techniques, behaviour and their perception of the work environment and its social characteristics.

0.2.2 Organizational considerations

Work organization (e.g. task duration, job duration, recovery time, shift patterns) is a contributing factor in the prevention or development of musculoskeletal disorders. For example, recovery periods help to mitigate possible muscular fatigue and help to avoid the overuse 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.

Work organization includes appropriate training of workers, including how to safely perform tasks, how to recognize and respond to hazardous conditions in workplaces, and which procedures and communication channels to use to report and correct hazards. Regularly and properly maintained equipment and facilities contribute to safer work, including manual handling tasks. The selection of

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equipment and supplies which are appropriate for the workplace and task conditions helps to make work demands safer.

0.2.3 Psychological health and safety and the ergonomics approach

The ergonomics approach considers the cognitive or psychological demands on humans, as well as the psychosocial environment in which work takes place. Psychological response to work and workplace conditions (psychosocial factors) has an important influence on mental, physiological and musculoskeletal health. Psychosocial factors in the workplace include the design, organization and management of work, work content, job complexity, job demands (cognitive and physical), job content and the overall social environment (i.e. the context of work).

Undesirable psychosocial aspects of a job can include:

— little or no control over work methods or organization;

— high levels of attention and concentration required;

— poor use of skills;

— little or no involvement in decision-making;

— repetitive, monotonous tasks only;

— machine- or system-paced work;

— work demands perceived as excessive;

— payment systems which encourage working too quickly or without breaks;

— work systems that limit opportunities for social interaction;

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

— no training and skill enhancement encouraged or supported;

— poor co-worker or supervisory support.

Many of the effects of these factors on workers occur via stress-related processes, which can in turn have a direct effect on biochemical and physiological responses, which can increase the likelihood of experiencing musculoskeletal injury. Thus, for the prevention of musculoskeletal disorders (MSDs), these psychosocial stressors should be controlled in addition to the biomechanical risk factors. For more information on the effects of the psychosocial stressors on MSDs, see References [63] to [66]. For further information on psychological health and safety in the workplace, see References [1] to [42]

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Ergonomics — Manual handling —

Part 1:
Lifting, lowering and carrying

1 Scope

This document specifies recommended limits for manual lifting, lowering and carrying while taking into account the intensity, the frequency and the duration of the task. It is designed to provide requirements and recommendations on the assessment of several task variables, allowing the health risks for the working population to be evaluated.

This document applies to manual handling of objects with a mass of 3 kg or more and to moderate walking speed, i.e. 0,5 m/s to 1,0 m/s on a horizontal level surface.

This document is based on an 8 h working day, but also covers more prolonged working times, up to 12 h. It also addresses the analysis of combined lifting, lowering and carrying tasks in a shift during a day.

This document does not cover the holding of objects (without walking), the pushing or pulling of objects or manual handling while seated. The pushing and pulling of objects are covered in the other parts of the ISO 11228 series.

This document does not cover handling people or animals. (For further information on handling people, refer to ISO/TR 12296.)

This document does not address the manual lifting 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

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 https://www.iso.org/obp

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

3.1
manual handling
activity requiring the use of human force to lift, lower, carry or otherwise move or restrain an object

3.2
lifting
manually (i.e. without using mechanical assistance) moving an object from its initial position

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3.3
lowering
manually (i.e. without using mechanical assistance) moving an object from its initial position downwards

Note 1 to entry: Included in lifting.

3.4
carrying
manually (i.e. without using mechanical assistance) moving an object which is held with either one or two hands, or positioned on one or two shoulders or on the neck, by walking one metre or more

Note 1 to entry: Does not include the use of backpacks.

3.5
risk assessment
overall process comprising a risk analysis and risk evaluation

3.6
reference conditions
set of conditions (environmental, physical, biomechanical and task-design-related) which are considered to be the ideal conditions for safe manual handling to take place

Note 1 to entry: See 4.2.1, 4.2.3.2, A.4 and H.1 for detailed definitions of lifting and carrying conditions.

3.7
repetitive lifting
lifting an object more than once every 10 min

Note 1 to entry: Infrequent lifting at one lift every 10 min is defined in Reference [57], where a multiplier of 1,0 is applied for all duration scenarios at a frequency of 1 lift per 10 min.

3.8
mid-sagittal plane
vertical plane in the anterior-posterior direction that divides a person assuming a neutral body posture into equal left and right halves

Note 1 to entry: See Figure C.1

Note 2 to entry: A neutral body posture is an upright standing posture with the arms hanging freely by the side of the body.

3.9
plane of asymmetry
vertical plane passing through the midpoint of the line between the inner ankle bones and the centre of gravity of the load when the load is at its most extreme displacement from the neutral, mid-sagittal plane

3.10
angle of asymmetry
angle formed between the lines that result from the intersections of the mid-sagittal plane and the plane of asymmetry

Note 1 to entry: If the feet are repositioned during the lift or lower sequence, the referent planes shall be determined at the point in the action sequence where the largest degree of asymmetrical twist is encountered (see Figure C.1).

