BRITISH STANDARD

BS EN
1005-2:2003

Safety of machinery — Human physical performance —

Part 2: Manual handling of machinery and component parts of machinery

The European Standard EN 1005-2:2003 has the status of a British Standard

ICS 13.110; 13.180

BSI
British Standards

National foreword

This British Standard is the official English language version of EN 1005-2:2003.

The UK participation in its preparation was entrusted by Technical Committee PH/9, Applied ergonomics, to Subcommittee PH/9/4, Anthropometry and biomechanics, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

This British Standard, was published under the authority of the Standards Policy and Strategy Committee on 19 June 2003

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 29 and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

ISBN 0 580 42101 5

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1005-2

April 2003

ICS 13.110; 13.180

English version

Safety of machinery - Human physical performance - Part 2: Manual handling of machinery and component parts of machinery

Sécurité des machines - Performance physique humaine - Partie 2: Manutention manuelle de machines et d'éléments de machines

Sicherheit von Maschinen - Menschliche körperliche Leistung - Teil 2: Manuelle Handhabung von Gegenständen in Verbindung mit Maschinen und Maschinenteilen

This European Standard was approved by CEN on 13 February 2003.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 1005-2:2003 E

Contents

Foreword

This document (EN 1005-2:2003) has been prepared by Technical Committee CEN /TC 122, "Ergonomics", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2003, and conflicting national standards shall be withdrawn at the latest by October 2003.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports essential requirements of EC Directive(s).

For relationship with EC Directives, see informative annex ZA, which is an integral part of this document.

EN 1005 consists of the following parts, under the general title "Safety of machinery - Human physical performance":

— Part 1: Terms and definitions;

— Part 2: Manual handling of machinery and component parts of machinery;

— Part 3: Recommended force limits for machinery operation;

— Part 4[1)]: Evaluation of working postures and movements in relation to machinery;

— Part 5[1)]: Risk assessment for repetitive handling at high frequency.

Annexes A, B and C are for informative.

This document includes a Bibliography.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

1) This European Standard is under preparation by CEN/TC 122/WG 4 "Biomechanics".

Introduction

When designing and constructing machinery, the manufacturer should meet the essential requirements for safety and health set out in the Machinery Directive. The manufacturer should assess the hazards of the machine and consider these hazards related to the life cycle of the machine.

This European Standard is one of several ergonomic standards for the safety of machinery. EN 614-1 describes the principles to be applied by designers in order to accommodate ergonomic factors.

This standard has been prepared to be a harmonised standard in the sense of the Machinery Directive and associated EFTA regulations.

This European Standard is a type B standard as stated in EN 1070.

The provisions of this document can be supplemented or modified by a type C standard.

NOTE For machines which are covered by the scope of a type C standard and which have been designed and built according to the provisions of that standard, the provisions of that type C standard take precedence over the provisions of this type B standard.

Manual handling of loads can lead to a high risk of injury to the musculoskeletal system if the loads to be handled are too heavy, and/or handled at high frequencies for long durations and/or in awkward postures. Disorders of the musculoskeletal system are of a common occurrence throughout Europe. Manually applied effort is often required by operators working with machines for their intended purpose. Risks exist if the design of the machinery is not in accordance with ergonomic design principles. When designing and constructing machinery where manual handling is required, this standard provides relevant data for working posture, load, frequency and duration. The design criteria given in this standard can be used by the designer when making risk assessments.

This standard requires machinery designers to adopt a three stage approach to:

a) avoid manual handling activities wherever possible;

b) utilise technical aids;

c) further reduce the inherent level of risk by optimising handling activities.

For machines and their component parts which cannot be moved or transported by hand, see 4.2 in EN 292-2:1991.

1 Scope

This European Standard specifies ergonomic recommendations for the design of machinery involving manual handling of machinery and component parts of machinery, including tools linked to the machine, in professional and domestic applications.

This European Standard applies to the manual handling of machinery, component parts of machinery and objects processed by the machine (input/output) of 3 kg or more, for carrying less than 2 m. Objects of less than 3 kg are dealt with in prEN 1005-5[1)]. The standard provides data for ergonomic design and risk assessment concerning lifting, lowering and carrying in relation to the assembly/erection, transport and commissioning (assembly, installation, adjustment), operation, fault finding, maintenance, setting, teaching or process changeover and decommissioning, disposal and dismantling of machinery.

This standard provides current data on the general population and certain sub-populations (clarified in annex A).

This part of the standard does not cover the holding of objects (without walking), pushing or pulling of objects, hand-held machines, or handling while seated.

This document is not applicable to specify the machinery which are manufactured before the date of publication of this document by CEN.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 292-2:1991, *Safety of machinery – Basic concepts, general principles for design – Part 2: Technical principles and specifications.*

EN 614-1, *Safety of machinery – Ergonomic design principles – Part 1: Terminology and general principles.*

EN 1005-1:2001*, Safety of machinery – Human physical performance – Part 1: Terms and definitions.*

EN 1050*, Safety of machinery – Principles for risk assessment.*

EN 1070:1998, *Safety of machinery – Terminology.*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 1005-1:2001 and EN 1070:1998 apply.

4 Recommendations for the design of machinery and component parts where objects are lifted, lowered and carried

4.1 General principles

In order to minimise the risks to the health and safety of the operator, when lifting, lowering and carrying the machine or component parts, the designer/manufacturer of the machine shall:

a) establish whether or not a hazard exists when manual handling activities are performed in relation to the intended use of the machine. If a hazard exists, the risk assessment model should be applied. (see 4.3.1, 4.3.2 and 4.3.3);

b) remove the hazard by excluding the need for manual handling activities (lifting, lowering and carrying) for the machinery or machinery-linked objects (see 4.2.1). If this is not possible, provide technical aids, additional to the system (see 4.2.2), and/or design/redesign the machinery and machinery-linked objects according to ergonomic principles (see 4.3);

c) provide technical specifications and instructions so that machinery is used appropriately and in the intended manner covered by the risk assessment, technical specifications and instructions for use.

In all cases, the designer shall provide instructions concerning construction, transport and commissioning, use and decommissioning of the machinery (see 4.4) to prevent risks for safety and health.

Technical aids for manual handling should preferably be incorporated into the machinery design and the machine.

Health, safety and productivity are most likely to be optimised if an ergonomic approach is used in designing the system of work as a whole.

4.2 Recommendations for the design of machinery

4.2.1 Systems without manual handling

The best way to eliminate manual handling risks is to remove the need to handle manually. In general, those designing new systems of work or installing new systems of machinery should consider introducing an integrated handling system that fully utilises powered handling, rather than a manual system.

