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Ergonomics — Manual handling —

Part 1:
Lifting and carrying

Ergonomie — Manutention manuelle —

Partie 1: Manutention verticale et manutention horizontale

Reference number
ISO 11228-1:2003(E)

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Foreword

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

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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 and carrying*

— *Part 2: Pushing and pulling*

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

Introduction

The three parts of ISO 11228 establish ergonomic recommendations for different manual handling tasks. All the parts apply to such vocational and non-occupational activities. The standards will provide information for designers, employers, employees and others involved in work, job and product design. It is connected with ISO 11226.

This part of ISO 11228 is the first International Standard on manual handling.

Disorders of the musculoskeletal system are common worldwide and one of the most frequent disorders in occupational health.

Factors such as the size and mass of the object being handled, working posture, and the frequency and duration of manual handling can alone, or in combination, lead to a hazardous handling activity and correspond to the risk of musculoskeletal disorders.

It is desirable to specify the recommended limits for the mass of objects in combination with working postures, and frequency and duration of manual handling which persons may be reasonably expected to exert when carrying out activities associated with manual handling.

An ergonomic approach has a significant impact on reducing the risks of lifting and carrying. Of particular relevance is a good design of the work, especially the tasks and the workplace, which may include the use of appropriate aids.

This part of ISO 11228 provides a step-by-step approach to estimating the health risks of manual lifting and carrying; at each step, recommended limits are proposed. In addition, practical guidance for ergonomic organization of manual handling is given in Annexes, A, B and C.

The risk-assessment model presented allows the estimation of the risk associated with a manual material-handling task. It takes into consideration the hazards (unfavourable conditions) related to the manual lifting and the time spent with manual-handling activities. Unfavourable conditions could be high masses to be manipulated or awkward postures required during the lifting process such as twisted or bent trunks or far reaches. This part of ISO 11228 provides information on both repetitive and non-repetitive lifting.

The recommended limits provided are based on the integration of data derived from four major research approaches, namely the epidemiological, the biomechanical, the physiological and the psychophysical approach.

Ergonomics — Manual handling —

Part 1:
Lifting and carrying

1 Scope

This part of ISO 11228 specifies recommended limits for manual lifting and carrying while taking into account, respectively, 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 does not include holding of objects (without walking), pushing or pulling of objects, lifting with one hand, manual handling while seated, and lifting by two or more people. Holding, pushing and pulling of objects will be included in other parts of ISO 11228.

This part of ISO 11228 is based on an 8 h working day. It does not concern analysis of combined tasks in a shift during a day.

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 7250:1996, *Basic human body measurements for technological design*

ISO 14121, *Safety of machinery — Principles of risk assessment*

EN 1005-2, *Safety of machinery — Human physical performance — Part 2: Manual handling of machinery and component parts of machinery*[1)]

1) To be published.

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

NOTE This also includes handling people or animals.

3.2
manual lifting
moving an object from its initial position upwards without mechanical assistance

NOTE This also includes handling people or animals.

3.3
manual lowering
moving an object from its initial position downwards without mechanical assistance

3.4
manual carrying
carrying when an object remains lifted and is moved horizontally by human force

NOTE This also includes handling people or animals.

3.5
ideal posture for manual handling
standing symmetrically and upright, keeping the horizontal distance between the centre of mass of the object being handled and the centre of mass of the worker less than 0,25 m, and the height of the grip less than 0,25 m above knuckle height

NOTE 1 The location of the centre of mass of the object is approximated by the vertical projection of the midpoint of the line between the hands at the grasping location. The location of the centre of the mass of the worker is approximated by the midpoint of the line between the inner points of the ankles.

NOTE 2 For anthropometric measurements see ISO 7250.

3.6
unfavourable environmental conditions
conditions that give an additional risk to the lifting or carrying task

EXAMPLES Hot or cold environment, slippery floor.

3.7
ideal conditions for manual handling
conditions that include ideal posture for manual handling, a firm grip on the object in neutral wrist posture, and favourable environmental conditions

3.8
repetitive handling
handling an object more than once every 5 min

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

See Figure A.2.

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 vertical projection of the centre of gravity of the load when the load is at its most extreme displacement from the neutral, mid-saggittal 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 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 A.2).

3.13
reference mass
mass considered appropriate for use with an identified user population during the application of the risk-assessment method described herein

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

NOTE The cumulative mass for carrying is separately defined in kilograms per minute which represents the risk for short term, in kilograms per hour which represents the risk for medium term and in kilograms per 8 hours representing the risk for long term.

4 Recommendation

4.1 Introduction

This clause provides information for the evaluation of manual lifting and carrying.

4.2 Ergonomic approach

In those cases where manual lifting and carrying cannot be avoided, one should make a health and safety risk assessment taking into account the mass of the object, the grip of the object, the position of the object relative to the position of the body, and the frequency and duration of a specific task.

