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Ergonomics — Application document for International Standards on manual handling (ISO 11228-1, ISO 11228-2 and ISO 11228-3) and evaluation of static working postures (ISO 11226)

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National foreword

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TECHNICAL REPORT

ISO/TR 12295

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Ergonomics — Application document for International Standards on manual handling (ISO 11228-1, ISO 11228-2 and ISO 11228-3) and evaluation of static working postures (ISO 11226)

Ergonomie — Document pour l'application des Normes Internationales sur la manutention manuelle (ISO 11228-1, ISO 11228-2 et ISO 11228-3) et l'évaluation des positions statiques de travail (ISO 11226)

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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 documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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The committee responsible for this document is ISO/TC 159, *Ergonomics*, Subcommittee SC 3, *Anthropometry and biomechanics*.

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Introduction

The ISO 11228 series and ISO 11226 establish ergonomic recommendations for different manual handling tasks and working postures.

All their parts apply to occupational and non-occupational activities. The standards will provide information for designers, employers, employees and others involved in work, job and product design, such as occupational health and safety professionals.

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

— *Part 1: Lifting and carrying*;

— *Part 2: Pushing and pulling*;

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

ISO 11226, *Ergonomics — Evaluation of static working postures*, gives recommended limits for static working postures with no, or with minimal external force exertion, while taking into account body angles and duration. It is designed to provide guidance on the assessment of several task variables by evaluating the health risks for the working population.

While ISO 11228 and ISO 11226 are each self-contained with respect to data and methods, users may need guidance in selecting or using the standards in their specific application.

This Technical Report serves as an application guide that offers a simple risk assessment methodology for small and medium enterprises and for non-professional activities. For expert users, more detailed assessment methodologies are presented in the annexes.

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Ergonomics — Application document for International Standards on manual handling (ISO 11228-1, ISO 11228-2 and ISO 11228-3) and evaluation of static working postures (ISO 11226)

1 Scope

This Technical Report is an application document that guides users of the ISO 11228 series of International Standards, which address manual handling, and ISO 11226, which deals with static working postures. Specifically, it guides the user and provides additional information in the selection and use of the appropriate standards.

Depending upon whether specific risks are present, it is intended to assist the user to decide which standards should be applied.

It has a dual scope:

a) To provide all users, and particularly those who are not experts in ergonomics, with criteria and procedures:

— to identify the situations in which they can apply the standards of the ISO 11228 series and/or ISO 11226;

— according to the criteria given in the relative standard, to provide a "quick assessment" method to easily recognize activities that are "certainly acceptable" or "certainly critical". If an activity is "not acceptable" it is necessary to complete a detailed risk-assessment as set out in the standard, but it should be possible to continue with the subsequent actions. Where the quick-assessment method shows that the activity risk falls between the two exposure conditions then it is necessary to refer to the detailed methods for risk assessment set out in the relevant standard.

This scope and approach is illustrated in the flowchart in Figure 1 and is described in the main text of this Technical Report.

The user will be required to answer a short series of practical "key questions" to assist him or her in selecting and applying the appropriate standard(s).

It is emphasized that the use of the quick-assessment method is best completed using a participatory approach involving workers in the enterprise. Such involvement is considered essential to identify effectively priorities for dealing with the different hazard and risk conditions and, where necessary, to identify effective risk reduction measures.

b) To provide all users, especially those who have sufficient experience in ergonomics, or are sufficiently familiar with the standards of the ISO 11228 series, with details and criteria for applying the risk assessment methods proposed in the original standards of the series. This information is fully consistent with the methods proposed in the standards, and does not introduce any change to the application of the mathematical risk level calculations defined in the existing standards. It has been collated from additional analyses to ease the use of the standards.