4.2.2 Manual handling with technical aids

Designers should ascertain whether suitable aids and equipment can be installed, particularly if the existing practice involves frequent manual handling of objects and manual handling of objects weighing more than the reference mass (see Table 1), or the precise movement of objects. Appropriate technical aids diminish or eliminate the risk of musculoskeletal injury but may induce risks, for example, by the need for maintenance work. They may also have implications for particular handling methods at subsequent points in the handling chain. Handling aids should be compatible with the rest of the work system, including layout and access routes. They should be effective for the full range of operational conditions likely to be encountered. In employing technical aids, more space could be required for access to allow appropriate working postures.

When designing systems including manual handling follow the recommendations given in 4.3.2.

When considering the limits for manually pushing and pulling of technical aids, reference should be made to EN 1005-3. When considering working postures, reference should be made to prEN 1005-4[1)].

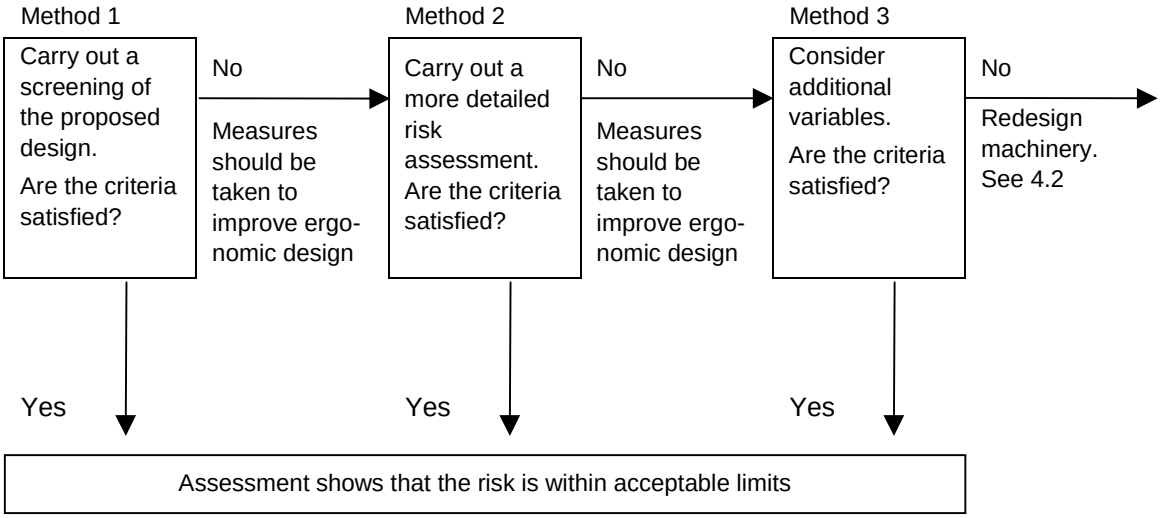
4.3 Risk assessment and recommendations for the design of machinery and component parts involving manual handling

4.3.1 Approach to risk assessment

To control the risks to an individual's health and safety, it is necessary for the designer to identify relevant hazards and to carry out an appropriate risk assessment. For general requirements of risk assessment, refer to EN 1050. Manual handling risks shall be reduced by applying ergonomic principles at the design stage of the machinery, see EN 614-1.

The risk assessment model presented here involves 3 methods. These methods have the same basis, but differ in their complexity of application.

The first method is a quick screening method. Method 2, an easy to handle method, shall be applied if the screening method indicates risks. Some additional risk factors can be taken into account in method 2. Method 3 is an extended assessment method, which assesses risks in a more thorough way and is supplemented by additional risk factors not presented in methods 1 and 2. All three methods have different levels of complexity. The most efficient approach is to begin the risk assessment by applying method 1 (the most simple one) and use methods 2 and/or 3 only if the assumptions and/or operational situations identified in method 1 are not met.



NOTE It is recommended to consider further steps to reduce risk factors to their lowest possible level.

Figure 1 — Flowchart identifying the step-wise approach to assessment

4.3.2 Hazard identification, risk estimation, risk evaluation and recommendations for risk reduction by design

In this paragraph recommendations for the design of a manual handling situation at a low risk level are given. The information is based on the state of the art of ergonomics. If these criteria are not met a risk assessment should be done.

The following aspects (see 4.3.2.1 to 4.3.2.3) shall be taken into account when assessing and reducing the risks.

4.3.2.1 Objects

4.3.2.1.1 Mass

The mass of the object (machines, machinery parts, input/output) includes everything connected with it such as packing, batteries, full magazines, etc. Technical aids needed for the manual handling activities are also included.

When designing machinery or components, the unit mass can be a hazard if an object is to be handled manually. To define the safe maximum limit for the mass refer to 4.3.3.

4.3.2.1.2 Mass distribution/stability

The object ‘s centre of gravity is determined by the distribution of mass. Wherever possible, the centre of gravity of the object should be within the object, distributed equally between both hands and positioned as close as possible to the body. While handling, movement of the object's centre of gravity should be constrained. When this is not possible (e.g. liquid), appropriate information should be marked on the object.

4.3.2.1.3 Size

Objects should be designed to be as compact as possible. When objects are gripped by both hands, the width of the object should not exceed shoulder width (approximately 60 cm) and the depth of the object should not exceed 50 cm (recommended to be 35 cm or less) in order to keep the load close to the body. The height of the object should be such that it does not obscure a person's visibility. If handling of the object needs one hand underneath and one hand above the object, the object should be redesigned.

4.3.2.1.4 Grip/handles

The surface properties of objects (including packaging materials of new component parts) should be suitable for handling. An object should be easy to grasp and hold and, therefore, should normally be equipped with handles or suitable cut-outs.

The placement of the handles should be consistent with the centre of gravity of the object and the type of action that is carried out, supporting to adopt the best working postures and movement during lifting and carrying. If the handle is supposed to be horizontal, this should be done by the machine. Handles should not have sharp edges or contain a risk of compressing the fingers. The shape of the handle should permit a hook-grip or power-grip with a neutral hand-arm posture.

The diameter of the handle should be between 2 cm and 4 cm.

The width of handle/cut-out should be a minimum of 12,5 cm to ensure clearance for a gloved hand, with 7 cm room above the fingers. The optimum shape of the handle should be cylindrical or elliptical. To assess the handgrip (coupling) go to 4.3.3.2. or 4.3.3.3.

4.3.2.2 Operation-machine interface

4.3.2.2.1 Horizontal location and distance

Obstruction between the object and the body, such that the object cannot be lifted, lowered or carried close to the body, is a hazard. The horizontal distance between the mid-point of the ankles and of the hands should be less than 25 cm. If the horizontal distance is greater than this value, a risk assessment should be carried out in accordance with 4.3.3.