3.11
reference mass
mass considered appropriate for use with an identified user population during the application of the risk-assessment method described herein

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3.12
cumulative carried mass
product of the carried mass and the carrying frequency

Note 1 to entry: The cumulative mass for carrying is defined in kilograms per minute to represent the risk for short-term carrying, in kilograms per hour to represent the risk for medium-term carrying and in kilograms per 8 h to represent the risk for long-term carrying.

3.13
recovery time
time used for determining the work/recovery pattern, which is the period of light work activity Note 1 to entry: Light work activity can include monitoring activities, light assembly work using the upper limbs, work not involving lifting or lowering or carrying > 3 kg, and work not involving pushing or pulling.

4 Risk reduction for manual lifting or carrying tasks

4.1 General

Risk assessment is the overall process of risk identification, risk analysis and risk evaluation, the results of which are ultimately used in the effort to reduce risk. The goal in manual materials handling risk reduction is to take measures to improve the design of the task, the object and the working environment relative to the characteristics of the individuals performing the work.

In those cases where manual handling cannot be avoided, a risk assessment shall be completed to determine if, and to what extent, modifications are recommended. The risk assessment takes into account the mass of the object, the grip on the object, the position of the object relative to the position of the body, and the frequency and duration of a specific task.

The risk assessment is accomplished using the step-by-step approach illustrated in Figure 1 (step model). With each successive step, the evaluator analyses the interrelated aspects of the tasks.

If recommended limits are exceeded, the task shall be adapted in such a way that all questions in the step-by-step approach are satisfied.

Employees engaged in manual handling should be provided with adequate information and training on how to perform these tasks safely. The provision of this information and training does not, in isolation, ensure safe manual handling in all cases. However, it is an integral part of the ergonomics approach, and the risk of injury can be reduced by adopting safe ways of manual handling (see A.6).

4.2 Risk assessment (step model)

4.2.1 Using the step model

The step model illustrated in Figure 1 describes the steps involved in beginning, and working through, a risk assessment of manual handling tasks, including lifting and carrying. Initially, the mass of the object being handled is determined; if it is more than 3 kg, the risk assessment is continued. The task is further analysed to determine if the mass exceeds recommended limits for handling (step 1).

The user shall make modifications where limits are exceeded. In those tasks where lifting and carrying is repetitive, the assessment is continued using the quick assessment procedure (step 2). Based on the outcome of step 2, the task will possibly:

— require immediate modifications for safety (see Annex A for further information);

— be determined to be acceptable; or

— need further, more detailed, risk evaluation (step 3).

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Step 3 is also used for evaluating tasks which take place using non-ideal postures.

The reference condition of manual lifting and lowering posture for manual handling is:

— an upright symmetrical trunk posture (no twisting or lateral bending);

— sagittal trunk inclination of no more than 15° (the minimum inclination observable with the human eye) from the vertical to accommodate the natural posture of the back;

— the horizontal distance between the object being handled and the centre of mass of the worker as close as possible;

— the grip height lying within knuckle and elbow height for lifting or between knuckle and shoulder height for carrying (for anthropometric measurements see ISO 7250-3).

Steps 4 and 5 assist with the further evaluation of the task for cumulative mass for lifting and carrying.

