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Ergonomics — Manual handling —

Part 1:
Lifting, lowering and carrying

ICS: 13.180

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CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
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Foreword

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ISO 11228-1 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, lowering and carrying*

— *Part 2: Pushing and pulling*

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

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Introduction

O.1 General

The three parts of ISO 11228 establish ergonomic recommendations for different dynamic manual handling tasks. (ISO 11226 provides information on the evaluation of static postures). The standards provide information for designers, employers, employees and others involved in work, job and product design.

This part of ISO 11228 (Part 1), provides a step-by-step approach to assessing the risks of manual lifting, lowering and carrying; at each step, recommended limits are proposed. Further practical guidance and examples are provided in Annexes.

Disorders of the musculoskeletal system are common worldwide and one of the most frequent disorders in occupational health. The risk-assessment model in this Standard 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 (such as twisting, bending, over reaching), 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 Standard is based on the integration of data derived from four major research approaches, namely the epidemiological, the biomechanical, the physiological and the psychophysical approach.

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0.2 The Ergonomics Approach

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 ergonomics 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. Individual characteristics include physical and mental capabilities, skills, work techniques, behaviour and their perception of the work environment and its social characteristics.

0.2.1 Organizational Considerations

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

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

0.2.2 Psychological Health and Safety and the Ergonomic Approach

The ergonomic 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 could 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;

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– work demands perceived as excessive;

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– 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 (resources, remuneration, self-esteem, status, etc.);

- no training and skill enhancement encouraged or supported.

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 in addition to the physical demands addressed in this Standard series, the overall system, including work organization, work environment characteristics as well as cognitive and physical demands are included in the ergonomic approach. For further information on psychological health and safety in the workplace, see CAN/CSA Z1003-13/BNQ 9700-803/2013 or Mental Health Commission of Canada. *Psychological health and safety — An action guide for employers* (Santé et sécurité psychologiques — Guide de l'employeur), 2012.

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Ergonomics — Manual handling —

Part 1:
Lifting, lowering and carrying

1 Scope

This part of ISO 11228 specifies recommended limits for manual lifting, lowering and carrying while taking into account, the intensity, the frequency and the duration of the task. This part of ISO 11228 is designed to provide guidance on the assessment of several task variables, allowing the health risks for the working population to be evaluated.

This part of ISO 11228 applies to manual handling of objects with a mass of 3 kg or more.

This part of ISO 11228 applies to moderate walking speed, i.e. 0,5 m/s to 1,0 m/s on a horizontal level surface.

This part of ISO 11228 is based on an 8 h working day, but also addresses more prolonged work times, up to 12 hours. It also addresses the analysis of combined lifting, lowering and carrying tasks in a shift during a day.

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This part of ISO 11228 does not include holding of objects (without walking), pushing or pulling of objects or, manual handling while seated. Pushing and pulling of objects will be included in other parts of ISO 11228.

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This part of ISO 11228 does not include handling people or animals. (For further information on handling people, refer to ISO TR 12296)

NOTE This part of ISO 11228 also 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 and disabled persons.

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

ISO/IEC Guide 73:2009, *Risk management - Vocabulary*

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3 Terms and definitions

For the purposes of this document, the following definitions apply.

3.1
manual handling
any 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 upwards or downwards (includes lowering)

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

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

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

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3.6
ideal posture for manual handling
upright symmetrical trunk posture (no twisting or lateral bending), sagittal trunk inclination of no more than 15° from the vertical to accommodate the natural posture of the back, keeping the horizontal distance between the object being handled and the centre of mass of the worker as close as possible, and keeping the grip height within knuckle and elbow height for lifting or shoulder height in case of carrying

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NOTE 1 to entry 15° is the minimum inclination that can be distinguished from human visual observation.

NOTE 2 to entry For anthropometric measurements see ISO 7250 part 3.

3.7
reference conditions for manual handling
conditions include the ideal posture for manual handling, a firm power grip on the object in neutral wrist posture, and favourable environmental (not too hot or cold, not slippery)

NOTE 1 to entry See A.4 for a more detailed list of conditions

3.8
repetitive handling
handling an object more than once every 10 min

NOTE 1 to entry infrequent lifting at 1 lift every 10 minutes is defined in the Application Manual by NIOSH (1994) paragraph 1.3.5.4 where a multiplier of 1.0 is applied for all duration scenarios at a frequency of 1 lift per 10 minutes.

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3.9
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

3.10
neutral body posture
upright standing posture with the arms hanging freely by the side of the body

3.11
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

3.12
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/lower sequence, the referent planes must be determined at the point in the action sequence wherein the largest degree of asymmetrical twist is encountered (see Figure C.1).