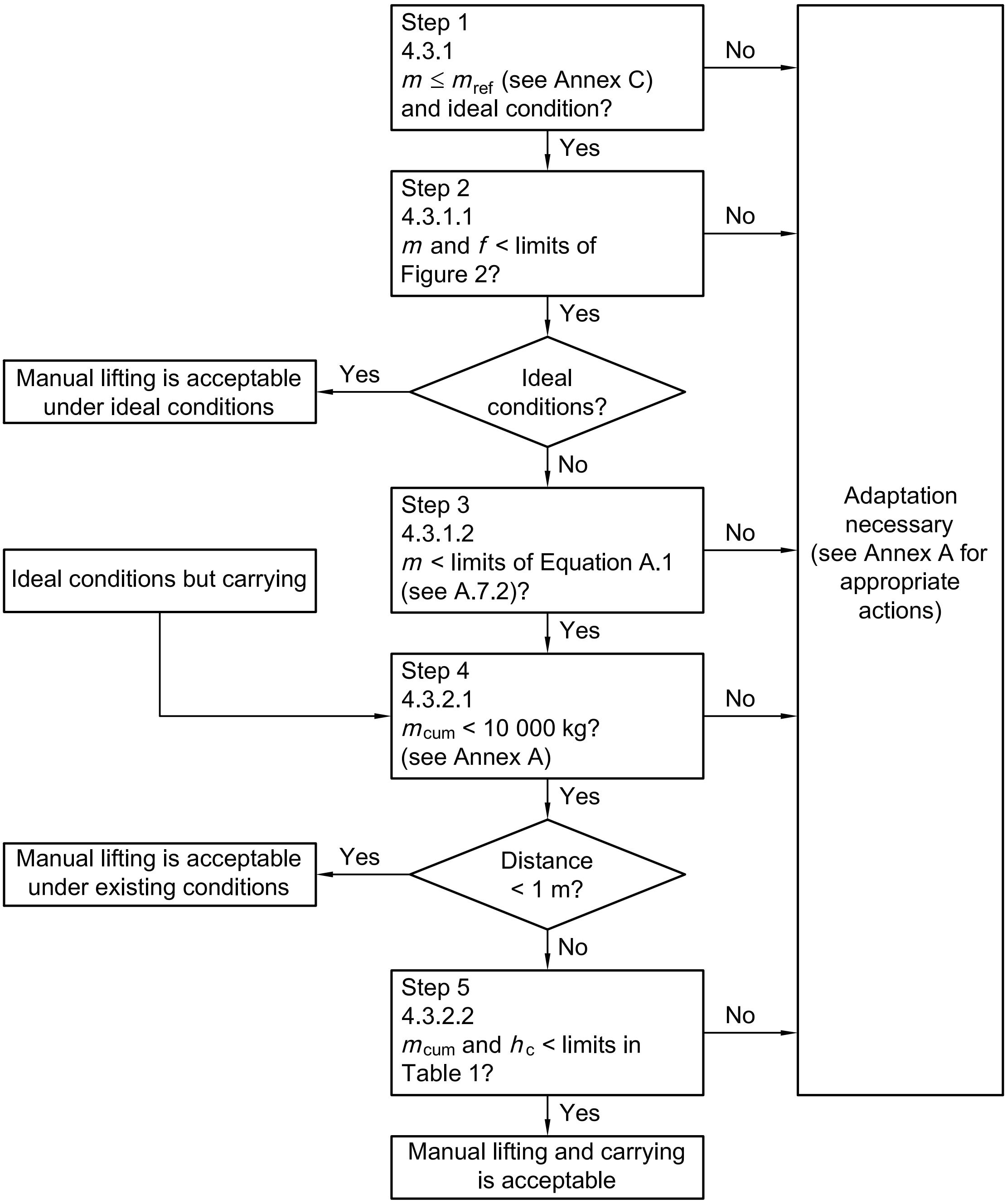
The risk assessment can be accomplished using a step by step approach (see Figure 1). With each successive step, the evaluator needs to judge the interrelated aspects of the various tasks. It is stressed that employers should provide their employees with adequate information and training for all situations addressed by this part of ISO 11228. Employees and others can lower the risk of injury by adopting safe ways of manual handling (see Annex A).

Risk assessment consists of four stages: peril recognition, hazard identification, risk estimation and risk evaluation, in accordance with ISO 14121, EN 1005-2 and ISO/IEC Guide 51. For information about hazard identification see Annex A.

If recommended limits are exceeded, measures should be taken to prevent the task from being carried out manually, or adapt the task in such a way that all questions in the step model are satisfied. The primary objective of risk reduction is to take measures to improve the design of manual-handling operations, the task, the object and the working environment relative to the characteristics of the individuals, as appropriate. It should not be assumed that the provision of information and training alone will ensure safe manual handling (see Annex A).

4.3 Risk estimation and risk evaluation

The step model illustrated in Figure 1 describes the procedures for addressing the interrelated aspects of manual lifting and carrying (4.3.1 and 4.3.2).



m mass of object to be lifted

m_{ref} reference mass for identified user population group

f frequency

m_{cum} cumulative mass

h_c distance (of carrying)

Figure 1 — Step model

4.3.1 Manual lifting

An initial screening of non-repetitive manual lifting in ideal conditions requires the determination of the object's mass (step 1). The recommended limit for the mass of the object is presented in Annex C. Step 1 gives general guidance for designers and employers. For additional information see A.7.

Screening of repetitive tasks requires determining the object mass in combination with lifting frequency (see step 2; 4.3.1.1). When limits for mass and frequency are not exceeded, continue to step 3; otherwise adaptation is necessary (see Annex A). For screening of lifting tasks in non-ideal postures, step 3; 4.3.1.2 should be used.

For screening the cumulative mass per day for manual lifting (step 4), the recommended limits in 4.3.2.1 should be applied.

4.3.1.1 Recommended limits for mass and frequency (step 2)

For repetitive manual lifting in ideal conditions, the recommended upper limit for frequency, taking into account the mass of the object, is presented in Figure 2. Figure 2 contains graphs for lifting durations of less than or equal to 1 hour per day and durations of 1 h to 2 hours per day respectively. The absolute maximal lifting frequency is 15 lifts per minute. In this case, the total duration of lifts shall not exceed 1 hour per day and the object mass shall not exceed 7 kg.

For repetitive manual lifting in ideal conditions, step 2 should be sufficient, otherwise continue to step 3.