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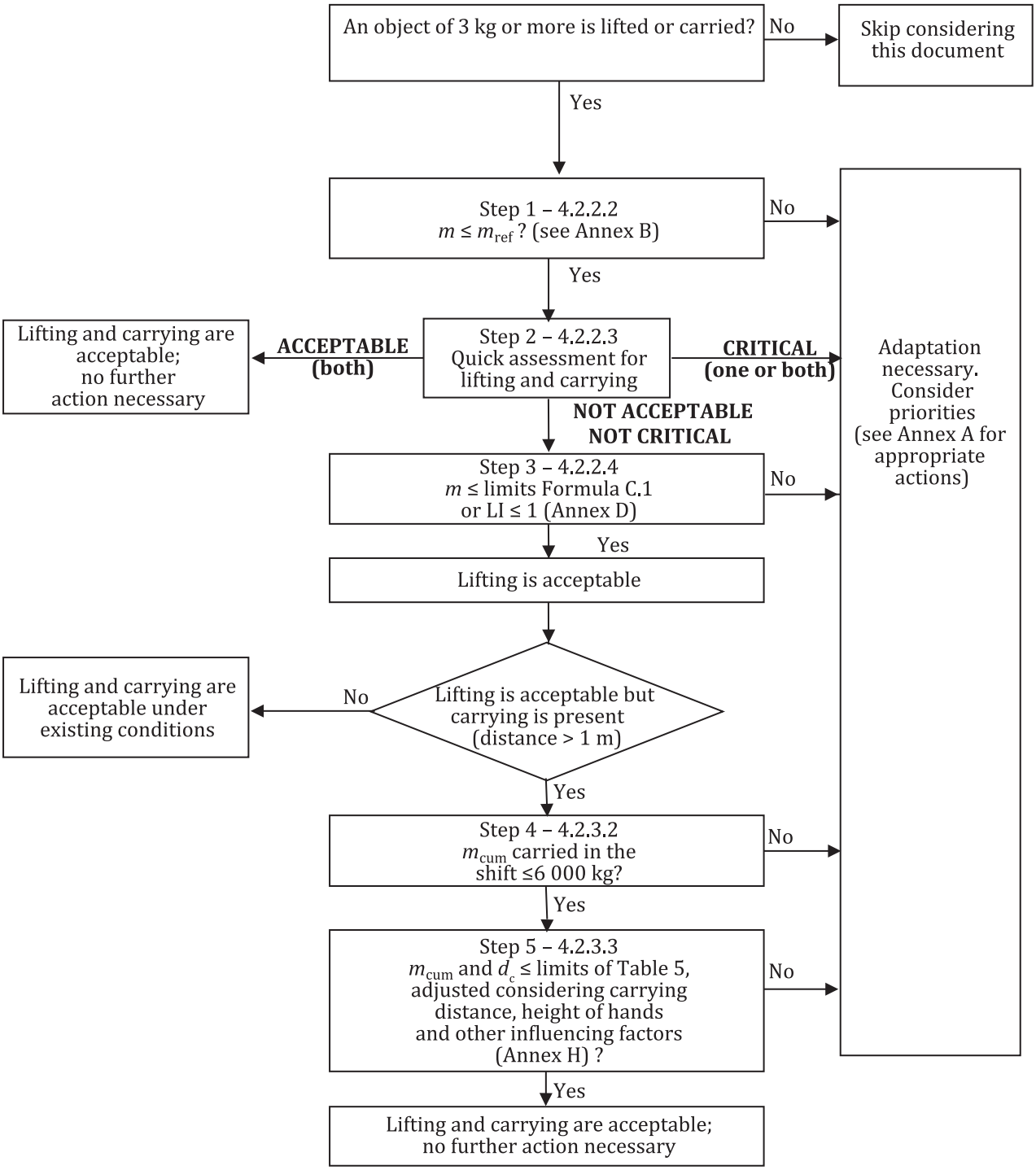

Key

m	mass of object to be lifted
M_{ref}	reference mass for identified user population group
M_{cum}	cumulative mass (carried)
d_c	duration (of carrying)
LI	lifting index

Figure 1 — Step model

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4.2.2 Recommended limit for manual lifting, lowering and carrying

4.2.2.1 Weight of the object

Whenever an object of 3 kg or more is lifted or carried, a risk assessment shall be performed, beginning with the initial screening, step 1. Note that throughout the text whenever the term “lifting” is used the act of “lowering” is implied.

4.2.2.2 (Step 1) Initial screening

An initial screening of non-repetitive lifting and carrying (performed with reference conditions in place) requires the determination of the object's mass (step 1). The recommended limit for the mass of the object, referred to as the reference mass, m_{ref}, and based on population characteristics, is presented in Annex B. For general guidance for designers and additional information related to step 1, see Annex A.

4.2.2.3 (Step 2) Quick assessment of repetitive lifting and carrying

Screening of repetitive lifting and carrying tasks of objects of 3 kg or more is performed using the quick assessment procedure.

The quick assessment procedure aims to identify, without the need for calculation, the presence of two opposite exposure conditions:

— acceptable condition, where unacceptable risk has not been identified;

— critical condition, where unacceptable risk has been identified.

When either of these conditions is met, it is not necessary to perform a more detailed evaluation of the exposure level. Instead, either no further modifications need to be considered (acceptable risk, see Table 1 and Table 2) or modifications should be made immediately (see Annex A for guidance) due to the presence of a critical condition (see Table 3). In either case, Table 4 shall also be referenced to identify the presence of any unfavourable working environment or object circumstances which can further increase the risk of the task (additional factors).

When neither of the two extreme conditions is met, it is necessary to conduct further risk evaluation by methods presented in step 3 (see 4.2.2.4).

Table 1 and Table 2 are used for establishing the acceptable risk condition. If all of the listed conditions are present (yes for each condition), the examined task is acceptable and it is not necessary to continue with a risk evaluation. If any answers are no, then Table 3 shall be used to confirm if there are critical conditions. If any of these conditions is met (a yes response), the task shall not be performed before modifications are made.