4.3.2.2.2 Vertical location and displacement

The vertical grip position (measured from the knuckle of the middle finger to the ground) should be adjustable between 60 cm and 90 cm. Vertical displacement of the object should not exceed 25 cm. If the vertical distance is lower or higher, and/or the vertical displacement exceeds 25 cm, then a risk assessment should be carried out in accordance with 4.3.3.

4.3.2.2.3 Frequency of operation

Machinery should be designed so that manual handling at high frequency is avoided. It should be possible to regulate the frequency of the machine in relation to manual handling. A machinery design should, wherever possible, allow some degree of autonomy. To assess the risks arising from a combination of the frequency and mass, refer to 4.3.3.

4.3.2.2.4 Working postures

The designer should avoid awkward postures (e.g. twisting and bending, lifting from the ground) and prolonged activities which lead to body fatigue during manual handling, for every stage of machinery-operation (including assembly/erection, transport and commissioning, use and decommissioning). Occasional changes in posture should be provided (see prEN 1005-4).

4.3.2.2.5 Manual carrying of loads

In general, machines should be designed so that manual carrying is avoided. Where this is not possible, the maximum manual carrying distance should be as low as possible (less than 2 m).

4.3.2.2.6 One-handed handling

If an object is handled with one hand only it may be a hazard. If one-hand handling cannot be avoided a risk assessment should be carried out (see 4.3.3.3).

4.3.2.2.7 Handling by two persons

Handling by two (or more) persons can be used to reduce the load on one operator, but it also creates additional hazards because of difficulties in co-ordinating the movements and force exertions between the two (or more) people performing the lift together. Ergonomic design shall eliminate the need for using two (or more) people for lifts except in occasionally occurring special cases, for which a risk assessment should be carried out (see 4.3.3.3).

4.3.2.2.8 Handling including rotation of object

Manual handling of objects by turning around its axis should be avoided. Redesign is recommended by which machinery or technical aids take over the handling.

4.3.2.2.9 Additional physical demands

Additional physical demands to the manual handling task may imply new hazards. If they cannot be avoided, a risk assessment should be carried out (see 4.3.3.3).

4.3.2.2.10 Coupling

Unfavourable coupling conditions between hands and the objects handled or between the feet and floor may result in hazardous situations. If they cannot be avoided, a risk assessment should be carried out (see 4.3.3.3).

4.3.2.3 Environmental factors

Environmental factors can create hazards and can impose additional risk.

If they cannot be avoided, qualified personnel should make a risk assessment. Environmental factors include vibration, climate, thermal conditions (see EN ISO 7730), illumination, slippery ground, noise and chemical agents (see ENV 26385).

4.3.3 Risk assessment model

This risk assessment model consists of three methods. Method 1 is a quick screening method. Method 2 shall be applied if the screening method indicates risks. Some additional risk factors can be taken into account in method 2. Method 3 is an extended assessment method which assesses risks in a more thorough way and is supplemented by additional risk factors not presented in methods 1 or 2. All three methods have different levels of complexity. The most efficient approach is to begin the risk assessment by applying method 1 (the simplest procedure) and use methods 2 or 3 only if the assumptions or operational situations identified in method 1 are not met. Each method requires three steps to be carried out:

— Step 1: consider the reference mass in relation to the intended user population (see Table 1);

— Step 2: carry out the risk assessment according to the worksheet, see 4.3.3.1 to 4.3.3.3;

— Step 3: identify the action required:

  — no action, if risk level is tolerable;

  — redesign or;

  — use a more complex assessment method.

It is free to the designer to redesign already after Method 1, step 3 and not to go to Method 2. It is not a complete iteration but a more detailed risk assessment in Method 2 and Method 3, based on same methodology.

For practical application see annex C.

Table 1 — Reference mass (M_{ref}) taking into consideration the intended user population

Field of application	M_{ref} [kg]	Percentage of			Population group	
		F and M	F_{emales}	M_{ales}		
Domestic use[a]	5	Data not available			Children and the elderly	Total population
	10	99	99	99	General domestic population	
Professional use (general)[b]	15	95	90	99	General working population, including the young and old	General working population
	25	85	70	90	Adult working population	
Professional use (exceptional)[c]	30 35 40	Data not available			Special working population	Special working population

[a] When designing a machine for domestic use, 10 kg should be used as a general reference mass in the risk assessment. If children and elderly are included in the intended user population, the reference mass should be lowered to 5 kg.

[b] When designing a machine for professional use, a reference mass of 25 kg should not be exceeded in general.

[c] While every effort should be made to avoid manual handling activities or reduce the risks to the lowest possible level, there may be exceptional circumstances where the reference mass might exceed 25 kg (e.g. where technological developments or interventions are not sufficiently advanced). Under these special conditions other measures have to be taken to control the risk according to EN 614-1 (e.g. technical aids, instructions and / or special training for the intended operator group).

4.3.3.1 Method 1: Screening by means of critical values

In this method the designer may choose one of three operational situations which is appropriate to the design. By using this method a quick screening can be carried out. Limiting condition is that assumptions for handling operation are fulfilled.

4.3.3.1.1 Consider the reference mass (step 1)

Identify the intended user population and select the reference mass (M_{ref}) according to the intended user population (Table 1).

4.3.3.1.2 Carry out the risk assessment (step 2)

Identify (tick) whether the handling operation meets the following criteria:

- two-handed operation only;
- unrestricted standing posture and movements;
- handling by one person only;
- smooth lifting;
- good coupling between the hands and the objects handled;
- good coupling between the feet and floor;
- manual handling activities, other than lifting, are minimal;
- the objects to be lifted are not very cold[2)] , hot or contaminated;

2) see prEN ISO 13732-3 'Ergonomics of the thermal environment – Touching of cold surfaces – Part 3: Ergonomics data and guidance for application (ISO/DIS 13732-3:2002)'

— moderate ambient thermal environment.

If one or more of these criteria are not met, method 2 applies. If all criteria are met, then select one of the following critical variables. These apply to a work shift of 8 h or less.

4.3.3.1.2.1 Critical variables

a) Critical mass (case 1)

— the load handled does not exceed 70 % of the reference mass selected from Table 1;

— vertical displacement of the load is less than or equal 25 cm and does not occur below hip or above shoulder height;

— the trunk is upright and not rotated;

— the load is kept close to the body;

— the frequency of lifts is equal to or less than $3{,}33 \times 10^{-3}$ Hz (1 lift per 5 min).

b) Critical vertical mass displacement (case 2)

— the load handled does not exceed 60 % of the reference mass selected from Table 1;

— the vertical displacement does not occur above shoulder height or below knee height;

— the trunk is upright and not rotated;

— the load is kept close to the body;

— the frequency of lifts is equal or less than $3{,}33 \times 10^{-3}$ Hz (1 lift per 5 min).

c) Critical frequency (case 3)

— the load handled does not exceed 30 % of the mass selected from Table 1;

— vertical displacement of the load is less than or equal 25 cm and does not occur below hip or above shoulder height;

— the frequency of lifts is equal or less than 0,08 Hz (5 lifts per min);

— the trunk is upright and not rotated;

— the load is kept close to the body

or

— the load handled does not exceed 50 % of the reference mass selected from Table 1;

— vertical displacement of the load is less than or equal 25 cm and does not occur below hip or above shoulder height;

— the frequency of lifts is equal or less than 0,04 (2,5 lifts per min);

— the trunk is upright and not rotated;

— the load is kept close to the body.

