TECHNICAL REPORT

ISO/TR 12100-1

First edition
1992-12-15

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

Part 1 :
Basic terminology, methodology

Sécurité des machines — Notions fondamentales, principes généraux de conception —
Partie 1 : Terminologie de base, méthodologie

Reference number
ISO/TR 12100-1 : 1992 (E)

Foreword

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International Organization for Standardization
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Printed in Switzerland

In its resolution 6 (November 1991), Technical Committee ISO/TC 199, *Safety of machinery*, endorsed the contents of European Standard EN 292-1 : 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 and B of this part of ISO/TR 12100 are for information only.

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EUROPEAN STANDARD EN 292-1:1991

NORME EUROPEENNE

EUROPAISCHE NORM September 1991

UDC 62-78:614.8:331.454:001.4

Descriptors: Safety of machines, design, definitions, hazards, safety measures, categories

English version

Safety of machinery - Basic concepts, general principles for design - Part 1: Basic terminology, methodology

Sécurité des machines - Notions fondamentales, principes généraux de conception - Partie 1: Terminologie de base, méthodologie

Sicherheit von Maschinen - Grundbegriffe, allgemeine Gestaltungsleitsätze - Teil 1: Grundsätzliche Terminologie, Methodologie

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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Foreword

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

Part 2 of EN 292 deals with "Technical principles and specifications" (see clause 0 "Introduction" for more detailed explanations).

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 basic terminology and specifies general design methods, to help designers and manufacturers in achieving safety in the design of machinery (see 3.1) for professional and non-professional purposes. It may also be used for other technical products having similar hazards.

It is recommended that this standard is incorporated in training courses and manuals to convey basic terminology and general design methods to designers.

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 292-2	Safety of machinery - Basic concepts, general principles for design - Part 2 : Technical principles and specifications.
ENV .. ...[1)]	Safety of machinery - Terminology
EN 414	Safety of machinery - Rules for the drafting and presentation of safety standards

1) Predraft standard under study by CEN/TC 114/WG 3.

EN.. ... [2] Safety of machinery - Risk assessment

EN 60 204-1:1985[3] Electrical equipment of industrial machines - Part 1 : General requirements

3 Basic concepts (see also ENV .. ...[1] "Terminology")

For the purposes of this standard, the following definitions apply :

3.1 Machinery (machine)

An assembly of linked parts or components, at least one of which moves, with the appropriate machine actuators, control and power circuits, etc., joined together for a specific application, in particular for the processing, treatment, moving or packaging of a material.

The term machinery also covers an assembly of machines which, in order to achieve one and the same end, are arranged and controlled so that they function as an integral whole.

Annex A provides the general schematic representation of a machine.

3.2 Reliability

The ability of a machine or components, or equipment, to perform a required function under specified conditions and for a given period of time without failing.

3.3 Maintainability of a machine

The ability of a machine to be maintained in a state which enables it to fulfil its function under conditions of intended use (see 3.12), or restored into such a state, the necessary actions (maintenance) being carried out according to specified practices and using specified means.

3.4 Safety of a machine

The ability of a machine to perform its function, to be transported, installed, adjusted, maintained, dismantled and disposed of under conditions of intended use (see 3.12) specified in the instruction handbook (and, in some cases, within a given period of time indicated in the instruction handbook) without causing injury or damage to health.

3.5 Hazard

A source of possible injury or damage to health.

NOTE : The word "hazard" is generally used in conjunction with other words defining its origin or the nature of the expected injury or damage to health : electrical shock hazard, crushing hazard, shearing hazard, toxic hazard, etc. Hazards generated by machinery are described in clause 4.

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2) Draft standard(s) under study by CEN/TC 114/WG 14

3) A revised version of EN 60 204-1:1985 should be submitted, in 1991, to the Unique Acceptance Procedure (UAP).

3.6 Hazardous situation

Any situation in which a person is exposed to a hazard or to hazards.

3.7 Risk

A combination of the probability and the degree of the possible injury or damage to health in a hazardous situation.

3.8 Risk assessment

A comprehensive estimation of the probability and the degree of the possible injury or damage to health in a hazardous situation in order to select appropriate safety measures.

NOTE : Clause 6 deals with risk assessment.

3.9 Hazardous machine function

Any function of a machine which generates a hazard when operating.

3.10 Danger zone

Any zone within and/or around machinery in which a person is exposed to risk of injury or damage to health.

NOTE : The hazard generating the risk envisaged in this definition :

- either is permanently present during the intended use of the machine (motion of hazardous moving elements, electric arc during a welding phase, etc.),
- or may appear unexpectedly (unintended/unexpected start-up, etc.).

3.11 Design of a machine

A series of actions including :

a) The study of the machine itself, taking into account all phases of its "life" :

1) Construction

2) Transport and commissioning
   - assembly, installation,
   - adjustment,

3) Use
- setting, teaching/programming or process changeover,
- operation,
- cleaning,
- fault finding,
- maintenance.

4) De-commissioning, dismantling and, as far as safety is concerned, disposal.

b) The drafting of the instructions relating to all above-mentioned phases of the "life" of the machine (except construction), dealt with in 5.5 of EN 292-2.

3.12 Intended use of a machine

The use for which the machine is suited according to the information provided by the manufacturer or which is deemed usual according to its design, construction and function.

Intended use also involves the compliance with the technical instructions laid down notably in the instruction handbook (see 5.5 in EN 292-2), taking into account reasonably foreseeable misuse.

NOTE : With regard to foreseeable misuse, the following behaviour should be particularly taken into account in the risk assessment :

- the foreseeable incorrect behaviours resulting from normal carelessness, but not resulting from deliberate misuse of the machine,
- the reflex behaviour of a person in case of malfunction, incident, failure, etc. , during use of the machine,
- the behaviour resulting from taking the "line of least resistance" in carrying out a task,
- for some machines (especially machines for non-professional use), the foreseeable behaviour of certain persons, such as children or disabled.

See also 5.7.1.

3.13 Safety functions

3.13.1 Safety critical functions

Those functions of a machine, the malfunction of which would immediately increase the risk of injury or damage to health.

There are two categories of safety critical functions :

a) **Safety-specific functions**, which are safety critical functions specifically intended to achieve safety.

EXAMPLES
- function preventing unintended/unexpected start-up (interlocking device associated with a guard ...),
- single-cycle function,
- two-hand control function,
- etc.

b) **Safety-related functions**, which are safety critical functions other than safety-specific functions.

EXAMPLES
- manual control of a hazardous mechanism during setting phases, with by-passed (muted) safety devices (see 3.7.9 and 4.1.4 in EN 292-2),

- speed or temperature control keeping the machine within safe operating limits.

3.13.2 Back-up safety functions

Those functions whose failure does not immediately generate a hazard, however it reduces the level of safety. This covers notably automatic monitoring (see 3.7.6 in EN 292-2) of any safety critical function (e.g. monitoring of the correct operation of a position switch belonging to an interlocking device).

3.14 Automatic monitoring

A back-up safety function which 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.

There are two categories of automatic monitoring :

- "continuous" automatic monitoring, whereby a safety measure is immediately initiated when a failure occurs,

- "discontinuous" automatic monitoring, whereby a safety measure is initiated during a following machine cycle, if a failure has occurred.

