TECHNICAL REPORT

ISO/TR 12100-2

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Safety of machinery — Basic concepts, general principles for design —

Part 2 :
Technical principles and specifications

Sécurité des machines — Notions fondamentales, principes généraux de conception —
Partie 2 : Principes et spécifications techniques

Reference number
ISO/TR 12100-2 : 1992 (E)

Foreword

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The main task of ISO technical committees is to prepare International Standards. In exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

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In its resolution 6 (November 1991), Technical Committee ISO/TC 199, *Safety of machinery*, endorsed the contents of European Standard EN 292-2 : 1991 prepared by Technical Committee CEN/TC 114, *Safety of machinery*. It recommended further that this European Standard be published as an ISO Technical Report of type 2 and be implemented with the highest priority throughout ISO/IEC and publicized as widely as possible.

This document is being issued in the type 2 Technical Report series of publications (according to part 1 of the ISO/IEC Directives) as a "prospective standard for provisional application" in the field of safety of machinery because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

A review of this type 2 Technical Report will be carried out not later than three years after its publication with the options of: extension for another three years; conversion into an International Standard; or withdrawal.

ISO/TR 12100 consists of the following parts, under the general title *Safety of machinery — Basic concepts, general principles for design*:

— *Part 1: Basic terminology, methodology*

— *Part 2: Technical principles and specifications*

Annexes A, B, C and D of this part of ISO/TR 12100 are for information only.

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EUROPEAN STANDARD EN 292-2:1991

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Descriptors: Safety of machines, design, accident prevention, generalities, specifications, human factors engineering, I safety, control devices, safety devices, information, indexes (documentation)

English version

Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles and specifications

Sécurité des machines - Notions fondamentales, principes généraux de conception - Partie 2: Principes techniques et spécifications

Sicherheit von Maschinen - Grundbegriffe, allgemeine Gestaltungsleitsätze - Teil 2: Technische Leitsätze und Spezifikationen

This European Standard was approved by CEN on 1991-09-20
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 Central Secretariat 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 Central Secretariat has the same status as the official versions.

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CEN

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Foreword

This standard has been prepared by CEN/TC 114/WG 1 "Basic concepts".

Part 1 of this standard deals with "Basic terminology, methodology" (see clause 0 "Introduction" for more detailed explanations).

NOTE : At several places EN 292-2 refers to specific clauses of EN 60 204-1:1985 "Electrical equipment of industrial machines, Part 1 - General requirements".

It is important to note that this electrical standard has undergone a major revision and that a draft prEN 60 204-1 "Safety of machinery - Electrical equipment of machines, Part 1 - General requirements" should be submitted to the Unique Acceptance Procedure (UAP) in 1991. It is therefore likely that, by the time EN 292 is in use, there will be a new version of EN 60 204-1 available which should be used.

To avoid confusion in the interim period, the table below indicates the subclauses of EN 292-2 which refer to EN 60 204-1:1985 (column 1) and the corresponding subclauses of EN 60 204-1:1985 (column 2) and prEN 60 204-1:1991 (column 3).

Table 1

EN 292-2, § :	EN 60 204-1:1985, § :	prEN 60 204-1:1991, § :
3.4	5.1.2.3	6.4
3.7.11	5.4 to 5.8, 6, 7, 8	7.5 and 8 to 13
3.9	5.1 5.2 5.3	6 7.2 7.3
5.4	3.1	18
5.5.1.c)	3.2	19
6.1.1	5.6.1	9.2.5.4 and 10.7
6.2.2	5.6.2	5.3

0 Introduction

This standard has been produced to assist designers, manufacturers and other interested bodies to interpret the essential safety requirements in order to achieve conformity with European Legislation on machinery safety.

It is the first in a programme of standards produced by CEN/CENELEC u der mandates from CEC and EFTA. This programme has been divided into several categories to avoid duplication and to develop a logic which will enable rapid production of standards and easy cross-reference between standards.

The hierarchy of standards is as follows :

a) **Type A standards** (fundamental safety standards) giving basic concepts, principles for design, and general aspects that can be applied to all machinery.

b) **Type B standards** (group safety standards) dealing with one safety aspect or one type of safety related device that can be used across a wide range of machinery :

- type B1 standards on particular safety aspects (e.g. safety distances, surface temperature, noise),

- type B2 standards on safety related devices (e.g. two-hand controls, interlocking devices, pressure sensitive devices, guards).

c) **Type C standards** (machine safety standards) giving detailed safety requirements for a particular machine or group of machines.

The primary purpose of EN 292 is to provide designers, manufacturers, etc. with an overall framework and guidance to enable them to produce machines that are safe for their intended use. It also provides a strategy for standard makers producing type C standards, in conjunction with ENV .. ... "Terminology" and EN 414 "Rules for the drafting and presentation of safety standards". In addition, this strategy is also a useful guide for designers and manufacturers of machines when no C standard exists ; it can also assist designers to use the type B standards to best advantage and to prepare the construction file.

The programme of standards is continuously evolving and some clauses of EN 292 are now the subject of type A or B standards being prepared. Where such a type A or B standard exists, a reference to this standard will be added to the relevant clause heading of EN 292. **It is intended that, where another type A or a type B standard covering a specific clause of EN 292 exists, it takes precedence over EN 292.**

NOTE : In particular, any definition of term(s) given in other type A or in type B1 and B2 standards has precedence over the corresponding definition given in EN 292.

EN 292 consists of two parts :

- **Part 1** "Safety of machinery - Basic concepts, general principles for design - **Basic terminology, methodology**" expressing the basic overall methodology to be followed when producing safety standards for machinery, together with the basic terminology related to the philosophy underlying this work,

- **Part 2** "Safety of machinery - Basic concepts, general principles for design - **Technical principles and specifications**" giving advice on how this philosophy can be applied using available techniques.

The overall purpose of EN 292 is to provide manufacturers, designers, etc. with the strategy or framework necessary to achieve conformity with the European Legislation in the most pragmatic way. An essential element in this process is an understanding of the underlying legal framework, which is expressed in the essential safety requirements of the Machinery Directive and the equivalent EFTA agreements. Therefore, it has been decided to reprint annex I of the Directive 89/392/EEC as an annex to EN 292-2.

It is intended to revise EN 292 at an early date to take account of subsequent standards and legislation.

1 Scope

This European standard defines technical principles and specifications to help designers and manufacturers in achieving safety in the design of machinery (see 3.1 in EN 292-1) for professional and non-professional purposes. It may also be used for other technical products having similar hazards.

Parts 1 and 2 should be used together when considering the solution to a specific problem. They can be used independently of other documents, or as a basis for the preparation of other type A standards or type B and C standards.

EN 292-2 in conjunction with part 1 would also assist in a preliminary assessment of machines with regard to their safety, where there is no relevant type C standard available.

It is recommended that this standard is incorporated in training courses or in manuals to convey technical principles and specifications to designers, etc.

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.

EN 292-1	Safety of machinery - Basic concepts, general principles for design - Part 1 : Basic terminology, methodology
EN 294	Safety of machinery - Safety distances to prevent danger zones being reached by the upper limbs
EN 349 [1]	Safety of machinery - Minimum distances to avoid crushing of parts of the human body
EN 418 [2]	Safety of machinery - Emergency stop equipment - Functional aspects
EN.. ... [3]	Safety of machinery - Guards (fixed, movable.)
EN.. ... [4]	Safety of machinery - Two-hand control device
EN.. ... [5]	Safety of machinery - Pressure sensitive safety devices - Mats and floors

1) Draft standard submitted to CEN/CENELEC inquiry in 1991.
2) Draft standard submitted to CEN/CENELEC inquiry in 1991.
3) Draft standard prepared by CEN/TC 114/WG 11.
4) Draft standard prepared by CEN/TC 114-CLC/TC44X/JWG7.
5) Draft standard prepared by CEN/TC 114-CLC/TC44X/JWG8.

EN.. ... [6] Safety of machinery - Interlocking devices with and without guard locking - General principles and specifications for design

EN.. ... [7] Safety of machinery - Principles for the design of safety related control systems

EN.. ... [8] Safety of machinery - Safety requirements for fluid power systems and components - Hydraulics

EN.. ... [9] Safety of machinery - Safety requirements for fluid power systems and components - Pneumatics

EN.. ... [10] Safety of machinery - Electrosensitive protective devices
Part 1 : General requirements

EN.. ... [11] Safety of machinery - Ergonomic design principles
Part 1 : Terminology and general principles
Part 2 : Interaction between machinery design and work tasks

EN.. ... [12] Safety of machinery - Ergonomic requirements and data for the design of displays and control actuators
Part 1 : Human interaction with displays and control actuators
Part 2 : Displays
Part 3 : Control actuators

EN 50 020:1977/A1:1979/A2:1985 Electrical apparatus for potentially explosive atmospheres - Intrinsic safety "i"

EN 60 204-1:1985[13] Electrical equipment of industrial machines
Part 1 : General requirements

ISO 447:1984 Machine tools - Direction of operation of controls

3 Risk reduction by design

Risk reduction by design consists in following actions, used separately or combined :

- **avoiding or reducing as** many of the **hazards** as possible by suitable choice of design features (see 3.1 to 3.9), and

- **limiting persons exposure to hazards** by reducing the need for operator intervention in danger zones (see 3.10 to 3.12).

3.1 Avoiding sharp edges and corners, protruding parts, etc.

In so far as their purpose allows, accessible parts of the machinery shall have no sharp edges, no sharp angles, no rough surfaces, no protruding parts likely to cause injury, and no openings which may "trap" parts of the body or clothing. In particular, sheet metal edges shall be deburred, flanged or trimmed, open ends of tubes which may cause a "trap" shall be capped, etc.

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6) Draft standard prepared by CEN/TC 114/WG 10.
7) Draft standard prepared by CEN/TC 114-CLC/TC44X/JWG6.
8) Draft standard prepared by CEN/TC 114/WG 12.
9) Draft standard prepared by CEN/TC 114/WG 12.
10) Draft standard prepared by CLC/TC 44X/WG 2.
11) Draft standard prepared by CEN/TC 122/WG 2.
12) Draft standard prepared by CEN/TC 122/WG 6.
13) See Foreword.

3.2 Making machines inherently safe by virtue of :

- **the shape and the relative location of their mechanical component parts** ; for instance, crushing and shearing hazards are avoided by increasing the minimum space between the moving parts, such that the part of the body under consideration can enter the gap safely, or by reducing the gap so that no part of the body can enter it (see EN 349 "Minimum distances to avoid crushing of parts of the human body" and EN 294 "Safety distances to prevent danger zones being reached by upper limbs").

- **the limitation of the actuating force** to a sufficiently low value, so that the element does not generate a mechanical hazard[14],

- **the limitation of the mass and/or velocity** of the movable elements, and hence of their kinetic energy [15],

- **the limitation by design of noise and vibration,**

- etc.