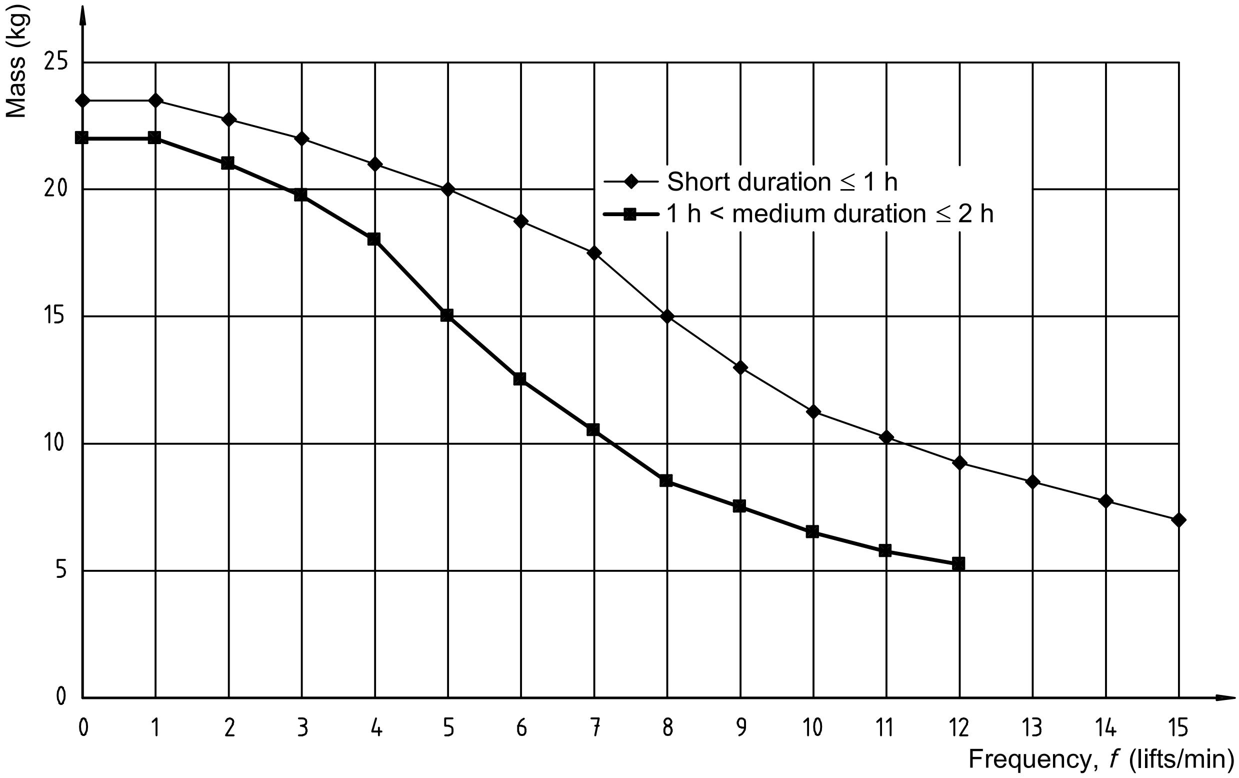


Figure 2 — Maximum frequency for manual lifting related to mass of the object in ideal conditions for two different lifting durations, corresponding to Table A.1

4.3.1.2 Recommended limits for mass frequency and object position (step 3)

For determining the recommended limits for the mass of objects relative to working posture/object position and lifting frequency and duration, the equations in A.7 should be used. In A.7, several assumptions that must be taken into account are presented. Given these variables, if the recommended limit for manual handling is exceeded, then the task should be adapted by changing the mass, the lifting frequency, the lifting duration or the object position.

4.3.2 Cumulative mass of manual lifting and carrying

For screening the cumulative mass of manual carrying and lifting per day (see step 4, 4.3.2.1), the recommended limits in 4.3.1.1 should initially be used. For determining the cumulative mass of carrying related to distance, refer to 4.3.2.2 (step 5). For an object to be carried once for a modest distance (one or two steps), the limits for lifting should be applied. In addition, there are recommended limits for the total cumulative mass given for a 1 h or 8 h workday.

4.3.2.1 Recommended limit for cumulative mass per day (step 4)

The cumulative mass is calculated as a product of mass and frequency of carrying. These two values both are limited in steps 1 and 2. In this way, the mass reference should never exceed 25 kg and frequency of carrying should never exceed 15 times/min. Under ideal conditions, the recommended limit for cumulative mass of manual carrying is 10 000 kg per 8 h. When the carrying distance is long (20 m), this limit has to be decreased to 6 000 kg per 8 h.

4.3.2.2 Recommended limit for cumulative mass related to distance (step 5)

For manual carrying in ideal conditions, the recommended limits for cumulative mass, related to the carrying distance, are presented in Table 1. This table provides the limits as follow:

— in kilograms per minute, which should protect against the excess of local load;

— in kilograms per hour, which should protect against excess of general load;

— in kilograms per 8 hours, which limits the long-term risk.

The limits are not simple multiplications, because the risks for short term, medium term and long term are qualitatively different. The last column of Table 1 shows examples of different combinations of mass and frequency. These examples show that the limits in kilograms per minute cannot always be applied because of the limits of maximal mass and frequency (5 kg × 15/min = 75 kg/min even for a distance of 1 m, and 25 kg cannot be lifted more than once per min, see Figure 2).

In the practical application this part of ISO 11228, first the limits of maximal mass and frequency have the priority; when those limits are respected, the limits to carrying have to be applied. Conversely, if the distance of carrying cannot be reduced, mass and/or frequency should be modified.

Under unfavourable environmental conditions, or when lifting from/to low levels, e.g. below knee height, or when the arms are lifted above the shoulders, the recommended limits for cumulative mass for carrying in Table 1 should be substantially reduced (at least by one-third).

4.4 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 of which are given in A.3 to A.6.

4.5 Additional considerations

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

Technical means of reducing risk should be provided, and complemented with information and appropriate training with respect to work-related risks.

Table 1 — Recommended limits for cumulative mass related to carrying distance (for general working population)

Carrying distance	Carrying frequency f_{max}	Cumulative mass m_{max}			Examples of product $m \cdot f$
m	min^{-1}	kg/min	kg/h	kg/8 h	
20	1	15	750	6 000	5 kg × 3 times/min 15 kg × 1 time/min 25 kg × 0,5 time/min
10	2	30	1 500	10 000	5 kg × 6 times/min 15 kg × 2 times/min 25 kg × 1 time/min
4	4	60	3 000	10 000	5 kg × 12 times/min 15 kg × 4 times/min 25 kg × 1 time/min
2	5	75	4 500	10 000	5 kg × 15 times/min 15 kg × 5 times/min 25 kg × 1 time/min
1	8	120	7 200	10 000	5 kg × 15 times/min 15 kg × 8 times/min 25 kg × 1 time/min

NOTE 1 In the calculation of the cumulative mass, a reference mass of 15 kg and a frequency of carrying of 15 times/min are used for the general working population.