3.15 Unexpected (or unintended) start-up

Any start-up which, because of its unexpected nature, generates a risk to persons.

3.16 Failure to danger

Any failure in the machinery, or in its power supply, that generates a hazardous situation.

3.17 Fail-safe condition (minimized failure to danger)

A theoretical condition which would be reached if a safety function remained unchanged in the case of a failure of the power supply or of any component contributing to the achievement of this condition.

In practice, achievement of this condition gets closer as the effect of failures on the considered safety function is reduced.

3.18 Risk reduction by design

Safety measures consisting of :

- avoiding or reducing as many of the hazards as possible by suitable choice of design features, and

- limiting exposure to hazards which are unavoidable or cannot be reduced sufficiently ; this is achieved by reducing the need for operator intervention in danger zones.

NOTE : Clause 3 of EN 292-2 deals with risk reduction by design.

3.19 Safeguarding

Safety measures consisting of the use of specific technical means called safeguards (guards, safety devices), to protect persons from the hazards which cannot reasonably be removed or sufficiently limited by design.

NOTE : Clause 4 of EN 292-2 deals with safeguarding.

3.20 Information for use

Safety measures consisting 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.

NOTE : Clause 5 of EN 292-2 deals with information for use.

3.21 Operator

The person or persons given the task of installing, operating, adjusting, maintaining, cleaning, repairing, or transporting machinery.

3.22 Guard

Part of a machine specifically used to provide protection by means of a physical barrier. Depending on its construction, a guard may be called casing, cover, screen, door, enclosing guard, etc.

NOTE 1 : A guard may act :

- alone ; it is then only effective when it is closed,

- in conjunction with an interlocking device with or without guard locking ; in this case, protection is ensured whatever the position of the guard.

NOTE 2 : "Closed" means "kept in place" for a fixed guard.

3.22.1 Fixed guard

Guard kept in place (i.e. closed) :

- either permanently (by welding, etc.),

- or by means of fasteners (screws, nuts, etc.) making removal/opening impossible without using tools.

3.22.2 Movable guard

Guard generally connected by mechanical means (e.g. hinges or slides) to the machine frame or an adjacent fixed element and which can be opened without the use of tools.

3.22.3 Adjustable guard

Fixed or movable guard which is adjustable as a whole or which incorporates adjustable part(s). The adjustment remains fixed during a particular operation.

3.22.4 Interlocking guard

Guard associated with an interlocking device (see 3.23.1), so that :

- the hazardous machine functions "covered" by the guard cannot operate until the guard is closed,

- if the guard is opened while hazardous machine functions are operating, a stop instruction is given,

- when the guard is closed, the hazardous machine functions "covered" by the guard can operate, but the closure of the guard does not by itself initiate their operation.

3.22.5 Interlocking guard with guard locking

Guard associated with an interlocking device (see 3.23.1) and a guard locking device so that :

- the hazardous machine functions "covered" by the guard cannot operate until the guard is closed and locked,

- the guard remains closed and locked until the risk of injury from the hazardous machine functions has passed,

- when the guard is closed and locked, the hazardous machine functions "covered" by the guard can operate, but the closure and locking of the guard do not by themselves initiate their operation.

3.22.6 Control guard

Guard associated with an interlocking device (with or without guard locking) (see 3.23.1) so that :

- the hazardous machine functions "covered" by the guard cannot operate until the guard is closed,

- closing the guard initiates operation of the hazardous machine function(s).

3.23 Safety device

Device (other than a guard) which eliminates or reduces risk, alone or associated with a guard.

3.23.1 Interlocking device (interlock)

Mechanical, electrical or other type of device, the purpose of which is to prevent the operation of machine elements under specified conditions (generally as long as a guard is not closed).

3.23.2 Enabling (control) device

Additional manually operated control device used in conjunction with a start control and which, when continuously actuated, allows a machine to function.

3.23.3 Hold-to-run control device

Control device which initiates and maintains operation of machine elements only as long as the manual control (actuator) is actuated. The manual control (actuator) returns automatically to the stop position when released.

3.23.4 Two-hand control device

Hold-to-run control device which requires at least the simultaneous actuation of two manual controls (actuators) in order to trigger and to maintain operation of the machine or machine elements, thus affording a measure of protection for the person operating the manual controls (actuators).

3.23.5 Trip device

Device which causes a machine or machine elements to stop (or ensures an otherwise safe condition) when a person or a part of his body goes beyond a safe limit.

Trip devices may be :

- **mechanically actuated** : e.g. trip wires, telescopic probes, pressure sensitive devices, etc. ,

- **non-mechanically actuated** : e.g. photo-electric devices, devices using capacitive, ultrasonic, etc. means to achieve detection.

3.23.6 Mechanical restraint device

Device which introduces into a mechanism a mechanical obstacle (wedge, spindle, strut, scotch, etc.) which, by virtue of its own strength, can prevent any hazardous movement (for instance, the fall of a ram due to the failure of the normal retaining system).

3.23.7 Limiting device

Device which prevents a machine or machine elements from exceeding a designed limit (e.g. space limit, pressure limit, etc.).

3.23.8 Limited movement control device

Control device, the actuation of which permits only a limited amount of travel of a machine element, thus minimizing risk as much as possible ; further movement is precluded until there is a subsequent and separate actuation of the control.

3.24 Deterring/impedeing device

Any physical obstacle which, without totally preventing access to a danger zone, reduces the probability of access to this zone by offering an obstruction to free access.

4 Description of hazards generated by machinery

4.1 General

The purpose of this clause is to identify and to describe (by their nature or by their consequences) the various hazards which machinery is likely to generate, in order to facilitate the **hazard analysis** which is to be carried out, in particular :

- when designing a machine,
- when working out a safety standard relating to a machine,
- when assessing risk,

4.2 Mechanical hazard

Mechanical hazard is a general designation for all physical factors which may give rise to injury due to the mechanical action of machine parts, tools, workpieces or of projected solid or fluid materials.

4.2.1 The elementary forms of mechanical hazard are notably :

- crushing hazard,
- shearing hazard,
- cutting or severing hazard,
- entanglement hazard,
- drawing-in or trapping hazard,
- impact hazard,
- stabbing or puncture hazard,
- friction or abrasion hazard,
- high pressure fluid ejection hazard.

4.2.2 The mechanical hazard which may be generated by machine parts (or workpieces) is conditioned, among other factors, by :

- **shape** : cutting elements, sharp edges, angular parts, even if they are motionless,

- **relative location**, which may create crushing, shearing, entanglement, etc. zones, when they are moving,

- **mass and stability** (potential energy of elements which may move under the effect of gravity),

- **mass and velocity** (kinetic energy of elements in controlled or uncontrolled motion),

- **acceleration**,

- **inadequate mechanical strength**, which may generate hazardous breakages or bursts,

- **potential energy** of elastic elements (springs), or of liquids or gases under pressure or vacuum.

4.2.3 Because of their mechanical nature, **slip, trip and falling hazards** in relationship with machinery are also included in subclause 4.2.

