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INTELLIGENT DEVICES FOR HANDLING

Ergonomics

Machinery Directive

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This ***E.***U. ***directive***, issued under the principle of free trade in goods among E.U. member countries, is primarily aimed at designers and manufacturers of machinery and equipment and tends to ensure acceptable and uniform levels of safety and health protection for users. According to it, newly designed machines, or "old" machines that undergo changes in construction or intended use, ***must comply with a set of safety and ergonomic requirements*** established in principle by the same standard and *concretely* by a series of so-called ***"harmonized norms"*** *(or standards)* issued, under an E.U. mandate, by CEN (European Committee for Standardization).

Harmonized Standards

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The CEN (European Committee for Standardization) technical committee dealing with Ergonomics has the initials CEN TC 122. At present, this ergonomics technical committee has activated 10 working groups (WGs)

CEN TC 122 Ergonomics - working groups (WGs).

1. ANTHROPOMETRY
2. GENERAL PRINCIPLES
3. CONTACT TEMPERATURES
4. BIOMECHANICS
5. VIDEO TERMINALS
6. SIGNALS/COMMANDS
7. COMMUNICATIONS
8. PROTECTIVE MEANS
9. MOBILE MACHINES
10. MICROCLIMA

Ergonomically designing work systems and machinery means improving safety, human work efficiency and promoting better living and working conditions. Good ergonomic design also favorably affects work systems and the reliability of the human operator placed within them.

EU standards related to ergonomics

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STANDARDS	NUMBERS
Principles for ergonomic design: interaction between machine and task design.	EN 614-2
Anthropometric data: criteria and measurements	EN ISO 7250 EN 547(-1)(-2)-3
Anthropometric requirements for the design of workplaces at machines. Manual handling of loads at machines (NIOSH method).	EN ISO 14738
Recommended force limits in operations performed on machines.	EN 1005-2
Evaluation of work postures and movements in relation to machine use. High-frequency repetitive movements in relation to machine use.	EN 1005-3 EN 1005-4 pr EN 1005-5

EN 547 parts 1-2-3; ISO EN 7250

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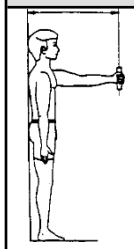
A set of technical standards (EN 547 parts 1-2-3; ISO EN 7250) proposes the measurement criteria and specific human measures needed to calculate job sizes. The latter are based on information obtained from population groups, both male and female, that are representative of European reality. The standard stipulates that the population average should not be taken as a benchmark in the design but the 5th or 95th percentile. The table below shows some examples of anthropometric measurements as indicated by the standard

PARAMETER *(continued)*	PARAMETER DEFINITION	VALUE OF THE 5TH % (mm)	95 % VALUE (mm)
 C	Grip length in grip, front	615	
S	Forearm grip length	170	
T	Arm grip length	495	

ISO EN 14738

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The standard provides a logical procedure and dimensional parameters for the ***design of workplaces***, including industrial ***workplaces***, taking into account task characteristics and anthropometric reference data.

For each main posture selected, ***details*** are provided through special tables with ***respect to the dimensional and functional aspects of the workplace***; these details, in general, use anthropometric data (with the relative variability in the European adult population) already provided in a previous standard, and tend to guarantee the dimensions and functional capacities of at least 90 percent of the same population.

Regarding the ***sitting posture***, details are given about the optimal arrangement of working objects according to the preferred visual angles (horizontal and vertical), the preferred heights of the working surface, the characteristics of the seat, the operating areas (in the different planes of space) above the working surface for comfortable reachability of objects with the upper limbs (Tab.18.6), and the space for lower limb accommodation.

For ***seated positions at*** the ***top***, in addition to the previous details, we dwell on the characteristics of lower limb space in cases of adjustable and non-adjustable worktops, respectively.

For ***standing seated positions***, special attention is paid to the relationship between the workbench and the peculiar seat ("sit-to-stand"), the characteristics of the latter, and the space for the lower limbs.

For ***standing positions***, the details dwell on the height characteristics of the worktops in relation to the functional demand of the same and on the space for accommodation of the feet.