4.3.3.1.3 Select the action required (step 3)

If the design fits one of the operational situations (cases 1 to 3) described above, the risk assessment has been carried out successfully.

If none of the operational situations are satisfied, or any of the criteria specified in step 2 are not met, either

- consider modifying or redesign the machinery or
- use a more detailed assessment procedure to identify critical risk factors (method 2).

4.3.3.2 Method 2: Estimation by tables

4.3.3.2.1 Consider the reference mass (step 1)

Identify the intended user population and select the reference mass (M_{ref}) according to the intended user population (Table 1).

4.3.3.2.2 Carry out the risk assessment (step 2)

Identify (tick) whether the handling operation meets the following criteria:

- two-handed operation only;
- unrestricted standing posture and movements;
- handling by one person only;
- smooth lifting;
- good coupling between the feet and floor;
- manual handling activities, other than lifting are minimal;
- the objects to be lifted are not very cold, hot or contaminated;
- moderate ambient thermal environment.

If one or more of these criteria are not met, refer to method 3.

If all criteria are met, then determine the level of risk by calculating the recommended mass limit (R_{ML2}) using the multipliers provided in Table 2 and then the risk index (R_I) as follows:

$$R_I = \frac{\text{actual mass}}{R_{ML2}}$$

4.3.3.2.3 Select the action required (step 3)

- If $R_I \leq 0{,}85$, the risk may be regarded as tolerable (green).
- $0{,}85 < R_I < 1{,}0$ indicates that significant risk exists (yellow). It is recommended that:
  - method 3 is applied in order to identify how the risk may be reduced or
  - the machinery be either redesigned or
  - ensure that the risk is tolerable.

$R_I \geq 1{,}0$ means that redesign is necessary. The design can be improved by changing the situations that lead to low multipliers (red).

Calculate the recommended mass limit (R_{ML2}) for method 2 as follows:

$R_{ML2} = M_{ref} \times V_M \times D_M \times H_M \times A_M \times C_M \times F_{M,}$

whereas the reference mass (M_{ref}) is indicated in kg.

Table 2 — Multipliers for the calculation of the recommended mass limit (R_{ML2})

Vertical multiplier (V_M)							
Vertical location[3] [cm]	0	25	50	75	100	130	> 175
Multiplier	0,78	0,85	0,93	1,00	0,93	0,84	0,00
Distance multiplier (D_M)							
Vertical displacement[3] [cm]	25	30	40	50	70	100	> 175
Multiplier	1,00	0,97	0,93	0,91	0,88	0,87	0,00
Horizontal multiplier (H_M)							
Horizontal location[3] [cm]	25	30	40	50	56	60	> 63
Multiplier	1,00	0,83	0,63	0,50	0,45	0,42	0,00
Asymmetric multiplier (A_M)							
Angle of asymmetry[3] [°]	0	30	60	90	120	135	> 135
Multiplier	1,00	0,90	0,81	0,71	0,62	0,57	0,00

Coupling multiplier (C_M)			
Quality of grip	Good	Fair	Poor
Description	see annex C	see annex C	see annex C
Multiplier	1,00	0,95	0,90

Frequency multiplier (F_M)[4]

	Frequency						
Hz	0,0033	0,0166	0,0666	0,1000	0,1500	0,2000	> 0,2500
lifts/min	0,20	1	4	6	9	12	> 15
Duration (d) d ≤ 1h	1,00	0,94	0,84	0,75	0,52	0,37	0,00
1h < d ≤ 2h	0,95	0,88	0,72	0,50	0,30	0,00	0,00
2h < d ≤ 8h	0,85	0,75	0,45	0,27	0,00	0,00	0,00

3) For definition see EN 1005-1.

4) For high frequencies see prEN 1005-5.

4.3.3.3 Method 3: Calculation by formula

4.3.3.3.1 Consider the reference mass (step 1)

Identify the intended user population and

select the reference mass (M_{ref}) according to the intended user population (Table 1)

4.3.3.3.2 Carry out the risk assessment (step 2)

Identify (tick) whether the handling operation meets the following criteria:

- unrestricted standing posture and movements;
- smooth lifting;
- good coupling between the feet and floor;
- the objects to be lifted are not very cold, hot or contaminated;
- moderate ambient thermal environment.

If one or more of these criteria are not met, ensure that the risk is tolerable (see EN 614-1).

If all criteria are met, then carry out the risk estimation by calculation of the recommended mass limit (R_{ML}).

4.3.3.3.2.1 Risk estimation by calculation of the recommended mass limit (R_{ML2})

a) Case 1

Use the calculated recommended mass limit of method 2 (R_{ML2}) in the equation:

$$R_{ML} = R_{ML2} \times O_M \times P_M \times A_T$$

where:

R_{ML2} is recommended mass limit (method 2);

O_M is one handed operation, if true $O_M = 0{,}6$; otherwise $O_M = 1{,}0$;

P_M is two person operation, if true $P_M = 0{,}85$; otherwise $P_M = 1{,}0$;

A_T is the additional task multiplier, if true $A_T = 0{,}8$; otherwise $A_T = 1{,}0$.

b) Case 2

If in method 2 there are no appropriate values for vertical multiplier (V_M), distance multiplier (D_M), horizontal multiplier (H_M), asymmetric multiplier (A_M), coupling multiplier (C_M) or frequency multiplier (F_M), select a reference mass (M_{ref}) for the intended user population by referring to

Table 1 and use the following equation:

$$R_{ML} = M_{ref} \times V_M \times D_M \times H_M \times A_M \times C_M \times F_M \times O_M \times P_M \times A_T$$

the following applies:

$V_M = 1 - 0{,}003\,|V - 75|$ if $V < 0$ cm, $V_M = 0{,}78$ if $V > 175$ cm, $V_M = 0$

$D_M = 0{,}82 + 4{,}5/D$ if $D < 25$ cm, $D_M = 1$ if $D > 175$ cm, $D_M = 0$

$H_M = 25/H$ if $H < 25$ cm, $H_M = 1$ if $H > 63$ cm, $H_M = 0$

$A_M = 1 - (0{,}0032A)$ if $A > 135°$, $A_M = 0$

where:

M_{ref} is the reference mass from Table 1, in kg;

V is the vertical location, in cm;

D is the vertical displacement, in cm;

H is the horizontal location, in cm;

A is the asymmetric angle, in degrees;

C_M is the coupling multiplier from Table 2;

F_M is the frequency multiplier from Table 3.