3.3 Taking into account design codes, data about material properties and, in a more general way, all professional rules regarding machine design and construction (e.g. calculation rules, etc.)

a) **Mechanical stresses** :

For example :

- stress limitation by implementation of correct calculation, construction and fastening methods as regards, for example, bolted assemblies, welded assemblies, etc.,

- stress limitation by overload prevention, ("fusible" plugs, pressure-limiting valves, breakage points, torque-limiting devices, etc.),

- avoiding fatigue in elements under variable stresses (notably cyclic stresses),

- static and dynamic balancing of rotating elements.

b) **Materials** :

For example, consideration of :

- material properties,

- corrosion, ageing, abrasion and wear,

- material homogeneity,

- to..icity of materials.

14) When such a limitation does not hinder the intended function.
15) When such a limitation does not hinder the intended function.

3.4 Using inherently safe technologies, processes, power supplies

For example :

- on machines intended for use in explosive atmospheres :
  - **fully pneumatic or hydraulic control system and actuators, or**
  - **"intrinsically safe" electrical equipment** (see EN 50 020),
- **electrical supply under "functional extra-low voltage"** (see 5.1.2.3 of EN 60 204-1[16]),
- use of **fire resistant and non-toxic fluids** in hydraulic equipment of machines.

3.5 Applying the principle of the positive mechanical action of a component on another component

If a moving mechanical component inevitably moves another component along with it, either by direct contact or via rigid elements, these components are said to be **connected in the positive mode** (or **positively**). The same applies to a component which prevents any movement of another component purely by virtue of its presence.

On the contrary, where a mechanical component moves and thus allows another one to move freely (by gravity, by spring force, etc.), there is no positive mechanical action of the first one on the other one.

3.6 Observing ergonomic principles (See also draft standards prepared by CEN/TC 122 "Ergonomics" and, among others, EN .. ... "Ergonomic design principles" and EN .. ... "Ergonomic requirements and data for the design of displays and control actuators")

The observance of ergonomic principles in designing machinery contributes to increasing safety by reducing stress and physical effort of operator, and thus improving the performance and reliability of the operation, thereby reducing the probability of errors at all stages of machine use.

Note shall be taken of these principles when allocating functions to operator and machine (degree of automation) in the basic design.

Account shall be taken of body sizes likely to be found in European countries, strengths and postures, movement amplitudes, frequency of cyclic actions, to avoid hindrance, strain, physical or psychic damage.

All elements of the "operator-machine" interface such as controls, signalling or data display elements, shall be designed in such a way that **clear and unambiguous interaction between the operator and the machine** is possible.

Designers' attention is especially drawn to following ergonomic aspects of machine design :

3.6.1 Avoiding stressful postures and movements during use of the machine, maintenance, etc. (for instance by providing facilities to adjust the machine to suit the various operators, etc).

3.6.2 Adapting machines, and more especially hand-held machines, to human effort and displacement characteristics and to hand, arm, leg, ... anatomy.

16) See Foreword.

3.6.3 Avoiding as far as possible noise, vibration, thermal effects (extreme temperatures), etc.

3.6.4 Avoiding linking the operator's working rythm to an automatic succession of cycles.

3.6.5 Providing local lighting on the machine for the illumination of the working area and of adjusting, setting-up, and maintenance zones when the design features of the machine and/or its guards render inadequate the ambient lighting of normal intensity ; flicker, dazzling, shadows and stroboscopic effects shall be avoided if they may cause a risk ; if the position of the lighting source has to be adjusted, its location shall be such that it does not cause any hazard to persons making the adjustment.

3.6.6 Designing, locating and identifying manual controls (actuators) so that :

- they are clearly visible and identifiable and appropriately marked where necessary (see 5.4),

- they can be safely operated without hesitation or loss of time and without ambiguity, (e.g a standard layout of controls reduces the possibility of error when an operator changes from a machine to another one of similar type having the same pattern of operation),

- their location (for push-buttons) and their movement (for levers and handwheels) are consistent with their effect (see ISO 447).

- their operation cannot cause additional risk.

Where a control is designed and constructed to perform several different actions, namely where there is no one-to-one correspondence (e.g. keyboards, etc.), the action to be performed shall be clearly displayed and subject to confirmation where necessary.

Controls shall be so arranged that their layout, travel and resistance to operation are compatible with the action to be performed, taking account of ergonomic principles. Constraints due to the necessary or foreseeable use of personal protection equipment (such as footwear, gloves, etc.) shall be taken into account.

3.6.7 Designing and locating indicators, dials and visual display units so that :

- they fit within the parameters and characteristics of human perception,

- information displayed can be detected, identified and interpreted conveniently ; i.e. long lasting, distinct, unambiguous and understandable with respect to the operators requirements and the intended use,

- the operator is able to perceive them from the control position,

- from the main control position, the operator is able to ensure that there are no exposed persons in the danger zones ; if this is impossible, the control system shall be designed and constructed so that an acoustic and/or visual warning signal is given whenever the machinery is about to start and so that the exposed person has the time and the means to take action to prevent the machinery starting up.

3.7 Applying safety principles when designing control systems (see also EN .. ... "Principles for the design of safety related control systems")

Insufficient attention to the design of machine control systems can lead to unforeseen and potentially hazardous machine behaviour.

Typical causes of hazardous machine behaviour are :

- an unsuitable design or a deterioration (accidental or deliberate) of the control system logic,
- a temporary or permanent defect or failure of one or several components of the control system,
- a variation or a failure in the power supply of the control system,
- a wrong design or location of controls.

Typical examples of hazardous machine behaviour are :

- unintended/unexpected start up,
- uncontrolled speed change,
- failure to stop moving parts,
- dropping or ejection of a mobile part of the machine or of a workpiece clamped by the machine,
- inhibition of safety devices.

Control systems shall be provided with the means to enable operator interventions to be carried out safely and easily ; this requires :

- systematic analysis of start and stop conditions,
- provision for specific operating modes (e.g. start-up after normal stop, restart after cycle interruption or after emergency stop, removal of the workpieces contained in the machine, operation of a part of the machine in case of a failure of a machine element, etc.),
- clear display of the faults when using an electronic control system and a visual display unit,
- taking into account the particular requirements of complex machinery.

In order to prevent **hazardous machine behaviour** and to achieve safety functions, **the design of control systems shall comply with following principles and/or methods, applied singly or combined as appropriate to the circumstances** :

3.7.1 The primary action for starting or accelerating the movement of a mechanism should be performed by application or increase of voltage or fluid pressure, or, if binary logic elements are considered, by passage from state 0 to state 1 (if state 1 represents the highest energy state).

On the contrary, the primary action for **stopping or slowing-down** shall be performed by **removal or reduction of voltage or fluid pressure**, or, if binary logic elements are considered, by passage from state 1 to state 0 (if state 1 represents the highest energy state).

3.7.2 The spontaneous restart of a machine when it is re-energized after power interruption, if such a restart may generate a hazard, shall be prevented (for instance, by use of a self-maintained relay, contactor or valve).

3.7.3 **Component reliability considered as the basis of the integrity of the safety functions** : this principle is applied whenever, in order to fulfil a function, the miscarriage of which would compromise safety (safety function), components are used which are able to withstand all disturbances and stresses associated with the usage of the equipment in the conditions of intended use, for the period of time fixed for the use, without failures generating a hazardous malfunctioning of the machine.

NOTE : Environmental stresses which are to be taken into consideration are, for instance : impact, vibration, cold, heat, moisture, dust, aggressive substances, static electricity, magnetic and electric fields.

Disturbances which may be generated by those stresses are, for instance : insulation failures, temporary or permanent failures in the function of control system components.

See also 3.10

3.7.4 **Use of "oriented failure mode" components or systems**, i.e. of components or systems the predominant failure mode of which is known in advance, and always the same.

3.7.5 **Duplication (or redundancy) of "critical" components** : other components than well-tried (inherently safe) components may be used to perform a safety function, provided that, in case of failure of one component, another one (or others) can further on perform this function, thus affording the required level of safety. It is then essential to provide for **automatic monitoring** (see 3.7.6 hereunder) in combination **with diversity of design and/or technology** to avoid common cause failures (e.g. from electromagnetic disturbance). In this case, the risk of failure to danger is greatly reduced (one gets closer to a fail-safe condition), because a hazardous situation appears only if both (or all) critical elements fail during the same cycle.

3.7.6 **Automatic monitoring**

Automatic monitoring ensures that a safety measure is initiated if the ability of a component or an element to perform its function is diminished, or if the process conditions are changed in such a way that hazards are generated.

The safety measures may be :

- the stopping of the hazardous process,
- preventing the re-start of this process after the first stop following the occurrence of the failure in the component or element,
- the triggering of an alarm.

3.7.7 Safeguarding safety functions in re-programmable control systems

Systems intended to be capable of re-programming present additional safety problems. Such systems include :

- disc, cam or drum arrangements operating switches, valves or linkages,
- selector switches or valves affecting otherwise "hardware based logic",
- card readers,
- punch tape readers,
- magnetic tapes or discs,
- electronic or optical storage.

When such arrangements are used in a safety critical control system, care shall be taken to provide reliable means which prevent inadvertent or deliberate alteration of the stored program. Such means can include :

- pinned cams,
- embedded software, e.g. read only memory (ROM),
- locks restricting access,
- password access to software.

NOTE : Fault-finding systems should be used to check errors resulting from reprogramming, whenever possible.

3.7.8 Principles relating to manual control

a) Manual controls (actuators) shall be designed and located according to the relevant ergonomic principles (see 3.6.6).

b) A stop control shall be placed near each start control. Where the start/stop function is performed by means of a hold-to-run control, a separate stop control shall be provided if a risk may result from the hold-to-run control failing to deliver a stop command when released.

c) Controls shall be located outside the danger zones, except for certain controls where, of necessity, they are located within a danger zone, such as emergency stop, teach pendant, etc.

d) As far as possible, controls (especially start controls) shall be located so that the operator, when actuating them, can see the controlled elements.

e) If it is possible to start the same hazardous element by means of several controls, the control circuit shall be so arranged, that only one control is effective at a given time. This applies especially to machines which can be manually controlled by means, among others, of a portable control unit (teach pendant, for instance), with which the operator may enter danger zones. This does not apply to two-hand control devices (see 3.23.4 in EN 292-1).

f) Controls shall be designed or protected so that their effect, where a risk is involved, cannot occur without intentional operation.

3.7.9 Selection of control and operating modes

If machinery has been designed and built to allow for its use in several control or operating modes presenting different safety levels (e.g. to allow for adjustment, maintenance, inspection, etc.), it shall be fitted with a mode selector which can be locked in each position. Each position of the selector shall correspond to a single operating or control mode.

The selector may be replaced by another selection means which restricts the use of certain functions of the machinery to certain categories of operator (e.g. access codes for certain numerically controlled functions, etc.).