4.3 Electrical hazard

This hazard may cause injury or death from electric shock, or burn ; these may be caused :

- by contact of persons with :

  . live parts, i.e. parts which normally carry a voltage (direct contact) ;

  . parts which have become live under fault conditions, especially as a result of an insulation failure (indirect contact) ;

- by approach of persons to live parts, especially in the range of high voltage ;

- by insulation not suitable for foreseeable conditions of use ;

- by electrostatic phenomena such as contact of persons with charged parts ;

- by thermal radiation or phenomena, such as projection of molten particles, and chemical effects from short-circuits, overloads, etc.

It may also cause falls of persons (or of objects dropped by persons) as a result of the surprise induced by electric shock.

4.4 Thermal hazard

Thermal hazard may result in :

- **burns and scalds**, from contact with objects or materials with an extreme temperature, flames or explosions and radiation from heat sources,

- **health-damaging effects** generated by hot or cold work environment.

4.5 Hazards generated by noise

Noise may result in :

- permanent loss of hearing acuteness,
- tinnitus,
- tiredness, stress, etc,
- other effects such as loss of balance, loss of awareness etc.,
- interference with speech communication, acoustic signals, etc.

4.6 Hazards generated by vibration

Vibration may be transmitted to the whole body and particularly to hands and arms (use of hand-held machines).

The most severe vibration (or less severe vibration over a long time) may generate serious disorders (vascular disorders such as white-finger, neurological, osteo-articular disorders, lumbago and sciatica, etc.).

4.7 Hazards generated by radiation

These hazards are produced by a variety of sources and may be generated by non-ionizing or ionizing radiations :

- low frequency,
- radio frequency and micro-waves,
- infra-red,
- visible light,
- ultra-violet,
- X and γ rays,
- α ,ß rays, electron or ion beams,
- neutrons.

4.8 Hazards generated by materials and substances

Materials and substances processed, used or exhausted by machinery, and materials used to construct machinery may generate several different hazards :

- hazards resulting from contact with, or inhalation of, fluids, gases, mists, fumes and dusts, having an harmful, toxic, corrosive and/or irritant effect,

- fire and explosion hazards,

- biological (e.g. mould) and micro-biological (viral or bacterial) hazards.

4.9 Hazards generated by neglecting ergonomic principles in machine design

Mismatch of machinery with human characteristics and abilities may show itself by :

- **physiological effects** resulting, for instance, from unhealthy postures, excessive or repetitive efforts, etc.,

- **psycho-physiological effects** generated by mental overload or underload, stress, etc., arising from the operation, supervision or maintenance of a machine within the limits of its intended use (see 3.12),

- **human errors.**

4.10 Hazard combinations

Some individual hazards which seem to be minor may, when combined with each other, be equivalent to a major hazard.

5 Strategy for selecting safety measures

Safety measures are a combination of the measures incorporated at the design stage and those measures required to be implemented by the user.

The designer shall, in all circumstances, in the following order :

- specify the limits of the machine (see 5.1),

- identify the hazards and assess the risks (see 5.2),

- remove the hazards or limit the risks as much as possible (see 5.3),

- design guards and/or safety devices (safeguards) against any remaining risks (see 5.4),

- inform and warn the user about any residual risks (see 5.5),

- consider any necessary additional precautions (see 5.6).

NOTE : The strategy recommended in this clause is iterative : several successive applications of the procedure represented schematically in table 2, separated by experimental phases, are sometimes necessary to obtain a satisfactory result. In carrying out this process, it is necessary to take account of :

- safety of the machine,

- ability of the machine to perform its function and to be set up, adjusted and maintained,

- manufacturing and operational cost of the machine,

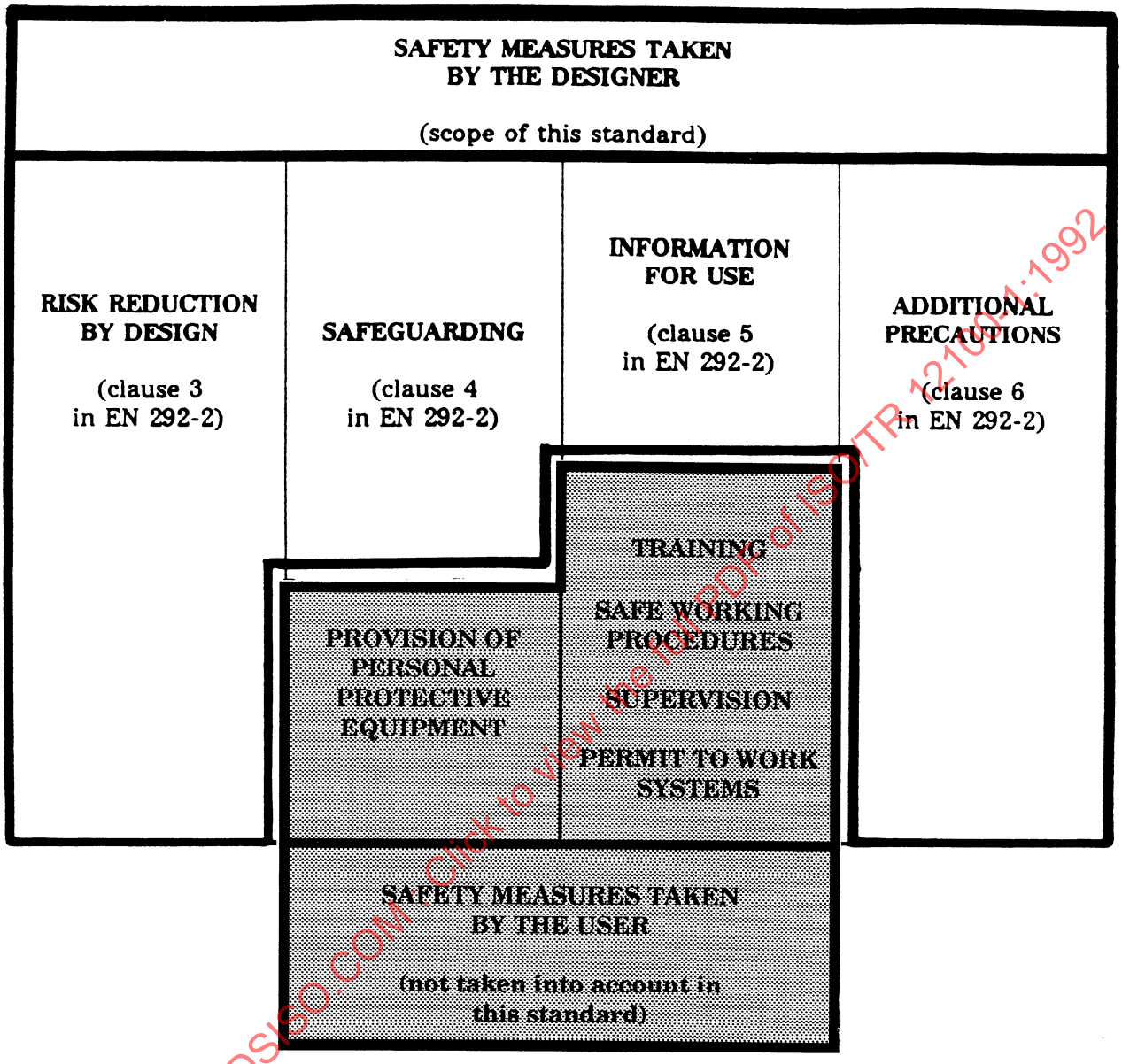
in that order of preference.