O_M is the one hand multiplier, if true $O_M = 0{,}6$
otherwise $O_M = 1{,}0$;

P_M is the two person multiplier, if true $P_M = 0{,}85$
otherwise $P_M = 1{,}0$;

A_T is the additional task multiplier, if true = 0,8
otherwise $A_T = 1{,}0$;

Calculate the risk index (R_I) as follows:

$$R_I = \frac{\text{actual mass}}{R_{ML}}$$

4.3.3.3.3 Select the action required (step 3)

— If $R_I \leq 0{,}85$, the risk may be regarded as tolerable.

— $0{,}85 < R_I < 1{,}0$ indicates that significant risk exists. It is recommended:

  — to redesign the machinery or

  — to ensure that the risk is tolerable.

— $R_I \geq 1{,}0$ means that redesign is necessary. The design can be improved by changing the situations that lead to low multipliers.

Table 3 — Frequency multiplier (F_M)

Frequency		Frequency multiplier (F_M)					
		Work duration (d)					
		2 h < d ≤ 8 h		1 h < d ≤ 2 h		d ≤ 1 h	
Hz	lifts/min	V [a] < 75 cm	V [a] ≥ 75 cm	V [a] < 75 cm	V [a] ≥ 75 cm	V [a] < 75 cm	V [a] ≥ 75 cm
≤ 0,00333	≤ 0,2	0,85	0,85	0,95	0,95	1,00	1,00
0,00833	0,5	0,81	0,81	0,92	0,92	0,97	0,97
0,01666	1	0,75	0,75	0,88	0,88	0,94	0,94
0,03333	2	0,65	0,65	0,84	0,84	0,91	0,91
0,05000	3	0,55	0,55	0,79	0,79	0,88	0,88
0,06666	4	0,45	0,45	0,72	0,72	0,84	0,84
0,08333	5	0,35	0,35	0,60	0,60	0,80	0,80
0,10000	6	0,27	0,27	0,50	0,50	0,75	0,75
0,11666	7	0,22	0,22	0,42	0,42	0,70	0,70
0,13333	8	0,18	0,18	0,35	0,35	0,60	0,60
0,15000	9	0,00	0,15	0,30	0,30	0,52	0,52
0,16666	10	0,00	0,13	0,26	0,26	0,45	0,45
0,18333	11	0,00	0,00	0,00	0,23	0,41	0,41
0,20000	12	0,00	0,00	0,00	0,21	0,37	0,37
0,21666	13	0,00	0,00	0,00	0,00	0,00	0,34
0,23333	14	0,00	0,00	0,00	0,00	0,00	0,31
0,25000	15	0,00	0,00	0,00	0,00	0,00	0,28
>0,2500	> 15	0,00	0,00	0,00	0,00	0,00	0,00
[a] V is the vertical location							

4.4 Information for use

The designer should provide working instructions covering all phases of a machine's life (construction, transport and commissioning, use and decommissioning). These instructions should take into account the level of training of the operators.

For general aspects included in the working instructions see EN 292-2:1991, clause 5 and 1.7.4 of annex A.

The instructions (related to manual handling) should include:

a) General information

— purpose for intended use;

— information on foreseeable use;

— risks and residual risks;

— adequate warning of inherent risks;

— preventive measures to be taken by the user.

b) Intended use of the machinery

— space needed;

— storage and floor surface conditions;

— conditions to diminish discomfort, fatigue and stress;

— housekeeping;

— disposal of waste.

c) Object mass

— maximum object mass;

— consequences of handling the mass.

d) Technical equipment

— when used;

— requirements to be met during its use (with examples);

— its usage.

e) Markings

— mass, if the mass of the object is more than 25 kg, this should be marked on the machine or the object;

— mass distribution if not equally distributed;

— positioning of the mark (on object, packaging);

— signs with prohibited applications should be provided;

— signs with precautions about shifting centre of gravity;

— defective packaging material.

f) Instruction

— what technical equipment must be used and when;

— description of proper working techniques and intended working practices;

— conditions for construction, transport and commissioning, use, decommissioning, disposal and dismantling;

— prohibited applications.

The instructions should be presented in a handbook.

Annex A
(informative)

Populations characteristics and system design

A.1 Population characteristics

The table presented here applies to the general working population. This information is in accordance with measurements of maximum energetic capacity, subjective estimation of tolerability limits and objective measurements of physical capabilities[5)].

Table A.1 — Population percentages in relation to measurement criteria and the object mass

Options	Psychophysical data indicating tolerability capacity	Measurements of forces indicating limits	Measurements on the maximum metabolic ability limits
10 kg	99 % (F + M) 99 % F 99,9 % M	99 % (F + M) 99 % F 99,9 % M	99 % (F + M) 99 % F 99,9 % M
20 kg	95 % (F + M) 90 % F 99,9 % M	95 % (F + M) 90 % F 99,9 % M	95 % (F + M) 80 to 85 % F 99 % M
25 kg	85 % (F + M) 75 % F 99,9 % M	85 % (F + M) 72 to 75 % F 99,9 % M	85 % (F + M) 70 % F 99 % M
F: Female M: Male			

In addition to this table the following sub-populations have been identified as groups with an increased risk of sustaining injury: the young, the elderly, pregnant women and people with a history of back complaints. For pregnant women undertaking regularly lifting a value exceeding 5 kg is not advisable and for the young and elderly population this should not exceed 15 kg.

A.2 System design

The following interrelated aspects should be considered:

A.2.1 Avoid constrained postures

Thought should be given to the design/redesign of machines which lead to constrained working postures and monotonous work. In these circumstances discomfort and fatigue increases rapidly and muscular efficiency falls. Machinery should be designed to minimise, as far as possible, static postures.

A.2.2 Acceleration and movement accuracy

Acceleration places higher force requirements and strain on the body. Movement accuracy increases the time needed for manual handling and increases muscle effort. Accuracy of precise positioning should be supplied by the design.

5) Application of this information is limited and it is inappropriate to consider these values as safe limits. It will be the task of future research to confirm safe limits for the data contained in this standard.

A.2.3 Minimise the discomfort, fatigue and stress on the operator

Research and experience in industry has shown that preventing discomfort, fatigue and stress during physically demanding work reduces ill-health and increases output. It is important to consider three factors:

a) physiological effort required;

b) the amount of work in constrained postures;

c) the large variation in individual susceptibility to fatigue.