3.7.10 Control mode for setting, teaching, process changeover, fault-finding, cleaning or maintenance

Where, for setting, teaching, process changeover, fault-finding, cleaning or maintenance of machinery, a guard has to be displaced or removed and/or a safety device has to be neutralized, and where it is necessary for the purpose of these operations for the machinery to be put in operation, safety of the operator shall be achieved, where practicable, using a manual control mode which simultaneously :

- disables the automatic control mode (this implies, among others, that no hazardous operation may result from any sensor changing its state),

- permits operation of the hazardous elements only by triggering an enabling device, a hold-to-run control device or a two-hand control device (see 3.23.4 in EN 292-1),

- permits operation of the hazardous elements only in enhanced safety conditions (e.g. reduced speed, reduced power/force, step-by-step - e.g. with a limited movement control device (see 3.23.8 in EN 292-1) - or other adequate provision) while preventing risks from linked sequences.

This control mode shall be associated with some of following measures :

- restriction of access to the danger zone as far as possible,

- emergency stop control within immediate reach of the operator,

- portable control unit (teach pendant) and/or local controls allowing sight of the controlled elements.

3.7.11 **Other standardized measures for the design of electrical** (electromechanical and electronic) **control systems with a view to preventing hazardous malfunctioning**

For **all machines**, electromagnetic compatibility of electronic equipment shall comply with the relevant standards.

For **industrial machines**, EN 60 204-1[17] deals with control system design, especially in 5.4 to 5.8, 6, 7 and 8.

3.8 **Preventing hazards from pneumatic and hydraulic equipment** (see also EN .. ... "Safety requirements for fluid power systems and components - Hydraulics" and EN .. ... "Safety requirements for fluid power systems and components - Pneumatics")

Pneumatic and hydraulic equipment of machinery shall be so designed that :

- the maximum allowed pressure cannot be exceeded in the circuits (e.g. by means of pressure limiting devices),

- no hazard may result from pressure losses, pressure drops or losses of vacuum,

- no hazardous fluid jet may result from leakages or component failures,

- air receivers, air reservoirs or similar vessels (such as in hydro-pneumatic accumulators) comply with the design rules for these elements,

- all elements of the equipment, and especially pipes and hoses, be protected against harmful external effects,

- as far as possible, reservoirs and similar vessels (e.g. hydro-pneumatic accumulators) be automatically depressurized when isolating the machine from its power supply (see 6.2.2) and, if it is not possible, means be provided for their isolation and/or local depressurizing and pressure indication,

- all elements which may remain under pressure after isolation of the machine from its energy supply be provided with clearly identified exhaust devices, and a warning label drawing attention to the necessity of depressurizing those elements before any setting or maintenance activity on the machine.

3.9 **Preventing electrical hazard**

For the design of the electrical equipment of industrial machines, EN 60 204-1[18] indicates general specifications especially in :

- sub-section 5.1, dealing with the prevention of electric shock,

- sub-section 5.2, dealing with the protection against short-circuits,

- sub-section 5.3, dealing with the protection against overloading.

17) See Foreword.
18) See Foreword.

3.10 Limiting exposure to hazards through reliability of equipment

Increased reliability of all component parts of machinery reduces the frequency of incidents requiring rectification, thereby reducing exposure to hazards.

This applies to power systems (operating part) as well as to control systems, to safety functions as well as to other functions of machinery.

Safety-critical components (as, for instance, certain sensors) with a known reliability shall be used.

The elements of guards and of safety devices shall be particularly reliable, as their failure can expose persons to hazards, and also as poor reliability would encourage attempts to defeat them.

See also 3.7.3.

3.11 Limiting exposure to hazards through mechanization or automation of loading (feeding)/unloading (removal) operations

Mechanization and automation of machine loading/unloading operations and more generally of handling operations (of workpieces, materials, substances, etc.) limit the risk generated by these operations by reducing persons exposure to hazards at the operating points.

Automation can be achieved e.g. by robots, handling devices, transfer mechanisms, push rods, air blast, etc.. Mechanization can be achieved e.g. by feeding slides, hand-operated indexing tables, etc..

While automatic feeding and removal devices have much to offer in preventing accidents to machine operators, they can create danger when any faults are being rectified. Care shall be taken to ensure that the use of these devices does not introduce further trapping hazards between the devices and parts of the machine or materials being processed. Suitable safeguards (see clause 4) shall be provided if this cannot be ensured.

3.12 Limiting exposure to hazards through location of the setting and maintenance points outside of danger zones

The need for access to danger zones shall be minimized by locating maintenance, lubrication and setting points outside these zones.

4 Safeguarding

Safeguards (guards, safety devices) shall be used to protect persons from the hazards which cannot reasonably be avoided or sufficiently limited by design (see clause 5 in EN 292-1).

The different kinds of guards and safety devices are defined in 3.22 and 3.23 of EN 292-1.

Certain safeguards may be used to avoid exposure to more than one hazard (e.g. a fixed guard preventing access to a zone where a mechanical hazard is present being used to reduce noise level and collect toxic emissions).

4.1 Selection of guards and safety devices

4.1.1 General

This clause gives guidelines for the selection of guards and safety devices the primary purpose of which is safeguarding against hazards generated by moving parts, according to the **nature of those parts** (see table 2) and to the **need for access to the danger zone(s)** (see 4.1.2 to 4.1.4).

The exact choice of a safeguard for a particular machine shall be made on the basis of the risk assessment for that machine, and the chosen safeguard shall be described in detail in a "C" standard.

In selecting an appropriate safeguard for a particular type of machinery or danger zone, it shall be borne in mind that a fixed guard is simple, and shall be used where access of an operator to the danger zone is not required during normal operation (operation without any malfunction) of the machinery.

As the need for access increases in frequency, the inconvenience resulting from removing and putting back in place a fixed guard increases until it is such that, for example, an interlocking movable guard or trip device should be used.

NOTE 1 : A combination of safeguards may sometimes be required. For example, where, in conjunction with a fixed guard, a mechanical loading (feeding) device is employed to feed a workpiece into a machine (see 3.11), thereby removing the need for access to the primary danger zone, a trip device (see 3.23.5 in EN 292-1) may be required to protect against the secondary drawing-in or shearing hazard between the mechanical loading (feeding) device, when reachable, and the fixed guard.

NOTE 2 : For danger zones generated by moving parts, table 2 provides specific guidelines.

4.1.2 Where access of an operator to the danger zone is not required during normal operation

Where access to the danger zone is not required during normal operation of the machinery, safeguards should be selected from the following :

a) **Fixed guard** (see 3.22.1 in EN 292-1), including, where necessary, feeding and take-off devices (see 3.11), a false table, a barrier of adequate height, a tunnel guard, etc. Openings in the guard shall be in accordance with EN 294 "Safety distances to prevent danger zones being reached by upper limbs".

b) **Interlocking guard** (see 3.22.4 and 3.22.5 in EN 292-1).

c) **Self-closing guard.**

d) **Trip device** (see 3.23.5 in EN 292-1), including a sensitive screen or barrier - e.g. photo-electric device - or a pressure sensitive mat.

NOTE : For danger zones generated by moving parts, table 2 provides specific guidelines.

4.1.3 Where access to the danger zone is required during normal operation

Where access to the danger zone is required during normal operation of the machinery, safeguards should be selected from the following :

a) **Interlocking guard** (see 3.22.4 and 3.22.5 in EN 292-1)

b) **Trip device** (see 3.23.5 in EN 292-1).

c) **Adjustable guard** (see 3.22.3 in EN 292-1).

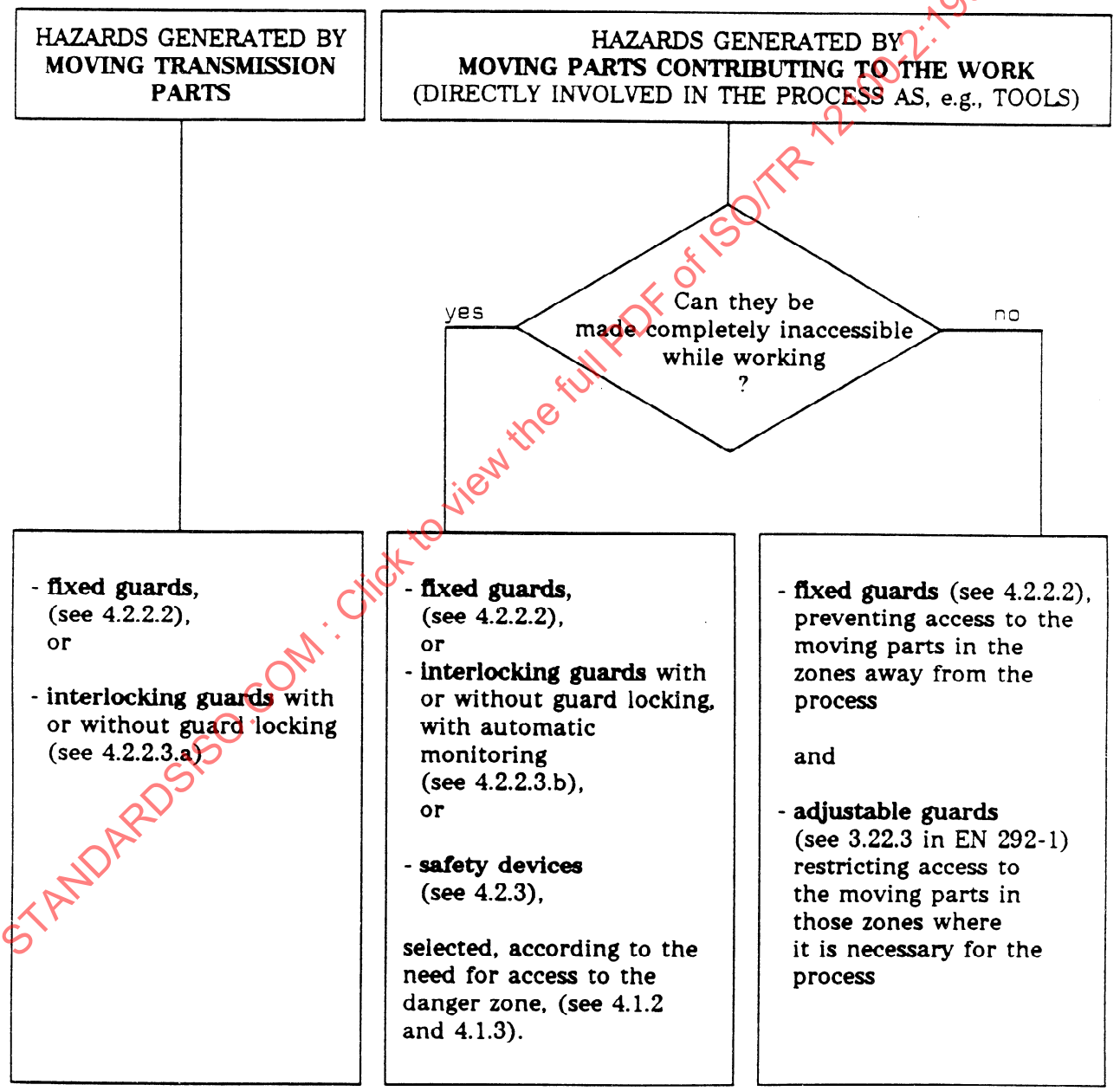
d) **Self-closing guard.**

e) **Two-hand control device** (see 3.23.4 in EN 292-1) : care shall be taken in selecting this device, as it protects generally only the person operating the controls and does not prevent others in the vicinity from gaining access to the dangerous zones.

f) **Control guard** (see 3.22.6 in EN 292-1 and 4.2.2.5 hereafter).