This second part of the scope will be achieved through Annexes A, B, and C related to ISO 11228-1, ISO 11228-2 and ISO 11228-3, respectively. These annexes provide information relevant to the practical application of methods and procedures presented in ISO 11228 series based on application experiences of the standards. Some modifications of the methods explained in the standards are described in the present Technical Report, which are intended to be supplemental to the users,

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with a particular focus on applications where multiple manual tasks are performed by the same worker(s).

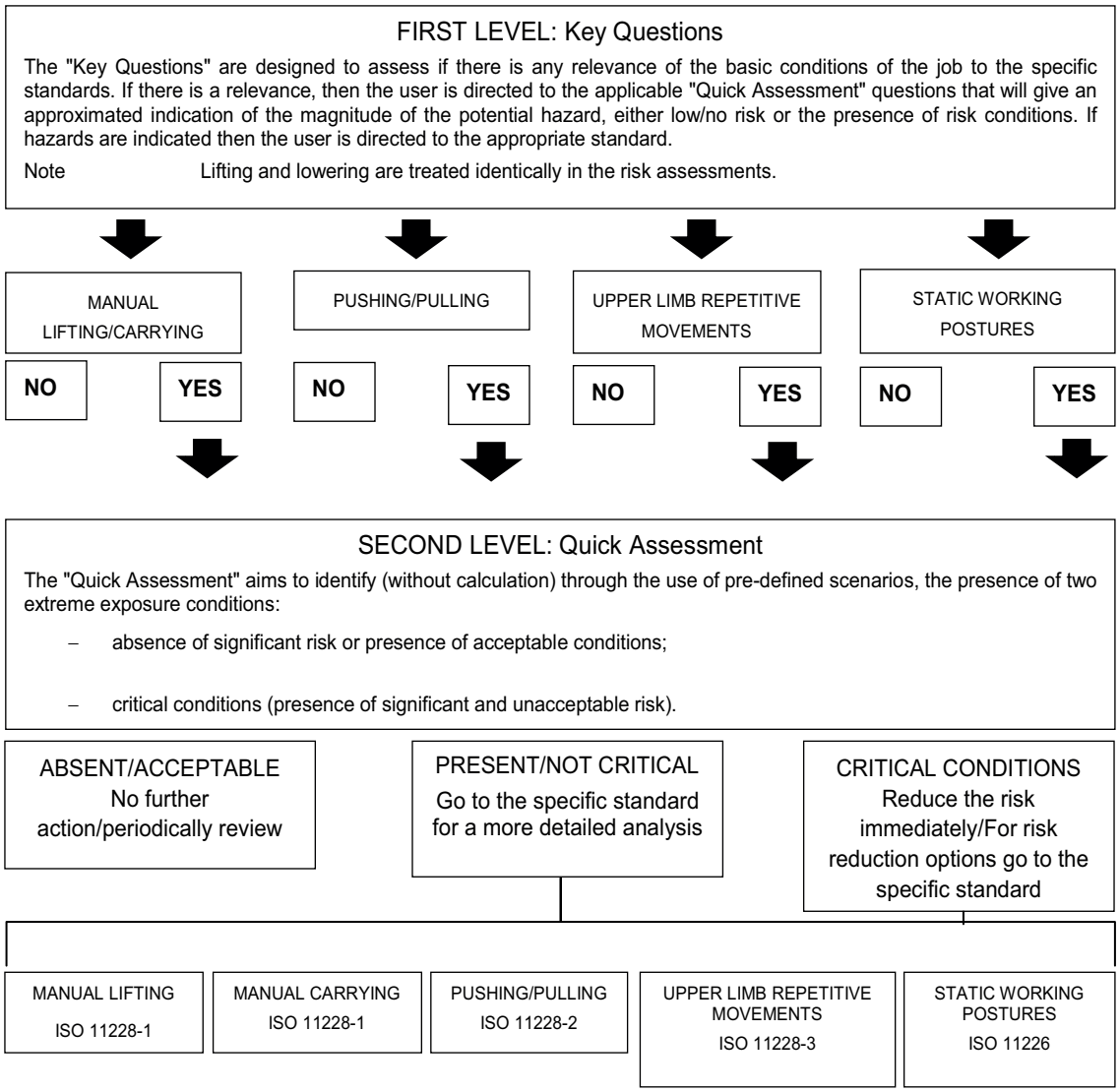

Figure 1 — The different levels of approach to ISO 11226 and the ISO 11228 series