In either case, Table 4 shall also be systematically used to identify the presence of any unfavourable working environment or object characteristics which will potentially further increase the risk of the task. These factors can be related to the work environment or to the object characteristics, and they shall be addressed to help reduce risk.

Table 1 — Lifting and lowering — Quick assessment — Acceptable condition

Lifting and lowering			
3 kg to 5 kg	Asymmetry (e.g. body rotation, trunk twisting) is absent	No	Yes
	Load is maintained close to the body (e.g. where space between the body and the item is minimized)	No	Yes
	Load vertical displacement is between hips and shoulders	No	Yes
	Maximum frequency: less than five lifts per minute	No	Yes

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Table 1 *(continued)*

> 5 kg to 10 kg	Asymmetry (e.g. body rotation, trunk twisting) is absent	No	Yes
	Load is maintained close to the body (e.g. where space between the body and the item is minimized)	No	Yes
	Load vertical displacement is between hips and shoulder	No	Yes
	Maximum frequency: less than one lift per minute	No	Yes
More than 10 kg	Loads of more than 10 kg are absent	No	Yes
If all of the questions are answered yes, then the examined lifting task is acceptable and it is not necessary to continue the risk evaluation, except to review Table 4 for other factors to be considered. If at least one of the questions is answered no, the evaluation shall continue (see Table 3 and Table 4).			

Table 2 — Carrying — Quick assessment — Acceptable condition

Carrying				
Calculate the cumulative mass (total kg carried during the given durations for the given distance below). Is the carried cumulative mass less than or equal to recommended cumulative masses values considering distances (±5 m) and duration (1 min; 1 h; 4 h; 8 h)?				
Duration	**Distance 1 m to ≤ 5 m per action**	**Distance > 5 m to 10 m per action**		
6 h to 8 h	4 800 kg	3 600 kg	No	Yes
4 h	4 000 kg	3 000 kg	No	Yes
1 h	2 000 kg	1 500 kg	No	Yes
1 min	60 kg	45 kg	No	Yes
	Acceptable conditions for carrying: carry with two hands over a maximum distance of 10 m, picking up and setting down the object at height, where the pick-up and set-down height ranges between 0,75 m and 1,10 m, with the full cycle including returning back to the start point empty-handed over the same distance. The carrying exercise is performed in a comfortable indoor environment, on a hard, flat, non-slip floor, without any obstacles in the way, and in a workspace allowing free body movement and posture. No constraints are placed on the subject. Awkward postures during the carrying are not present.		No	Yes
If all of the questions are answered yes, then the examined carrying task is acceptable and it is not necessary to continue the risk evaluation except to review Table 4 for other factors to be considered. If at least one of the questions is answered no, the evaluation shall continue (see Table 3 and Table 4).				

Table 3 — Lifting or carrying— Quick Assessment — Critical condition

Critical condition for lifting: task layout and frequency conditions exceeding the maximum suggested			
Vertical location	The hand location at the beginning and end of the lift is higher than 175 cm or lower than the surface at the feet	No	Yes
Vertical displacement	The vertical distance between the origin and the destination of the lifted object is more than 175 cm	No	Yes
Horizontal distance	The horizontal distance between the body and load is greater than full arm reach (>63 cm)	No	Yes
Asymmetry	Extreme body twisting (to either side by more than 45°) without moving the feet	No	Yes

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Table 3 *(continued)*

Frequency of lifts[56]	More than 15 lifts per min of short duration (manual handling lasting no more than 60 min consecutively in the shift, followed by at least 60 min of recovery time)	No	Yes
	More than 12 lifts per minute of medium duration (manual handling lasting no more than 120 min consecutively in the shift, followed by at least 30 min of recovery time	No	Yes
	More than 10 lifts per minute of long duration (manual handling lasting more than 120 min consecutively in the shift)	No	Yes
Critical condition for lifting or carrying: presence of loads exceeding the following limits (see Table B.2 for further information)			
Females (20 to 45 years)	20 kg	No	Yes
Females (<20 or > 45 years)	15 kg	No	Yes
Males (20 to 45 years)	25 kg	No	Yes
Males (<20 or > 45 years)	20 kg	No	Yes
Critical condition for carrying: presence of cumulative carried mass greater than those indicated also with acceptable conditions for carrying			
Carrying distance (per action) 1 m to 5 m over a 6 h to 8 h period?	6 000 kg in 6 h to 8 h	No	Yes
Carrying distance (per action) 5 m to 10 m over a 6 h to 8 h period?	3 600 kg in 6 h to 8 h	No	Yes
Carrying distance (per action) 10 m to 20 m over a 6 h to 8 h period?	1 200 kg in 6 h to 8 h	No	Yes
Carrying distance (per action) more than 20 m	Carrying distance is usually more than 20 m	No	Yes
If at least one of the conditions has a yes response, then consider risk as high and a critical condition is present. Proceed with task redesign and continue to Table 4 to identify additional factors to be considered, and then continue to Annex A for identifying urgent corrective actions.			