NOTE : For danger zones generated by moving parts, table 2 provides specific guidelines.

Table 2 - Guidelines to help make the choice of safeguards against hazards generated by moving parts



4.1.4 Where access to the danger zone is required for machine setting, teaching, process changeover, fault finding, cleaning or maintenance

As far as possible, machines shall be designed so that the safeguards provided for the protection of the production operator may ensure also safety of personnel in charge of setting, teaching, etc., without hindering them in performing their task.

When this is not possible (e.g. when it is necessary to remove fixed guards or to make safety devices ineffective, with operation of the machine still possible), the machine shall be provided with appropriate means reducing the risk as much as possible and using manual control as mentioned in 3.7.10.

NOTE : Isolation and energy dissipation for machine shut-down (see 6.2.2) ensure the highest level of safety when carrying out tasks (especially maintenance and repair tasks) which do not require the machine to remain connected to its power supply.

4.2 Requirements for the design and construction of guards and safety devices (see also EN .. ... "Guards (fixed, movable.)", EN .. ... "Principles for the design of safety related control systems", EN .. ... "Two-hand control device", EN .. ... "Pressure sensitive safety devices - Mats and floors", EN .. ... "Interlocking devices with and without guard locking ", EN .. ... "Electrosensitive protective devices").

4.2.1 General requirements

In designing safeguards, the types of guard and of safety device and their methods of construction shall be selected to take account of the mechanical and other hazards involved. Guards and safety devices shall be compatible with the working environment of the machine and designed so that they cannot be easily defeated. They shall provide the minimum possible interference with activities during operation and other phases of machine life, in order to reduce any incentive to defeat them.

Guards and safety devices shall :

- be of robust construction,
- not give rise to any additional hazard,
- not be easy to by-pass or render non-operational,
- be located at an adequate distance from the danger zone (see EN 294),
- cause minimum obstruction to the view of the production process,
- enable essential work to be carried out on installation and/or replacement of tools and also for maintenance by restricting access only to the area where the work has to be done, if possible without the guard or safety device having to be removed.

4.2.2 Requirements for guards

4.2.2.1 Guards may have to achieve following functions :

- **prevention of access** to the space enclosed by the guard, and/or

- **containment/capture** of materials, workpieces, chips, liquids, radiation, dust, fumes, gases, noise, etc., which may be ejected, dropped or emitted by the machine.

Additionally, they may need to have particular properties relating to electricity, temperature, fire, explosion, vibration, visibility, etc. (see EN .. ... "Guards (fixed, movable.)").

4.2.2.2 Requirements for fixed guards

Fixed guards shall be securely held in place :

- either permanently (by welding, etc.),

- or by means of fasteners (screws, nuts, etc.) making removal/opening impossible without using tools ; where possible, they should not remain closed without their fasteners.

4.2.2.3 Requirements for movable guards

a) Movable guards against hazards generated by **moving transmission parts** shall :

- as far as possible remain fixed to the machinery (generally by means of hinges or guides) when open ,

- be interlocking guards with or without guard locking (see 3.22.4 and 3.22.5 in EN 292-1) in order to prevent moving parts starting up as long as these parts can be reached and to give a stop command whenever they are no longer closed

See also table 2.

b) Movable guards against hazards generated by **other moving parts** shall be designed and associated with the machine control system so that :

- moving parts cannot start up while they are within the operator's reach and the operator cannot reach moving parts once they have started up ; this can be achieved by interlocking guards without guard locking (see 3.22.4 in EN 292-1) or with guard locking (see 3.22.5 in EN 292-1),

- they can be adjusted only by means of an intentional action, such as the use of a tool, key, etc.,

- the absence or failure of one of their components prevents starting or stops the moving parts ; this can be achieved by automatic monitoring (see 3.14 in EN 292-1),

- protection against ejection hazard is ensured by appropriate means

See also table 2.

c) Movable guards against **other hazards** shall comply with a) and/or b) above, according to the result of the risk assessment.

4.2.2.4 Requirements for adjustable guards

Adjustable guards may be used where the danger zone cannot be completely enclosed.

They shall :

- be adjustable manually or automatically according to the type of work involved,
- be readily adjustable without the use of tools,
- reduce as far as possible the risk from ejection.

4.2.2.5 Control guards

Control guards (see 3.22.6 in EN 292-1) may be used only :

- if there is no possibility for an operator or a part of his body to stay in the danger zone or between the danger zone and the guard while the guard is closed,

and

- if opening the control guard or an interlocking guard is the only way to enter the danger zone,

and

- if the interlocking device associated with the control guard is of the highest possible reliability (as its failure may lead to an unintended/unexpected start up).

NOTE : The danger zone considered above is any zone where the operation of hazardous elements is initiated by closure of the control guard.

4.2.2.6 Hazards from guards

Care shall be taken to prevent hazards which might be generated by :

- the guard construction (sharp edges or corners, material, etc.),
- the movements of the guard (shearing or crushing zones generated by power-driven guards and by heavy guards which are liable to fall).

4.2.3 Technical characteristics of safety devices (see 3.23 in EN 292-1)

Performing a safety critical function, a safety device shall be designed according to one or several of the principles formulated in 3.7.3 to 3.7.6.

Safety devices shall be operated and connected with the control system so that they cannot be easily defeated.

The level of performance of safety devices shall be consistent with the control system into which they are integrated.

4.2.4 Provisions for alternative types of safeguards

Provisions should be made to facilitate the fitting of alternative types of safeguards on machinery where it is known that this fitting will be necessary because the work to be done on it will vary.

5 Information for use

Information for use consists of communication links, such as texts, words, signs, signals, symbols or diagrams, used separately or in combination, to convey information to the user. It is directed to professional and/or non-professional users.

The information for use is an integral part of the supply of a machine, as indicated in the definition of the design of a machine (see 3.11 in EN 292-1).

5.1 General requirements

5.1.1 Information for use shall clearly define the purpose for which the machine is intended and shall contain all directions required to ensure safe and correct use of the machine.

It shall inform and warn the users about residual risks, i.e. those which cannot be eliminated or sufficiently reduced by design and against which safeguarding is not - or not totally - effective (see 5.5 in EN 292-1).

It shall not exclude uses of the machine that can reasonably be expected from its designation and description and shall also provide adequate warning of inherent risk if the machine is used in ways other than described in the information (see 3.11 in EN 292-1).

5.1.2 Information for use shall not compensate for design deficiencies.

5.1.3 Information for use shall cover, separately or in combination, transport, commissioning (assembly, installation and adjustment), use (setting, teaching or process changeover, operation, cleaning, fault finding and maintenance of the machine), and, if necessary, de-commissioning, dismantling and disposal.

5.2 Location and nature of information for use

Depending on :

- the risk,
- the time when the information is needed by the user,
- the machine design,

it shall be decided whether the information - or parts thereof - are to be given :

- in/on the machine itself (see 5.3 and 5.4), and/or
- in accompanying documents (in particular instruction handbook), (see 5.5),

and/or what other means such as signals and warnings should be chosen.

Standardized phrases shall be considered where important messages such as warnings need to be given (see annex B "Bibliography").

5.3 Signals and warning devices

Visual signals, such as flashing lights, and audible signals such as sirens may be used to warn of an impending hazardous event such as machine start-up or overspeed.

It is essential that these signals :

- are emitted before the occurrence of the hazardous event,
- are unambiguous,
- can be clearly perceived and differentiated from all other signals used,
- can be clearly recognized by the users.

The warning devices shall be designed and located such that checking is easy. The instruction handbook shall prescribe regular checking of warning devices.

The attention of designers is drawn to the risks from "sensorial saturation" which results from too frequent emission of visual and/or acoustic signals, which may also lead to defeating the warning devices.

NOTE : Consultation of the user is often necessary.

5.4 Markings, signs (pictograms), written warnings

Machinery shall bear all markings which are necessary :

a) **For its unambiguous identification** ; at least :

- name and address of the manufacturer,
- designation of series or type,
- serial, number, if any.

b) **In order to indicate its compliance with mandatory requirements** :

- marks[19],
- written warnings (e.g. for machines which are usable in potentially explosive atmosphere).

c) **For its safe use** for example :

- maximum speed of rotating parts,
- maximum diameter of tools,
- mass (of removable parts, etc.),
- necessity of wearing personal protective equipment,
- guard adjustment data,
- frequency of inspection.

Information printed directly on the machine should be permanent and remain legible throughout the expected life of the machine.

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19) For EEC countries, EC mark, which includes the year of construction.

Signs or written warnings only saying "danger" shall not be used.

Markings, signs and written warnings shall be readily understandable and unambiguous, especially as regards the part of the function(s) of the machine which they are related to. Readily understandable signs (pictograms) shall be used in preference to written warnings.

Written warnings shall be drawn up in the language(s) of the country in which the machine is to be used and, on request, in the language(s) understood by operators.

Markings shall comply with recognized standards (see standards quoted as examples in annex B "Bibliography", particularly for pictograms, symbols, colours, etc.).

See 3.1 in EN 60 204-1[20] as regards marking of electrical equipment.

5.5 Accompanying documents (in particular : instruction handbook)

5.5.1 Contents

The instruction handbook or other written instructions (e.g. on the packaging) should contain among others :

a) **Information relating to transport, handling and storage of the machine**

For example :

- storage conditions for the machine,
- dimensions, mass value(s), position of the centre(s) of gravity,
- indications for handling (e.g. drawings indicating application points for lifting equipment).

b) **Information relating to commissioning of the machine**

For example :

- fixing/anchoring and vibration dampening requirements,
- assembly and mounting conditions,
- space needed for use and maintenance,
- permissible environmental conditions (temperature, moisture, vibration, electromagnetic radiation, etc.),
- instructions for connecting the machine to power supply (particularly about protection against electrical overloading),
- advice about waste removal/disposal,
- if necessary, recommendations about prevention measures which have to be taken by the user (special safety devices, safety distances, safety signs and signals, etc.).

