TECHNICAL REPORT

ISO/TR 18569

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Safety of machinery — Guidelines for the understanding and use of safety of machinery standards

Sécurité des machines — Lignes directrices pour la compréhension et l'utilisation des normes sur la sécurité des machines

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, 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), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 18569 was prepared by Technical Committee ISO/TC 199, *Safety of machinery.*

Safety of machinery — Guidelines for the understanding and use of safety of machinery standards

1 Scope

This Technical Report provides assistance to the designer or manufacturer of machinery and related equipment on the contents and how to apply the relevant Type A and Type B safety of machinery standards.

ISO/TR 18569 provides an overview which gives a general outline of the basic steps which can assist the manufacturer to declare conformity with the EU Machinery Directive and related standards or apply supporting standards in the case when specific Type C standards do not exist. It provides an outline of the various standards associated with machinery safety.

NOTE This Technical Report does not address Type C standards.

2 Classification of machinery safety standards

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

Table 1 — Type A standards

ISO/IEC	CEN/CENELEC	Title
ISO 12100-1	EN ISO 12100-1	*Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*
ISO 12100-2	EN ISO 12100-2	*Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles*
ISO 14121	EN 1050	*Safety of machinery — Principles of risk assessment*
—	EN 1070	*Safety of machinery — Terminology* (This document is an anthology of terms and their definitions taken from other documents.)

2.2 Type B standards (generic 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).

Table 2 — Type B standards

ISO/IEC	CEN/CENELEC	Title
General		
ISO 13849-1	EN 954-1	*Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*
ISO 13849-2	EN ISO 13849-2	*Safety of machinery — Safety-related parts of control systems — Part 2: Validation*
ISO 13850	EN 418	*Safety of machinery — Emergency stop — Principles for design*
ISO 13851	EN 574	*Safety of machinery — Two-hand control devices — Functional aspects and design principles*
ISO 13852	EN 294	*Safety of machinery — Safety distances to prevent danger zones being reached by the upper limbs*
ISO 13853	EN 811	*Safety of machinery — Safety distances to prevent danger zones being reached by the lower limbs*
ISO 13854	EN 349	*Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*
ISO 13855	EN 999	*Safety of machinery — Positioning of protective equipment with respect to the approach speeds of parts of the human body*
ISO 13856-1	EN 1760-1	*Safety of machinery — Pressure-sensitive protective devices — Part 1: General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors*
ISO 13856-2	EN 1760-2	*Safety of machinery — Pressure-sensitive protective devices — Part 2: General principles for the design and testing of pressure-sensitive edges and pressure-sensitive bars*
ISO 14118	EN 1037	*Safety of machinery — Prevention of unexpected start-up*
ISO 14119	EN 1088	*Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*
ISO 14120	EN 953	*Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*
ISO 14122-1	EN ISO 14122-1	*Safety of machinery — Permanent means of access to machinery — Part 1: Choice of fixed means of access between two levels*
ISO 14122-2	EN ISO 14122-2	*Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms and walkways*
ISO 14122-3	EN ISO 14122-3	*Safety of machinery — Permanent means of access to machinery — Part 3: Stairs, stepladders and guard-rails*
ISO 14122-4	EN ISO 14122-4	*Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders*
ISO 14123-1	EN 626-1	*Safety of machinery — Reduction of risks to health from hazardous substances emitted by machinery — Part 1: Principles and specifications for machinery manufacturers*
ISO 14123-2	EN 626-2	*Safety of machinery — Reduction of risks to health from hazardous substances emitted by machinery — Part 2: Methodology leading to the verification procedure*
ISO 14159	—	*Safety of machinery — Hygiene requirements for the design of machinery*
—	EN 1093-1	*Safety of machinery — Evaluation of the emission of airborne hazardous substances — Part 1: Selection of test methods*

Table 2 (*continued*)