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 11226, *Ergonomics — Evaluation of static working postures*

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

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

ISO 11228-3, *Ergonomics — Manual handling — Part 3: Handling of low loads at high frequency*

ISO 12100, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

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3 Using the "Key Questions" and the "Quick Assessment"

Follow the steps below and answer each of the key questions.

3.1 Step 1 — Procedure to enter the standards: the "Key Questions"

In Step 1 the "Key Questions" will direct you to the relevant standard or standards that are appropriate for your job conditions. "Key Questions" are designed to identify if hazards are present and whether a further analysis (using relevant standards) is necessary. See Table 1.

Table 1 — The key questions

1	*Application of ISO 11228-1*		
Is there manual lifting/lowering or carrying of an object of 3 kg or more present?		NO	YES
if NO, then this standard is not relevant, go to the next "Key Questions" regarding the other standards **If YES** then go to step 2 " Quick Assessment"			
2	*Application of ISO 11228-2*		
Is there a two-handed whole-body pushing and pulling of loads present?		NO	YES
if NO, then this standard is not relevant, go to the next "Key Questions" regarding the other standards **If YES** then go to step 2 "Quick Assessment"			
3	*Application of ISO 11228-3*		
Are there one or more repetitive tasks of the upper limbs with a total duration of 1 hour or more per shift? Where the definition of "repetitive task" is: *a task characterized by repeated work cycles* *or* *tasks during which the same working actions are repeated for more than 50% of the cycle time.*		NO	YES
If NO, then this standard is not relevant, go to the next "Key Questions" regarding the other standards **If YES** then go to step 2 "Quick Assessment"			
4	*Application of ISO 11226*		
Are there static or awkward working postures of the HEAD/NECK, TRUNK and/or UPPER AND LOWER LIMBS maintained for more than 4 seconds consecutively and repeated for a significant part of the working time? **For example:** - ***HEAD/NECK*** *(neck bent back/forward/sideways, twisted)* - ***TRUNK*** *(trunk bent forward/sideways/, bent back with no support, twisted)* - ***UPPER LIMBS*** *(hand(s) at or above head, elbow(s) at or above shoulder, elbow/hand(s) behind the body, hand(s) turned with palms completely up or down, extreme elbow flexion-extension, wrist bent forward/back/sideways)* - ***LOWER LIMBS*** *(squatting or kneeling) maintained for more than 4 seconds consecutively and repeated for a significant part of the working time*		NO	YES
if NO, then this standard is not relevant **If YES** then go to step 2 "Quick Assessment"			

3.2 Step 2 — The "Quick Assessment"

The "Quick Assessment" aims to identify, without the need for calculation, the presence of two opposite exposure conditions:

— the absence of risk or acceptable risk;

— the presence of a relevant risk (or the presence of extremely hazardous risk factors that are not acceptable), also labelled as critical conditions (critical code).

When either of these conditions is met, it is not necessary to make a more detailed estimation of the exposure level using the corresponding standard (the applicable standard can still provide ideas and

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information for the correction of the risk factors). However, when none of the two "extreme" conditions is met, it is necessary to conduct a risk assessment by methods reported in the corresponding standard.

3.2.1 Lifting/lowering and carrying — Preliminary additional aspects

A preliminary check of some adverse environmental, object and organizational conditions is highly recommended since those conditions could represent an additional risk in manual handling.

See Table 2.