20) See Foreword.

c) **Information relating to the machine itself**

For example :

- detailed description of the machine, its fittings, its guards and/or safety devices,

- comprehensive range of applications for which the machine is intended, including prohibited usages, if any, taking into account variations of the original machine if appropriate,

- diagrams (especially schematic representation of safety functions as defined in 3.13 in EN 292-1),

- data[21] about noise and vibration generated by the machine, about radiations, gases, vapours, dust emitted by it,

- data about electrical equipment (see 3.2 of EN 60 204-1[22]),

- documents attesting that the machine complies with mandatory requirements.

d) **Information relating to the use of the machine**

For example :

- description of manual controls (actuators),

- instructions for setting and adjustment,

- modes and means for stopping (especially emergency stop),

- information about the risks which could not be eliminated by the safety measures taken by the designer,

- information about particular risks which may be generated by certain applications, by the use of certain fittings, and about specific safeguards which are necessary for such applications,

- information about prohibited applications,

- instructions for fault identification and location, for repair, and for re-starting after an intervention,

- if necessary, instructions relating to personal protective equipment which is to be used and to training which is required.

21) With reference to the measuring method.
22) See Foreword.

e) **Information for maintenance**

For example :

- nature and frequency of inspections,

- instructions relating to maintenance operations which require a definite technical knowledge or particular skills and hence should be carried out exclusively by skilled persons (maintenance staff, specialists)[23],

- instructions relating to maintenance actions (replacement of parts, etc.) the execution of which does not require specific skills and hence may be carried out by users (operators, etc.),

- drawings and diagrams enabling maintenance personnel to carry out their task rationally (especially fault-finding tasks).

f) **Information relating to de-commissioning, dismantling and, as far as safety is concerned, disposal**

g) **Information for emergency situations**

For example :

- type of fire-fighting equipment to be used,

- warning about possible emission/leakage of harmful substance(s), and if possible indication of means to fight their effects.

5.5.2 **Production of the instruction handbook**

a) Type and size of **print** shall ensure the best possible legibility. Safety warnings and/or cautions should be emphasized by the use of colours, symbols and/or large print.

b) Information for use shall be given in the official **language(s)** of the country in which the machine is to be used. If more than one language is to be used, each language should be readily distinguished from the other(s), and efforts should be made to keep the translated text and the relevant illustration together.

c) Whenever possible, text should be supported by **illustrations**. Illustrations should be supplemented with written details enabling, for instance, manual controls (actuators) to be located and identified ; they should not be separated from the accompanying text, and should follow sequential operations.

d) Consideration should be given to presenting information in tabular form where this will aid understanding. **Tables** should be adjacent to the relevant text.

e) The use of **colours** should be considered, particularly in relation to components requiring quick identification.

f) When information for use is lengthy, a **table of contents** and/or an **index** should be given.

23) Maintenance instructions provided for **skilled persons** (second dash in e) and maintenance instructions provided for **unskilled persons** (third dash in e) should appear **clearly separated from each other.**

5.5.3 Advice for drafting and editing information for use

a) **Relationship to model** : the information shall clearly relate to the specific model of machine.

b) **Communication principles** : when information for use is being prepared, the communication process **"see - think - use"** should be followed in order to achieve the maximum effect and should follow sequential operations.

The questions **"how ?"** and **"why ?"** should be anticipated and the answers provided.

c) Information for use shall be as simple and as brief as possible, and should be expressed in consistent terms and units with a clear explanation of unusual technical terms.

d) When it is foreseen that a machine will be put to non-professional use, the instructions should be written in a form that is readily understood by the non-professional users.

If personal protective equipment is required for the safe use of the machine, clear advice should be given and this information shall be prominently displayed at the point of sale, e.g. on the packaging as well as on the machine.

e) **Durability and availability of the documents**

Documents giving instructions for use should be produced in durable form (i.e. they should be able to survive frequent handling by the user). It may be useful to mark them **"keep for future reference"**.

6 Additional precautions

6.1 Precautions in view of emergency situations

6.1.1 Emergency stopping device (see also EN 418 "Emergency stop equipment")

Each machine shall be fitted with one or more emergency stopping devices to enable actual or impending hazardous situations to be averted. The following exceptions apply :

- machines in which an emergency stopping device would not lessen the risk either because it would not reduce the stopping time or because it would not enable the special measures required to deal with the risk to be taken,

- hand-held portable machines and hand-guided machines.

This device shall :

- have clearly identifiable, clearly visible and quickly accessible manual controls (actuators),

- stop the dangerous process as quickly as possible, without creating additional hazards,

- where necessary, trigger or permit the triggering of certain safeguard movements.

After having been actuated, the emergency stop control shall remain engaged ; it shall be possible to disengage it only by an appropriate operation ; disengaging the control shall not restart the machinery, but only permit restarting.

More details for the design of electrical emergency stopping devices are provided by 5.6.1 of EN 60 204-1[24].

6.1.2 Precautions for the escape and rescue of trapped persons

Such precautions may consist, for example of :

- escape routes and shelters in installations generating operator-trapping hazards,
- arrangements for moving some elements by hand, after an emergency stop,
- arrangements for reversing the movement of some elements.

6.2 Equipment, systems and arrangements contributing to safety

6.2.1 Provisions for the maintainability of a machine

When designing a machine, the following maintainability factors should be taken into account :

- accessibility of internal parts,
- ease of handling and human capabilities,
- suitable choice of workplaces,
- limitation of the number of special tools and equipments,
- ease of supervision.

6.2.2 Provisions for isolation and energy dissipation

Especially with regard to their maintenance and repair, machines shall be equipped with the technical means to achieve the isolation from power supply(ies) and dissipation of stored energy as a result of following actions :

a) **Isolating** the machine from all power supplies or other services. Isolation shall be either visible (visible interruption of continuity in the power supply) or visibly ensured by permitting a check of the position of the operating control on the isolating unit, and it shall be made clear which areas of the machine are isolated.

b) If necessary (for instance on large machines or in installations), **locking** all the isolating units in the "isolated" position.

c) **Taking measures** so as to ensure, downstream of the isolating points, that there is no more :

- potential energy (e.g. electric power, fluid pressure or mechanical power which may be released),
- kinetic energy (e.g. components which can continue to move through inertia).

d) **Verifying** the effect of the measures mentioned in c) by a safe system of work

24) See Foreword.

These measures bring the machine to "zero energy state" ; isolation and energy dissipation afford a very high safety level.

The means for isolating a machine from the **electric power supply** are defined in 5.6.2 of EN 60 204-1[25].

6.2.3 Provisions for easy and safe handling of machines and their heavy component parts

Machines and their component parts which cannot be moved or transported by hand shall be provided or capable of being provided with suitable attachment devices for transport by means of lifting gear.

These attachments or provisions may be, for instance :

- standardized lifting appliances with slings, hooks, eyebolts, or tapped holes for appliance fixing,

- appliances for automatic grabbing with a lifting hook when attachment is not possible from the ground,

- guiding grooves for machines to be transported by a fork truck,

- indication, on the machine itself and on some of its removable parts, of the value of their mass expressed in kilograms (kg),

- lifting gear and appliances integrated into the machine.

Parts of machinery which can be removed manually in operation shall be provided with means for their safe removal and replacement and should be marked with weight details.

6.2.4 Provision for safe access to machinery

Machinery shall be so designed as to enable operation and all routine tasks relating to setting, maintenance, etc. to be carried out, as far as possible, by a person remaining at ground level.

Where this is not possible, machines shall have built-in platforms, stairs or other facilities to provide safe access for those tasks, but care should be taken to ensure that such platforms or stairs do not give access to danger zones of machinery. Where less frequent access is required, fixed ladders with handrails can be used.

The walking areas shall be made from materials which remain as slip resistant as practicable under working conditions and, depending on the height from the ground, suitable handrails, posts and toe boards and/or hand holds shall be provided.

In large automated installations, particular attention shall be given to safe means of access such as walkways, conveyor bridges or crossover points.

6.2.5 Provisions for stability of machines and their elements

Machines and their elements shall be designed to be stable, i.e. so that they do not fall over and are not capable of being unintentionally moved by vibration, wind pressure, impact or other foreseeable external forces, or internal dynamic forces (inertia forces, electrodynamic forces ...).

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25) See Foreword.

If this recommendation cannot be fulfilled adequately by design (e.g. by stable weight distribution), then stability shall be obtained by special safety measures. For example, movements of parts of the machine may be restricted, indicators, alarms to warn if stability is endangered, or interlocks to prevent tipping may be provided, or the machine may be securely anchored to a foundation. **Both static and dynamic stability shall be considered.** If special safety measures are required, a warning shall be provided on the machine and/or in the instruction handbook.

For some hand-held machines - e.g. portable circular saws - which make contact with the workpiece by a sole, stability during operation is conditioned by the shape and dimensions of this sole.

6.2.6 Provision of diagnostic systems to aid fault-finding and rectification

Whenever possible, diagnostic systems to aid fault finding should be included at the design stage.

Such systems not only improve availability and maintainability of machinery ; they also reduce the exposure of maintenance staff to hazards.

Annex A (informative)

Annex I of the 'Machinery Directive'

A.1 Annex I of the Council Directive of 14 June 1989 on the approximation of the laws of the Member States relating to machinery (89/392/EEC) :

Essential health and safety requirements relating to the design and construction of machinery

PRELIMINARY OBSERVATIONS

1. The obligations laid down by the essential health and safety requirements apply only when the corresponding hazard exists for the machinery in question when it is used under the conditions foreseen by the manufacturer. In any event, requirements 1.1.2, 1.7.3 and 1.7.4 apply to all machinery covered by this Directive.

2. The essential health and safety requirements laid down in this Directive are mandatory. However, taking into account the state of the art, it may not be possible to meet the objectives set by them. In this case, the machinery must as far as possible be designed and constructed with the purpose of approaching those objectives.

1. ESSENTIAL HEALTH AND SAFETY REQUIREMENTS

1.1. **General remarks**

1.1.1. *Definitions*

For the purpose of this Directive

1. 'danger zone' means any zone within and/or around machinery in which an exposed person is subject to a risk to his health or safety;
2. 'exposed person' means any person wholly or partially in a danger zone;
3. 'operator' means the person or persons given the task of installing, operating, adjusting, maintaining, cleaning, repairing or transporting machinery.

1.1.2. *Principles of safety integration*

(a) Machinery must be so constructed that it is fitted for its function, and can be adjusted and maintained without putting persons at risk when these operations are carried out under the conditions foreseen by the manufacturer.

The aim of measures taken must be to eliminate any risk of accident throughout the foreseeable lifetime of the machinery, including the phases of assembly and dismantling, even where risks of accident arise from foreseeable abnormal situations.

(b) In selecting the most appropriate methods, the manufacturer must apply the following principles, in the order given:

— eliminate or reduce risks as far as possible (inherently safe machinery design and construction),

— take the necessary protection measures in relation to risks that cannot be eliminated,

— inform users of the residual risks due to any shortcomings of the protection measures adopted, indicate whether any particular training is required and specify any need to provide personal protection equipment.

(c) When designing and constructing machinery, and when drafting the instructions, the manufacturer must envisage not only the normal use of the machinery but also uses which could reasonably be expected.

The machinery must be designed to prevent abnormal use if such use would engender a risk. In other cases the instructions must draw the user's attention to ways — which experience has shown might occur — in which the machinery should not be used.