Table 4 — Lifting and carrying — Additional factors to be considered

Is the working environment unfavourable for lifting and carrying?		
Presence of extreme (low or high) thermal stress (e.g. temperature, humidity, air movement)	No	Yes
Presence of slippery, uneven, unstable floor	No	Yes
Presence of insufficient space for lifting and carrying	No	Yes
Are there unfavourable object characteristics for lifting and carrying?		
The size of the object reduces the worker's view and hinders movement	No	Yes
The load centre of gravity is not stable (e.g. liquids, items moving around inside of object)	No	Yes
The object shape or configuration presents sharp edges, surfaces or protrusions	No	Yes
The contact surfaces are too cold or too hot	No	Yes
Improper handholds or coupling		
Does the lifting or carrying task(s) last more than 8 h a day?	No	Yes
If at least one of the questions is answered yes, the specified condition shall be addressed and the risks minimized.		

4.2.2.4 (Step 3) Recommended limits for mass, frequency and object position

When none of the two conditions identified in step 2 is met, it is necessary to conduct a risk evaluation (step 3) to determine the recommended limits for the task.

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To determine the recommended mass limit (RML; Annex C) while taking into account working posture, object position and lifting frequency and duration, use Formulae (C.1) to (C.5). These formulae take into account task variables (characteristics of the task). A lifting index (LI; Annex D) is also calculated for further risk exposure information. The analyst first checks if the RML for lifting is exceeded and, if so, checks if the LI exceeds appropriate limits (Table D.1). If both are exceeded then the task shall be adapted by changing the mass, the lifting frequency, the lifting duration or the object position. Table D.1 provides interpretation of the results and consequent measures. Annex E reports a simplified model for RML and LI calculation. Annex F reports procedures for analysing multiple manual lifting tasks (composite, variable and sequential lifting tasks), Annex G reports examples of analysis of simple and variable lifting tasks. Annex I reports a brief review of the relevant literature regarding the interpretation of the lifting index and is the basis for Table D.1.

4.2.3 Cumulative mass of carrying

4.2.3.1 General

For an object to be carried once for a modest distance (one or two steps or less than 1 m), only the limits for lifting shall be applied as per steps 1, 2 and 3.

For screening the cumulative mass per day for carrying (step 4), the recommended limits in 4.2.2.2 and 4.2.2.3 shall initially be used. Once this has been completed, limits recommended in 4.2.3.2 for a reference carrying condition shall be applied.

For determining the cumulative mass of carrying related to distance, time patterns and other influencing factors, refer to 4.2.3.3 (step 5).

4.2.3.2 (Step 4) Recommended limit for cumulative mass per day

The cumulative mass in a certain period is calculated as a product of mass and frequency of carrying. These two values are limited in steps 1, 2 and 3. In this way, the reference mass cannot exceed a maximum of 25 kg (i.e. mass shall decrease from 25 kg as the frequency increases) and the frequency of carrying should never exceed a maximum of 15 times per minute (i.e. frequency shall decrease from 15 times per minute when the mass being carried is increased).

Reference conditions are described as carrying an object with two hands over a distance of 2 m, picking up and setting down the object at height, where the pick-up and set-down height ranges between 0,75 m and 1,10 m, with the full cycle including returning back to the start point empty-handed over the same distance. The carrying exercise is performed in a comfortable indoor environment, on a hard, flat, non-slip floor, without any obstacles in the way, and in a workspace allowing free body movement and posture. No constraints are placed on the subject.

Reference conditions regarding distance, way back and environmental and workspace conditions shall be adopted for carrying on shoulder(s) or neck. The height of picking up and object release is about shoulder height (125 cm to 155 cm). Alternatively, these actions are performed by a co-worker, for example a co-worker placing a load on the shoulder of another worker who then carries it.

With reference conditions in place, the recommended limit for cumulative mass of carrying is 6 000 kg per 8 h.

4.2.3.3 (Step 5) Recommended limit for cumulative mass of carrying related to time patterns, distance and other influencing factors

For carrying with reference conditions in place, the recommended limits for cumulative mass considering the different duration scenarios for carrying are presented in Table 5[11],[28],[36],[38].

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Table 5 — Recommended limits in the carrying reference conditions for cumulative mass related to carrying duration during the shift (for general working population)

Carrying distance > 1 m and ≤ 2 m	kg per min	kg per 1 h	kg per 2 h	kg per 3 h	kg per 4 h	kg per 5 h	kg per 6 h to 8 h
Recommended limits for cumulative mass for manual carrying	75	2 500	3 400	4 200	5 000	5 600	6 000

To evaluate the cumulative mass carried, the duration of the carrying tasks in a period of time shall be considered. Table 5 provides recommended limit values of cumulative mass based on time devoted to manual handling (including loads that are both lifted and then carried) in the shift and represents the product of handling different possible masses at different frequencies. For example, the limit of a cumulative mass of 75 kg for a single minute can be achieved by a mass of 12,5 kg × 6 times/min.