Table 2 — Lifting/lowering and carrying – Additional factors to be considered

Is the working environment unfavourable for manual lifting and carrying?		
Presence of extreme (low or high) temperature	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 manual lifting and carrying?		
The size of object reduces the operator's view and hinder movement	NO	YES
The centre of gravity of the load 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 task(s) with manual lifting or carrying last more than 8 hours a day?	NO	YES
If all of the questions are answered" NO", then continue the "Quick Assessment". If at least one of the questions is answered "YES", then APPLY The standard ISO 11228-1. The consequent specific additional risks HAVE TO be carefully considered to MINIMIZE THESE RISKS.		

3.2.2 Lifting/lowering and carrying — Quick assessment

For establishing the acceptable (no) risk the following Tables 3 and 4 should be used. They follow the approach in step 1 and 2 of ISO 11228-1. If all of the listed conditions are present (i.e. "YES" answers), the assessed task is acceptable (Green area) and it is not necessary to continue the risk evaluation.

If any of the conditions is not met, apply ISO 11228-1, step 3 — Lifting equation.

The "Quick Assessment" could also be used for identifying critical conditions (for lifting and carrying). The term critical condition means that the manual lifting and/or carrying of objects is not recommended. If any of the conditions reported in Table 5 is met, a critical situation in lifting and/or carrying is present, and an ergonomics intervention is necessary to redesign the task as a high priority.

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Table 3 — Lifting/lowering — Quick Assessment — Acceptable condition

3 TO 5 kg	Asymmetry (e.g. body rotation, trunk twisting) is absent	NO	YES
	Load is maintained close to the body	NO	YES
	Load vertical displacement is between hips and shoulders	NO	YES
	Maximum frequency: less than 5 lifts per minute	NO	YES
5,1 TO 10 kg	Asymmetry (e.g. body rotation, trunk twisting) is absent	NO	YES
	Load is maintained close to the body	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 task is in green area (ACCEPTABLE) and it is not necessary to continue the risk evaluation. If at least one of the questions is answered "NO", then evaluate the task(s) by ISO 11228-1.			

Table 4 — Carrying — Quick Assessment — Acceptable condition

Recommended Cumulative Mass (total load (in kg) carried during the given durations for the specified distance below): is the cumulative mass carried LESS than recommended values considering the distance (more/less than 10 meters) and duration (1 minute; 1 hour; 8 hours) ?				
Duration	**Distance ≤ 10 m per action**	**Distance > 10 m per action**		
8 hrs	10000 kg	6000 kg	NO	YES
1 h	1500 kg	750 kg	NO	YES
1 min	30 kg	15 kg	NO	YES
	Awkward postures during the carrying are not present		NO	YES
If all of the questions are answered "YES", then the examined task is in green area (ACCEPTABLE) and it is not necessary to continue the risk evaluation. If at least one of the questions is answered "NO", then evaluate the task(s) by ISO 11228-1.				

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Table 5 — Lifting/lowering and carrying — Quick Assessment — Critical condition

If one or more of the following conditions is present, consider risk as HIGH and it is necessary to proceed with task re-design.			
CRITICAL CONDITION: presence of lifting/carrying 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 0 cm.	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	NO	YES
ASYMMETRY	Extreme body twisting without moving the feet	NO	YES
FREQUENCY	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 break-light task)	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 break--light task)	NO	YES
	More than 8 lift 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 the following limits			
Males (18-45 years)	**25 kg**	NO	YES
Females (18-45 years)	**20 kg**	NO	YES
Males (<18 or >45 years)	**20 kg**	NO	YES
Females (<18 or >45 years)	**15 kg**	NO	YES
CRITICAL CONDITION FOR CARRYING: presence of cumulative carried mass greater than those indicated			
Carrying distance 20 m or more in 8 hours / Carrying distance per action 20 m or more	**6000 kg in 8 hours**	NO	YES
Carrying distance less than 20 m in 8 hours / Carrying distance per action less than 20 m	**10000 kg in 8 hours**	NO	YES
If at least one of the conditions have a "YES" response then a critical condition is present. If a critical condition is present then apply ISO 11228-1 for identifying urgent corrective actions.			