Any measures which can be incorporated at the design stage are preferable to any which are implemented by the user (see table 1 hereafter).

The users responsibilities regarding implementation of measures to minimize residual risks are not covered by this standard.

For the continued safe operation of the machine, it is important that the safety measures allow its easy use and do not hinder its intended use. Failure to do this could lead to safety measures being by-passed in order to achieve maximum utility of the machine (see also 5.7.1).

Table 1 - Relationship between the duties of the designer and of the user



5.1 Specification of the limits of the machine

The **design of a machine** (see 3.11) begins with the determination of limits :

- use limits : determination of the **intended use** of the machine (see 3.12), etc.,

- space limits : range of movement, space requirements for installation of the machine, "operator-machine" and "machine-power supply" interfaces, etc.,

- time limits : determination of the foreseeable "life limit" of the machine, taking into account its intended use, and/or of some of its components (tools, wear parts, electrical components, etc.).

5.2 Systematic assessment of hazardous situations (see 3.6)

Having identified the various hazards that may be generated by the machine (see clause 4), the designer shall attempt to foresee **all situations which might lead to these hazards causing injury or damage to health**. For this purpose, he shall take into account :

5.2.1 **Human interaction with all phases of the "life" of the machine**, as listed in 3.11 a).

5.2.2 **Possible states of the machine** :

a) **The machine performs the intended function** (the machine operates normally).

b) **The machine does not perform the intended function** (malfunction) due to a variety of reasons, including :

- variation of a property or of a dimension of the processed material or of the workpiece,
- failure of one (or more) of its component parts or services,
- external disturbances (e.g. shocks, vibration, electromagnetic fields),
- design error or deficiency (e.g. software errors),
- disturbance of its power supply,
- loss of control of the machine by the operator (especially for hand-held machines).

5.2.3 **Foreseeable cases in which a misuse of the machine might occur** (see examples at the end of 3.12).

5.3 Removal of the hazards or limitation of the risk (risk reduction by design)

This objective may be met by completely removing or minimizing as far as possible, separately or simultaneously, each of the two factors which determine the risk (see 6.2).

All technical measures which make it possible to reach this objective contribute to **risk reduction by design** (see clause 3 in EN 292-2).

5.4 Safeguarding against hazards which can not be avoided or sufficiently limited according to 5.3 (see clause 4 in EN 292-2).

5.5 Informing and warning users about residual risks

It is necessary to inform and warn the users about residual risks, i.e. those against which risk reduction by design and safeguarding techniques are not - or not totally - effective (see clause 5 in EN 292-2) ; the instructions and warnings shall prescribe the procedures and operating modes intended to overcome the relevant hazards, indicate if a particular training is needed and if it is necessary to specify personal protective equipment (see 5.1.1 and 5.1.3 in EN 292-2).

5.6 Additional precautions

At this stage, the designer shall determine whether additional arrangements are necessary to deal with **emergency situations** (see 6.1 in EN 292-2) or **can improve safety as a secondary effect of their primary function** (see 6.2 in EN 292-2) ; e.g. **ease** of maintenance (maintainability) is also a safety factor.

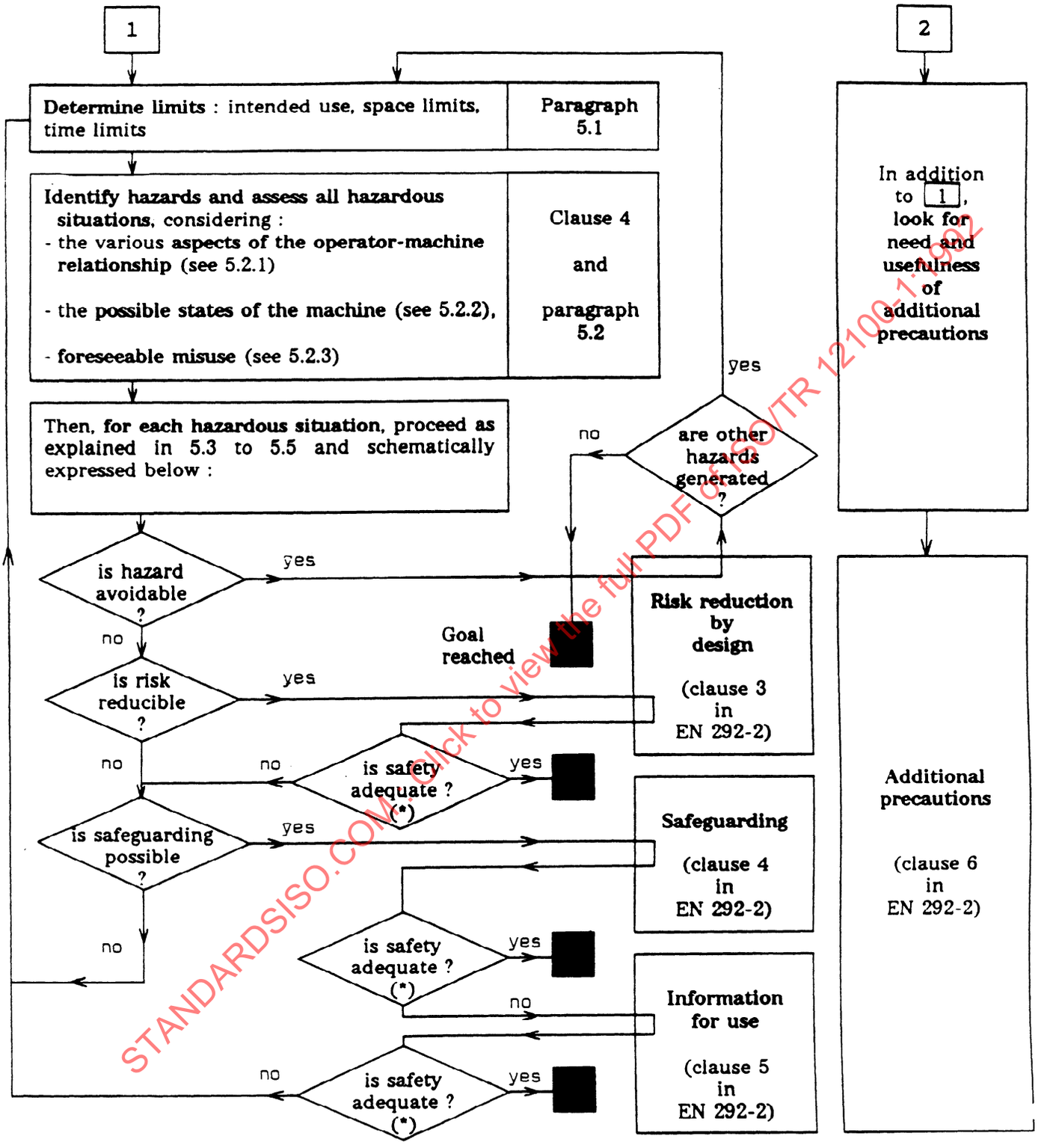
5.7 Remarks

5.7.1 The designer should determine as completely as possible the different machine operating modes and the different intervention procedures for the operators. Appropriate safety measures can then be associated with each of these modes and procedures. This prevents operators from being induced to use hazardous operating modes and intervention techniques because of technical difficulties (see also 3.12).

