

TECHNICAL REPORT

ISO/TR 12100-2

First edition
1992-12-15

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

Part 2 : Technical principles and specifications

iTeh STANDARD PREVIEW

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Sécurité des machines — Notions fondamentales, principes généraux de conception —

Partie 2 : Principes et spécifications techniques

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.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.

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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

NORME EUROPEENNE

EUROPAISCHE NORM

September 1991

UDC 62-78:614.8:331.454

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

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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.

CEN members are the national standards bodies of Austria, Belgium, 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

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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 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 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.

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- 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 60 204-1:1985¹³⁾ Electrical equipment of industrial machines
Part 1 : General requirements

[ISO/TR 12100-2:1992](#)

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

[c34ae5e2c999/iso-tr-12100-2-1992](#)

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.

-
- 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 hazard¹⁴⁾,
- 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 60 204-1¹⁶⁾),
- 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.

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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 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 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.

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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).