NOTE 2 The total cumulative mass of lifting and manual carrying should never exceed 10 000 kg/day, whichever is the daily duration of work.

NOTE 3 23 kg is included in the 25 kg mass.

Annex A
(informative)

Ergonomic approach

A.1 Introduction

Scientific knowledge stresses the importance of an ergonomic approach in removing or reducing the risk of manual handling injury. Ergonomics focuses on the design of work and its accommodation of human needs and physical and mental capabilities. See EN 614. An ergonomic approach considers manual handling tasks in their entirety, taking into account a range of relevant factors including the nature of the task, the characteristics of the object, the working environment and an individual's limitations and capabilities.

A.2 Avoidance of manual handling

In seeking to avoid injury from manual handling, it is pertinent to ask whether manual handling of the objects could 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 may create other, different risks. Mechanization, for example, by the introduction of a lift truck, hoist, trolley, sack truck, chute, pallet inverter, etc., will need to be well maintained and a defect-reporting and -correction system should be installed in place. All handling aids should be compatible with the rest of the work system, be effective, appropriately designed and easily operated. Training concerning handling aids should cover their appropriate usage, and knowledge of safe storage and of procedures to be used in the event of their breakdown. Training should also include techniques on appropriate body positioning when using the equipment. Operating instructions and safety concerns should be placed on the equipment.

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

A.3 Design of the work: task, workplace and work organization

A.3.1 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 stretching, 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 could be avoided; a common instance would include stretching across to an object from the far side of a pallet and would be resolved by the use of pallet-rotating equipment. Another example, where awkward postures are seen and alternatives are achievable, would be 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 placement of the handles should be symmetrical to the centre of gravity and be of sufficient dimensions.

A.3.2 Workplace

The work area should be designed to minimize the amount of manual effort, thus reducing the need for twisting, bending, stretching 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 may be transferred.

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

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 whilst 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. The presence of obstacles such as used wrapping materials can also pose slipping hazards and should be cleared.

A.3.3 Work organization

The amount of work undertaken in fixed postures is also an important consideration. Recommendations on this issue are made in ISO 11226 concerning working postures. The frequency of handling an object can influence the risk of injury. Particular care is necessary where the rate of work cannot be varied by the handler. 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 production output, though this issue is complicated by a large variation in individual susceptibility to fatigue.

Handling by two or more people may make 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 could cope with individually. As an approximate guide, the capability of a two-person team is two-thirds the sum of their individual capabilities and, for a three-person team, the capability is half the sum of their individual capabilities. Additional difficulties may arise if team members impede each others' 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. Special attention may need to be given 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 may impair manual dexterity; other clothing such as uniforms may 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 and provide proper protection.

A.4 Design of the object

The object to be handled may constitute a hazard because of its mass or resistance to movement, its size, shape or rigidity or the absence of handgrips. In determining if a load represents a risk, proper account must 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 will affect the way in which it can be held. In general, if any dimension of the object exceeds about shoulder width, its handling is likely to pose an increased risk of injury. This will be especially so if this size is exceeded in more than one dimension. The risk will be 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 may result. Sometimes, as with a sealed and unmarked carton, an offset centre of gravity is not visibly apparent. In these circumstances, the risk of injury is increased since the handler may 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 shifting whilst being handled. Equally, greater care is needed when handling objects which are inherently difficult to grasp. In addition, there may be physical or chemical hazards which should also be indicated, e.g. the object may have sharp edges, be too hot or too cold to touch, or contain materials or substances which may be hazardous if spilled.

A.5 Design considerations when handling people or animals

The handling of live objects presents specific problems. Domestic and wild animals can behave unpredictably. Skill and experience are essential. When handled in boxes, crates or portable kennels, movement of an animal may be unseen and the centre of mass will perceptibly change, at various times and suddenly. The greatest single handling problem concerns the movement and activities of physically dependent people: in the community, in hospitals and as casualties. For patients and disabled persons in the community, the dominant considerations may be medical ones and the immediate needs of dressing, washing, toileting etc. Except in the case of emergencies, there is an absolute need to assess the handling problems for each individual, anticipating any change in health, paying particular attention to the ergonomics and planning of the handling environment. Those who are responsible for nursing and domestic care should draw up a care plan to give guidance to the carers on the most appropriate methods of movement and transfer. They should have access to published data on patient-handling techniques and on the selection of furniture and equipment for lifting and handling patients.

Notwithstanding these special considerations, handling of live objects should be subject to the basic principles set out in this part of ISO 11228. The handling of live and other objects in unforeseeable emergency and rescue situations are outside the scope of this part of ISO 11228. Personnel employed in such services should take into special consideration the age and decreased strength capabilities of certain patients.

A.6 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 may 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 may 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 may 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, e.g. around buildings. Assistance or mechanical devices may be especially necessary when carrying large sheets or bulky objects in such conditions.

For ideal conditions of manual materials handling, the following criteria are recommended:

- 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 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.

A.7 Assessment method for recommended limits for mass, frequency and object position

A.7.1 Non-repetitive lifting tasks

For non-repetitive lifting tasks, the mass of the object or the working postures used to manipulate the load might lead to health risks. High masses (i.e. higher than the reference mass) should be avoided as well as unfavourable postures like a bent or twisted trunk or a far reach.

To estimate the influence of an unfavourable posture, use the risk-assessment model equation in A.7.2 with a frequency multiplier of “1”. The horizontal multiplier will indicate the severity of a possible far reach; vertical, distance and asymmetry multipliers will show the negative influence of a twisted or bent trunk.

A.7.2 Repetitive lifting tasks

The recommended limits are derived from a model with the following assumptions:

— are only valid for two-handed, smooth lifting with no sudden acceleration effects (i.e. jerking);

— cannot be used for tasks where the worker is partly supported (e.g. one foot not on the floor);

— width of the object 0,75 m or less for populations with smaller statures (body height);

— are only valid for unrestricted lifting postures;

— are only valid when good coupling exists (i.e. hand holds are secure, and shoe/floor slip potential is low);

— are only valid under favourable conditions.