3.13
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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3.14
cumulative mass
product of the carried mass and the carrying frequency

NOTE The cumulative mass for carrying is defined in kilograms per minute to represent the risk for short term, in kilograms per hour to represent the risk for medium term and in kilograms per 8 hours to represent the risk for long term carrying

3.14
recovery time
used for determining the work/recovery pattern which is the period of light work activity (e.g. monitoring activities, light assembly work using the upper limbs, work not involving lifting/lowering, carrying of > 3 kg or pushing/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.

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The risk assessment is accomplished using the step-by-step approach illustrated in Figure 1 (Step Model). With each successive step, the evaluator analyzes 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 shall be provided with adequate information and training on how to perform these tasks safely. The provision of this information and training will 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 Annex A.7).

4.2 Risk assessment (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. It illustrates the step model recommended in this standard for addressing the interrelated aspects of lifting and carrying (4.2.1 and 4.2.2).

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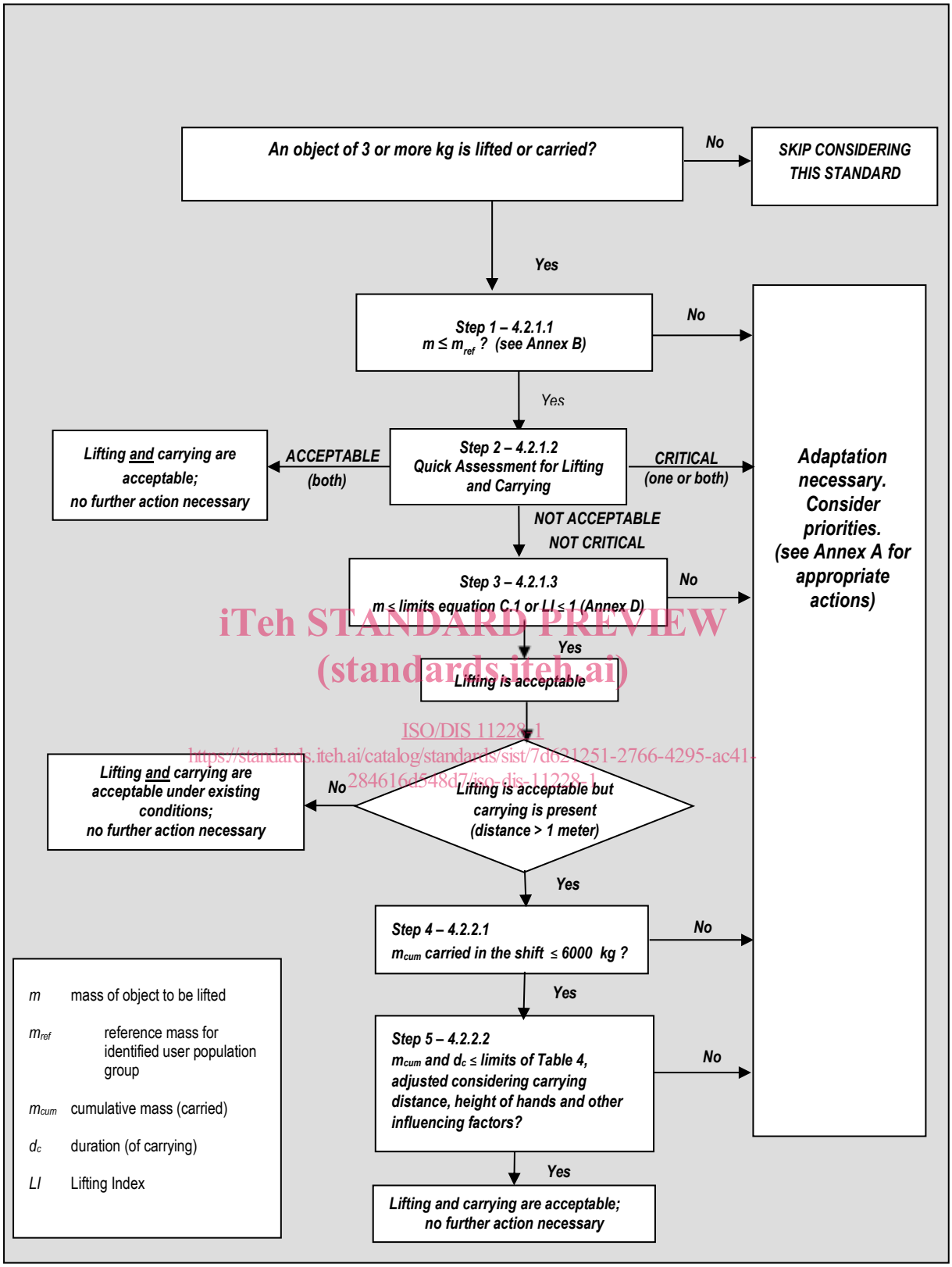

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Figure 1 — Step model

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Initially, the mass of the object being handled is determined; if it is more than 3kg, the risk assessment is continued. The task is further analysed to determine if the mass exceeds recommended limits for handling (step 1)".