When carrying conditions differ from the reference condition, recommended limits in Table 5 shall be adjusted by applying correction ratios (multipliers) into the calculation. The multipliers represent true conditions of the task as observed (e.g. carrying distance, height of pick up or set down and other relevant conditions). Multipliers are provided in Annex H.

4.3 Risk reduction

Risk reduction can be achieved by minimizing or excluding hazards resulting from the task, the object, the workplace, the work organization or the environmental conditions; examples are given in A.3 to A.5.

4.4 Additional considerations

Health surveillance should be provided by the employer with respect to work-related risks.

Health surveillance is preventive in nature and should ensure, before starting the job and then on an ongoing basis, that the relationship between the individual's health status and his or her working conditions is satisfactory.

More specifically, health surveillance aims to:

— identify any negative health conditions at an early enough stage to prevent them from worsening;

— identify people who require greater protective measures in addition to those adopted for other workers;

— contribute, based on appropriate feedback, towards enhancing the accuracy of collective and individual risk assessments;

— monitor preventive measures to ensure their continuing adequacy;

— collect exposure or injury data in order to compare different groups of workers and different scenarios;

— collect data on absences caused by specific disorders so as to estimate the cost of non-prevention.

Health surveillance related to manual handling should be focused both on the spine and on other parts of the body, especially considering the involvement of the shoulders and the upper limbs. Personal mental health (e.g. depression) and work-related psychosocial factors (e.g. job satisfaction, supervisory support) should also be considered in health surveillance for comprehensive prevention of musculoskeletal injuries or disorders in the workplace.

Technical or mechanical means of reducing risk should be provided and complemented with information and appropriate training on how to use manual materials handling aids appropriately (see A.6). All workers should be provided with information regarding work-related hazards, their risks and how to safely minimize exposure.

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Annex A
(informative)

Ergonomics approach to the design of lifting and carrying tasks

A.1 General

Scientific knowledge stresses the importance of an ergonomic approach in removing or reducing the risk of manual-handling-related injury. Ergonomics focuses on the design of work and its accommodation of human needs and physical and mental capabilities.

In seeking to avoid injury from manual handling, it is pertinent to ask whether manual handling which is hazardous or presents a risk of injury can be eliminated altogether. Those designing new systems of work, or installing new plants, should consider introducing an integrated handling system that, where appropriate, fully utilizes powered or mechanical handling rather than a manual system. It should, however, be remembered that the introduction of automation or mechanization can create different risks. Mechanization, for example, by the introduction of a lift truck, hoist, trolley, sack truck, chute or pallet inverter, needs to be well maintained and a defect-reporting and -correction system should be implemented. All handling aids should be compatible with the rest of the work system, effective, appropriately designed and easily operated. Training concerning handling aids should cover their appropriate usage, and knowledge of safe storage and procedures to be used in the event of breakdown. Training should also include techniques on appropriate body positioning when using the equipment. Operating instructions and safety concerns should be clearly placed on the equipment.

If manual handling cannot be avoided, technical aids should be available. Handling devices such as hand-held straps, slide mats, hooks or suction pads can simplify the problem of handling an object.

A.2 Design of the work: task, workplace and work organization

A.2.1 Task

Stress levels on the back increase substantially as the distance between the object and the body increases. Therefore, in the planning of tasks it is relevant to avoid long reaching, twisting, stooping, bending and awkward movements or postures. Being able to gain secure and close footing to the object is central to designing for good posture. Often obstacles that prevent this can be avoided; a common example is long reaches across to an object from the far side of a pallet, which can be resolved by the use of pallet-rotating equipment. Another example where awkward postures are seen and alternatives are achievable is retrieving objects from the rear of deep shelves or racks less stressfully by installing rollers. The best height for storage is between the mid-thigh and chest height of the workers involved, with lighter items being stored above or below this region.

A good grip is essential for avoiding accidents with respect to handling and is often determined by the characteristics of the object. This means that the object should normally be equipped with suitable handles, cut-outs or finger slots. Objects with large dimensions should have two handles. The handles should be of sufficient dimensions and should be placed so that the centre of gravity falls at the midpoint of the line between the two handles.

A.2.2 Workplace

The work area should be designed to minimize the amount of manual effort, thus reducing the need for twisting, bending, reaching and carrying. The distance that both typical and infrequently handled objects have to be moved should be taken into account, together with the heights between which objects can be transferred.