ISO/IEC	CEN/CENELEC	Title
—	EN 1093-3	*Safety of machinery — Evaluation of the emission of airborne hazardous substances — Part 3: Emission rate of a specified pollutant — Bench test method using the real pollutant*
—	EN 1093-4	*Safety of machinery — Evaluation of the emission of airborne hazardous substances — Part 4: Capture efficiency of an exhaust system — Tracer method*
—	EN 1093-6	*Safety of machinery — Evaluation of the emission of airborne hazardous substances — Part 6: Separation efficiency by mass, unducted outlet*
—	EN 1093-7	*Safety of machinery — Evaluation of the emission of airborne hazardous substances — Part 7: Separation efficiency by mass, ducted outlet*
—	EN 1093-8	*Safety of machinery — Evaluation of the emission of airborne hazardous substances — Part 8: Pollutant concentration parameter, test bench method*
—	EN 1093-9	*Safety of machinery — Evaluation of the emission of airborne hazardous substances — Part 9: Pollutant concentration parameter, room method*
—	EN 1093-11	*Safety of machinery — Evaluation of the emission of airborne hazardous substances — Part 11: Decontamination index*
—	EN 1127-1	*Explosive atmospheres — Explosion prevention and protection — Part 1: Basic concepts and methodology*
—	EN 12198-1	*Safety of machinery — Assessment and reduction of risks arising from radiation emitted by machinery — Part 1: General principles*
—	EN 12198-2	*Safety of machinery — Assessment and reduction of risks arising from radiation emitted by machinery — Part 2: Radiation emission measurement procedure*
—	EN 12198-3	*Safety of machinery — Assessment and reduction of risks arising from radiation emitted by machinery — Part 3: Reduction of radiation by attenuation or screening*
Electrical		
IEC 60204–1	EN 60204-1	*Safety of machinery — Electrical equipment of machines — Part 1: General requirements*
IEC 61131-1	EN 61131-1	*Programmable controllers — Part 1: General information*
IEC 61131-2	EN 61131-2	*Programmable controllers — Part 2: Equipment requirements and tests*
IEC 61131-3	EN 61131-3	*Programmable controllers — Part 3: Programming languages*
IEC 61131-7	EN 61131-7	*Programmable controllers — Part 7: Fuzzy control programming*
IEC/TR 61131-8	—	*Programmable controllers — Part 8: Guidelines for the application and implementation of programming languages*
IEC 61310-1	EN 61310-1	*Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, auditory and tactile signals*
IEC 61310-2	EN 61310-2	*Safety of machinery — Indication, marking and actuation — Part 2: Requirements for marking*
IEC 61310-3	EN 61310-3	*Safety of machinery — Indication, marking and actuation — Part 3: Requirements for the location and operation of actuators*
IEC 61496-1	EN 61496-1	*Safety of machinery — Electro-sensitive protective equipment — Part 1: General requirements and tests*
IEC 61496-2	—	*Safety of machinery — Electro-sensitive protective equipment — Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)*

Table 2 (*continued*)

ISO/IEC	CEN/CENELEC	Title
IEC 61496-3	EN 61496-3	*Safety of machinery — Electro-sensitive protective equipment — Part 3: Particular requirements for active opto-electronic protective devices responsive to diffuse reflection (AOPDDR)*
Fluid power		
ISO 4413	EN 982	*Hydraulic fluid power — General rules relating to systems* (EN title: *Safety of machinery — Safety requirements for fluid power systems and their components — Hydraulics*)
ISO 4414	EN 983	*Pneumatic fluid power — General rules relating to systems* (EN title: *Safety of machinery — Safety requirements for fluid power systems and their components — Pneumatics*)
Vibration		
—	EN 1032	*Mechanical vibration — Testing of mobile machinery in order to determine the whole-body vibration emission value — General*
—	EN 1033	*Hand-arm vibration — Laboratory measurement of vibration at the grip surface of hand-guided machinery — General*
Electromagnetic compatibility (EMC)		
—	EN 50081-1	*Electromagnetic compatibility — Generic emission standard — Part 1: Residential, commercial and light industry*
—	EN 50081-2	*Electromagnetic compatibility — Generic emission standard — Part 2: Industrial environment*
—	EN 50082-1	*Electromagnetic compatibility — Generic immunity standard — Part 1: Residential, commercial and light industry*
IEC 61000-4-2	EN 61000-4-2	*Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 2: Electrostatic discharge immunity test — Basic EMC Publication*
IEC 61000-4-3	EN 61000-4-3	*Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 3: Radiated, radio-frequency, electromagnetic field immunity test*
IEC 61000-4-4	EN 61000-4-4	*Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 4: Electrical fast transient/burst immunity test — Basic EMC Publication*
IEC 61000-4-5	EN 61000-4-5	*Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 5: Surge immunity test*
IEC 61000-4-8	EN 61000-4-8	*Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 8: Power frequency magnetic field immunity test — Basic EMC Publication*
IEC 61000-4-11	EN 61000-4-11	*Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 11: Voltage dips, short interruptions and voltage variations immunity tests*
IEC 61000-6-2	EN 61000-6-2	*Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments*
Acoustics		
ISO 3740	EN ISO 3740	*Acoustics — Determination of sound power levels of noise sources — Guidelines for the use of basic standards*

Table 2 (*continued*)