Where limits are exceeded, as well as 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 may require immediate modifications for safety (see Annex A for further information), or it may be determined to be acceptable, or it may need further, more detailed risk evaluation (step 3). Step 3 is also used for evaluating tasks which take place using non-ideal postures.

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

4.2.1 Recommended limit for manual lifting and carrying

Whenever an object of 3 or more kg is lifted or carried, a risk assessment shall be performed, beginning with the initial screening, step 1.

4.2.1.1 Initial screening (step 1)

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 upon population characteristics, is presented in Annex B. For general guidance for designers and additional information related to step 1, see Annex C.

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4.2.1.2 Quick assessment of repetitive lifting and carrying (step 2)

Screening of repetitive lifting and carrying tasks of objects of 3 kg or more, is performed using the "Quick Assessment" procedure.

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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), and

— "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), or modifications should be made immediately (see Annex A) due to the presence of a "critical condition" (see Table 2). In either case, Table 3 shall also be referenced to identify the presence of any unfavourable working environment or object circumstances which may 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 4.2.1.3).

Table 1 is 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 2 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 3 shall also be systematically used to identify the presence of any unfavourable working environment or object circumstances which may further increase the risk of the task ("additional factors"). These factors can be related to the work environment or to the object characteristics, and they must be addressed to help reduce risk.

Table 1 — Lifting/carrying — Quick Assessment — Acceptable condition

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LIFTING AND LOWERING			
3 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 5 lifts per minute	NO	YES
>5 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 1 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 3 for other factors to be considered. If at least one of the questions is answered "NO", the evaluation must continue (see Table 2 and Table 3).			
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 (more/less than 5 meters) and duration (1 minute; 1 hour; 4 hours; 8 hours)?			
Duration	**Distance 1 to ≤ 5 m per action**	**Distance > 5 to 10 m per action**	
6-8 h	4800 kg	3600 kg	NO YES
4 h	4000 kg	3000 kg	NO YES
1 h	2000 kg	1500 kg	NO YES
1 min	60 kg	45 kg	NO YES
	Acceptable conditions for carrying: carry with two hands over a distance of maximum 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 3 for other factors to be considered. If at least one of the questions is answered "NO", the evaluation must continue (See Table 2 and Table 3).			

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Table 2 — Lifting/carrying— Quick Assessment — Critical condition

If one or more of the following conditions is present, consider risk as HIGH and proceed with task re-design.			
CRITICAL CONDITION FOR LIFTING: task lay-out and frequency conditions exceeding the maximum suggested			
VERTICAL LOCATION	The hand location at the beginning/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

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HORIZONTAL DISTANCE	The horizontal distance between the body and load is greater than full arm reach	NO	YES
ASYMMETRY	Extreme body twisting (to either side by more than 45 degrees) without moving the feet	NO	YES
FREQUENCY OF LIFTS (as defined by the *Applications Manual for the Revised NIOSH Lifting Equation*, [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 minutes of Recovery Time	NO	YES
	More than 12 lifts per min of MEDIUM DURATION (manual handling lasting no more than 120 min consecutively in the shift, followed by at least 30 minutes of Recovery Time	NO	YES
	More than 10 lifts per min of LONG DURATION (manual handling lasting more than 120 min consecutively in the shift)	NO	YES
CRITICAL CONDITION FOR LIFTING/CARRYING: presence of loads exceeding following limits (see Annex B, Table B.2 for further information)			
Females (20 - 45 years)	**20 kg**	NO	YES
Females (<20 or >45 years)	**15 kg**	NO	YES
Males (20 - 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 to 5 meters over a 6-8 hours period?	**6000 kg in 6-8 hours**	NO	YES
Carrying distance (per action) 5 to 10 m over a 6-8 hours period?	**3600 kg in 6-8 hours**	NO	YES
Carrying distance (per action) 10 to 20 m over a 6-8 hours period?	**1200 kg in 6-8 hours**	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 a critical condition is present. If a critical condition is present continue to Table 3 to identify additional factors to be considered, and then continue to Annex A for identifying urgent corrective actions.			

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Table 3 — 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 etc)	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 object reduces the worker's view and hinders movement	NO	YES
The load centre of gravity is not stable (example: liquids, items moving around inside of object)	NO	YES
The object shape/configuration presents sharp edges, surfaces or protrusions	NO	YES
The contact surfaces are too cold or too hot	NO	YES
Does the lifting or carrying task(s) last more than 8 hours a day?	NO	YES
If at least one of the questions is answered YES, the specified condition must be addressed and the risks minimized.		

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