Annex B
(informative)

Recommended thermal comfort requirements

It is recommended to apply EN ISO 7730 for thermal comfort requirements.

The recommended limits for thermal comfort requirements during manual handling are 19 ° C to 26 °C; 30 % to 70 % humidity and air velocity ≤ 0,2 m/s.

Annex C
(informative)

Risk assessment worksheets

The risk assessment model consists of three methods increasing in the level of complexity. The first method is a quick screening procedure to assess the task. Method 2 should be applied if the screening procedure indicates risks. This method takes account of additional risk factors. It is advisable to begin the risk assessment by applying method 1 (the most simple procedure) and use methods 2 or 3 only if the assumptions or operational situations identified in method 1 are not met.

Each method requires three steps to be carried out:

Step 1: Consider the reference mass

in relation to the intended user population (see Table C.1).

Step 2: Assess the risk factors

according to the worksheet.

Step 3: Identify the action required:

— no action, if risk level is tolerable;

— redesign, if the risk level is not tolerable or check that the risk is tolerable;

— use a more complex risk assessment method.

Table C.1 — Reference mass (M_{ref}) taking into consideration the intended user population[6)]

Field of application	M_{ref} [kg]	Percentage of			Population group	
		F and M	F_{emales}	M_{ales}		
Domestic use[a]	5	Data not available			Children and the elderly	Total population
	10	99	99	99	General domestic population	
Professional use (general)[b]	15	95	90	99	General working population, including the young and old	General working population
	25	85	70	90	Adult working population	
Professional use (exceptional)[c]	30 35 40	Data not available			Special working population	Special working population

[a] When designing a machine for domestic use, 10 kg should be used as a general reference mass in the risk assessment. If children and elderly are included in the intended user population, the reference mass should be lowered to 5 kg.

[b] When designing a machine for professional use, a reference mass of 25 kg should not be exceeded in general.

[c] While every effort should be made to avoid manual handling activities or reduce the risks to the lowest possible level, there may be exceptional circumstances where the reference mass might exceed 25 kg (e.g. where technological developments or interventions are not sufficiently advanced). Under these special conditions other measures have to be taken to control the risk according to EN 614-1 (e.g. technical aids, instructions and / or special training for the intended operator group).

6) Identical with Table 1.

Worksheet 1

Risk assessment: Method 1 - Screening by means of critical values

EN 1005 Safety of machinery - Human physical performance -
Part 2: Manual handling of machinery and component parts of machinery

This method provides a quick screening procedure to identify whether the handling operation represent a risk to the operator(s). Step 2 requires one of three critical operational situations (cases 1 to 3) to be selected. The limiting condition is that all assumptions for handling operations are fulfilled.

Step 1: Consider the reference mass

Identify the intended user population and select the reference mass (M_{ref}) according to the intended user population (Table C.1)

Step 2: Carry out the risk assessment

Please tick the following criteria for the handling operation, if met:

- ❑ two-handed operation only
- ❑ unrestricted standing posture and movements
- ❑ handling by one person only
- ❑ smooth lifting
- ❑ good coupling between the hands and the objects handled
- ❑ good coupling between the feet and floor
- ❑ manual handling activities, other than lifting, are minimal
- ❑ the objects to be lifted are not cold, hot or contaminated
- ❑ moderate ambient thermal environment

If one or more of these criteria are not met, refer to method 2.
If all criteria are met, then select one of the following critical variables. These apply to a work shift of 8 h or less.

Case 1 *critical mass*

- ❑ the load handled does not exceed 70 % of the reference mass selected from Table C.1
- ❑ vertical displacement of the load is less or equal 25 cm and between hip and shoulder height
- ❑ the trunk is upright and not rotated
- ❑ the load is kept close to the body
- ❑ the frequency of lifts is equal to or less than 0,00333 Hz (1 lift every 5 min)

Case 2 *critical vertical mass displacement*

- ❑ the load handled does not exceed 60 % of the reference mass selected from Table C.1
- ❑ vertical displacement of the load is not above shoulder height or below knee height
- ❑ the trunk is upright and not rotated
- ❑ the load is kept close to the body
- ❑ the frequency of lifts is equal to or less than 0,00333 Hz (1 lift every 5 min)

Case 3 *critical frequency*

- ❑ the load handled does not exceed 30 % of the reference mass selected from Table C.1
- ❑ vertical displacement of the load is less or equal 25 cm and between hip and shoulder height
- ❑ the frequency of lifts is equal or less than 0,08 Hz (5 lifts every min)
- ❑ the trunk is upright and not rotated
- ❑ the load is kept close to the body

Or

- ❑ the load handled does not exceed 50 % of the reference mass selected from Table C.1
- ❑ vertical displacement of the load is less or equal 25 cm and between hip and shoulder height
- ❑ the frequency of lifts is equal or less than 0,04 Hz (2,5 lifts every min)
- ❑ the trunk is upright and not rotated
- ❑ the load is kept close to the body

Step 3: Select the action required

If the design fits one of the operational situations (cases 1 to 3) described above, the risk assessment has been carried out successfully.
If none of the operational situations are satisfied, or any of the criteria specified in step 2 are not met, either

⇒ consider modifying or redesign the machinery or
⇒ use a more detailed risk assessment procedure to identify critical risk factors (method 2).

Worksheet 2a

Risk assessment: Method 2 - Estimation by tables

EN 1005 Safety of machinery - Human physical performance -
Part 2: Manual handling of machinery and component parts of machinery

Step 1: Consider the reference mass

Identify the intended user population and select the reference mass (M_{ref}) according to the intended user population (Table C.1)

Step 2: Carry out the risk assessment

Please indicate (tick), whether the handling operation meets the following criteria:

- ❑ two-handed operation only
- ❑ unrestricted standing posture and movements
- ❑ handling by one person only
- ❑ smooth lifting
- ❑ good coupling between the feet and floor
- ❑ manual handling activities, other than lifting, are minimal
- ❑ the objects to be handled are not cold, hot or contaminated
- ❑ moderate ambient thermal environment

If one or more of these criteria are not met, refer to method 3.

If all criteria are met, then determine the level of risk by:

1. calculating the recommended mass limit (R_{ML2}) using the multipliers provided in Table C.1
2. calculating the risk index (R_I) as follows:

$$\text{risk index } (R_I) = \frac{\text{actual mass}}{R_{ML}} = \frac{\quad\text{[kg]}}{\text{[kg]}}$$

Step 3: Select the action required

- $\boldsymbol{R_I \leq 0{,}85}$ the risk may be regarded as tolerable.
- $\boldsymbol{0{,}85 < R_I < 1{,}0}$ significant risk exists. It is recommended that:
  ⇒ Method 3 is applied in order to identify how the risk may be reduced or
  ⇒ the machinery be either redesigned or
  ⇒ ensure, that the risk is tolerable.
- $\boldsymbol{R_I \geq 1{,}0}$ redesign is necessary. The design can be improved by changing the situations that lead to low multipliers.