(d) Under the intended conditions of use, the discomfort, fatigue and psychological stress faced by the operator must be reduced to the minimum possible taking ergonomic principles into account.

(e) When designing and constructing machinery, the manufacturer must take account of the constraints to which the operator is subject as a result of the necessary or foreseeable use of personal protection equipment (such as footwear, gloves, etc.).

(f) Machinery must be supplied with all the essential special equipment and accessories to enable it to be adjusted, maintained and used without risk.

1.1.3. *Materials and products*

The materials used to construct machinery or products used and created during its use must not endanger exposed persons' safety or health.

In particular, where fluids are used, machinery must be designed and constructed for use without risks due to filling, use, recovery or draining.

1.1.4. *Lighting*

The manufacturer must supply integral lighting suitable for the operations concerned where its lack is likely to cause a risk despite ambient lighting of normal intensity.

The manufacturer must ensure that there is no area of shadow likely to cause nuisance, that there is no irritating dazzle and that there are no dangerous stroboscopic effects due to the lighting provided by the manufacturer.

Internal parts requiring frequent inspection, and adjustment and maintenance areas, must be provided with appropriate lighting.

1.1.5. *Design of machinery to facilitate its handling*

Machinery or each component part thereof must:

— be capable of being handled safely,

— be packaged or designed so that it can be stored safely and without damage (e.g. adequate stability, special supports, etc.).

Where the weight, size or shape of machinery or its various component parts prevents them from being moved by hand, the machinery or each component part must:

— either be fitted with attachments for lifting gear, or

— be designed so that it can be fitted with such attachments (e.g. threaded holes), or

— be shaped in such a way that standard lifting gear can easily be attached.

Where machinery or one of its component parts is to be moved by hand, it must:

— either be easily movable, or

— be equipped for picking up (e.g. hand-grips, etc.) and moving in complete safety.

Special arrangements must be made for the handling of tools and/or machinery parts, even if lightweight, which could be dangerous (shape, material, etc.).

1.2. **Controls**

1.2.1. *Safety and reliability of control systems*

Control systems must be designed and constructed so that they are safe and reliable, in a way that will prevent a dangerous situation arising. Above all they must be designed and constructed in such a way that:

— they can withstand the rigours of normal use and external factors,

— errors in logic do not lead to dangerous situations.

1.2.2. *Control devices*

Control devices must be:

— clearly visible and identifiable and appropriately marked where necessary,

— positioned for safe operation without hesitation or loss of time, and without ambiguity,

— designed so that the movement of the control is consistent with its effect,

— located outside the danger zones, except for certain controls where necessary, such as emergency stop, console for training of robots,

— positioned so that their operation cannot cause additional risk,

— designed or protected so that the desired effect, where a risk is involved, cannot occur without an intentional operation,

— made so as to withstand forseeable strain; particular attention must be paid to emergency stop devices liable to be subjected to considerable strain.

Where a control is designed and constructed to perform several different actions, namely where there is no one-to-one correspondence (e.g. keyboards, etc.), the action to be performed must be clearly displayed and subject to confirmation where necessary.

Controls must be so arranged that their layout, travel and resistance to operation are compatible with the action to be performed, taking account of ergonomic principles. Constraints due to the necessary or foreseeable use of personal protection equipment (such as footwear, gloves, etc.) must be taken into account.

Machinery must be fitted with indicators (dials, signals, etc.) as required for safe operation. The operator must be able to read them from the control position.

From the main control position the operator must be able to ensure that there are no exposed persons in the danger zones.

If this is impossible, the control system must be designed and constructed so that an acoustic and/or visual warning signal is given whenever the machinery is about to start. The exposed person must have the time and the means to take rapid action to prevent the machinery starting up.

1.2.3. *Starting*

It must be possible to start machinery only be voluntary actuation of a control provided for the purpose.

The same requirement applies:

— when restarting the machinery after a stoppage, whatever the cause,

— when effecting a significant change in the operating conditions (e.g. speed, pressure, etc.),

unless such restarting or change in operating conditions is without risk to exposed persons.

This essential requirement does not apply to the restarting of the machinery or to the change in operating conditions resulting from the normal sequence of an automatic cycle.

Where machinery has several starting controls and the operators can therefore put each other in danger, additional devices (e.g. enabling devices or selectors allowing only one part of the starting mechanism to be actuated at any one time) must be fitted to rule out such risks.

If must be possible for automated plant functioning in automatic mode to be restarted easily after a stoppage once the safety conditions have been fulfilled.

1.2.4. *Stopping device*

Normal stopping

Each machine must be fitted with a control whereby the machine can be brought safely to a complete stop.

Each workstation must be fitted with a control to stop some or all of the moving parts of the machinery, depending on the type of hazard, so that the machinery is rendered safe. The machinery's stop control must have priority over the start controls.

Once the machinery or its dangerous parts have stopped, the energy supply to the actuators concerned must be cut off.

Emergency stop

Each machine must be fitted with one or more emergency stop devices to enable actual or impending danger to be averted. The following exceptions apply:

— machines in which an emergency stop device would not lessen the risk, either because it would not reduce the stopping time or because it would not enable the special measures required to deal with the risk to be taken,

— hand-held portable machines and hand-guided machines.

This device must:

— have clearly identifiable, clearly visible and quickly accessible controls,

— stop the dangerous process as quickly as possible, without creating additional hazards,

— where necessary, trigger or permit the triggering of certain safeguard movements.

The emergency stop control must remain engaged; it must be possible to disengage it only by an appropriate operation; disengaging the control must not restart the machinery, but only permit restarting; the stop control must not trigger the stopping function before being in the engaged position.

Complex installations

In the case of machinery or parts of machinery designed to work together, the manufacturer must so design and construct the machinery that the stop controls, including the emergency stop, can stop not only the machinery itself but also all equipment upstream and/or downstream if its continued operation can be dangerous.

1.2.5. *Mode selection*

The control mode selected must override all other control systems with the exception of the emergency stop.

If machinery has been designed and built to allow for its use in several control or operating modes presenting different safety levels (e.g. to allow for adjustment, maintenance, inspection, etc.), it must be fitted with a mode selector which can be locked in each position. Each position of the selector must correspond to a single operating or control mode.

The selector may be replaced by another selection method which restricts the use of certain functions of the machinery to certain categories of operator (e.g. access codes for certain numerically controlled functions, etc.).

If, for certain operations, the machinery must be able to operate with its protection devices neutralized, the mode selector must simultaneously:

— disable the automatic control mode,

— permit movements only by controls requiring sustained action,

— permit the operation of dangerous moving parts only in enhanced safety conditions (e.g. reduced speed, reduced power, step-by-step, or other adequate provision) while preventing hazards from linked sequences,

— prevent any movement liable to pose a danger by acting voluntarily or involuntarily on the machine's internal sensors.

In addition, the operator must be able to control operation of the parts he is working on at the adjustment point.

1.2.6. *Failure of the power supply*

The interruption, re-establishment after an interruption or fluctuation in whatever manner of the power supply to the machinery must not lead to a dangerous situation.

In particular:

— the machinery must not start unexpectedly,

— the machinery must not be prevented from stopping if the command has already been given,

— no moving part of the machinery or piece held by the machinery must fall or be ejected,

— automatic or manual stopping of the moving parts whatever they may be must be unimpeded,

— the protection devices must remain fully effective.

1.2.7. *Failure of the control circuit*

A fault in the control circuit logic, or failure of or damage to the control circuit must not lead to dangerous situations.

In particular:

— the machinery must not start unexpectedly,

— the machinery must not be prevented from stopping if the command has already been given,

— no moving part of the machinery or piece held by the machinery must fall or be ejected,

— automatic or manual stopping of the moving parts whatever they may be must be unimpeded,

— the protection devices must remain fully effective.

1.2.8. *Software*

Interactive software between the operator and the command or control system of a machine must be user-friendly.

1.3. **Protection against mechanical hazards**

1.3.1. *Stability*

Machinery, components and fittings thereof must be so designed and constructed that they are stable enough, under the foreseen operating conditions (if necessary taking climatic conditions into account) for use without risk of overturning, falling or unexpected movement.

If the shape of the machinery itself or its intended installation does not offer sufficient stability, appropriate means of anchorage must be incorporated and indicated in the instructions.

1.3.2. *Risk of break-up during operation*

The various parts of machinery and their linkages must be able to withstand the stresses to which they are subject when used as foreseen by the manufacturer.

The durability of the materials used must be adequate for the nature of the work place foreseen by the manufacturer, in particular as regards the phenomena of fatigue, ageing, corrosion and abrasion.

The manufacturer must indicate in the instructions the type and frequency of inspection and maintenance required for safety reasons. He must, where appropriate, indicate the parts subject to wear and the criteria for replacement.

Where a risk of rupture or disintegration remains despite the measures taken (e.g. as with grinding wheels) the moving parts must be mounted and positioned in such a way that in case of rupture their fragments will be contained.

Both rigid and flexible pipes carrying fluids, particularly those under high pressure, must be able to withstand the foreseen internal and external stresses and must be firmly attached and/or protected against all manner of external stresses and strains; precautions must be taken to ensure that no risk is posed by a rupture (sudden movement, high-pressure jets, etc.).

Where the material to be processed is fed to the tool automatically, the following conditions must be fulfilled to avoid risks to the persons exposed (e.g. tool breakage):

— when the workpiece comes into contact with the tool the latter must have attained its normal working conditions,

— when the tool starts and/or stops (intentionally or accidentally) the feed movement and the tool movement must be coordinated.

1.3.3. *Risks due to falling or ejected objects*

Precautions must be taken to prevent risks from falling or ejected objects (e.g. workpieces, tools, cuttings, fragments, waste, etc.).

1.3.4. *Risks due to surfaces, edges or angles*

In so far as their purpose allows, accessible parts of the machinery must have no sharp edges, no sharp angles, and no rough surfaces likely to cause injury.

1.3.5. *Risks related to combined machinery*

Where the machinery is intended to carry out several different operations with the manual removal of the piece between each operation (combined machinery), it must be designed and constructed in such a way as to enable each element to be used separately without the other elements constituting a danger or risk for the exposed person.

For this purpose, it must be possible to start and stop seperately any elements that are not protected.

1.3.6. *Risks relating to variations in the rotational speed of tools*

When the machine is designed to perform operations under different conditions of use (e.g. different speeds or energy supply), it must be designed and constructed in such a way that selection and adjustment of these conditions can be carried out safely and reliably.

1.3.7. *Prevention of risks related to moving parts*

The moving parts of machinery must be designed, built and laid out to avoid hazards or, where hazards persist, fixed with guards or protective devices in such a way as to prevent all risk of contact which could lead to accidents.