ISO/IEC	CEN/CENELEC	Title
ISO 3741	EN ISO 3741	*Acoustics — Determination of sound power levels of noise sources using sound pressure — Precision methods for reverberation rooms*
ISO 3743-1	EN ISO 3743-1	*Acoustics — Determination of sound power levels of noise sources – Engineering methods for small, movable sources in reverberant fields — Part 1: Comparison method for hard-walled test rooms*
ISO 3743-2	EN ISO 3743-2	*Acoustics — Determination of sound power levels of noise sources — Engineering methods for small, movable sources in reverberant fields — Part 2: Methods for special reverberation test rooms*
ISO 3744	EN ISO 3744	*Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering method in an essentially free field over a reflecting plane*
ISO 3745	EN ISO 3745	*Acoustics — Determination of sound power levels of noise sources using sound pressure — Precision methods for anechoic and hemi-anechoic rooms*
ISO 3746	EN ISO 3746	*Acoustics — Determination of sound power levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane*
ISO 3747	EN ISO 3747	*Acoustics — Determination of sound power levels of noise sources using sound pressure — Comparison method* in situ
ISO 4871	EN ISO 4871	*Acoustics — Declaration and verification of noise emission values of machinery and equipment*
ISO 9614-1	EN ISO 9614-1	*Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 1: Measurement at discrete points*
ISO 9614-2	EN ISO 9614-2	*Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 2: Measurement by scanning*
ISO 9614-3	EN ISO 9614-3	*Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 3: Precision method for measurement by scanning*
ISO 11200	EN ISO 11200	*Acoustics — Noise emitted by machinery and equipment — Guidelines for the use of basic standards for the determination of emission sound pressure levels at a work station and at other specified positions*
ISO 11201	EN ISO 11201	*Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Engineering method in an essentially free field over a reflecting plane*
ISO 11202	EN ISO 11202	*Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Survey method* in situ
ISO 11203	EN ISO 11203	*Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions from the sound power level*
ISO 11204	EN ISO 11204	*Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Method requiring environmental corrections*
ISO 11205	EN ISO 11205	*Acoustics — Noise emitted by machinery and equipment — Engineering method for the determination of emission sound pressure levels* in situ *at the work station and at other specified positions using sound intensity*
ISO/TR 11688-1	EN ISO 11688-1	*Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning*
ISO 11690-1	EN ISO 11690-1	*Acoustics — Recommended practice for the design of low-noise workplaces containing machinery — Part 1: Noise control strategies*

Table 2 (*continued*)

ISO/IEC	CEN/CENELEC	Title
ISO 11690-2	EN ISO 11690-2	*Acoustics — Recommended practice for the design of low-noise workplaces containing machinery — Part 2: Noise control measures*
ISO 12001	EN ISO 12001	*Acoustics — Noise emitted by machinery and equipment — Rules for the drafting and presentation of a noise test code*
Ergonomics		
ISO 6385	ENV 26385	*Ergonomic principles in the design of work systems*
ISO 7243	EN 27243	*Hot environments — Estimation of heat stress on working man, based on the WBGT index (wet bulb globe temperature)*
ISO 7250	EN ISO 7250	*Basic human body measurements for technological design*
ISO 7726	EN 27726	*Ergonomics of the thermal environment — Instruments for measuring physical quantities*
ISO 7730	EN ISO 7730	*Moderate thermal environments — Determination of the PMV and the PPD indices and specification of the conditions for thermal comfort*
ISO 7933	EN 12515	*Ergonomics of the thermal environment — Analytical determination and interpretation of heat stress using calculation of the predicted heat strain*
ISO 8996	EN 28996	*Ergonomics of the thermal environment — Determination of metabolic rate*
ISO 9241-1	EN ISO 9241-1	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 1: General introduction*
ISO 9241-2	EN 29241-2	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 2: Guidance on task requirements*
ISO 9241-3	EN 29241-3	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 3: Visual display requirements*
ISO 9241-4	EN ISO 9241-4	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 4: Keyboard requirements*
ISO 9241-5	EN ISO 9241-5	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 5: Workstation layout and postural requirements*
ISO 9241-6	EN ISO 9241-6	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 6: Guidance on the work environment*
ISO 9241-7	EN ISO 9241-7	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 7: Requirements for display with reflections*
ISO 9241-8	EN ISO 9241-8	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 8: Requirements for displayed colours*
ISO 9241-9	EN ISO 9241-9	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 9: Requirements for non-keyboard input devices*
ISO 9241-10	EN ISO 9241-10	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 10: Dialogue principles*
ISO 9241-11	EN ISO 9241-11	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 11: Guidance on usability*
ISO 9241-12	EN ISO 9241-12	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 12: Presentation of information*
ISO 9241-13	EN ISO 9241-13	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 13: User guidance*
ISO 9241-14	EN ISO 9241-14	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 14: Menu dialogues*

Table 2 (*continued*)