5.7.2 If the safety measures taken by the designer, according to the approach described above, do not totally meet the essential safety requirements, this shall be compensated by safe working practices (training, safe working procedures, supervision, permit to work systems, etc.) which are the user's responsibility and, hence, out of the scope of this standard.

5.7.3 In the case of non-professional use, it shall be anticipated that prior training and/or instruction will not be given and the design of the machine (safety measures taken by the designer,including information) should take this into account (see 5.1.1 in EN 292-2).

Table 2 - Schematic representation of the strategy for selecting designed-in safety measures



(*) "Is safety adequate ?" means :
- **Has the required level of safety been reached** ? (see clause 6 "Risk assessment")
- Is it certain that an **equivalent level of safety** cannot be obtained more easily ?
- Is it certain that the measures taken :
  . **do not excessively reduce the ability of the machine to perform its function** ?
  . **do not generate new, unexpected hazards or problems** ?
- Are there solutions for **all operating conditions, for all intervention procedures** (see 5.7.1) ?
- Are the solutions compatible with each other ?
- Are the operator's working conditions not jeopardized by those solutions ?

6 Risk assessment (see also EN .. ...[2] "Risk assessment")

6.1 Introduction

The aim of this clause is to show how and to what extent, the process - usually empirical - by which designers take advantage of their experience to assess the risk related to a particular situation can be made more rational **in order to improve the selection of safety measures for each type of hazard.**

NOTE 1 : It shall be assumed that, when present on a machine, a hazard will sooner or later lead to an injury or damage to health if no safety measure is taken.

NOTE 2 : A machine shall be safe in the sense of 3.4 of this standard. However, absolute safety is not a fully attainable state, and the objective to be met is the highest possible level of safety taking into account the state of the art.

The state of the art determines the constraints - including cost constraints - placed upon actual construction and use of the machine. The means employed to meet a safety objective which are acceptable according to the state of the art at a particular time, are no longer acceptable when developments allow the next generation of the same machine to be safer, or allow the design of a different and safer machine for the same purpose.

NOTE 3 : The concept of risk assessment is intended to help designers and safety engineers to define the most appropriate measures, so enabling them to achieve the highest possible level of safety, according to the state of the art and the resulting constraints.

It cannot be used, on the sole basis of accident data showing a small number of accidents or a low severity of them, to question the level of safety required for a machine. In particular, the absence of an accident history shall not be taken as an automatic presumption of a low level of risk, and hence shall not allow less stringent safety measures.

6.2 Factors to be taken into account when assessing a risk

The risk associated with a particular situation or technical process is derived from the combination of both following factors :

a) **Probability of the occurrence of an injury or damage to health**

This probability is related to the frequency of access, or to the time of presence, of persons in danger zones (see definition in 3.10), called **exposure to hazard**.

b) **Highest foreseeable severity of this injury or damage to health**

In a particular hazardous situation, the degree of injury or damage to health may vary as a function of many factors which can only be partly foreseen. When carrying out a risk assessment, the **most severe injury or damage to health** that is likely to occur from each identified hazard shall be taken into account, even if the probability of occurrence of such an injury or damage to health is not high.

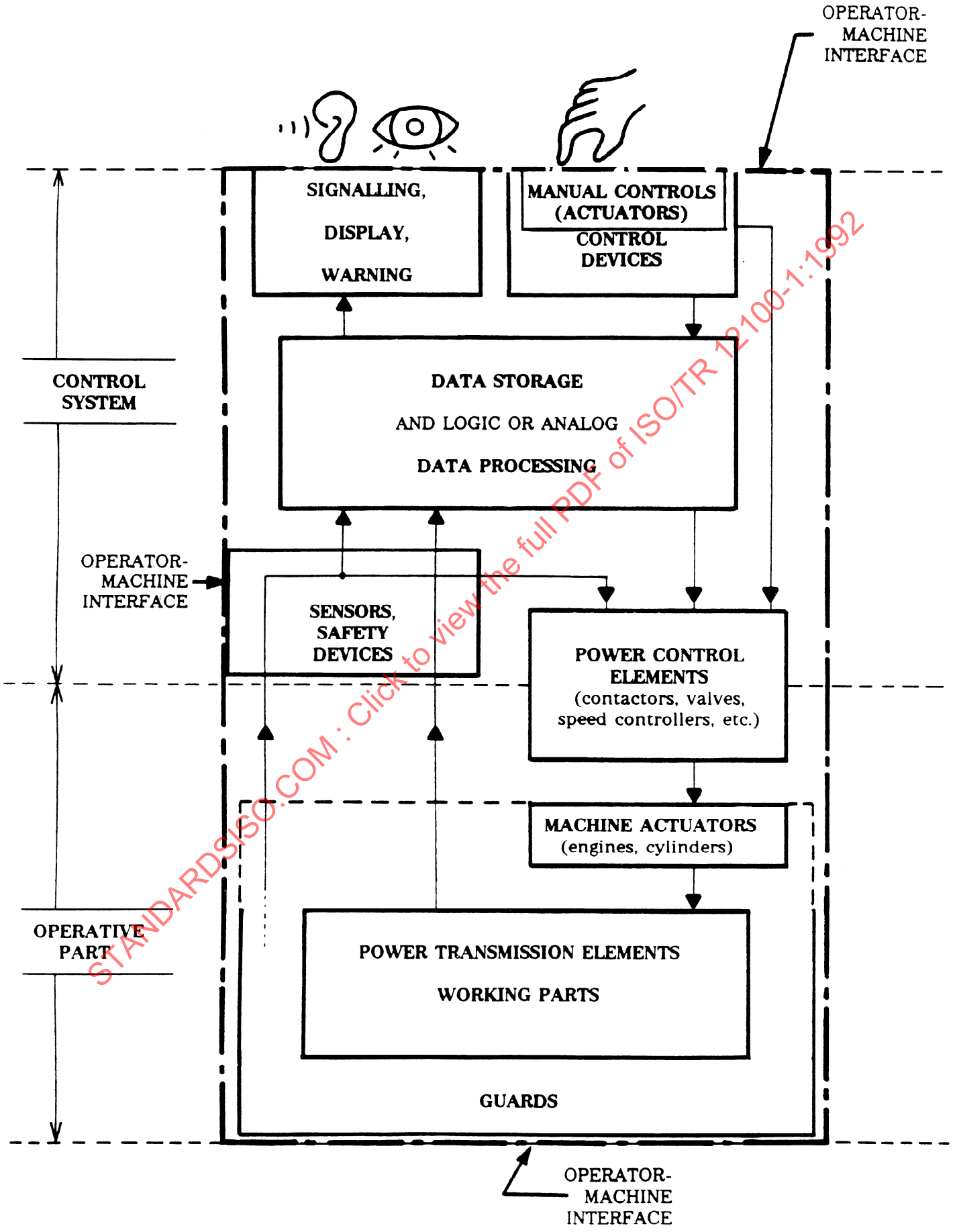
The analysis of the technical and human elements on which each risk factor a) and b) above is dependent is very useful for the selection of appropriate safety measures when designing a machine.