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Gangways and other working areas should be large enough to allow adequate room to manoeuvre. Sufficient space is a prerequisite for efficiently carrying out work in appropriate working postures. Also, the use of suitable mechanical devices often requires more room than manual lifting.

A person carrying an object should have a clear view ahead, unobstructed by the object. Lifting and carrying on stairways and on ladders should be avoided.

It is important to provide adequate space around the object and in the gangways, as well as sufficient headroom to avoid stooping postures while handling an object.

Floor or ground surfaces should be level, well maintained, not slippery and clear of obstacles to avoid potential slipping or tripping accidents. The presence of steps, steep slopes and ladders can increase the risk of injury by adding to the complexity of movement when handling objects. Debris and materials (e.g. used wrapping materials) can also pose tripping and slipping hazards and should be cleared.

A.2.3 Work organization

The amount of work undertaken in fixed postures is also an important consideration. Recommendations on this issue are made in ISO 11226. The frequency of handling an object can influence the risk of injury. Particular care is necessary where the handler cannot control or vary the rate of work. Consideration should, therefore, be given to whether there are adequate opportunities for rest (i.e. momentary pauses or breaks from work) or recovery (i.e. changing to another task which uses a different set of muscles). Job enrichment, job enlargement and job rotation have a key role to play in countering potential fatigue and maintaining levels of safe production output, though this issue is complicated by a large variation in individual susceptibility to fatigue.

Handling by two or more people can render possible an operation that is beyond the capability of one person or reduce the risk of injury to a single person. The object that a team can handle safely is less than the sum of the masses that the team members can cope with individually. Additional difficulties can arise if team members impede each other's vision or movement and if the object offers insufficient suitable handholds.

When engineering or other controls do not provide adequate protection, personal protective equipment should be used only as a last resort. Advance planning is especially important in dealing with hazardous materials or other potentially dangerous loads. It can be necessary to give special attention to handling methods and provision made for dealing with an emergency, including emergency equipment and clear instructions. Where the wearing of personal protective equipment cannot be avoided, its implications for the risk of manual handling injury should be taken into consideration. For example, gloves can impair manual dexterity; other clothing, such as uniforms, can inhibit free movement during manual handling. Personal protective equipment, such as gloves, aprons, overalls, gaiters or safety footwear, should be well fitting. Footwear should provide adequate support, be stable, have a non-slip base, have anti-fatigue qualities and provide proper protection.

A.3 Design of the object

The object to be handled can constitute a hazard because of its mass or resistance to movement, size, shape, rigidity or the absence of handgrips. In determining if a load represents a risk, proper account shall also be made of the circumstances in which the load is handled. For example, postural recommendations, frequency and duration of handling, workplace design and aspects of work organization, such as incentive schemes and piecework, should be considered.

The shape of an object affects the way in which it can be held. In general, if any dimension of the object exceeds about shoulder width or if it is not a compact object, its handling is likely to pose an increased risk of injury. This is especially the case where this size is exceeded in more than one dimension. The risk is further increased if the object does not possess convenient handholds.

If the centre of gravity of the object is not positioned centrally within the object, an inappropriate handling style can result. Sometimes, as with a sealed and unmarked carton, an offset centre of gravity

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is not visibly apparent. In these circumstances, the risk of injury is increased since the handler can unwittingly hold the object with its centre of gravity further from the body than is necessary.

Consideration should be given to using pack filling for objects liable to shift when being handled. Equally, greater care is needed when handling objects which are inherently difficult to grasp. In addition, there can be physical or chemical hazards which should also be indicated, for example the object can have sharp edges, be too hot or too cold to touch, or contain materials or substances which can be hazardous if spilled.

A.4 Design of the working environment

General environmental conditions, including illumination, noise and climate, should be within tolerable levels. It is recommended to apply ISO 7730 for thermal comfort requirements. Extra care should be taken if work has to be done at extremes of temperature. For example, high temperatures or humidity can cause rapid fatigue; work at low temperatures can require gloves to prevent numbness of the hands but can also lead to a loss of manual dexterity. Air circulation (indoor and outdoor) is also a factor that influences body temperature. Rapid air circulation cools the body and should be avoided as far as possible. In very hot climates or working conditions, rapid air circulation can be desirable. It is important that there should be sufficient light to enable the workers to see clearly what they are doing and also prevent poor working postures. High noise levels can lead to reduced vigilance. For outdoor work, account needs to be taken of the effects of changing weather conditions. Extra care is needed in strong winds or where gusts are likely, for example around buildings. Assistance or mechanical devices can be especially necessary when carrying large sheets or bulky objects in such conditions.