The primary task variables include the following data (See Figure A.1):

— object mass, m, in kilograms;

— horizontal distance, h, in metres, measured from the mid-point of the line joining the ankles to the mid-point at which the hands grasp the object whilst in the lifting position;

— vertical location, v, in metres, determined by measuring the distance from the floor to the point at which the hands grasp the object;

— vertical travel displacement, d, in metres, from origin to destination of lift;

- frequency of lifting, f, expressed as average number of lifts per minute;
- duration of manual lifting, in hours;
- angle of asymmetry, α, in degrees;
- quality of gripping, c.

The limit for the mass of the object is derived using the following equation:

$$m \leqslant m_{ref} \times h_M \times v_M \times d_M \times \alpha_M \times f_M \times c_M \quad (A.1)$$

where

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

h_M is the horizontal distance multiplier, derived from Equation (A.2);

v_M is the vertical location multiplier, derived from Equation (A.3);

d_M is the vertical-displacement multiplier, derived from Equation (A.4);

α_M is the asymmetry multiplier, derived from Equation (A.5);

f_M is the frequency multiplier, see Table A.1;

c_M is the coupling multiplier for the quality of gripping, see Table A.2.

The multipliers for Equation A.1 are obtained from Equations (A.2) to (A.5) and Tables A.1 to A.3. If such a multiplier exceeds a value of 1, its value should be taken as 1.

$$h_M = \frac{0{,}25}{h} \qquad \text{If } h \leqslant 0{,}25 \text{ then } h_M = 1$$

$$\text{If } h > 0{,}63 \text{ then } h_M = 0 \quad (A.2)$$

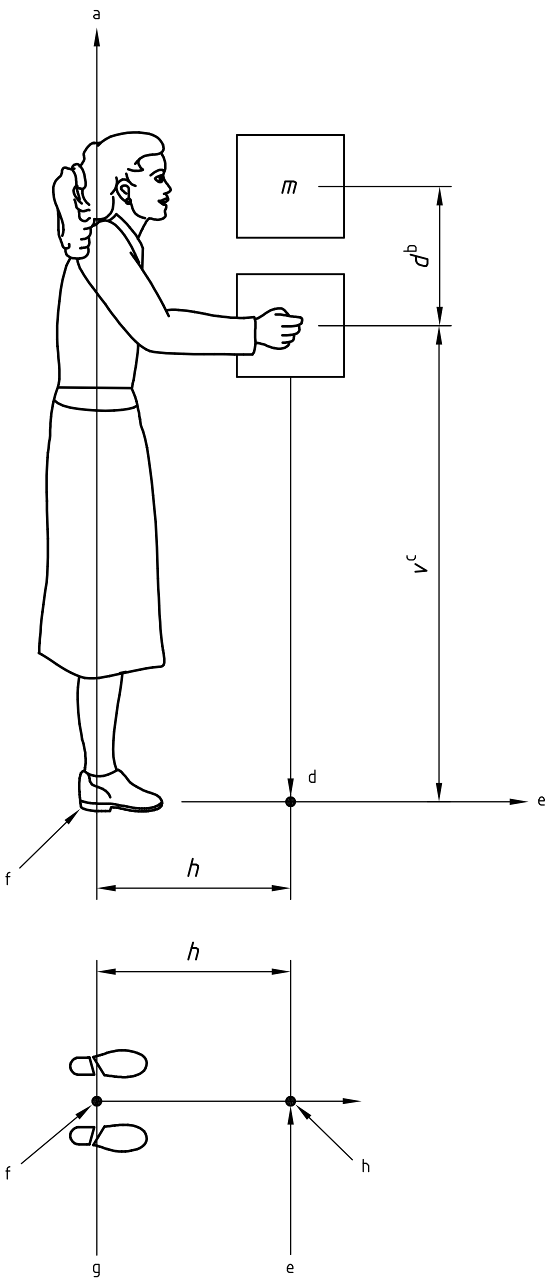
$$v_M = 1 - 0{,}3 \times |0{,}75 - v| \qquad \text{If } v > 1{,}75 \text{ then } v_M = 0$$

$$\text{If } v < 0 \text{ then } v_M = 0 \quad (A.3)$$

$$d_M = 0{,}82 + \frac{0{,}045}{d} \qquad \text{If } d > 1{,}75 \text{ then } d_M = 0$$

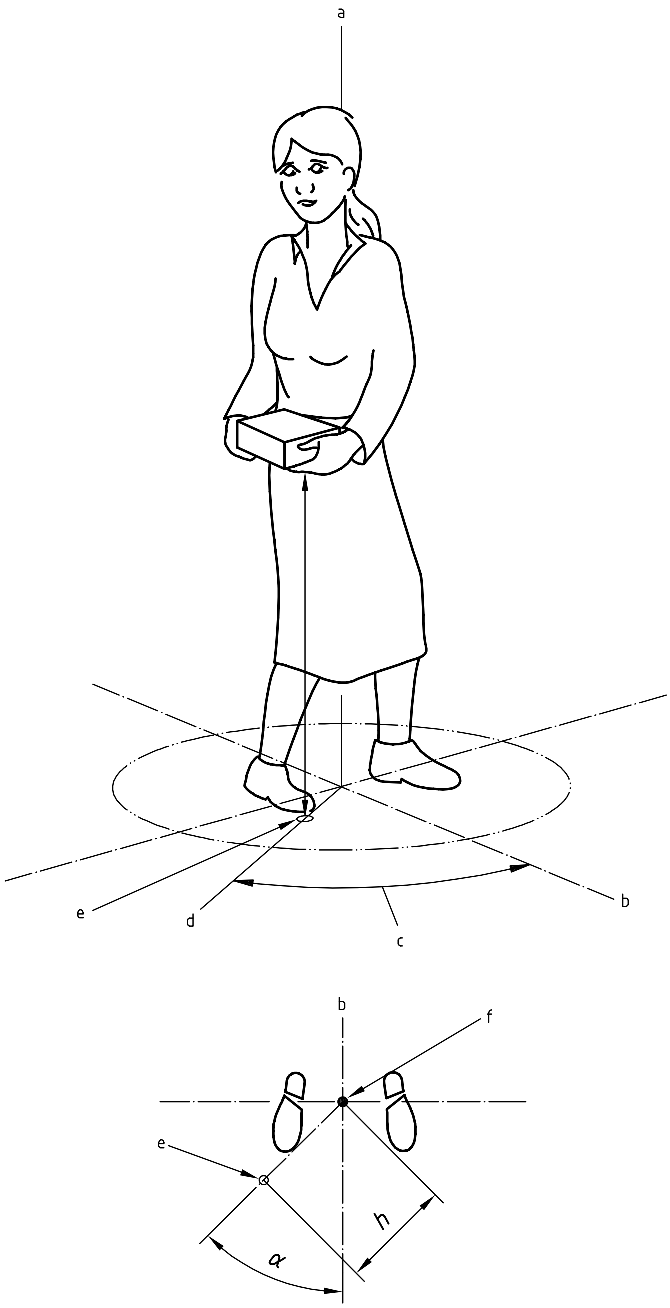
$$\text{If } d < 0{,}25 \text{ then } d_M = 1 \quad (A.4)$$