ISO EN 14738; EXAMPLES

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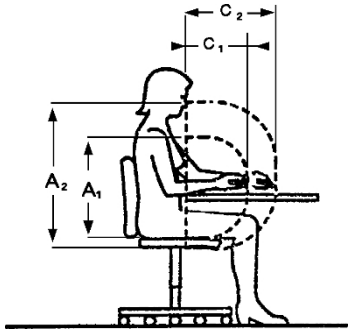
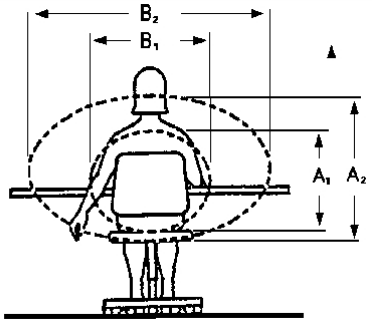
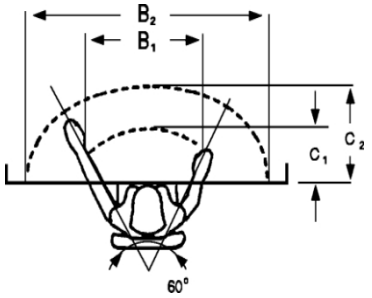
POSTURE	MEASURE	VALUE (mm)	USE OF MEASUREMENT
	A1	505	normal work area : height
	A2	730	maximum working area : height
	B1	480	normal work area: width
	B2	1300	maximum work area : width
	C1	170-290	normal work area: depth
	C2	415	maximum work area : depth

ISO EN 1005-2

Manual handling of loads

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For the evaluation of lifting actions, thus excluding pulling and pushing actions, European and ISO standards have adopted the evaluation models of NIOSH (National Institute of Occupational Health and Safety) USA.

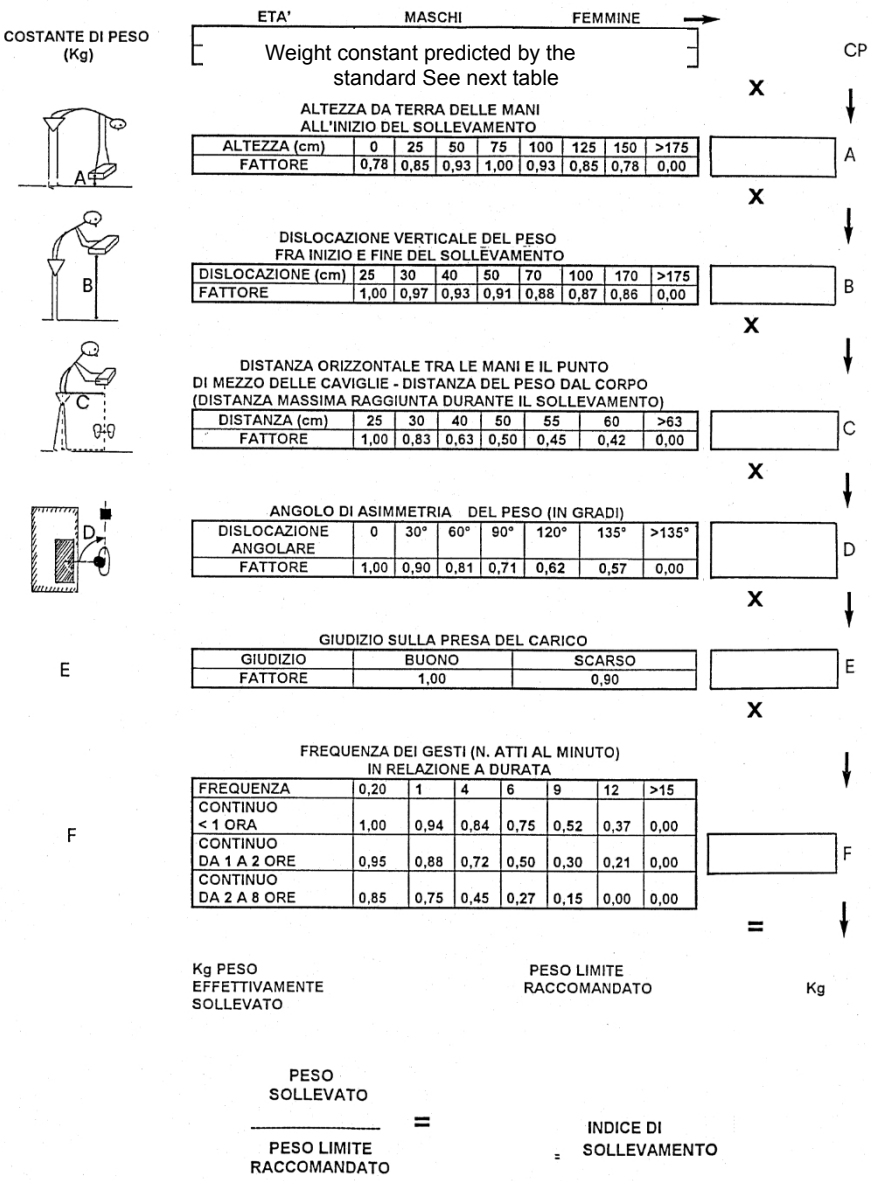
The procedure requires that, starting from a theoretical allowable weight constant, demultiplying factors are applied that take into account the particular operating conditions and associated risk