Reference conditions for manual materials handling include the following criteria:

— moderate ambient thermal environment;

— two-handed operation only;

— unrestricted standing posture;

— handling by one person only;

— smooth lifting;

— good coupling between the hands and the objects handled;

— good coupling between the feet and the floor;

— manual handling activities, other than lifting, are minimal;

— the objects to be lifted are not cold, hot or contaminated;

— vertical displacement of the load is less than or equal to 0,25 m and does not occur below knuckle or above shoulder height;

— the trunk is upright and not rotated;

— the load is kept close to the body;

— the load is carried less than 20 m.

A.5 Individual considerations

Manual handling injuries are associated with the nature of the operations, the way they are organized and variations among individual physical capabilities. It is a fact that the ability to lift and carry does vary among individuals.

In general, the lifting strength for women as a group is up to two-thirds that of men. However, the range of strength and ability among individuals is large and means that some women can deal safely

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with heavier objects than some men. In those cases where neither manual lifting nor carrying can be eliminated in the short term, special demands on the physical capability of the worker, regardless of gender, can be necessary.

Young and old workers can have particular needs. For example, younger people are likely to be less skilled. Older people are more susceptible to sudden strains due to a decreasing elasticity of parts of the musculoskeletal system. With age, there is a reduction in physical capability, which becomes more significant after the age of 45.

There is good evidence that an individual with a medical history of a back disorder is more susceptible to recurrent episodes of back pain. Workers with a history of back disorders should be assessed and monitored. Eventually, it can become necessary to make modifications to prevent further recurrence of back problems.

Workers who suffer from spinal pathologies (Table A.1), both malformative and degenerative in nature, both work-related and not work-related, that are influenced by biomechanical overload, should be exposed to a lower level of manual handling than the general healthy population[18],[24],[25],[26],[62].

To accommodate these workers in workplaces, the reference masses given in Table B.1 which are protective for almost 99 % of the population (10 kg or 15 kg) can be used for calculating the appropriate RML and LI. This results in lifting conditions where the RML is not exceeded or the LI is less than or equal to 1.

In particular, also considering the type and severity of spinal pathologies reported in Table A.1:

— for males with pathologies of medium severity, the RML and the LI are calculated using 15 kg as the reference mass;

— for females with medium to severe pathologies and males with severe pathologies, the RML and the LI are calculated using a reference mass of 10 kg;

Loads shall only be lifted vertically between the height of the knees and the shoulders, and the frequency and duration of time assigned to lifting in the shift shall be limited.

It is important to recognize that these provisions for defining “acceptable” weights for lifting, by subjects with spinal pathologies, be used with caution and using a practical approach, possibly involving physician monitoring where appropriate. They are based on research-derived conclusions. However, the effectiveness of individual measures to restrict exposure to risk on a case-by-case basis is required in the field (through close follow-up of individual health and working conditions).

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Table A.1 — Classification of moderate and severe spinal pathologies[19],[25],[61],[62]

"Moderate" pathologies
Significant scoliosis (20° Cobb with torsion 2; 30° Cobb with torsion 1+)
Baastrup syndrome
Scheuermann disease (with structured curving of the spine)
Klippel-Feil syndrome (even with only one synostosis)
Cervical and/or dorsal hernia
Grade 1 spondylolisthesis, spondylolysis
Sacralization (fully or partially fused or articulated)
Spinal canal stenosis without neurological signs
Severe lumbar disk disease (spondylodiscopathy)
Inverted lumbar lordosis with disc disease
Slight vertebral instability (10 % or 15 % in the presence of certain pathologies)
Lumbar protrusion with dural sac impingement
Surgically reduced lumbar disc herniation without adverse outcomes
"Severe" pathologies
Herniated disc
Surgically reduced lumbar disc herniation with adverse outcomes
Spinal canal stenosis with root or dural sac impairment
Grade 2 spondylolisthesis (>25 % slippage)
Klippel-Feil syndrome (cervical or dorsal synostosis with vertebral instability)
Significant scoliosis (at least COBB 30° and torsion 2)
Scheuermann disease with approximately 40° structured curving of the spine and lumbar disc disease
Severe vertebral instability (i.e. spondylolisthesis, Klippel-Feil syndrome, disc disease, fractures with vertebral slippage of 25 %)
Degenerative or newly formed lesions of the bones and joints (e.g. severe osteoporosis, vertebral angioma)
Systemic disease with severe spinal impairment

A.6 Information and training

As a complement to a safe system of work, effective training has an important part to play in preventing and reducing manual handling injuries. To be effective, training shall be work-related and reinforced at regular intervals.

Elements within a training program can include:

— how to recognize potentially hazardous handling operations, how to advocate improvements, how to deal with unfamiliar handling operations;

— the appropriate use of handling aids and personal protective equipment;

— ergonomic principles of task, object and working environment design;

— safe handling techniques, including practical training elements.

Additional elements to be included within a training program are anatomy and physiology of the back, body mechanics and proper lifting techniques, and exercises to stretch and strengthen the back muscles.

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