$$\alpha_M = 1 - 0{,}003\,2 \times \alpha \qquad \text{If } \alpha > 135^\circ \text{ then } \alpha_M = 0 \quad (A.5)$$



a Vertical
b Vertical travel displacement
c Vertical location
d Projection from centre of gravity of load
e Horizontal
f Mid-point between inner ankle bones
g Lateral
h Centre of load

Figure A.1 — Task variables



a Vertical
b Mid-sagittal plane
c Asymmetry angle (α)
d Asymmetry line
e Projection from centre of gravity of load
f Mid-point between inner ankle bones

Figure A.2 — Angle of asymmetry

The equation has to be calculated for both the start and end-point of each task. End-point calculations may only be of importance if there is a definite precision placement involved. If the item is thrown into place without undue stress on the body in the extended position, then calculating the end-point value is not necessary.

The appropriate frequency multiplier, f_M, is determined by first considering the continuous duration of the repetitive lifting task and then considering the duration of the rest period that immediately follows the repetitive lifting task.

The categories of continuous, repetitive lifting tasks, their durations, and the required duration of the rest period that is to immediately follow the lifting task are provided in Table A.3.

It is critical to note that the combination of the work period and the rest period must be jointly considered to be a work-rest cycle, wherein the rest period provides sufficient opportunity for the worker to recover following a continuous period of lifting-related work. Accordingly, if two successive work periods are separated by a rest period of inadequate duration, then the worker cannot adequately recover, and the entire period (the two work periods plus the rest period) must be treated as if it were a single, continuous work period. [The impact of such circumstances is to make the resultant work period substantially longer, with the consequence that the value for the frequency constant (k_f) is lowered.]

The value of f_M is then determined from Table A.1. The use of Table A.1 requires three components of information:

— the frequency of lifting (number of lifts per minute);

— the duration (t_L) of the continuous, repetitive lifting task;

— the vertical location (v) of the hands on the object-to-be-lifted at the beginning of the lift.

The quality of gripping is defined as

a) good: if the object can be grasped by wrapping the hand comfortably around the handles or hand-hold cutouts of the object without significant deviations from the neutral wrist posture, or the object itself, without causing excessive wrist deviations or awkward postures;

b) fair: if the object has handles or cutouts that do not fulfil the criteria of good quality of gripping or if the object itself can be grasped with a grip in which the hand can be flexed by about 90°;

c) poor: if the criteria of good or fair quality of gripping are not fulfilled.

Table A.1 — Values of frequency multiplier (f_M) of Equation (A.1)

Frequency of lifting number of lifts/min	Values of f_M					
	$t_L \leqslant 1$ h		1 h $< t_L \leqslant 2$ h		2 h $< t_L \leqslant 8$ h	
	$v < 0,75$ m	$v \geqslant 0,75$ m	$v < 0,75$ m	$v \geqslant 0,75$ m	$v < 0,75$ m	$v \geqslant 0,75$ m
$\leqslant$ 0,2	1,00	1,00	0,95	0,95	0,85	0,85
0,5	0,97	0,97	0,92	0,92	0,81	0,81
1	0,94	0,94	0,88	0,88	0,75	0,75
2	0,91	0,91	0,84	0,84	0,65	0,65
3	0,88	0,88	0,79	0,79	0,55	0,55
4	0,84	0,84	0,72	0,72	0,45	0,45
5	0,80	0,80	0,60	0,60	0,35	0,35
6	0,75	0,75	0,50	0,50	0,27	0,27
7	0,70	0,70	0,42	0,42	0,22	0,22
8	0,60	0,60	0,35	0,35	0,18	0,18
9	0,52	0,52	0,30	0,30	0,00	0,15
10	0,45	0,45	0,26	0,26	0,00	0,13
11	0,41	0,41	0,00	0,23	0,00	0,00
12	0,37	0,37	0,00	0,21	0,00	0,00
13	0,00	0,34	0,00	0,00	0,00	0,00
14	0,00	0,31	0,00	0,00	0,00	0,00
15	0,00	0,28	0,00	0,00	0,00	0,00
> 15	0,00	0,00	0,00	0,00	0,00	0,00

Table A.2 — Coupling multiplier (c_M) for the quality of gripping

Quality of gripping	Values of c_M	
	Height < 0,75 m	**Height** $\geqslant$ 0,75 m
Good	1,00	1,00
Fair	0,95	1,00
Poor	0,90	0,90

Table A.3 — Continuous lifting tasks and their required rest periods

Categories	Definitions, t	Required resting period
Short duration	$t \leqslant 1$ h	$\geqslant$ 120 % of duration of the continuous, repetitive lifting task
Medium duration	1 h $< t \leqslant 2$ h	$\geqslant$ 30 % of duration of the continuous, repetitive lifting task
Long duration	2 h $< t \leqslant 8$ h	No amount is specified; normal morning, afternoon and lunch breaks are presumed
NOTE For respective frequency coefficients see Table A.1.		