Worksheet 2b

Risk assessment: Method 2 - Estimation by tables

EN 1005 Safety of machinery - Human physical performance -
Part 2: Manual handling of machinery and component parts of machinery

Table C.2 — Calculation of the recommended mass limit (R_{ML2})

R_{ML2} =

Reference mass (M_{ref})

Reference mass [kg] (see Table C.1)	M_{ref}

Vertical multiplier (V_M) x

Vertical location [cm]	0	25	50	75	100	130	> 175	V_M
factor	0,78	0,85	0,93	1,00	0,93	0,84	0,00	

Distance multiplier (D_M) x

Vertical displacement [cm]	25	30	40	50	70	100	> 175	D_M
factor	1,00	0,97	0,93	0,91	0,88	0,87	0,00	

Horizontal multiplier (H_M) x

Horizontal location [cm]	25	30	40	50	55	60	> 63	H_M
factor	1,00	0,83	0,63	0,50	0,45	0,42	0,00	

Asymmetric multiplier (A_M) x

angle of asymmetry [°]	0	30	60	90	120	135	> 135	A_M
factor	1,00	0,90	0,81	0,71	0,62	0,57	0,00	

Coupling multiplier (C_M) x

quality of grip	good	fair	poor	C_M
description	load length ≤ 40 cm; load height ≤ 30 cm; good handles or hand-hold cut-outs. Easy to handle loose parts and objects with wrap around grasp and without excessive wrist deviation.	load length ≤40 cm; load height ≤ 30 cm; and poor handles or hand-hold cut-outs or 90° finger flexion. Easy to handle loose parts and objects with 90° finger flexion and without excessive wrist deviation.	load length > 40 cm or; load height > 30 cm; or difficult to handle parts or sagging objects or asymmetric center of mass or unstable contents or hard to grasp object or use of gloves.	
Factor	1,00	0,95	0,90	

Frequency multiplier (F_M) dependent from work duration (d) x

		frequency							
	[Hz]	0,0033	0,0166	0,0666	0,1000	0,1500	0,2000	> 0,2500	F_M
	[lifts / min]	0,2	1	4	6	9	12	> 15	
work duration (d)	d ≤ 1 h	1,00	0,94	0,84	0,75	0,52	0,37	0,00	
	1 h < d ≤ 2 h	0,95	0,88	0,72	0,50	0,30	0,00	0,00	
	2 h< d ≤ 8 h	0,85	0,75	0,45	0,27	0,00	0,00	0,00	

=

$R_{ML2} = M_{ref} \times V_M \times D_M \times H_M \times A_M \times C_M \times F_M$	=	[kg]

Worksheet 3a

Risk assessment: Method 3 - Calculation by formula

EN 1005 Safety of machinery - Human physical performance -
Part 2: Manual handling of machinery and component parts of machinery

Step 1: Consider the reference mass

Identify the intended user population and select the reference mass (M_{ref}) according to the intended user population (Table C.1)

Step 2: Carry out the risk assessment

Please identify (tick), whether the handling operation meets the following criteria:

- ❑ unrestricted standing posture and movements;
- ❑ smooth lifting;
- ❑ good coupling between the feet and floor;
- ❑ the objects to be handled are not cold, hot or contaminated;
- ❑ moderate ambient thermal environment.

If one or more of the criteria are not met, consider ways of meeting each of the criteria, refer to clause 4 of this standard.
If all criteria are met, calculate the recommended mass limit (R_{ML}).

Case 1

If the recommended mass limit (R_{ML2}) is already known (calculated during method 2)

then calculate the recommended mass limit (R_{ML}) as follows:

$\boldsymbol{R_{ML} = R_{ML2} \times O_M \times P_M \times A_T}$ **[kg]**

where:

O_M one handed operation	if true $O_M = 0,6$	otherwise $O_M = 1,0$
P_M two person operation	if true $P_M = 0,85$	otherwise $P_M = 1,0$
A_T additional physically demanding tasks	if true $A_T = 0,8$	otherwise $A_T = 1,0$

Case 2

If the recommended mass limit (R_{ML}) has <u>not</u> been calculated

then calculate the recommended mass limit (R_{ML}) as follows:

$\boldsymbol{R_{ML} = M_{ref} \times V_M \times D_M \times H_M \times A_M \times C_M \times F_M \times O_M \times P_M \times A_T}$

the following definitions apply:

$V_M = 1 - 0,003 \lvert V - 75 \rvert$	if $V < 0$ cm, $V_M = 0,78$	if $V > 175$ cm, $V_M = 0$
$D_M = 0,82 + 4,5/D$	if $D < 25$ cm, $D_M = 1$	if $D > 175$ cm, $D_M = 0$
$A_M = 1 - (0,0032A)$		if $A > 135°$, $A_M = 0$
$H_M = 25/H$	if $H < 25$ cm, $H_M = 1$	if $H > 63$ cm, $H_M = 0$

M_{ref}	the reference mass from Table C.1, in kg		
V	vertical location of the load, in cm		
D	vertical displacement of the load, in cm		
H	horizontal location of the load, in cm		
A	angle of asymmetry, in degree		
C_M	coupling multiplier from Table C.1		
F_M	frequency multiplier from Table C.2		
O_M	one handed operation	if true $O_M = 0,6$	otherwise $O_M = 1,0$
P_M	two person operation	if true $P_M = 0,85$	otherwise $P_M = 1,0$
A_T	additional physically demanding tasks	if true $A_T = 0,8$	otherwise $A_T = 1,0$

calculate the risk index (R_I) as follows:

$$\text{risk index } (R_I) = \frac{\text{actual mass}}{R_{ML}} = \frac{\quad}{\quad} \frac{[\text{kg}]}{[\text{kg}]}$$

Step 3: Select the action required

- $\boldsymbol{R_I \leq 0,85}$ the risk may be regarded as tolerable.
- $\boldsymbol{0,85 < R_I < 1,0}$ significant risk exists. It is recommended to:
  - ⇒ redesign the machinery or
  - ⇒ ensure, that the risk is tolerable.
- $\boldsymbol{R_I \geq 1,0}$ redesign is necessary. The design can be improved by changing the situations that lead to low multipliers.