ISO/IEC	CEN/CENELEC	Title
ISO 9241-15	EN ISO 9241-15	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 15: Command dialogues*
ISO 9241-16	EN ISO 9241-16	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 16: Direct manipulation dialogues*
ISO 9241-17	EN ISO 9241-17	*Ergonomic requirements for office work with visual display terminals (VDTs) — Part 17: Form filling dialogues*
ISO 9355-1	EN 894-1	*Ergonomic requirements for the design of displays and control actuators — Part 1: Human interactions with displays and control actuators*
ISO 9355-2	EN 894-2	*Ergonomic requirements for the design of displays and control actuators — Part 2: Displays*
—	EN 894-3	*Safety of machinery — Ergonomic requirements for the design of displays and control actuators — Part 3: Control actuators*
ISO 9886	EN ISO 9886	*Ergonomics — Evaluation of thermal strain by physiological measurements*
ISO 9920	EN ISO 9920	*Ergonomics of the thermal environment — Estimation of the thermal insulation and evaporative resistance of a clothing ensemble*
ISO 9921	EN ISO 9921	*Ergonomics — Assessment of speech communication*
ISO 10075	EN ISO 10075-1	*Ergonomic principles related to mental work-load — General terms and definitions*
ISO 10075-2	EN ISO 10075-2	*Ergonomic principles related to mental workload — Part 2: Design principles*
ISO 10075-3	EN ISO 10075-3	*Ergonomic principles related to mental workload — Part 3: Principles and requirements concerning methods for measuring and assessing mental workload*
ISO 10551	EN ISO 10551	*Ergonomics of the thermal environment — Assessment of the influence of the thermal environment using subjective judgement scales*
ISO 11064-1	EN ISO 11064-1	*Ergonomic design of control centres — Part 1: Principles for the design of control centres*
ISO 11064-2	EN ISO 11064-2	*Ergonomic design of control centres — Part 2: Principles for the arrangement of control suites*
ISO 11064-3	EN ISO 11064-3	*Ergonomic design of control centres — Part 3: Control room layout*
ISO/TR 11079	ENV ISO 11079	*Evaluation of cold environments — Determination of required clothing insulation (IREQ)*
ISO 11226	EN 1005-4	*Ergonomics — Evaluation of static working postures* (EN title: *Safety of machinery — Human physical performance — Part 4: Evaluation of working postures and movements in relation to machinery*)
—	EN 1005-3	*Safety of machinery — Human physical performance — Part 3: Recommended force limits for machinery operation*
ISO 11228-1	EN 1005-2	*Ergonomics — Manual handling — Part 1: Lifting and carrying* (EN title: *Safety of machinery — Human physical performance — Part 2: Manual handling of machinery and component parts of machinery*)
—	EN 1005-1	*Safety of machinery — Human physical performance — Part 1: Terms and definitions*
ISO 11399	EN ISO 11399	*Ergonomics of the thermal environment — Principles and application of relevant International Standards*
ISO 11428	EN 842	*Ergonomics — Visual danger signals — General requirements, design and testing* (EN title: *Safety of machinery — Visual danger signals — General requirements, design and testing*)

Table 2 (*continued*)

ISO/IEC	CEN/CENELEC	Title
ISO 11429	EN 981	*Ergonomics — System of auditory and visual danger and information signals* (EN title: *Safety of machinery — System of auditory and visual danger and information signals*)
ISO 12894	EN ISO 12894	*Ergonomics of the thermal environment — Medical supervision of individuals exposed to extreme hot or cold environments*
ISO 13406-1	EN ISO 13406-1	*Ergonomic requirements for work with visual displays based on flat panels — Part 1: Introduction*
ISO 13406-2	EN ISO 13406-2	*Ergonomic requirements for work with visual displays based on flat panels — Part 2: Ergonomic requirements for flat panel displays*
ISO 13407	EN ISO 13407	*Human-centred design processes for interactive systems*
ISO 13731	EN ISO 13731	*Ergonomics of the thermal environment — Vocabulary and symbols*
—	EN 563	*Safety of machinery — Temperatures of touchable surfaces — Ergonomics data to establish temperature limit values for hot surfaces*
ISO 14738	EN ISO 14738	*Safety of machinery — Anthropometric requirements for the design of workstations at machinery*
ISO 14915-1	EN ISO 14915-1	*Software ergonomics for multimedia user interfaces — Part 1: Design principles and framework*
ISO 14915-3	EN ISO 14915-3	*Software ergonomics for multimedia user interfaces — Part 3: Media selection and combination*
ISO 15534-1	EN 547-1	*Ergonomic design for the safety of machinery — Part 1: Principles for determining the dimensions required for openings for whole-body access into machinery* (EN title: *Safety of machinery — Human body measurements — Part 1: Principles for determining the dimensions required for openings for whole body access into machinery*)
ISO 15534-2	EN 547-2	*Ergonomic design for the safety of machinery — Part 2: Principles for determining the dimensions required for access openings* (EN title: *Safety of machinery — Human body measurements — Part 2: Principles for determining the dimensions required for access openings*)
ISO 15534-3	EN 547-3	*Ergonomic design for the safety of machinery — Part 3: Anthropometric data* (EN title: *Safety of machinery — Human body measurements — Part 3: Anthropometric data*)
ISO 15535	EN ISO 15535	*General requirements for establishing anthropometric databases*
ISO 15536-1	EN ISO 15536-1	*Ergonomics — Computer manikins and body templates — Part 1: General requirements*
ISO 15537	EN ISO 15537	*Principles for selecting and using test persons for testing anthropometric aspects of industrial products and designs*