In the diagram, for each fundamental element that contributes to risk, quantitative values (qualitative in the case of the grip judgment only) that the element can take are provided and in correspondence the corresponding demultiplicative factor of the initial weight value is given.

By applying the procedure to all elements considered, the recommended weight limit in the examined context can be arrived at.

The next step is to calculate the ratio of actual weight lifted (numerator) to recommended weight limit (denominator) to obtain a summary indicator of risk.

Risk is zero for indicators below 0.85 (green area), implies machine revisiting for values between 0.85-1.0 (yellow area), requires health surveillance actions for indicator values above 1.0 (red area)



ISO EN 1005-2

Weight constants and acceptance rates in the general and working population

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Scope of application	Cost of weight kg	Percentage of Acceptability (%) M&F	F	M	Population groups	
Domestic use	5	Data not available			Children and the elderly	Total Population
	10	99	99	99	General household population	
	15	95	90	99	General working population including young and old	General working population
Professional use	**25**	85	70	90	Adult working population	
	30 35 40	Data not available			Skilled labor population	Specialized working population in particular circumstances

ISO EN 1005-3; Generalities

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The standard provides a logical procedure and parameters for determining force limits in operations performed on machines and assessing the associated risk.

The procedure involves three steps:

a) Determination of maximum force capacity (Fb)

b) Weighting against other risk factors

c) Tolerability and risk assessment

ISO EN 1005-3; step 1

Determination of maximum force capacity (Fb)

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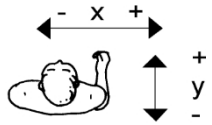
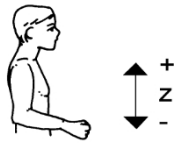
This first step involves calculating the maximum isometric force (Fb) required to perform specific actions, with reference to specific user populations. 2 alternatives are envisaged: the first uses force capacity values relative to the general European population, using, of these values, the 15th percentile for professional use and the 1st percentile for home use (Tab.18.8). The second researches (specific appendices guide this procedure) the strength capacity data of other specific population subgroups, while still deriving from them the same percentiles described earlier as reference data for professional use (15th percentile) and for home use (1st percentile). For example:

POSTURE	ACTION	PROFESSIONAL USE (Newton)	DOMESTIC USE. (Newton)
	**Hand work (one hand): grip**	250	184
	**Arm work (sitting position, a arm)**:		
	up (z, +)	50	31
	down (z, -)	75	44
	out (x, +)	55	31
	in (x, -)	75	49
	**push (y, +):**		
	with backrest	275	186
	without backrest	62	30
	pull (y, -):		
	with support	225	169
	without support	55	28

ISO EN 1005-3; step 2

Weighting against other risk factors

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- *The multiplier for speed:* if movements are very rapid, the capacity for force development is reduced. $_{Fb}$ should be multiplied by a reduction factor if there are obvious high-speed movements, according to the following scheme:

NO	YES	High speed
1,0	0,8	Multiplier $_{mV}$

- *The multiplier for frequency*: the force ($_{Fb}$) should be reduced according to the action time and action frequency, according to the following scheme:

Action time (min)	≤ 0,2	0,2 - 2	2 - 20	> 20	Frequency of action [min $^{-1}$]
≤ 0,05	1.0	0.8	0.5	0.3	Multiplier $_{mF}$
> 0,05	0.6	0.4	0.2	Not applicable	

- *The multiplier for duration:* the force ($_{Fb}$) should be reduced according to the daily duration of the task, according to the following scheme:

≤ 1	1-2	2-8	Work time (in hours) with similar actions
1.0	0.8	0.5	Multiplier $_{mD}$

Therefore, the calculation of force capacity reduction is obtained by the following formula: $_{Fbr}$ = $_{Fb}$ x $_{mV}$ x $_{mF}$ x $_{mD}$

ISO EN 1005-3; step 3

Tolerability and risk assessment

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Finally, an additional multiplier($_{mR}$) is applied to the value of maximum force capacity, weighted by the factors speed, frequency and duration ($_{Fbr}$). This multiplier takes into account the existing difference between capacity and "tolerability" of an effort (capacity for physiological use of certain body tissues such as muscles, tendons, joints) and operates according to this by creating a margin of safety and therefore acceptability of the level of force required to perform actions.