Worksheet 3b

Risk assessment: Method 3 - Calculation by formula

EN 1005 Safety of machinery - Human physical performance -

Part 2: Manual handling of machinery and component parts of machinery

Table C.3 — Coupling multiplier (CM)

quality of grip	good	fair	poor
description	load length ≤ 40 cm; load height ≤ 30 cm; good handles or hand-hold cut-outs. Easy to handle loose parts and objects with wrap around grasp and without excessive wrist deviation.	load length ≤ 40 cm; load height ≤ 30 cm; and poor handles or hand-hold cut-outs or 90° finger flexion. Easy to handle loose parts and objects with 90° finger flexion and without excessive wrist deviation.	load length > 40 cm or; load height > 30 cm; or difficult to handle parts or sagging objects or asymmetric center of mass or unstable contents or hard to grasp object or use of gloves.
factor	1,00	0,95	0,90

Table C.4 — Frequency multiplier (FM)

frequency		work duration *d*					
		2 h < *d* ≤ 8 h		1 h < *d* ≤ 2 h		*d* ≤ 1 h	
[Hz]	[Lifts/minute]	*V* < 75 cm	*V* ≥ 75 cm	*V* < 75 cm	*V* ≥ 75 cm	*V* < 75 cm	*V* ≥ 75 cm
≤ 0,00333	≤ 0,2	0,85	0,85	0,95	0,95	1,00	1,00
0,00833	0,5	0,81	0,81	0,92	0,92	0,97	0,97
0,01666	1	0,75	0,75	0,88	0,88	0,94	0,94
0,03333	2	0,65	0,65	0,84	0,84	0,91	0,91
0,05000	3	0,55	0,55	0,79	0,79	0,88	0,88
0,06666	4	0,45	0,45	0,72	0,72	0,84	0,84
0,08333	5	0,35	0,35	0,60	0,60	0,80	0,80
0,10000	6	0,27	0,27	0,50	0,50	0,75	0,75
0,11666	7	0,22	0,22	0,42	0,42	0,70	0,70
0,13333	8	0,18	0,18	0,35	0,35	0,60	0,60
0,15000	9	0,00	0,15	0,30	0,30	0,52	0,52
0,16666	10	0,00	0,13	0,26	0,26	0,45	0,45
0,18333	11	0,00	0,00	0,00	0,23	0,41	0,41
0,20000	12	0,00	0,00	0,00	0,21	0,37	0,37
0,21666	13	0,00	0,00	0,00	0,00	0,00	0,34
0,23333	14	0,00	0,00	0,00	0,00	0,00	0,31
0,25000	15	0,00	0,00	0,00	0,00	0,00	0,28
>0,2500	>15	0,00	0,00	0,00	0,00	0,00	0,00

V is the vertical location

Annex ZA
(informative)

Relationship of this document with EC Directives

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports essential requirements of EC Directive(s):

Machinery Directive 98/37/EC amended by Directive 98/79/EC

The clauses of this standard are likely to support requirements of Machinery Directive.

Compliance with this document provides one means of conforming with the specific essential requirements of the Directive concerned and associated EFTA regulations.

WARNING Other requirements and other EC Directives may be applicable to the product(s) falling within the scope of this document.

Bibliography

[1] EN 292-1, *Safety of machinery – Basic concepts, general principles for design – Part 1: Basic terminology, methodology.*

[2] EN 547-1, *Safety of machinery – Human body measurements – Part 1: Principles for determining the dimensions required for openings for whole body access into machinery.*

[3] EN 547-2*, Safety of machinery – Human body measurements – Part 2: Principles for determining the dimensions required for access openings.*

[4] EN 547-3, *Safety of machinery – Human body measurements – Part 3: Anthropometric data.*

[5] EN 1005-3*, Safety of machinery – Human physical performance – Part 3: Recommended force limits for machinery operation.*

[6] prEN 1005-4[1)]*, Safety of machinery – Human physical performance – Part 4: Evaluation of working postures and movements in relation to machinery.*

[7] EN ISO 7730*, Moderate thermal environments – Determination of the PMV and PPD indices and specification of the conditions for thermal comfort (ISO 7730:1994).*

[8] ENV 26385, *Ergonomic principles of the design of work systems (ISO 6385:1981).*

[9] NF X 35-106-3, Safety of machinery - Human physical performance - Part 3 : Recommended force limits for machinery operation (French Version of EN 1005-3:2002)

[10] 90/269/EEC, Council Directive of 29 May 1990 on the minimum health and safety requirements for the manual handling of loads where there is a risk particularly of back injury to workers (fourth individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC)

[11] 89/391/EEC, Council Directive of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work

[12] Monroe Keyserling W.: Analysis of Manual Lifting Tasks: A Qualitative Alternative to the NIOSH Work Practices Guide, Am. Ind. Hyg. Assoc. J. 50(3):165-173 (1989)

[13] Andersson, Gunnar B.J. MD, PhD: Point of View: Evaluation of the Revised NIOSH Lifting Equation, A Cross-Sectional Epidemiologic Study, Spine 1999 February; 24(4):395

[14] Garg, Arun: An Evaluation of the NIOSH Guidelines for Manual Lifting, with Special Reference to Horizontal Distance, Am. Ind. Hyg. Assoc. J. 50(3):157-164 (1989)

[15] Waters, Thomas R. PhD; Baron, Sherry L. MD, MPH; Piacitelli, Laurie A. MS; Andersen, Vern P. PhD; Skov, Torsten PhD; Haring-Sweeney, Marie PhD; Wall, David K. MAS; Fine, Lawrence J. MD, DrPH: Evaluation of the Revised NIOSH Lifting Equation, Spine 1999 February; 24(4):386-394

[16] Guideline on Safety and Health Protection during manual handling. Special edition 9 and 43 of the Series of the Federal Institute of Occupational Medicine. Berlin 1994 and 1997

[17] Scientific support documentation for the revised 1991 Lifting Equation: Technical contract reports. National Institute for Occupational Safety and Health, Cincinnati, OH; May 1991; U.S. Department of Commerce, National Technical Information Service, Springfield, VA 22161

[18] Applications manual for the revised NIOSH Lifting Equation. U.S. Department of Health and Human Services, Public Health Service, Centres for Disease Control and Prevention, National Institute for Occupational Safety and Health, Cincinnati, OH 45226, January 1994

[19] Directorate of the Danish National Labour Inspection Service for machinery, Heavy lifts "backaches" compendium[7)] , Copenhagen, 1986

[20] EN 614-2, *Safety of machinery - Ergonomic design principles - Part 2: Interactions between the design of machinery and work tasks.*

7) Address: Landskronagade 33-35, 2100 Copenhagen, Denmark.

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001. Email: orders@bsi-global.com. Standards are also available from the BSI website at http://www.bsi-global.com.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: +44 (0)20 8996 7111. Fax: +44 (0)20 8996 7048. Email: info@bsi-global.com.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002. Fax: +44 (0)20 8996 7001. Email: membership@bsi-global.com.

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsi-global.com/bsonline.

Further information about BSI is available on the BSI website at http://www.bsi-global.com.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL