

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

## Part 2: Technical principles and specifications

The European Standard EN 292-2:1991 has the status of a  
British Standard

ICS 01.040.13; 13.110

# Cooperating organizations

The European Committee for Standardization, under whose supervision this European Standard was prepared, comprises the national standards organizations of the following Western European countries.

|                |                                                      |
|----------------|------------------------------------------------------|
| Austria        | Oesterreichisches Normungsinstitut                   |
| Belgium        | Institut belge de normalisation                      |
| Denmark        | Dansk Standardiseringsraad                           |
| Finland        | Suomen Standardisoimislito, r.y.                     |
| France         | Association française de normalisation               |
| Germany        | Deutsches Institut für Normung e.V.                  |
| Greece         | Hellenic Organization for Standardization            |
| Iceland        | Technological Institute of Iceland                   |
| Ireland        | National Standards Authority of Ireland              |
| Italy          | Ente Nazionale Italiano di Unificazione              |
| Luxembourg     | Inspection du Travail et des Mines                   |
| Netherlands    | Nederlands Normalisatie-instituut                    |
| Norway         | Norges Standardiseringsforbund                       |
| Portugal       | Instituto Português da Qualidade                     |
| Spain          | Asociación Española de Normalización y Certificación |
| Sweden         | Standardiseringskommissionen i Sverige               |
| Switzerland    | Association suisse de normalisation                  |
| United Kingdom | British Standards Institution                        |

This British Standard was published under the authority of the Standards Board and comes into effect on 20 December 1991

© BSI 10-1999

The following BSI references relate to the work on this standard:  
Committee reference MCE/3  
Draft for comment 89/75660 DC

ISBN 0 580 20364 6

## Amendments issued since publication

| Amd. No. | Date          | Comments                              |
|----------|---------------|---------------------------------------|
| 8912     | December 1995 |                                       |
| 9342     | March 1997    | Indicated by a sideline in the margin |
|          |               |                                       |
|          |               |                                       |

# Contents

|                                    | Page               |
|------------------------------------|--------------------|
| Cooperating organizations          | Inside front cover |
| National foreword                  | ii                 |
| Foreword                           | 2                  |
| Text of EN 292-2                   | 5                  |
| National appendix NA (informative) | Inside back cover  |
| National appendix NB (informative) | Inside back cover  |

## National foreword

This part of BS EN 292 has been prepared under the direction of the Machinery and Components Standards Policy Committee and is the second in a series implementing corresponding European Standards on machinery safety matters, in the development of which the United Kingdom has played an active part. This standard is identical with EN 292-2:1991 “*Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles and specifications*”, incorporating Amendment No. 1 which was prepared by Technical Committee CEN/TC 114 of the European Committee for Standardization (CEN).

Annex A reprints Annex I of the Directive 89/392/EEC which is reproduced by permission of the Commission of the European Communities.

**Cross-references.** Details of European Standards quoted in this British Standard for which there is a corresponding British Standard are given in National appendix NB.

The other European Standards referred to in the text will be adopted as British Standards as they are published.

There is no British Standard corresponding to ISO 447:1984 “*Machine tools — Direction of operation of controls*”.

**Textual error.** When implementing Amendment No. 1 to the English language version of EN 292-2:1991 as the national standard, the textual error given below was discovered. It has been reported to the European Committee for Standardization (CEN) in a proposal to amend the text of the European Standard.

In Annex A, subclause 1.7.4, item f) of the list, paragraph 2 the values should be read as “(130 dB in relation to 20  $\mu$ Pa)” i.e. the value should be 20 micro-Pascals and not 20 milli-Pascals.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

### Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 54, an inside back cover and a back cover.

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

Sidelining in this document indicates the most recent changes by amendment.

---

ICS 01.040.13; 13.110

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 amendment 1 modifies the European Standard EN 292-2:1991. This amendment was approved by CEN on 1995-03-13. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this amendment 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 amendment 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.

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

## CEN

European Committee for Standardization  
Comité Européen de Normalisation  
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

---

© CEN 1995 Copyright reserved to all CEN members

Ref. No. EN 292-2:1991/A1-1995 E  
 **Documents**  
Document Sharing Hub

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 60204-1:1985 “*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 60204-1 “*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 60204-1 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 60204-1:1985 (column 1) and the corresponding subclauses of EN 60204-1:1985 (column 2) and prEN 60204-1:1991 (column 3).

Table 1

| EN 292-2, §: | EN 60204-1:1985, §: | prEN 60204-1:1991, §: |
|--------------|---------------------|-----------------------|
| 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                 | 6                     |
|              | 5.2                 | 7.2                   |
|              | 5.3                 | 7.3                   |
| 5.4          | 3.1                 | 18                    |
| 5.5.1c)      | 3.2                 | 19                    |
| 6.1.1        | 5.6.1               | 9.2.5.4 and 10.7      |
| 6.2.2        | 5.6.2               | 5.3                   |

This amendment shall be given the status of a National Amendment, either by publication of an identical text or by endorsement, at the latest by September 1995, and conflicting national standards shall be withdrawn at the latest by September 1995.

According to the CEN/CENELEC Internal Regulations, the following countries are bound to implement this amendment: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

Foreword to amendment A1

This amendment 1 to the European Standard EN 292-2 has been prepared by CEN/TC 114/WG 1, Basic concepts, under the responsibility of the Technical Committee CEN/TC 114 (The EN standard has been voted on in 1991), Safety of machinery. This amendment is intended to reproduce clauses 1 to 6 of Annex I of the Machinery Directive (89/392/EEC modified by 91/368/EEC and 93/44/EEC and 93/68/EEC).

NOTE This compilation of the different parts from the Directives mentioned above, is simply given as information to assist the user of this standard.

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

## Contents

|                                                                                                                                                                                                                                                                                                          |  | Page |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|------|
| Foreword                                                                                                                                                                                                                                                                                                 |  | 2    |
| 0 Introduction                                                                                                                                                                                                                                                                                           |  | 5    |
| 1 Scope                                                                                                                                                                                                                                                                                                  |  | 5    |
| 2 Normative references                                                                                                                                                                                                                                                                                   |  | 6    |
| 3 Risk reduction by design                                                                                                                                                                                                                                                                               |  | 6    |
| 3.1 Avoiding sharp edges and corners, protruding parts, etc.                                                                                                                                                                                                                                             |  | 6    |
| 3.2 Making machines inherently safe by virtue of                                                                                                                                                                                                                                                         |  | 7    |
| 3.3 Taking into account design codes, data about material properties, etc.                                                                                                                                                                                                                               |  | 7    |
| 3.4 Using inherently safe technologies, processes, energy supplies                                                                                                                                                                                                                                       |  | 7    |
| 3.5 Applying the principle of the positive mechanical action of a component on another component                                                                                                                                                                                                         |  | 7    |
| 3.6 Observing ergonomic principles                                                                                                                                                                                                                                                                       |  | 7    |
| 3.7 Applying safety principles when designing control systems                                                                                                                                                                                                                                            |  | 8    |
| 3.8 Preventing hazards from pneumatic and hydraulic equipment                                                                                                                                                                                                                                            |  | 11   |
| 3.9 Preventing electrical hazard                                                                                                                                                                                                                                                                         |  | 11   |
| 3.10 Limiting exposure to hazards through reliability of equipment                                                                                                                                                                                                                                       |  | 11   |
| 3.11 Limiting exposure to hazards through mechanization and automation of loading/unloading operations                                                                                                                                                                                                   |  | 11   |
| 3.12 Limiting exposure to hazards through location of the majority of setting and maintenance points outside the danger zones                                                                                                                                                                            |  | 11   |
| 4 Safeguarding                                                                                                                                                                                                                                                                                           |  | 11   |
| 4.1 Selection of guards and safety devices                                                                                                                                                                                                                                                               |  | 12   |
| 4.2 Requirements for the design and construction of guards and safety devices                                                                                                                                                                                                                            |  | 12   |
| 5 Information for use                                                                                                                                                                                                                                                                                    |  | 15   |
| 5.1 General requirements                                                                                                                                                                                                                                                                                 |  | 15   |
| 5.2 Location and nature of information for use                                                                                                                                                                                                                                                           |  | 15   |
| 5.3 Signals and warning devices                                                                                                                                                                                                                                                                          |  | 15   |
| 5.4 Markings, signs (pictograms), written warnings                                                                                                                                                                                                                                                       |  | 15   |
| 5.5 Accompanying documents                                                                                                                                                                                                                                                                               |  | 16   |
| 6 Additional precautions                                                                                                                                                                                                                                                                                 |  | 17   |
| 6.1 Precautions in view of emergency situations                                                                                                                                                                                                                                                          |  | 17   |
| 6.2 Equipment, systems and arrangements contributing to safety                                                                                                                                                                                                                                           |  | 18   |
| Annex A (informative) Annex I of the Directive on the approximation of the laws of the Member States relating to machinery (89/392/EEC modified by 91/368/EEC and 93/44/EEC): <i>Essential health and safety requirements relating to the design and construction of machinery and safety components</i> |  | 20   |
| Annex B (informative) Bibliography                                                                                                                                                                                                                                                                       |  | 44   |
| Annex C (informative) Main terminological discrepancies between EN 292 and Machinery Directive (89/392/EEC)                                                                                                                                                                                              |  | 44   |
| Annex D (informative) Trilingual alphabetical index                                                                                                                                                                                                                                                      |  | 45   |
| Table 1                                                                                                                                                                                                                                                                                                  |  | 2    |
| Table 2 — Guidelines to help make the choice of safeguards against hazards generated by moving parts                                                                                                                                                                                                     |  | 13   |