1.3.8. *Choice of protection against risks related to moving parts*

Guards or protection devices used to protect against the risks related to moving parts must be selected on the basis of the type of risk. The following guidelines must be used to help make the choice:

A. Moving transmission parts

Guards designed to protect exposed persons against the risks associated with moving transmission parts (such as pulleys, belts, gears, rack and pinions, shafts, etc.) must be:

— either fixed, complying with requirements 1.4.1 and 1.4.2.1, or

— movable, complying with requirements 1.4.1 and 1.4.2.2.A.

Movable guards should be used where frequent access is foreseen.

B. Moving parts directly involved in the process

Guards or protection devices designed to protect exposed persons against the risks associated with moving parts contributing to the work (such as cutting tools, moving parts of presses, cylinders, parts in the process of being machined, etc.) must be:

— wherever possible fixed guards complying with requirements 1.4.1 and 1.4.2.1,

— otherwise, movable guards complying with requirements 1.4.1 and 1.4.2.2.B or protection devices such as sensing devices (e.g. non-material barriers, sensor mats), remote-hold protection devices (e.g. two-hand controls), or protection devices intended automatically to prevent all or part of the operator's body from encroaching on the danger zone in accordance with requirements 1.4.1 and 1.4.3.

However, when certain moving parts directly involved in the process cannot be made completely or partially inaccessible during operation owing to operations requiring nearby operator intervention, where technically possible such parts must be fitted with:

— fixed guards, complying with requirements 1.4.1 and 1.4.2.1 preventing access to those sections of the parts that are not used in the work,

— adjustable guards, complying with requirements 1.4.1 and 1.4.2.3 restricting access to those sections of the moving parts that are strictly for the work.

1.4. **Required characteristics of guards and protection devices**

1.4.1. *General requirement*

Guards and protection devices must:

— be of robust construction,

— not give rise to any additional risk,

— not be easy to by-pass or render non-operational,

— be located at an adequate distance from the danger zone,

— cause minimum obstruction to the view of the production process,

— enable essential work to be carried out on installation and/or replacement of tools and also for maintenance by restricting access only to the area where the work has to be done, if possible without the guard or protection device having to be dismantled.

1.4.2. *Special requirements for guards*

1.4.2.1. Fixed guards

Fixed guards must be securely held in place.

They must be fixed by systems that can be opened only with tools.

Where possible, guards must be unable to remain in place without their fixings.

1.4.2.2. Movable guards

A. Type A movable guards must:

— as far as possible remain fixed to the machinery when open,

— be associated with a locking device to prevent moving parts starting up as long as these parts can be accessed and to give a stop command whenever they are no longer closed.

B. Type B movable guards must be designed and incorporated into the control system so that:

— moving parts cannot start up while they are within the operator's reach,

— the exposed person cannot reach moving parts once they have started up,

— they can be adjusted only by means of an intentional action, such as the use of a tool, key, etc.,

— the absence or failure of one of their components prevents starting or stops the moving parts,

— protection against any risk of ejection is proved by means of an appropriate barrier.

1.4.2.3. Adjustable guards restricting access

Adjustable guards restricting access to those areas of the moving parts strictly necessary for the work must:

— be adjustable manually or automatically according to the type of work involved,

— be readily adjustable without the use of tools,

— reduce as far as possible the risk of ejection.

1.4.3. *Special requirements for protection devices*

Protection devices must be designed and incorporated into the control system so that:

— moving parts cannot start up while they are within the operator's reach,

— the exposed person cannot reach moving parts once they have started up,

— they can be adjusted only be means of an intentional action, such as the use of a tool, key, etc.,

— the absence or failure of one of their components prevents starting or stops the moving parts.

1.5. **Protection against other hazards**

1.5.1. *Electricity supply*

Where machinery has an electricity supply it must be designed, constructed and equipped so that all hazards of an electrical nature are or can be prevented.

The specific rules in force relating to electrical equipment designed for use within certain voltage limits must apply to machinery which is subject to those limits.

1.5.2. *Static electricity*

Machinery must be so designed and constructed as to prevent or limit the build-up of potentially dangerous electrostatic charges and/or be fitted with a discharging system.

1.5.3. *Energy supply other than electricity*

Where machinery is powered by an energy other than electricity (e.g. hydraulic, pneumatic or thermal energy, etc.), it must be so designed, constructed and equipped as to avoid all potential hazards associated with these types of energy.

1.5.4. *Errors of fitting*

Errors likely to be made when fitting or refitting certain parts which could be a source of risk must be made impossible by the design of such parts or, failing this, by information given on the parts themselves and/or the housings. The same information must be given on moving parts and/or their housings where the direction of movement must be known to avoid a risk. Any further information that may be necessary must be given in the instructions.

Where a faulty connection can be the source of risk, incorrect fluid connections, including electrical conductors, must be made impossible by the design or, failing this, by information given on the pipes, cables, etc. and/or connector blocks.

1.5.5. *Extreme temperatures*

Steps must be taken to eliminate any risk of injury caused by contact with or proximity to machinery parts or materials at high or very low temperatures.

The risk of hot or very cold material being ejected should be assessed. Where this risk exists, the necessary steps must be taken to prevent it or, if this is not technically possible, to render it non-dangerous.

1.5.6. *Fire*

Machinery must be designed and constructed to avoid all risk of fire or overheating posed by the machinery itself or by gases, liquids, dusts, vapours or other substances produced or used by the machinery.

1.5.7. *Explosion*

Machinery must be designed and constructed to avoid any risk of explosion posed by the machinery itself or by gases, liquids, dusts, vapours or other substances produced or used by the machinery.

To that end the manufacturer must take steps to:

— avoid a dangerous concentration of products,

— prevent combustion of the potentially explosive atmosphere,

— minimize any explosion which may occur so that it does not endanger the surroundings.

The same precautions must be taken if the manufacturer foresees the use of the machinery in a potentially explosive atmosphere.

Electrical equipment forming part of the machinery must conform, as far as the risk from explosion is concerned, to the provision of the specific Directives in force.

1.5.8. *Noise*

Machinery must be so designed and constructed that risks resulting from the emission of airborne noise are reduced to the lowest level taking account of technical progress and the availability of means of reducing noise, in particular at source.

1.5.9. *Vibration*

Machinery must be so designed and constructed that risks resulting from vibrations produced by the machinery are reduced to the lowest level, taking account of technical progress and the availability of means of reducing vibration, in particular at source.

1.5.10. *Radiation*

Machinery must be so designed and constructed that any emission of radiation is limited to the extent necessary for its operation and that the effects on exposed persons are non-existent or reduced to non-dangerous proportions.

1.5.11. *External radiation*

Machinery must be so designed and constructed that external radiation does not interfere with its operation.

1.5.12. *Laser equipment*

Where laser equipment is used, the following provisions should be taken into account:

— laser equipment on machinery must be designed and constructed so as to prevent any accidental radiation,

— laser equipment on machinery must be protected so that effective radiation, radiation produced by reflection or diffusion and secondary radiation do not damage health,

— optical equipment for the observation or adjustment of laser equipment on machinery must be such that no health risk is created by the laser rays.

1.5.13. *Emissions of dust, gases, etc.*

Machinery must be so designed, constructed and/or equipped that risks due to gases, liquids, dust, vapours and other waste materials which it produces can be avoided.

Where a hazard exists, the machinery must be so equipped that the said substances can be contained and/or evacuated.

Where machinery is not enclosed during normal operation, the devices for containment and/or evacuation must be situated as close as possible to the source emission.

1.6. **Maintenance**

1.6.1. *Machinery maintenance*

Adjustment, lubrication and maintenance points must be located outside danger zones. It must be possible to carry out adjustment, maintenance, repair, cleaning and servicing operations while machinery is at a standstill.

If one or more of the above conditions cannot be satisfied for technical reasons, these operations must be possible without risk (see 1.2.5).

In the case of automated machinery and, where necessary, other machinery, the manufacturer must make provision for a connecting device for mounting diagnostic fault-finding equipment.

Automated machine components which have to be changed frequently, in particular for a change in manufacture or where they are liable to wear or likely to deteriorate following an accident, must be capable of being removed and replaced easily and in safety. Access to the components must enable these tasks to be carried out with the necessary technical means (tools, measuring instruments, etc.) in accordance with an operating method specified by the manufacturer.

1.6.2. *Access to operating position and servicing points*

The manufacturer must provide means of access (stairs, ladders, catwalks, etc.) to allow access in safety to all areas used for production, adjustment and maintenance operations.

Parts of the machinery where persons are liable to move about or stand must be designed and constructed to avoid falls.

1.6.3. *Isolation of energy sources*

All machinery must be fitted with means to isolate it from all energy sources. Such isolators must be clearly identified. They must be capable of being locked if reconnection could endanger exposed persons. In the case of machinery supplied with electricity through a plug capable of being plugged into a circuit, separation of the plug is sufficient.

The isolator must be capable of being locked also where an operator is unable, from any of the points to which he has access, to check that the energy is still cut off.

After the energy is cut off, it must be possible to dissipate normally any energy remaining or stored in the circuits of the machinery without risk to exposed persons.

As an exception to the above requirements, certain circuits may remain connected to their energy sources in order, for example, to hold parts, protect information, light interiors, etc. In this case, special steps must be taken to ensure operator safety.

1.6.4. *Operator intervention*

Machinery must be so designed, constructed and equipped that the need for operator intervention is limited.

If operator intervention cannot be avoided, it must be possible to carry it out easily and in safety.

1.7. **Indicators**

1.7.0. *Information devices*

The information needed to control machinery must be unambiguous and easily understood.

It must not be excessive to the extent of overloading the operator.

1.7.1. *Warning devices*

Where machinery is equipped with warning devices (such as signals, etc.), these must be unambiguous and easily perceived.

The operator must have facilities to check the operation of such warning devices at all times.

The requirements of the specific Directives concerning colours and safety signals must be complied with.

1.7.2. *Warning of residual risks*

Where risks remain despite all the measures adopted or in the case of potential risks which are not evident (e.g. electrical cabinets, radioactive sources, bleeding of a hydraulic circuit, hazard in an unseen area, etc.), the manufacturer must provide warnings.

Such warnings should preferably use readily understandable pictograms and/or be drawn up in one of the languages of the country in which the machinery is to be used, accompanied, on request, by the languages understood by the operators.

1.7.3. *Marking*

All machinery must be marked legibly and indelibly with the following minimum particulars:

— name and adress of the manufacturer,

— EC mark, which includes the year of construction (see Annex III),

— designation of series or type,

— serial number, if any.

Furthermore, where the manufacturer constructs machinery intended for use in a potentially explosive atmosphere, this must be indicated on the machinery.

Machinery must also bear full information relevant to its type and essential to its safe use (e.g. maximum speed of certain rotating parts, maximum diameter of tools to be fitted, mass, etc.).

1.7.4. *Instructions*

(a) All machinery must be accompanied by instructions including at least the following:

— a repeat of the information with which the machinery is marked (see 1.7.3), together with any appropriate additional information to facilitate maintenance (e.g. addresses of the importer, repairers, etc.),

— foreseen use of the machinery within the meaning of 1.1.2 (c),

— workstation(s) likely to be occupied by operators,

— instructions for safe:

  — putting into service,

  — use,

  — handling, giving the mass of the machinery and its various parts where they are regularly to be transported separately,

  — assembly, dismantling,

  — adjustment,

  — maintenance (servicing and repair),

  — wher necessary, training instructions.