3.2.3 Whole-body pushing and pulling — Additional factors to be considered

A preliminary check of some adverse environmental, object and organizational conditions is highly recommended since those conditions could represent an additional risk in both manual lifting and whole body pushing and pulling (Table 6).

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Table 6 — Pushing and Pulling — Additional factors to be considered

Working environment conditions		
Are floor surfaces slippery, not stable, uneven, have an upward or downward slope or are fissured, cracked or broken?	NO	YES
Are restricted or constrained movement paths present?	NO	YES
Is the temperature of the working area high	NO	YES
The characteristics of the object pushed or pulled		
Does the object (or trolley, transpallet, etc.) limit the vision of the operator or hinder the movement?	NO	YES
Is the object unstable?	NO	YES
Does the object (or trolley, transpallet, etc.) have hazardous features, sharp surfaces, projections etc. that can injure the operator?	NO	YES
Are the wheels or casters worn, broken or not properly maintained?	NO	YES
Are the wheels or casters unsuitable for the work conditions?	NO	YES
If the answers for all the conditions are "NO", then continue the quick assessment. If at least one of the answers is "YES", then apply ISO 11228-2. The consequent specific additional risks HAVE TO be carefully considered to MINIMIZE THESE RISKS.		

3.2.4 Whole-body pushing and pulling — Quick assessment

The "Quick Assessment" can be used for identifying *acceptable* (or Green) and *critical* (or Red) *conditions* (for pushing and pulling). For establishing the acceptable risk, Table 7 should be used (it is based upon method 1 of ISO 11228-2). If all of the listed conditions are present (reply "YES"), the examined task is acceptable and is not necessary to continue the risk evaluation. If at least one of the conditions reported in Table 8 is met, a critical situation in pushing and/or pulling is present, and an urgent ergonomic intervention is necessary to redesign the task as a high priority. The critical conditions given here are indicated in ISO 11228-2.

The suggested starting point is the estimation and evaluation of the forces necessary for performing the push-or-pull tasks under analysis. If the force is applied to the object beneath hip level or above mid-chest level one should apply the standard ISO 11228-2. This standard should also be applied in cases when the force magnitude is above approx. 50 N for continuous force exertion or approx. 100 N for peak-force application (for more information on how to measure forces see ISO 11228-2, Annex D). An approximation of these criteria is given by considering the experience of worker(s) in terms of the perceived effort. In determining the perceived effort, the use of CR-10 Borg scale [3] [4] is suggested for estimating the force developed during pushing and/or pulling. If the result is 3 or more on Borg scale (representing "moderate" level of force), one should apply the standard ISO 11228-2. If high forces are exerted or the point of force application is inappropriate (equivalently, a score of 8 or more in on CR-10 Borg Scale), a critical condition is present: it is necessary to apply ISO 11228-2 for identifying urgent corrective actions.

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Table 7 — Pushing and pulling — Quick Assessment — Acceptable condition

Hazard	**Force magnitude**		
	The force magnitude does not exceed approx. 30 N (or approximately 50 N for frequencies up to once per 5 min up to 50 m) for continuous (sustained) force exertion and approx. 100 N for peak (initial) force application. Alternatively, the perceived effort (obtained interviewing the workers using the CR-10 Borg scale) shows the presence, during the pushing-pulling task(s), of an up to SLIGHT force exertion (perceived effort) (score 2 or less in Borg CR-10 scale).	NO	YES
Hazard	**Task duration**		
	Does the task(s) with manual pushing and pulling last up to 8 hours a day?	NO	YES
Hazard	**Grasp height**		
	The push-or-pull force is applied to the object between hip and mid-chest level.	NO	YES
Hazard	**Posture**		
	The push-or-pull action is performed with an upright trunk (not twisted or bent).	NO	YES
Hazard	**Handling Area**		
	Hands are held inside shoulder width and in front of the body.	NO	YES
If all of the questions are answered "YES", then the examined task is in green area (ACCEPTABLE) and it is not necessary to continue the risk evaluation. If at least one of the questions is answered "NO", then evaluate the task(s) by ISO 11228-2.			