2.3 Type C standards (machine safety standards) dealing with detailed safety requirements for a particular machine or group of machines.

NOTE Type C standards are not covered by this Technical Report.

2.4 Overview — Basic flow diagram and grouping by activities

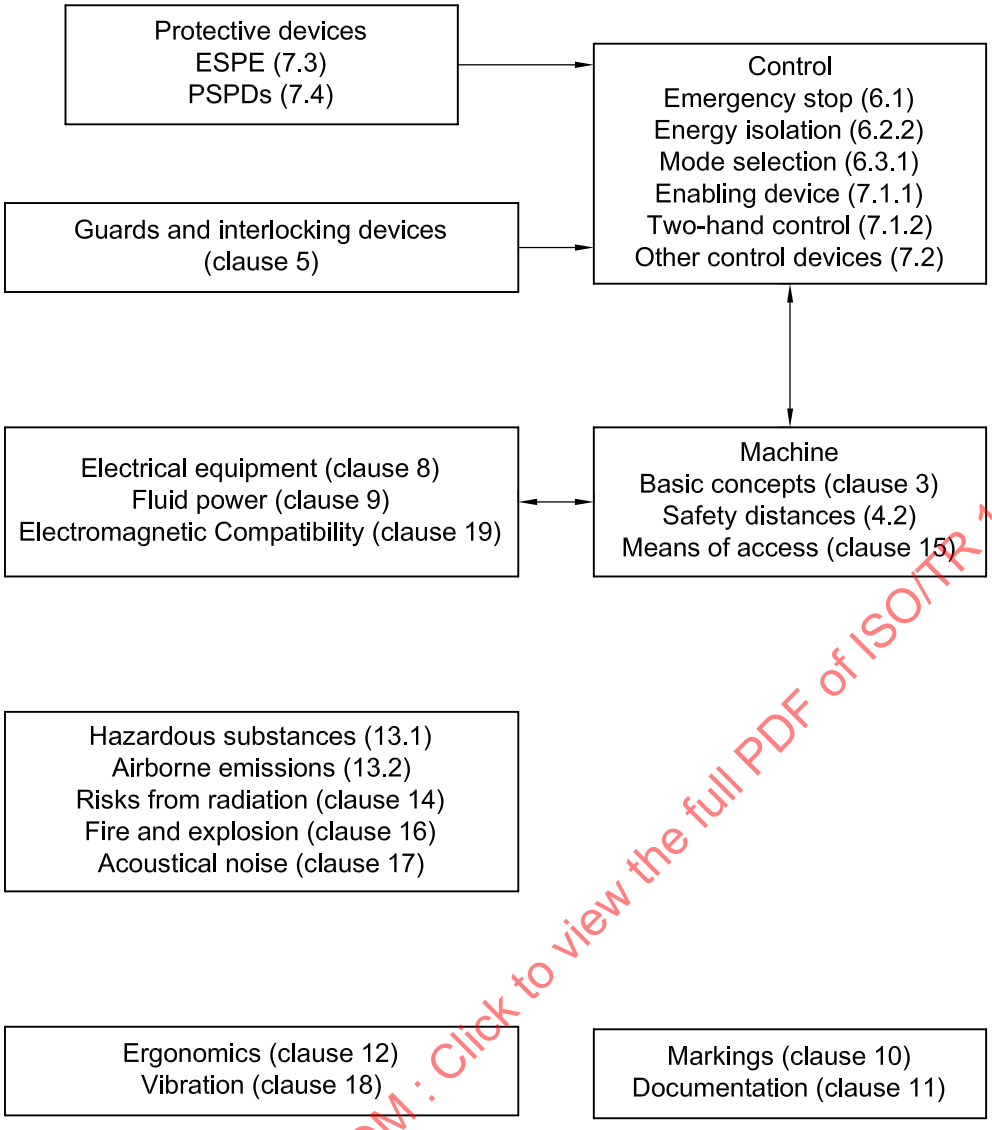


Figure 1 — Overview of the safety of machinery standards

3 Basic concepts, principles and requirements

The basic approach for machinery safety is shown in Figures 2a, 2b, 2c and 2d, which means the concept of risk reduction by using protective measures including safety functions, the iterative method for risk assessment/risk reduction and the selection and validation of safety functions (safety-related parts of control systems). The block in the upper left-hand corner of Figures 2a and 2c portrays the basic steps in the risk assessment procedure as detailed in ISO 14121, *Safety of machinery — Principles of risk assessment*. Figure 2b illustrates the concept of risk reduction using protective measures including safety functions (safety-related parts of control systems). Figure 2c illustrates the basic procedures for risk reduction which is further detailed in ISO 12100-1:2003, Figure 2. Figure 2d illustrates the determination of the protective measure when it has been determined to be a safety-related part of the control system.

The remainder of the document portrays the hierarchical risk reduction procedure undertaken by the supplier:

1) intrinsic design measures,
2) safeguarding and complementary protective measures and
3) information for use.

For further details on information for use, see ISO 12100-1:2003, Clause 5, ISO 12100-2:2003, Clause 6, and Clause 11 of this Technical Report.