NOTE : It shall be emphasized that, except for some injuries or damages to health from e.g. noise or toxic substances, some factors of which have been quantified[4] the risk assessment is usually subjective.

However, comparisons between similar hazardous situations associated with different types of machines are often possible, provided that sufficient information about hazards and about accident circumstances in those situations is available.

4) e.g. limit value of the duration of exposure to a determined noise level, maximum admissible concentration of a toxic substance in the atmosphere (occupational exposure limits), etc.

General schematic representation of a machine



Annex B

(informative)

TRILINGUAL ALPHABETIC INDEX
of specific terms and expressions used
in the EN 292 standard

INDEX ALPHABÉTIQUE TRILINGUE
des termes et expressions spécifiques utilisés
dans la norme EN 292

DREISPRACHIGES ALPHABETISCHES VERZEICHNIS
der in der Norm EN 292 verwendeten
Fachwörter und -ausdrücke

Index of specific terms and locutions used in the standard	Verzeichnis der in der Norm verwendeten Fachwörter und -ausdrücke	Répertoire des termes et expressions spécifiques utilisés dans la norme	Subclause Paragraphe Unterabschnitt	
A				
Access	Zugang	Accès	6.2.4	EN 292-2
Access to danger zone	Zugang zum Gefahrbereich	Accès à la zone dangereuse	4.1.2	EN 292-2
Access to danger zone	Zugang zum Gefahrbereich	Accès à la zone dangereuse	4.1.3	EN 292-2
Access to danger zone	Zugang zum Gefahrbereich	Accès à la zone dangereuse	4.1.4	EN 292-2
Accessibility	Zugänglichkeit	Accessibilité	6.2.1	EN 292-2
Actuator (Hydraulic/Pneumatic -)	Antrieb (hydraulischer, pneumatischer)	Actionneur (pneumatique, hydraulique)	3.4	EN 292-2
Actuator (Machine -)	Antrieb	Actionneur	A	EN 292-1
Adjustable guard	Einstellbare trennende Schutzeinrichtung	Protecteur réglable	3.22.3	EN 292-1
Adjustable guard	Einstellbare trennende Schutzeinrichtung	Protecteur réglable	4.1.3.c	EN 292-2
Adjustable guard	Einstellbare trennende Schutzeinrichtung	Protecteur réglable	4.2.2.4	EN 292-2
Adjustment	Einstellung	Mise au point	3.11.a.2	EN 292-1
Anchoring (to a foundation)	Verankerung (mit einem Fundament)	Ancrage (à un massif)	6.2.5	EN 292-2
Angular part	Spitzes Teil	Pièce de forme aiguë	4.2.2	EN 292-1
Application	Verwendungsart	Mode d'utilisation	5.5.1.d	EN 292-2
Application	Verwendungsart	Mode d'utilisation	5.5.1.d	EN 292-2
Automatic monitoring	Automatische Überwachung/Selbstüberwachung	Auto-surveillance	3.14	EN 292-1
Automatic monitoring	Automatische Überwachung/Selbstüberwachung	Auto-surveillance	3.7.6	EN 292-1
Availability (of a machine)	Verfügbarkeit (einer Maschine)	Disponibilité (d'une machine)	6.2.6	EN 292-2
B				
Back-up safety function	Indirekt wirkende Sicherheitsfunktion	Sécurité indirecte (Fonction de -)	3.13.2	EN 292-1
Barrier	Sperre	Barrière	3.22	EN 292-1
Basic concepts	Grundbegriffe	Notions fondamentales		
Burn	Verbrennung	Brûlure	4.3	EN 292-1
Burn	Verbrennung	Brûlure	4.4	EN 292-1

C				
Casing	Gehäuse	Carter	*3.22*	*EN 292-1*
Centre of gravity	Schwerpunkt	Centre de gravité	*5.5.1.a*	*EN 292-2*
Chip	Span	Copeau	*4.2.2.1*	*EN 292-2*
Cleaning	Reinigung	Nettoyage	*3.11.a.3*	*EN 292-1*
Colour	Farbe	Couleur	*5.4*	*EN 292-2*
Colour	Farbe	Couleur	*5.5.2.e*	*EN 292-2*
Commissioning	Inbetriebnahme	Mise en service	*3.11.a.2*	*EN 292-1*
Common cause failure/Common mode failure	Systematischer Mehrfachausfall	Défaillance de mode commun	*3.7.5*	*EN 292-2*
Construction	Herstellung/Bau	Construction	*3.11.a.1*	*EN 292-1*
Containment	Kapselung/Fernhaltung	Rétention (de matériaux, etc.)	*4.2.2.1*	*EN 292-2*
Control	Steuerung	Commande	*3.1*	*EN 292-1*
Control device	Steuereinrichtung	Appareil de commande	*A*	*EN 292-1*
Control guard	Steuernde trennende Schutzausrüstung	Protecteur commandant la mise en marche	*3.22.6*	*EN 292-1*
Control guard	Steuernde trennende Schutzausrüstung	Protecteur commandant la mise en marche	*4.2.2.5*	*EN 292-2*
Control mode	Steuerungsart	Commande (Mode de -)	*3.13.1.b*	*EN 292-1*
Control mode	Steuerungsart	Commande (Mode de -)	*3.7.10*	*EN 292-2*
Control system	Steuersystem/Steuerung	Commande (Système de -)	*3.7*	*EN 292-2*
Corner (sharp -)	Scharfe Ecke	Angle vif	*3.1*	*EN 292-2*
Cover	Abdeckung	Couvercle	*3.22*	*EN 292-1*
Critical element	Kritisches Bauteil	Élement critique	*3.7.5*	*EN 292-2*
Crushing hazard	Gefährdung durch Quetschen	Risque d'écrasement	*3.2*	*EN 292-2*
Crushing hazard	Gefährdung durch Quetschen	Risque d'écrasement	*4.2.1*	*EN 292-1*
Crushing Zone	Quetschbereich	Zone d'écrasement	*4.2.2*	*EN 292-1*
Cutting element	Schneidelement	Élément coupant	*4.2.2*	*EN 292-1*
Cutting hazard	Gefährdung durch Schneiden/Abschneiden	Risque de coupure	*4.2.1*	*EN 292-1*
Cycle non-repeat function	Stillsetzung nach jedem Arbeitsgang	Non-répétition de cycle (Fonction de -)	*3.13.1*	*EN 292-1*
D				
Damage to health	Gesundheitsschädigung	Atteinte à la santé	*6.2.a*	*EN 292-1*
Damage to health	Gesundheitsschädigung	Atteinte à la santé	*6.2.b*	*EN 292-1*
Danger	Gefahr	Danger	*5.4*	*EN 292-2*
Danger zone	Gefahrbereich	Zone dangereuse	*3.10*	*EN 292-1*
Danger zone	Gefahrbereich	Zone dangereuse	*3.12*	*EN 292-2*
De-commissioning	Außerbetriebnahme	Mise hors service	*3.11.a.4*	*EN 292-1*
Defeating (of a safety device)	Umgehen (einer Schutzeinrichtung)	Neutralisation (d'un dispositif de protection)	*3.10*	*EN 292-2*