A.8 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 is large and will mean that some women can deal safely with heavier objects than some men. In those cases where manual lifting and/or carrying cannot be eliminated within a short term, special demands on physical capability of the worker, regardless of gender, may be necessary.

Young and old workers may 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. Altering the working routine will often make a team capable of doing the same job. With age, there is a reduction in physical capability which becomes more significant after the age of 45.

Occupational health care may be helpful when assessing if the health of an individual is relevant to the task. If a person's health changes temporarily or permanently, it may be necessary to alter the system of work to suit the new circumstances or to move the person to other tasks.

Pregnant women and disabled persons are beyond the scope of this part of ISO 11228 because of the special needs and considerations that are relevant to their temporary or permanent physical status.

There is good evidence that an individual with a medical history of a back disorder is more liable to recurrent episodes of back pain. Workers with a history of back disorders should be given a trial period. Eventually, necessary adaptations may need to be installed to prevent further bouts of back problems.

A.9 Information and training

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

Elements within a training program may 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;

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

— handling techniques.

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.

A good technique is one where the person is balanced, is in complete control throughout the task, and uses the minimum amount of effort to achieve, where possible, a smooth, uninterrupted movement. When lifting or carrying the object, it should be kept as close to the body as possible and both hands should be used. When applying effort, jerky or twisting movements and stooped postures should be avoided.

Annex B
(informative)

Examples of manual handling of objects

B.1 Example of an assessment of and ergonomic approach to manual handling of objects

B.1.1 Example of the use of the step model (see 4.2 and Figure 1)

Men are working in a warehouse for 8 h per day. Their main task is to prepare orders for the big supermarkets. This consists of repetitive manual handling performed for approximately 75 % of the work shift, the remaining 25 % administrative tasks are performed.

The objects to be handled have a mass from 1 kg to 24 kg, on average about 9 kg. The average frequency of handling is about 4 cycles/min. The objects are packages without any gripping device, to be stocked at the pallets (see Figure B.1). The dimensions of the pallet are: 0,15 m × 0,80 m × 1,20 m. The horizontal distance to the object at the beginning of the pallet is 0,20 m and at the end can be over 1,00 m.

Dimensions in metres

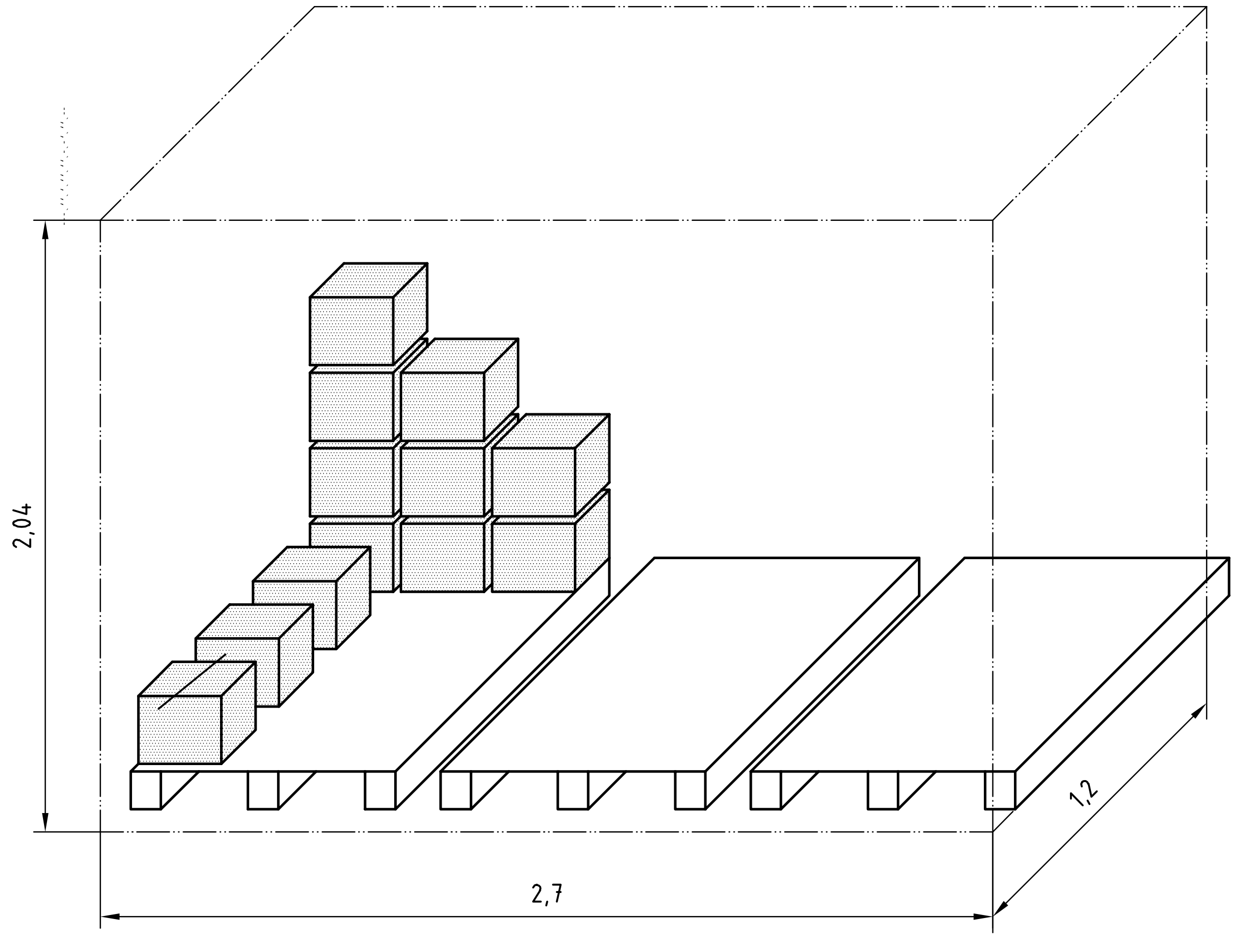


Figure B.1 — Frame of the access handling area

The vertical distance is about 1,75 m at the beginning of the pallet and 0,20 m at the end. The packages are handled at a vertical distance of about 1 m and a horizontal distance under 1 m. In 20 % of the cases, the worker is obliged to twist his trunk about 60°.

B.1.2 Relevant questions when screening the health risks of a lifting task

— Is this situation acceptable for manual handling ?

— If not, what can be done ?

B.1.3 Use of the step model

Step 1: yes

The maximal mass in this example is 24 kg; 25 kg is recommended as the mass constant for the adult-male working population. See Annex C.

Step 2: yes

The average frequency is 4 lifts/min during a 6 h shift, so the frequency multiplier f_M = 0,45 has to be used.

In this case, the mass limit of 11,25 kg is recommended. The average mass of handled objects is 9 kg.

Step 3: no

Two situations have to be considered: the best one and the worst one.

Under the best conditions, the horizontal and vertical position of load can be close to the recommended position; only two multipliers, d_M = 0,87 (vertical displacement = 1 m) and c_M = 0,9 (bad grip adaptation), have to be applied. In those conditions, the recommended limit is 9 kg and the situation is quite acceptable.

In the worst situation, the following multipliers have to be applied:

— v_M = 0,84 (for 0,20 m height of holding);

— d_M = 0,42 (for hold at a distance 0,60 m from the edge of the pallet);

— α_M = 0,81 (for an asymmetry angle of 60°);

— c_M = 0,9 (for a bad adaptation of grip).

Under those conditions, the recommended limit is 3,2 kg. The average mass is 3 times the recommended mass, so the situation is not acceptable and needs to be adapted.

Step 4: no

The carrying distance is under 1 m. The cumulative mass for the day shift (6 h) is 13 000 kg (9 kg with 4 lifts/min is 2 160 kg/h).

Adaptation should be necessary concerning essentially the reduction of the duration of the manual-handling tasks (the recommendation is met when the time is under 5 h).

B.1.4 Conclusions

Adaptation is necessary. Use the ergonomic approach which is presented in Annex A. Possible solutions could involve reducing one or more of the following factors:

— adapt the reach zone in proximity to the worker’s body;

— adapt the working posture to avoid asymmetric and bending postures;

— limit the average mass of objects;

— limit the average frequency of manual handling.

For example, if the body posture is kept more upright [with the hands constantly at fist (grip axis) height, see 4.4.4 in ISO 7250:1996], during the lifting by picking up the packages from a table, and each package can be kept close to the body when putting the package on the pallet, the task can be changed so that the feet are moved instead of the trunk. It is recommended to use packages that are suitable for the lifting task. Also the average working speed (frequency) for the task should be halved by the alternation of manual lifting with other tasks, which are relaxing for the lower back.

When the values of multipliers in Equation (A.1) cannot be reduced to a maximum recommended mass, the mass of the package should be reduced, or manual handling should be eliminated by mechanization and automation.

B.2 Example of an assessment of and ergonomic approach to a manual handling of live objects

The following example illustrates the application of the risk-assessment model, shown in Figure 1, to a situation involving live objects.

Lifting a baby from the ground to a work level is a typical lifting activity performed by nurses which, by its nature, may present a risk of back injury. Figure B.2 illustrates a lifting technique which can be ergonomic [Figure B.2a)] or risky [Figure B.2b)].

The weight of the baby is 9,5 kg. For the two following situations, the compression force (CF) in the level of the spine L5-S1 has been calculated by vector analysis.

CF = 670 N

a) Ergonomic way of lifting

CF = 2 080 N

b) Risky way of lifting

Figure B.2 — Lifting of a baby from the ground by one person

Annex C
(informative)

Reference mass

Table C.1 gives the reference mass taking into consideration different populations.

Table C.1 — Reference mass (m_{ref}) for different populations

<table>
<tr><th rowspan="2">Field of application</th><th rowspan="2">m_{ref}
kg</th><th colspan="3">Percentage of user population protected</th><th colspan="2" rowspan="2">Population group</th></tr>
<tr><th>F and M[a]</th><th>F</th><th>M</th></tr>
<tr><td rowspan="2">Non-occupational use</td><td>5</td><td colspan="3">Data not available</td><td>Children and the elderly</td><td rowspan="2">Total population</td></tr>
<tr><td>10</td><td>99</td><td>99</td><td>99</td><td>General domestic population</td></tr>
<tr><td rowspan="3">Professional use</td><td>15
20
23</td><td>95</td><td>90</td><td>99</td><td>General working population, including the young and old</td><td rowspan="2">General working population</td></tr>
<tr><td>25</td><td>85</td><td>70</td><td>95</td><td>Adult working population</td></tr>
<tr><td>30
35
40</td><td colspan="3">See NOTE</td><td>Specialized working population</td><td>Specialized working population under special circumstances</td></tr>
<tr><td colspan="7">NOTE Special circumstances. While every effort should be made to avoid manual-handling activities or reduce the risks to the lowest possible levels, there may be exceptional circumstances where the reference mass may exceed 25 kg (e.g. where technological developments or interventions are not sufficiently advanced). In these exceptional circumstances, increased attention and consideration must be given to the education and training of the individual (e.g. specialized knowledge concerning risk identification and risk reduction), the working conditions which prevail and the capabilities of the individual.</td></tr>
<tr><td colspan="7">[a] F: Female, M: Male</td></tr>
</table>

In order to lower the risk for people at work, particularly those with less physical capability, the recommended limit for mass should not exceed 15 kg. This will increase the level of health protection afforded to the working population by up to 95 %. In this instance, a reference mass of 15 kg instead of 25 kg should be used in Equation (A.1) (see A.7.2).

As workplaces should be accessible to everyone within the working population, exceeding the recommended limit for mass of 25 kg should be regarded as an exception. When exceeding the recommended limits, working conditions must remain safe. In these cases, it is especially important that workers are well trained and instructed for these specific tasks.

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