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Table 8 — Pushing and pulling — Quick Assessment — Critical condition

If one or more of the following conditions is present, consider risk as HIGH, and it is necessary to proceed with task re-design.			
Hazard	**FORCE MAGNITUDE**		
	A) Peak initial force during push-or-pull (to overcome rest state (inertia) or to accelerate or to decelerate an object): The force is at least 360 N (males) or 240 N (females). B) Continuous (sustained) push-or-pull (to keep an object in motion): The force is at least 250 N (males) or 150 N (females) Alternatively, during the pushing-pulling task(s), the perceived effort using the CR-10 Borg scale (obtained by interviewing the workers), shows the presence of high peaks of force (perceived effort) (a score of 8 or more on the Borg CR-10 scale)?	NO	YES
Hazard	**POSTURE**		
	The push-or-pull action is performed with the trunk significantly bent or twisted.	NO	YES
Hazard	**FORCE EXERTION**		
	The push-or-pull action is performed in a jerky manner or in an uncontrolled way.	NO	YES
Hazard	**GRASP HANDLING AREA**		
	Hands are held either outside the shoulder width or not in front of the body.	NO	YES
Hazard	**GRASP HEIGHT**		
	Hands are held higher than 150 cm or lower than 60 cm.	NO	YES
Hazard	**FORCE DIRECTION**		
	The push-or-pull action is superimposed by relevant vertical force components ("partial lifting")	NO	YES
Hazard	**TASK DURATION**		
	Does the task(s) with manual pushing and pulling lasts more than 8 hours a day?	NO	YES
If one or more answers are "YES", then a critical condition is present. If a critical condition is present then apply ISO 11228-2 for identifying corrective actions.			

3.2.5 Repetitive task(s) of the upper limbs — Quick assessment

For establishing acceptable risk use Table 9 (it incorporates the "Entry" steps in ISO 11228-3; i.e. hazard identification and preliminary simple risk estimation). If all of the listed conditions are present (i.e. reply YES), then the examined task is in the Green area (ACCEPTABLE), and it is not necessary to continue the risk evaluation. If any of the conditions is not met, address to ISO 11228-3, Method 1 and, when necessary, Method 2.

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Table 9 — Repetitive task(s) of the upper limbs — Quick Assessment — Acceptable condition

Are either upper limbs working for less than 50% of the total time duration of repetitive task(s)?	NO	YES
Are both elbows held below the shoulder level for almost 90% of the total duration of the repetitive task(s)?	NO	YES
Is there a moderate force (perceived effort = max 3 or 4 on CR-10 Borg scale) exerted by the operator for no more than 1 hour during the duration of the repetitive task(s)?	NO	YES
Absence of force peaks (perceived effort = 5 or more on CR-10 Borg scale)	NO	YES
Presence of breaks (including the lunch break) that lasts at least 8 min every 2 hours?	NO	YES
Are the repetitive task(s) performed for less than 8 hours a day?	NO	YES
If all of the questions are answered "YES", then the examined task is in Green area (ACCEPTABLE) and it is not necessary to continue the risk evaluation. If at least one of the questions is answered "NO", then evaluate the task(s) by ISO 11228-3.		

A quick assessment can also be used for identifying "critical conditions". If any of the conditions are met then a critical situation is present, and an ergonomics intervention is necessary to redesign the task as a high priority (Table 10).

Table 10 — Repetitive task(s) of the upper limbs — Quick Assessment — Critical condition

If at least one of the following conditions is present (YES), the risk has to be considered as CRITICAL and it is necessary to proceed with URGENT task re-design.		
Are technical actions of a single limb so fast that it cannot be counted by simple direct observation?	NO	YES
One or both arms are operating with the elbow at shoulder height for half or more than the total repetitive working time	NO	YES
A "pinch" grip (or all kinds of grasps using the fingers tips) is used for more than 80% of the repetitive working time.	NO	YES
Peak force applied (perceived effort = 5 or more in CR-10 Borg scale) for 10% or more of the total repetitive working time?	NO	YES
There is no more than one break (lunch break included) in a shift of 6-8 hours?	NO	YES
Total repetitive working time is exceeding 8 hours within a shift?	NO	YES
If at least one of the questions is answered "YES", then a critical condition is present. If a critical condition is present, then apply ISO 11228-3 for identifying urgent corrective actions.		

3.2.6 Static working postures — Quick assessment

To establish acceptable risk use Table 11. If any of the conditions are not met, it is necessary to apply ISO 11226.

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Table 11 — Static working postures — Quick Assessment

Head and trunk evaluation		
Are both the trunk posture AND the neck posture symmetrical?	NO	YES
Is the trunk flexion to the front less than 20° OR in case of backward inclination, is the trunk fully supported?	NO	YES
Is there trunk flexion between 20° and 60°, AND is the trunk fully supported?	NO	YES
Is neck extension absent OR in case of neck flexion, is it less than 25°?	NO	YES
Is backward head inclination fully supported OR, in case of head inclination to the front, is it less than 25°?	NO	YES
If sitting, is a convex spinal curvature absent?	NO	YES
Upper limb evaluation (evaluate the more loaded limb)		
Right/Left		
Are awkward upper arm postures absent?	NO	YES
Are the shoulders not raised?	NO	YES
Without full arm support, is the upper arm elevation less than 20°?	NO	YES
With full arm support, is the~~re~~ upper arm elevation up to 60°?	NO	YES
Are extreme elbow flexion/extension AND extreme forearm rotation absent?	NO	YES
Is extreme wrist deviation absent?	NO	YES
Lower limb evaluation (evaluate the more loaded limb)		
Right/Left		
Is extreme knee flexion absent?	NO	YES
Is the knee not flexed in standing postures?	NO	YES
Is there a neutral ankle position?	NO	YES
Is kneeling or crouching absent?	NO	YES
When sitting, is the knee angle between 90° and 135°?	NO	YES
If all of the questions are answered "YES", then the examined task is in Green area (ACCEPTABLE), and is not necessary to continue the risk evaluation. If at least one of the questions is answered "NO", then evaluate the task(s) by ISO 11226.		

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Annex A
(informative)

Application information for ISO 11228-1

The purpose of Annex A is to provide the users of ISO 11228-1 with useful information that is needed to perform a risk assessment.

This step is essential after completing the key-questions and the quick assessment.

The annex consists of the following information.

a) A specific reference to the standard:

— reference masses to be used when considering gender and age;

— classification of the results of risk assessment, introducing the concept of the Lifting Index (LI);

— demonstration (by an example) of a task evaluation that emphasizes the need to address work organization;

— an approach (derived from the standard) for the analysis of manual lifts operated by several (2 or more) workers.

b) Notes advances the standard:

— an approach for simple lifts carried with one upper limb;

— evaluation of variable lifting tasks (when different masses are lifted while holding different body postures (by taking into account various load placement positions) with examples for the calculation of Variable Lifting Index (VLI).

A.1 Reference mass (Note: in the standard)

Table C.1 of ISO 11228-1:2003) presents Reference Masses with estimated percentages of various user populations that will be protected when these Reference Mass are used in the given lifting task assessment method. By considering the contents of Table C.1 and of similar tables in other relevant standards (see EN 1005-2),[7] the following Reference Mass (Table A.1) could be adopted as a function of age and gender of the working population.