## 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 under 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 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, *Safety of machinery — Minimum distances to avoid crushing of parts of the human body*<sup>1)</sup>.

EN 418, *Safety of machinery — Emergency stop equipment — Functional aspects*<sup>2)</sup>.

EN .. ..., *Safety of machinery — Guards (fixed, movable)*<sup>3)</sup>.

EN .. ..., *Safety of machinery — Two-hand control device*<sup>4)</sup>.

EN .. ..., *Safety of machinery — Pressure sensitive safety devices — Mats and floors*<sup>5)</sup>.

EN .. ..., *Safety of machinery — Interlocking devices with and without guard locking — General principles and specifications for design*<sup>6)</sup>.

EN .. ..., *Safety of machinery — Principles for the design of safety related control systems*<sup>7)</sup>.

EN .. ..., *Safety of machinery — Safety requirements for fluid power systems and components — Hydraulics*<sup>8)</sup>.

EN .. ..., *Safety of machinery — Safety requirements for fluid power systems and components — Pneumatics*<sup>9)</sup>.

EN .. ..., *Safety of machinery — Electrosensitive protective devices — Part 1: General requirements*<sup>10)</sup>.

EN .. ..., *Safety of machinery — Ergonomic design principles — Part 1: Terminology and general principles — Part 2: Interaction between machinery design and work tasks*<sup>11)</sup>.

EN .. ..., *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*<sup>12)</sup>.

EN 50020:1977/A1:1979/A2:1985, *Electrical apparatus for potentially explosive atmospheres — Intrinsic safety “i”*.

EN 60204-1:1985, *Electrical equipment of industrial machines — Part 1: General requirements*<sup>13)</sup>.

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.

<sup>1)</sup> Draft standard submitted to CEN/CENELEC inquiry in 1991.

<sup>2)</sup> Draft standard submitted to CEN/CENELEC inquiry in 1991.

<sup>3)</sup> Draft standard prepared by CEN/TC 114/WG 11.

<sup>4)</sup> Draft standard prepared by CEN/TC 114-CLC/TC44X/JWG7.

<sup>5)</sup> Draft standard prepared by CEN/TC 114-CLC/TC44X/JWG8.

<sup>6)</sup> Draft standard prepared by CEN/TC 114/WG 10.

<sup>7)</sup> Draft standard prepared by CEN/TC 114-CLC/TC44X/JWG6.

<sup>8)</sup> Draft standard prepared by CEN/TC 114/WG 12.

<sup>9)</sup> Draft standard prepared by CEN/TC 114/WG 12.

<sup>10)</sup> Draft standard prepared by CLC/TC 44X/WG 2.

<sup>11)</sup> Draft standard prepared by CEN/TC 122/WG 2.

<sup>12)</sup> Draft standard prepared by CEN/TC 122/WG 6.

<sup>13)</sup> 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<sup>14)</sup>;
- the limitation of the mass and/or velocity of the movable elements, and hence of their kinetic energy<sup>15)</sup>;
- 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;
- toxicity of materials.

### 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 50020);
- electrical supply under “functional extra-low voltage” (see 5.1.2.3 of EN 60204-1<sup>16)</sup>);
- 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.

<sup>14)</sup> When such a limitation does not hinder the intended function.

<sup>15)</sup> When such a limitation does not hinder the intended function.

<sup>16)</sup> See foreword.

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.

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

**3.6.4** Avoiding linking the operator’s working rhythm 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 or 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.

When 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

- Manual controls (actuators) shall be designed and located according to the relevant ergonomic principles (see 3.6.6).
- 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.
- 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.
- As far as possible, controls (especially start controls) shall be located so that the operator, when actuating them, can see the controlled elements.
- 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).
- 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 the 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 60204-1<sup>17)</sup> deals with control system design, especially in 5.4 to 5.8, 6, 7 and 8.

<sup>17)</sup> See foreword.

### 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 60204-1<sup>18)</sup> 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.

### 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).

<sup>18)</sup> See foreword.

## 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.

### 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”).

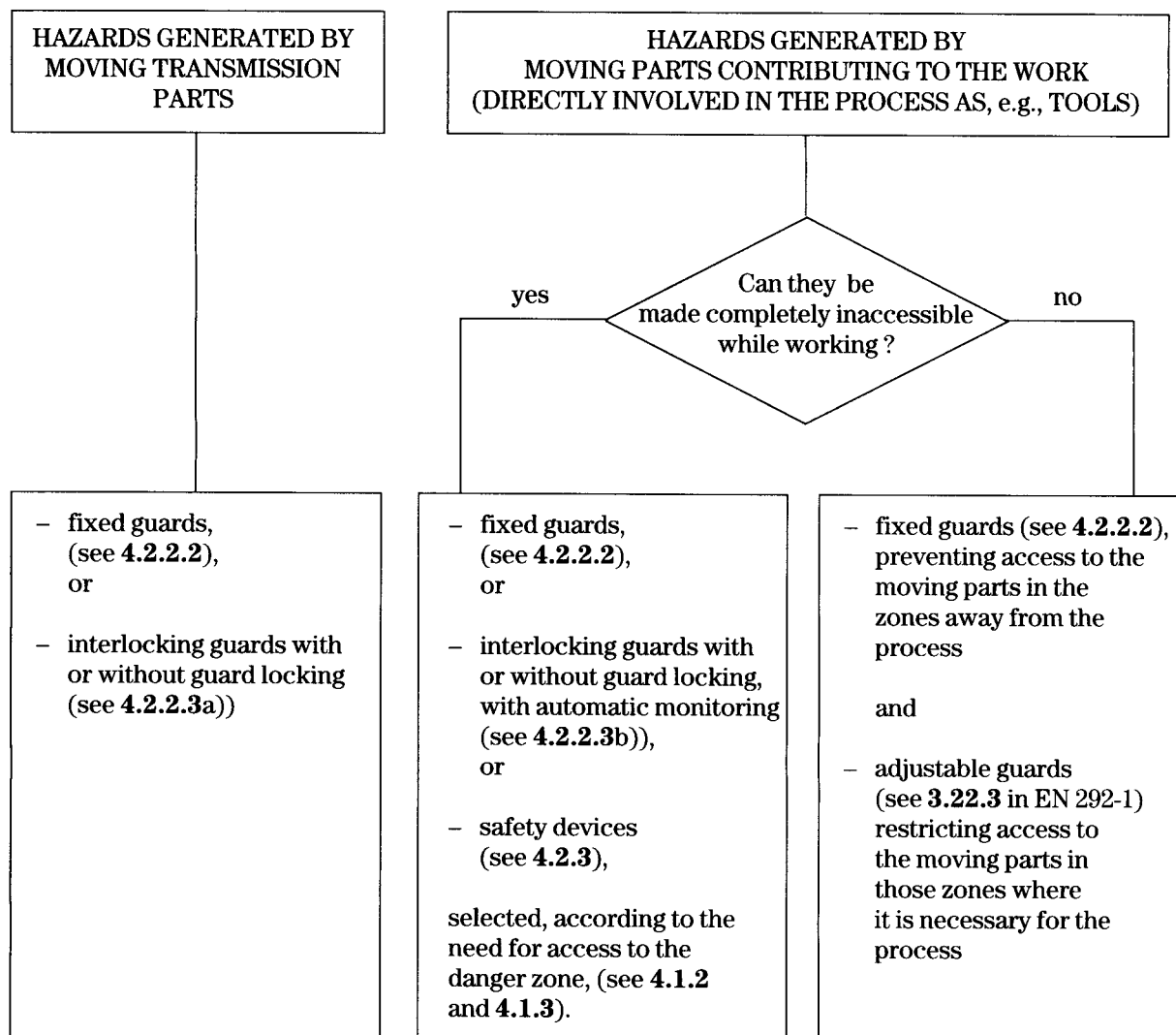
#### 4.2.1 General requirements

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.

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



## 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, materials, 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.