Where necessary, the instructions should draw attention to ways in which the machinery should not be used.

(b) The instructions must be drawn up by the manufacturer or his authorized representative established in the Community in one of the languages of the country in which the machinery is to be used and should preferably be accompanied by the same instructions drawn up in another Community language, such as that of the country in which the manufacturer or his authorized representative is established. By way of derogation from this requirement, the maintenance instructions for use by the specialized personnel frequently employed by the manufacturer or his authorized representative may be drawn up in only one of the official Community languages.

(c) The instructions must contain the drawings and diagrams necessary for putting into service, maintenance, inspection, checking of correct operation and, where appropriate, repair of the machinery, and all useful instructions in particular with regard to safety.

(d) Any sales literature describing the machinery must not contradict the instructions as regards safety aspects; it must give information regarding the airborne noise emissions referred to in (f) and, in the case of hand-held and/or hand-guided machinery, information regarding vibration as referred to in 2.2.

(e) Where necessary, the instructions must give the requirements relating to installation and assembly for reducing noise or vibration (e.g. use of dampers, type and mass of foundation block, etc.).

(f) The instructions must give the following information concerning airborne noise emissions by the machinery, either the actual value or a value established on the basis of measurements made on identical machinery:

— equivalent continuous A-weighted sound pressure level at workstations, where this exceeds 70 dB(A); where this level does not exceed 70 dB(A), this fact must be indicated,

— peak C-weighted instantaneous sound pressure value at workstations, where this exceeds 63 Pa (130 dB in relation to 20 μPa),

— sound power level emitted by the machinery where the equivalent continuous A-weighted sound pressure level at workstations exceeds 85 dB(A).

In the case of very large machinery, instead of the sound power level, the equivalent continuous sound pressure levels at specified positions around the machinery may be indicated.

Sound levels must be measured using the most appropriate method for the machinery.

The manufacturer must indicate the operating conditions of the machinery during measurement and what methods have been used for the measurement.

Where the workstation(s) are undefined or cannot be defined, sound pressure levels must be measured at a distance of 1 metre from the surface of the machinery and at height of 1,60 metres from the floor or access platform. The position and value of the maximum sound pressure must be indicated.

(g) If the manufacturer foresees that the machinery will be used in a potentially explosive atmosphere, the instructions must give all the necessary information.

(h) In the case of machinery which may also be intended for use by non-professional operators, the wording and layout of the instructions for use, whilst respecting the other essential requirements mentioned above, must take into account the level of general education and acumen that can reasonably be expected from such operators.

2. ADDITIONAL ESSENTIAL HEALTH AND SAFETY REQUIREMENTS FOR CERTAIN CATEGORIES OF MACHINERY

2.1. Agri-foodstuffs machinery

In addition to the essential health and safety requirements set out in 1 above, where machinery is intended to prepare and process foodstuffs (e.g. cooking, refrigeration, thawing, washing, handling, packaging, storage, transport or distribution), it must be so designed and constructed as to avoid any risk of infection, sickness or contagion and the following hygiene rules must be observed:

(a) materials in contact, or intended to come into contact, with the foodstuffs must satisfy the conditions set down in the relevant Directives. The machinery must be so designed and constructed that these materials can be clean before each use;

(b) all surfaces including their jc ˙ings must be smooth, and must have neither ridges nor crevices which could harbour organic materials;

(c) assemblies must be designed in such a way as to reduce projections, edges and recesses to a minimum. They should preferably be made by welding or continuous bonding. Screws, screwheads and rivets may not be used except where technically unavoidable;

(d) all surfaces in contact with the foodstuffs must be easily cleaned and disinfected, where possible after removing easily dismantled parts. The inside surfaces must have curves of a radius sufficient to allow thorough cleaning;

(e) liquid deriving from foodstuffs as well as cleaning, disinfecting and rinsing fluids should be able to be discharged from the machine without impediment (possibly in a 'clean' position);

(f) machinery must be so designed and constructed as to prevent any liquids or living creatures, in particular insects, entering, or any organic matter accumulating in areas that cannot be cleaned

(e.g. for machinery not mounted on feet or casters, by placing a seal between the machinery and its base, by the use of sealed units, etc.);

(g) machinery must be so designed and constructred that no ancillary substances (e.g. lubricants, etc.) can come into contact with foodstuffs. Where necessary, machinery must be designed and constructed so that continuing compliance with this requirement can be checked.

Instructions

In addition to the information required in section 1, the instructions must indicate recommended products and methods for cleaning, disinfecting and rinsing (not only for easily accessible areas but also where areas to which access is impossible or unadvisable, such as piping, have to be cleaned *in situ*).

2.2. **Portable hand-held and/or hand-guided machinery**

In addition to the essential health and safety requirements set out in 1 above, portable hand-held and/or hand-guided machinery must conform to the following essential health and safety requirements:

— according to the type of machinery, it must have a supporting surface of sufficient size and have a sufficient number of handles and supports of an appropriate size and arranged to ensure the stability of the machinery under the operating conditions foreseen by the manufacturer,

— except where technically impossible or where there is an independent control, in the case of handles which cannot be released on complete safety, it must be fitted with start and stop controls arranged in such a way that the operator can operate them without releasing the handles,

— it must be designed, constructed or equipped to eliminate the risks of accidental starting and/or continued operation after the operator has released the handles. Equivalent steps must be taken if this requirement is not technically feasible,

— portable hand-held machinery must be designed and constructed to allow, where necessary, a visual check of the contact of the tool with the material being processed.

Instructions

The instructions must give the following information concerning vibrations transmitted by hand-held and hand-guided machinery:

— the weighted root mean square acceleration value to which the arms are subjected, if it exceeds 2,5 m/s^2 as determined by the appropriate test code. Where the acceleration does not exceed 2,5 m/s^2, this must be mentioned.

If there is no applicable test code, the manufacturer must indicate the measurement methods and conditions under which measurements were made.

2.3. **Machinery for working wood and analogous materials**

In addition to the essential health and safety requirements set out in 1 above, machinery for working wood and machinery for working materials with physical and technological characteristics similar to those of wood, such as cork, bone, hardened rubber, hardened plastic material and other similar stiff material must conform to the following essential health and safety requirements:

(a) the machinery must be designed, constructed or equipped so that the piece being machined can be placed and guided in safety; where the piece is hand-held on a work-bench the latter must be sufficiently stable during the work and must not impede the movement of the piece;

(b) where the machinery is likely to be used in conditions involving the risk of ejection of pieces of wood, it must be designed, constructed or equipped to eliminate this ejection, or, if this is not the case, so that the ejection does not engender risks for the operator and/or exposed persons;

(c) the machinery must be equipped with an automatic brake that stops the tool in a sufficiently short time if there is a risk of contact with the tool whilst it runs down;

(d) where the tool is incorporated into a non-fully automated machine, the latter must be so designed and constructed as to eliminate or reduce the risk of serious accidental injury, for example by using cylindrical cutter blocks, restricting depth of cut, etc.

A.2 Amendments to Annex I of the Directive 89/392/EEC according to Directive 91/368/EEC published on 22 July 1991

The scope of the Directive 89/392/EEC has been extended by amending Directive 91/368/EEC, to include the risks relating to mobility and/or ability to lift loads.

As part of this revision, certain alterations and additions were made to Annex I of Directive 89/392/EEC. They relate to the **general aspects of machinery safety** and are relevant to the scope of EN 292-1 and EN 292-2.

These alterations and additions are specified in Directive 91/368/EEC, Article 1(6), a) to f), reproduced below.

> NOTE : The essential safety requirements **relating specifically to mobility and ability to lift loads** (expressed in Annex I of Directive 91/368/EEC and introduced into Annex I of Directive 89/392/EEC by Directive 91/368/EEC, article 1(6) g)) are not taken into account in EN 292-1 and EN 292-2, and are therefore not reproduced here.

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6. Annex I is amended as follows:

(a) In section 1.3.7 the following paragraph is added:

'All necessary steps must be taken to prevent accidental blockage of moving parts involved in the work. In cases where, despite the precautions taken, a blockage is likely to occur, specific protection devices or tools, the instruction handbook and possibly a sign on the machinery should be provided by the manufacturer to enable the equipment to be safely unblocked.';

(b) The following section is inserted:

'1.6.5. *Cleaning of internal parts*

The machinery must be designed and constructed in such a way that it is possible to clean internal parts which have contained dangerous substances or preparations without entering them; any necessary unblocking must also be possible from the outside. If it is absolutely impossible to avoid entering the machinery, the manufacturer must take steps during its construction to allow cleaning to take place with the minimum of danger.';

(c) In section 1.7.0 the following paragraph is added:

'Where the health and safety of exposed persons may be endagered by a fault in the operation of unsupervised machinery, the machinery must be equipped to give an appropriate acoustic or light signal as a warning.';

(d) In section 1.7.3 the following paragraphs are added:

'Where a machine part must be handled during use with lifting equipment, its mass must be indicated legibly, indelibly and unambiguously.

The interchangeable equipment referred to in Article 1 (2), third subparagraph must bear the same information.';

(e) In section 1.7.4 (a) the following indent is added:

'— where necessary, the essential characteristics of tools which may be fitted to the machinery.';

(f) In section 1.7.4 (f) the third paragraph is replaced by the following:

'Where the harmonized standards are not applied, sound levels must be measured using the most appropriate method for the machinery.';

Annex B (informative)

Bibliography

ISO 2972:1979 — Numerical control of machines - Symbols

ISO 6385:1981 — Ergonomic principles of the design of work systems

ISO 7000:1984 — Graphical symbols for use on equipment - Index and synopsis

ISO 7001:1980/A1:1985 — Public information symbols

ISO/IEC Guide 14:1977 — Product information for consumers

ISO/IEC Guide 51:1990 — Guidelines for the inclusion of safety aspects in standards

IEC 417:1973/A:1974/B:1975/C:1977/D:1978/E:1980/F:1982/G:1985 — Graphical symbols for use on equipment - Index, survey and compilation of the single sheets.

Annex C (informative)

Main terminological discrepancies between EN 292 and "Machinery Directive"

The terms listed below are used in the English language versions of EN 292 or the Directive, as shown, and shall be considered as equivalent

EN 292	"Machinery Directive" (89/392/EEC)
commissioning	putting into service
ejection hazard	risk of ejection
hold-to-run control	control requiring sustained action
intended use	intended conditions of use/foreseen use
interlocking device/interlock	locking device
personal protective equipment	personal protection equipment
pressure sensitive mat	sensor mat
safety device	protective device/protection device
shall	must
trip device	sensing device

Annex D

(informative)

TRILINGUAL ALPHABETIC INDEX
of specific terms and expressions used
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