Table A.1 — The reference masses (m_{ref})

Working population by gender and age	Reference mass (m_{ref})
Men (18–45 years old)	25 kg
Women (18–45 years old)	20 kg
Men (<18 or > 45 years old)	20 kg
Women (<18 or > 45 years old)	15 kg
NOTE A value of 23 kg is the reference mass used in the Lifting Equation by the National Institute of Occupational Safety and Health (NIOSH) of the US, and is the source of the lifting analysis method used in ISO 11228-1. The use of 23 kg as the reference mass accommodates at least 99 % of male healthy workers and at least 75 % of female healthy workers at LI = 1,0.	

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A.2 Lifting Index (LI) (recommended limits for mass, frequency and object position)

A.2.1 Recommended mass (Note: in the standard)

By utilizing the reference mass (m_{ref}) reported in Table A.1, and using procedures and equations given in ISO 11228-1:2003, A.7 that consider different multipliers representing the risk level determined by job organization and the object position (ISO 11228-1:2003, step 3, page 5), it is possible to compare the Actual lifted mass (m_A) with the resulting recommended limit (m_R) by the following equation (see also Figure A.1). Lowering is treated the same as lifting in the analysis:

$$m_R = m_{ref} \times h_M \times v_M \times d_M \times \alpha_M \times f_M \times c_M$$

where (see also Figure A.1)

— m_{ref} is the reference mass for the identified user population group;

— h_M is the horizontal distance multiplier, derived from the specific equation in ISO 11228-1:2003, A.7;

— v_M is the vertical location multiplier, derived from specific equation in ISO 11228-1:2003, A.7;

— d_M is the vertical-displacement multiplier, derived from specific equation ISO 11228-1:2003, A.7;

— α_M is the asymmetry multiplier, derived from specific equation in ISO 11228-1:2003, A.7;

— f_M is the frequency multiplier;

— c_M is the coupling multiplier for the quality of gripping the object.

The following conditions are important during the comparison of lifting masses:

— m_A is ≤ m_R (acceptable condition);

— m_A is > m_R (not recommended condition).

A.2.2 Computing the lifting index (Note: advances the standard)

An alternative way of performing a comparison between m_A and m_R is to compute the lifting index. The Lifting Index (LI) is equal to the ratio between m_A and the corresponding m_R, and is expressed as LI = m_A/ m

$$LI = m_A/m_R$$

If using the Lifting Index, the classification of assessment results coherent with the one given in ISO 11228-1, step 3 becomes:

— acceptable condition, if Lifting index ≤ 1;

— not recommended condition, if Lifting index > 1.

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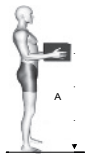
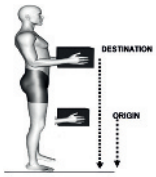
m_{ref}	Reference mass		Maximum recommended mass under optimal lifting conditions
v_M	Vertical multiplier		Distance of the hands from the floor at the start or end of lifting
d_M	Distance multiplier		Vertical distance of the load between the beginning and the end of lifting
h_M	Horizontal multiplier		Maximum distance between the load and the body during lifting
α_M	Asymmetric multiplier		Angular measure of displacement of the load from the sagittal plane
c_M	Coupling multiplier		Assessment of grip of the object (from tables)
f_M	Frequency multiplier		Frequency of lifts per minute and duration (from tables)

Figure A.1 — Multipliers used for computing the Recommended limit for mass (m_R) in ISO 11228-1, Step 3

A.2.3 Interpretation of the Lifting Index (LI) (Note: advances the standard)

For a better interpretation of the Lifting Index, especially when values are greater than 1 and, for addressing the intervention priorities, one can refer to Table A.2.

It is also encouraged to consult other relevant scientific literature to address optimum interventions.

Table A.2 — Interpretation of Lifting Index (m_A/m_R) values

Lifting Index Value	Exposure level	Interpretation	Consequences
LI ≤ 1,0	Acceptable	Exposure is acceptable for most members of reference working population.	Acceptable: no consequences
1,0 < LI ≤ 2,0	Risk present	A part of adult industrial working population could be exposed to a moderate risk level	Redesign tasks and workplaces according to priorities

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