This multiplier, when adopted, produces, as a consequence, three assessment zones that will guide the machine designer to a risk assessment for potential users:

RISK ZONES	mR	LEVEL OF RISK
Recommended	≤ 0,5	Negligible risk of disease
Not recommended	0,5 - 0,7	Nonnegligible risk of disease
To be avoided	> 0,7	Obvious and unacceptable risk of disease

ISO EN 1005-4

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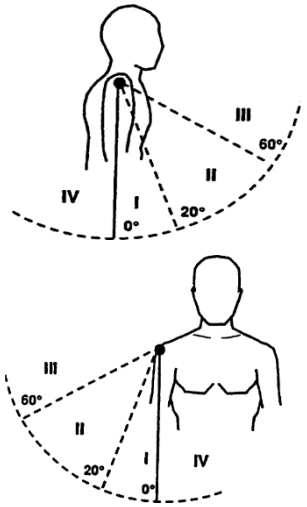
This standard, after recalling the general principles already presented about EN 614-2 and EN ISO 14738 standards, for the purpose of assessing the specific risk, adopts a zone classification to classify different postures and movements of different body districts.

For example, for evaluation of postures and flexion-extension and abduction movements of the arm with respect to the shoulder:

	STATIC POSTURE	MOVEMENTS	
		LOW FREQUENCY (<2 min.)	HIGH FREQUENCY. (>2 min.)
I°	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE
II°	CONDITION. ACCEPTABLE (A)	ACCEPTABLE	CONDITION. ACCEPTABLE (C)
III°	UNACCEPTABLE	CONDITION. ACCEPTABLE (B)	UNACCEPTABLE
IV°	UNACCEPTABLE	CONDITION. ACCEPTABLE (B)	UNACCEPTABLE



HIGH-FREQUENCY REPETITIVE MOVEMENTS IN CONNECTION WITH THE USE OF MACHINES (prEN 1005-5 And ISO/CD 11228-3)

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Both of these standards aim to assess the risk associated with repetitive upper limb movements performed at high speed. The CEN standard is referred to machine designers;
the ISO standard is aimed at anyone involved in the assessment and management of the specific risk: this accounts for slight differences in the approach of the two standards, which, however, use entirely overlapping criteria and methods.
Both standards use, virtually exclusively, the OCRA index method

L.D. 626/94
Title V

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In this Title, three articles (Nos. 47, 48, 49) and an annex transpose the EU directive substantially unchanged.

Article 47 - Scope of Application
Article 47, which defines the scope of application, clarifies in particular what is meant by actions or operations of manual handling of loads, including among them not only the more typical ones of lifting, but also the relevant ones of pushing, pulling and transporting loads that "IN CONSEQUENCE OF ERGONOMIC CONDITIONS ACHIEVE, AMONG OTHER THINGS, RISKS OF DORSO-LUMBAR INJURIES."

Art.48 - Duties of the employer
Article 48 identifies the specific obligations of the employer by outlining a precise strategy of actions. This strategy provides in the order of priority :

- The INDIVIDUATION of tasks involving manual handling potentially at risk
- MECHANIZATION of processes where there is handling of loads to eliminate risk.
- Where this is not possible, AUSILATION of the same processes and/or the adoption of appropriate organizational measures for maximum risk containment.
- The CONDITIONAL USE of manual force. In the latter case, it is first a matter of assessing the existence and extent of the risk and taking any measures to contain it
- HEALTH SURVEILLANCE (preventive and periodic health assessments) of workers engaged in residual manual handling activities.
- The INFORMATION and TRAINING (Art. 49) of the workers themselves, which, in some ways, is structured as actual training in the proper performance of the specific manual handling maneuvers, provided by the work task

Article 49 - information and training
The employer shall provide workers with information, particularly regarding (a) the weight of a load; (b) the center of gravity; and (c) the proper handling of loads and the risks workers face if these activities are not performed properly.
The employer shall ensure that workers receive appropriate training, particularly with regard to the above For

assessment techniques, it is useful to refer to the NIOSH method (ISO EN 1005-2)

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List of reportable occupational diseases