Defeating (of a safety device)	Umgehen (einer Schutzeinrichtung)	Neutralisation (d'un dispositif de protection)	*4.2*	*EN 292-2*
Defeating (of a warning device)	Umgehen (einer Warnanlage)	Fraude/Neutralisation frauduleuse (d'un dispositif d'avertissement)	*5.3*	*EN 292-2*
Depressurizing	Druckentspannung/-entlastung	Mise à la pression atmosphérique	*3.8*	*EN 292-2*
Design (of a machine)	Gestaltung/Konstruktion (einer Maschine)	Conception (d'une machine)	*3.11*	*EN 292-1*
Design (of a machine)	Gestaltung/Konstruktion (einer Maschine)	Conception (d'une machine)	*5.1*	*EN 292-1*
Diagnostic system	Diagnosesystem	Diagnostic (Système de -)	*6.2.6*	*EN 292-2*
Diagram (in the handbook)	Diagramm (in der Betriebsanleitung)	Schéma (dans la notice)	*5.5.1.c*	*EN 292-2*
Direct contact	Direktes Berühren	Contact direct	*4.3*	*EN 292-1*
Dismantling (of a machine)	Abbau (einer Maschine)	Démontage (d'une machine)	*3.11.a.4*	*EN 292-1*
Dismantling (of a machine)	Abbau (einer Maschine)	Démontage (d'une machine)	*3.4*	*EN 292-1*
Display	Anzeige	Affichage	*A*	*EN 292-1*
Disposal (of a machine)	Entsorgung (einer Maschine)	Mise au rebut (d'une machine)	*3.11.a.4*	*EN 292-1*
Door	Tür	Porte	*3.22*	*EN 292-1*
Drawing (in the handbook)	Zeichnung (in der Betriebsanleitung)	Dessin (dans la notice)	*5.5.1.e*	*EN 292-2*
Drawing-in/trapping hazard	Gefährdung durch Einziehen/Fangen	Risque d'entraînement ou d'emprisonnement	*4.2.1*	*EN 292-1*
Dust	Staub	Poussière	*4.8*	*EN 292-1*
Dynamic stability	Dynamische Standsicherheit	Stabilité dynamique	*6.2.5*	*EN 292-2*
E				
Edge (sharp -)	Scharfe Kante	Arête vive	*3.1*	*EN 292-2*
Electric field	Elektrisches Feld	Champ électrique	*3.7.3*	*EN 292-2*
Electric shock	Elektrischer Schlag	Choc électrique	*3.5*	*EN 292-1*
Electric shock	Elektrischer Schlag	Choc électrique	*3.9*	*EN 292-2*
Electric shock	Elektrischer Schlag	Choc électrique	*4.3*	*EN 292-1*
Electrical control system	Elektrische Steuerung	Commande électrique (Système de -)	*3.7.11*	*EN 292-2*
Electrical equipment	Elektrische Ausrüstung	Équipement électrique	*2*	*EN 292-1*
Electrical equipment	Elektrische Ausrüstung	Équipement électrique	*2*	*EN 292-2*
Electrical equipment	Elektrische Ausrüstung	Équipement électrique	*3.4*	*EN 292-2*
Electrical equipment	Elektrische Ausrüstung	Équipement électrique	*3.9*	*EN 292-2*
Electrical hazard	Elektrische Gefährdung	Risque électrique	*4.3*	*EN 292-1*
Electrical hazard (Preventing -)	Verhütung elektrischer Gefährdung	Risque électrique (Prévention du -)	*3.9*	*EN 292-2*
Electrical insulation	Elektrische Isolierung	Isolation électrique	*4.3*	*EN 292-1*
Electrical overloading	Überlastung (Elektrische)	Surcharge (électrique)	*5.5.1.b*	*EN 292-2*
Electromagnetic compatibility	Elektromagnetische Verträglichkeit	Compatibilité électromagnétique	*3.7.10*	*EN 292-2*
Emergency situation	Notfall	Situation d'urgence	*5.5.1.g*	*EN 292-2*
Emergency situation	Notfall	Situation d'urgence	*5.6*	*EN 292-1*

Emergency situation	Notfall	Situation d'urgence	*6.1*	*EN 292-2*
Emergency stop control	Not-Aus-Stellteil	Commande d'arrêt d'urgence	*3.7.10*	*EN 292-2*
Emergency stop control	Not-Aus-Stellteil	Commande d'arrêt d'urgence	*6.1.1*	*EN 292-2*
Emergency stopping device	Not-Aus-Einrichtung	Arrêt d'urgence (Dispositif d' -)	*6.1.1*	*EN 292-2*
Enabling (control) device	Zustimmungseinrichtung	Validation (Dispositif de -)	*3.23.2*	*EN 292-1*
Enclosing guard	Verkleidung	Enceinte	*3.22*	*EN 292-1*
Entanglement hazard	Gefährdung durch Erfassen/Aufwickeln	Risque de happement/d'enroulement	*4.2.1*	*EN 292-1*
Entanglement zone	Einziehbereich	Zone d'entraînement	*4.2.2*	*EN 292-1*
Environmental stress	Umgebungsstöreinfluß	Environnement (Contrainte d' -)	*3.7.3*	*EN 292-2*
Ergonomic principle	Ergonomisches Prinzip (-r Grundsatz)	Ergonomique (Principe -)	*3.6*	*EN 292-2*
Ergonomic principle	Ergonomisches Prinzip (-r Grundsatz)	Ergonomique (Principe -)	*4.9*	*EN 292-1*
Error (human)	Fehlverhalten (menschliches)	Erreur (humaine)	*4.9*	*EN 292-1*
Escape and rescue (of a person)	Befreiung und Rettung (einer Person)	Dégagement et sauvetage (d'une personne)	*6.1.2*	*EN 292-2*
Explosive atmosphere	Explosionsfähige Atmosphäre	Atmosphère explosible	*3.4*	*EN 292-2*
Exposure to hazard	Gefährdungsexposition/Aussetzung einer Gefährdung	Risque (Exposition au -)	*3*	*EN 292-2*
Exposure to hazard	Gefährdungsexposition/Aussetzung einer Gefährdung	Risque (Exposition au -)	*3.18*	*EN 292-1*
Exposure to hazard	Gefährdungsexposition/Aussetzung einer Gefährdung	Risque (Exposition au -)	*6.2.a*	*EN 292-1*
Exposure to hazards (Limiting -)	Begrenzung der Gefährdungsexposition	Risque (Limitation de l'exposition au -)	*3.10*	*EN 292-2*
Exposure to hazards (Limiting -)	Begrenzung der Gefährdungsexposition	Risque (Limitation de l'exposition au -)	*3.11*	*EN 292-2*
Exposure to hazards (Limiting -)	Begrenzung der Gefährdungsexposition	Risque (Limitation de l'exposition au -)	*3.12*	*EN 292-2*
F				
Fail-safe condition (minimized failure to danger)	Sicheres Fehlverhalten	Sécurité positive	*3.17*	*EN 292-1*
Failure	Ausfall	Défaillance	*3.16*	*EN 292-1*
Failure	Ausfall	Défaillance	*3.17*	*EN 292-1*
Failure to danger	Ausfall, der zum gefährlichen Zustand führt	Défaillance dangereuse	*3.16*	*EN 292-1*
Falling hazard	Absturzgefährdung	Risque de chute (de personne)	*4.2.3*	*EN 292-1*
Fault	Fehlzustand	Panne	*3.7*	*EN 292-2*
Fault finding	Fehlersuche	Défaut/panne (Recherche de -)	*3.11.a.3*	*EN 292-1*
Fault finding	Fehlersuche	Défaut/panne (Recherche de -)	*6.2.6*	*EN 292-2*
Fixed guard	Feststehende trennende Schutzeinrichtung	Protecteur fixe	*3.22.1*	*EN 292-1*
Fixed guard	Feststehende trennende Schutzeinrichtung	Protecteur fixe	*4.1.2*	*EN 292-2*

Fixed guard	Feststehende trennende Schutzeinrichtung	Protecteur fixe	*4.2.2.2*	*EN 292-2*
Foreseeable misuse	Vorhersehbarer Mißbrauch	Mauvais usage prévisible	*3.12*	*EN 292-1*
Foreseeable misuse	Vorhersehbarer Mißbrauch	Mauvais usage prévisible	*5.2.3*	*EN 292-1*
Foundation	Fundament	Massif	*6.2.5*	*EN 292-2*
Friction or abrasion hazard	Gefährdung durch Reibung/Abrieb	Risque d'abrasion	*4.2.1*	*EN 292-1*
G				
Guard	Trennende Schutzeinrichtung	Protecteur	*3.22*	*EN 292-1*
Guard	Trennende Schutzeinrichtung	Protecteur	*4.1*	*EN 292-2*
Guard	Trennende Schutzeinrichtung	Protecteur	*4.2.2*	*EN 292-2*
H				
Handling	Handhabung	Manutention	*5.5.1.a*	*EN 292-2*
Handling	Handhabung	Manutention	*6.2.3*	*EN 292-2*
Hardware based logic	Kontaktbehaftete Schaltung	Logique câblée	*3.7.7*	*EN 292-2*
Hazard	Gefährdung	Phénomène dangereux	*3.10*	*EN 292-2*
Hazard	Gefährdung	Phénomène dangereux	*3.5*	*EN 292-1*
Hazard	Gefährdung	Risque/Phénomène dangereux	*3.5*	*EN 292-1*
Hazard combination	Kombination von Gefährdungen	Risques (Combinaison de -)	*4.10*	*EN 292-1*
Hazard generated by material and substances	Gefährdung durch Werkstoff/andere Stoffe od. Substanzen	Risque engendré par des matériaux et des produits	*4.8*	*EN 292-1*
Hazard generated by neglecting ergonomics principles	Gefährdung durch Vernachlässigung ergonomischer Prinzipien	Risque engendré par le non-respect des principes ergonomiques)	*4.9*	*EN 292-1*
Hazard generated by noise	Gefährdung durch Lärm	Risque engendré par le bruit	*4.5*	*EN 292-1*
Hazard generated by radiation	Gefährdung durch Strahlung	Risque engendré par les rayonnements	*4.7*	*EN 292-1*
Hazard generated by vibration	Gefährdung durch Vibration	Risque engendré par les vibrations	*4.6*	*EN 292-1*
Hazardous malfunctioning	Gefährdung durch Fehlfunktion(en)	Dysfonctionnement dangereux	*3.7.11*	*EN 292-2*
Hazardous malfunctioning	Gefährdung durch Fehlfunktion(en)	Dysfonctionnement dangereux	*3.7.3*	*EN 292-2*
Hazardous situation	Gefährdungssituation	Situation dangereuse	*3.6*	*EN 292-1*
Hazardous situation	Gefährdungssituation	Situation dangereuse	*3.7.5*	*EN 292-2*
Hazardous situation	Gefährdungssituation	Situation dangereuse	*5.2*	*EN 292-1*
Hazardous situation	Gefährdungssituation	Situation dangereuse	*6.1.1*	*EN 292-2*
Heat	Hitze	Chaleur	*3.7.3*	*EN 292-2*
Heat source	Wärmequelle	Chaleur (Source de -)	*4.4*	*EN 292-1*

High pressure fluid ejection hazard	Gefährdung durch Herausspritzen von Flüssigkeit unter hohem Druck	Risque d'éjection de fluide sous haute pression	*4.2.1* *EN 292-1*
Hold-to-run control	Befehlseinrichtung mit selbsttätiger Rückstellung (Tippschalter)	Commande nécessitant une action maintenue	*3.23.3* *EN 292-1*
Hydraulic equipment	Hydraulische Ausrüstung	Équipement hydraulique	*3.8* *EN 292-2*
I			
Impact	Stoß	Choc	*3.7.3* *EN 292-2*
Impact hazard	Gefährdung durch Stoß	Risque de choc	*4.2.1* *EN 292-1*
Index	Verzeichnis	Index	*B* *EN 292-1*
Index	Verzeichnis	Index	*D* *EN 292-2*
Index (of the instruction handbook)	Verzeichnis (in der Betriebs- od. Gebrauchs-anleitung)	Index (de la notice d'instructions)	*5.5.2.f* *EN 292-2*
Indirect contact	Indirektes Berühren	Contact indirect	*4.3* *EN 292-1*
Information for use	Benutzerinformation	Informations pour l'utilisation	*3.20* *EN 292-1*
Information for use	Benutzerinformation	Informations pour l'utilisation	*5* *EN 292-2*
Inherently safe component	Eigensicherer Bauteil	Composant intrinsèquement sûr	*3.7.3* *EN 292-2*
Injury	Verletzung	Lésion	*3.1* *EN 292-2*
Injury	Verletzung	Lésion	*6.2.a* *EN 292-1*
Injury	Verletzung	Lésion	*6.2.b* *EN 292-1*
Inspection	Überwachung	Surveillance	*Tab. 1* *EN 292-1*
Inspection	Überwachung	Inspection	*3.7.9* *EN 292-2*
Inspection	Überwachung	Inspection	*5.7.2* *EN 292-1*
Inspection (Frequency of -)	Überwachung (Häufigkeit der -)	Inspections (Fréquence des -)	*5.4.c* *EN 292-2*
Installation	Anlage	Installation complexe	*6.2.2.b* *EN 292-2*
Installation (of the machine)	Installation (der Maschine)	Installation (de la machine)	*3.11.a.2* *EN 292-1*
Installation (of the machine)	Installation (der Maschine)	Installation (de la machine)	*5.1.3* *EN 292-2*
Instruction handbook	Betriebsanleitung	Notice d'instructions	*3.12* *EN 292-1*
Instruction handbook	Betriebsanleitung	Notice d'instructions	*5.5* *EN 292-2*
Instructions	Anleitungen	Instructions	*3.12* *EN 292-1*
Instructions	Anleitungen	Instructions	*5.5* *EN 292-2*
Insulation failure	Isolierungsfehler	Isolement (Défaut d' -)	*3.7.3* *EN 292-2*
Insulation failure	Isolierungsfehler	Isolement (Défaut d' -)	*4.3* *EN 292-1*
Intended use of a machine	Bestimmungsgemäße Verwendung einer Maschine	Utilisation normale d'une machine	*3.12* *EN 292-1*
Interlock (interlocking device)	Verriegelungseinrichtung (Verriegelung)	Verrouillage (Dispositif de -)	*3.23.1* *EN 292-1*