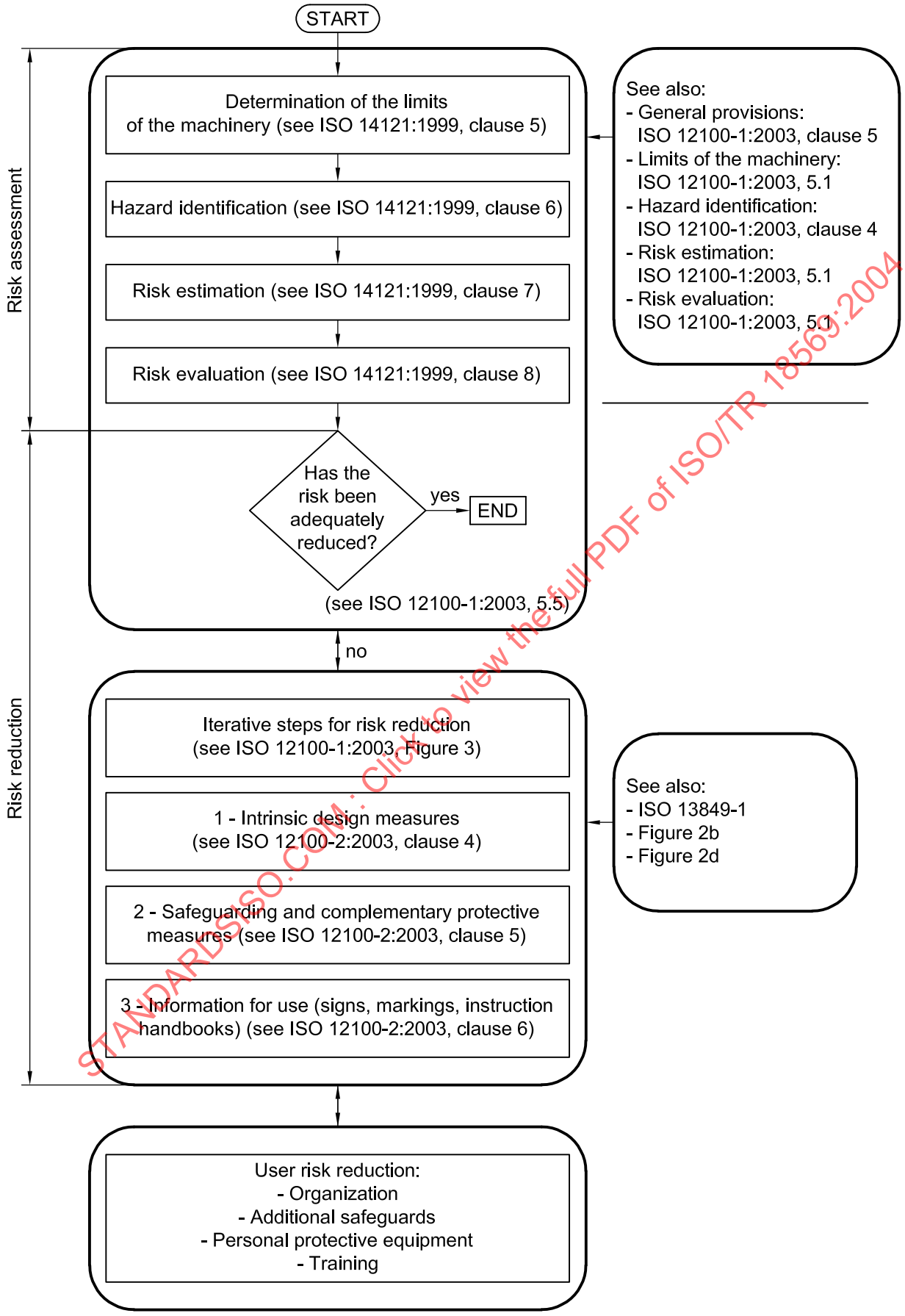
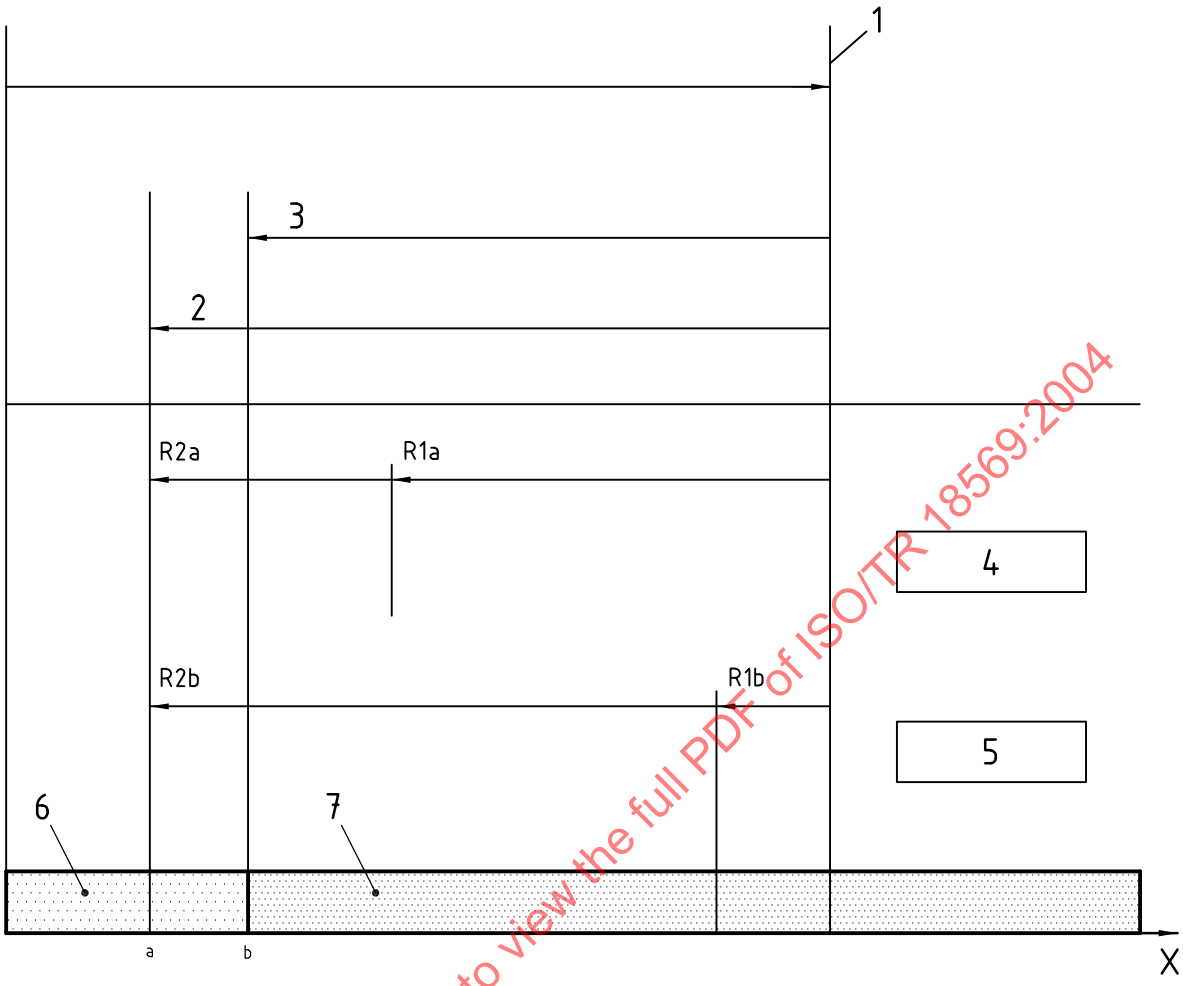


Figure 2a — Basic diagram illustrating risk assessment and risk reduction



1 For a given hazardous situation, the risk before protective measures are applied

2 Actual risk reduction

3 Risk reduction required from protective measures

4 Solution “a”: Important part of the risk reduction due to mechanical measures (e.g. closed tool), small part of the risk reduction due to SRP/CS

5 Solution “b”: Important part of the risk reduction due to SRP/CS (e.g. light curtain), small part of the risk reduction due to mechanical measures

6 Acceptable

7 Unacceptable

X Risk

[a] Residual risk

[b] Acceptable risk achieved

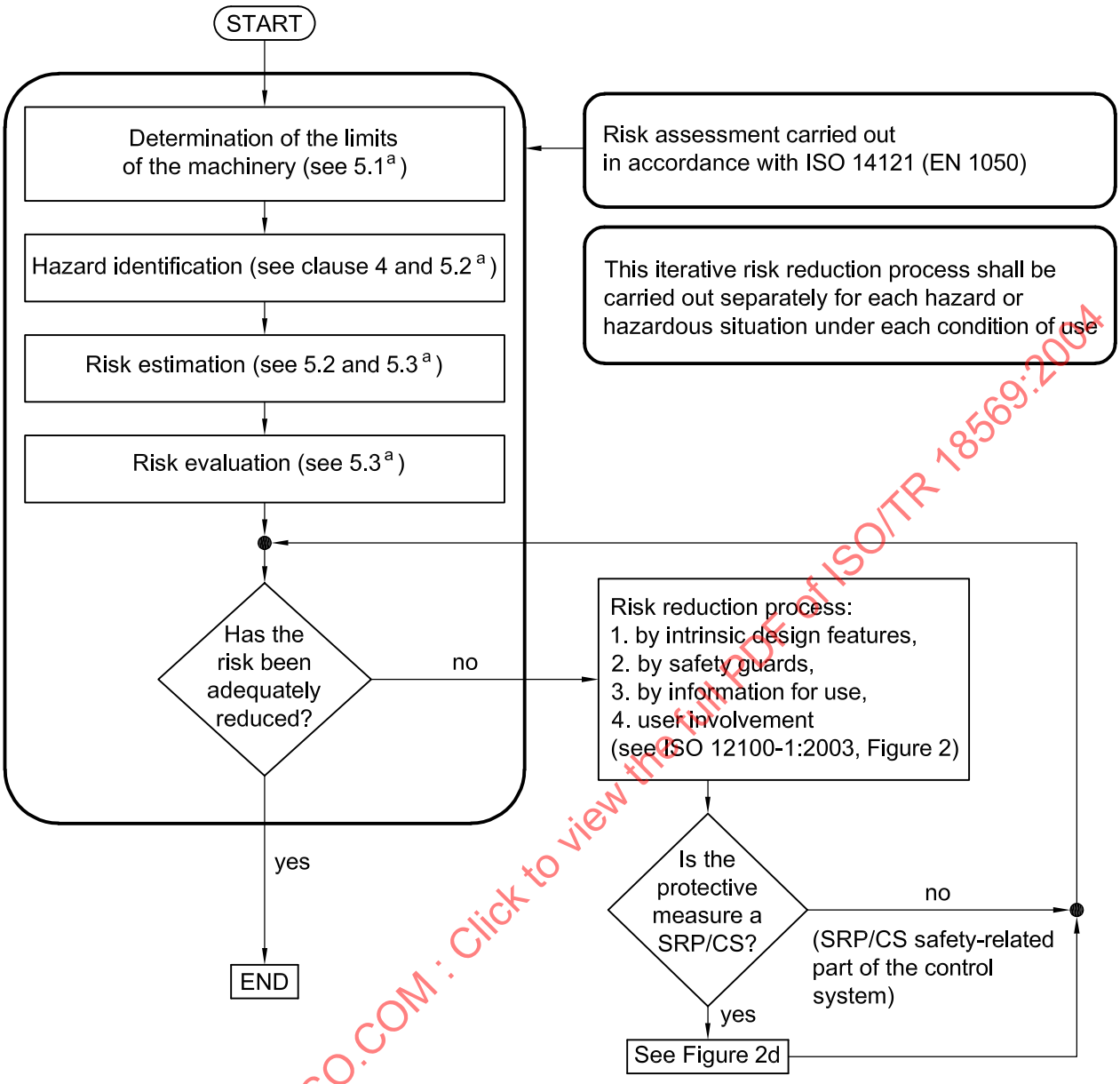
R1 Risk reduction from protective measures other than SRP/CS

R2 Risk reduction from the safety function carried out by the SRP/CS (scope of ISO 13849-1)

SRP/CS Safety-related part of the control system

See ISO 12100 for further information on risk reduction.

Figure 2b — Concept of risk reduction using protective measures including safety functions



a Subclause references to ISO 12100-1:2003

Figure 2c — Iterative process for the selection of protective measures

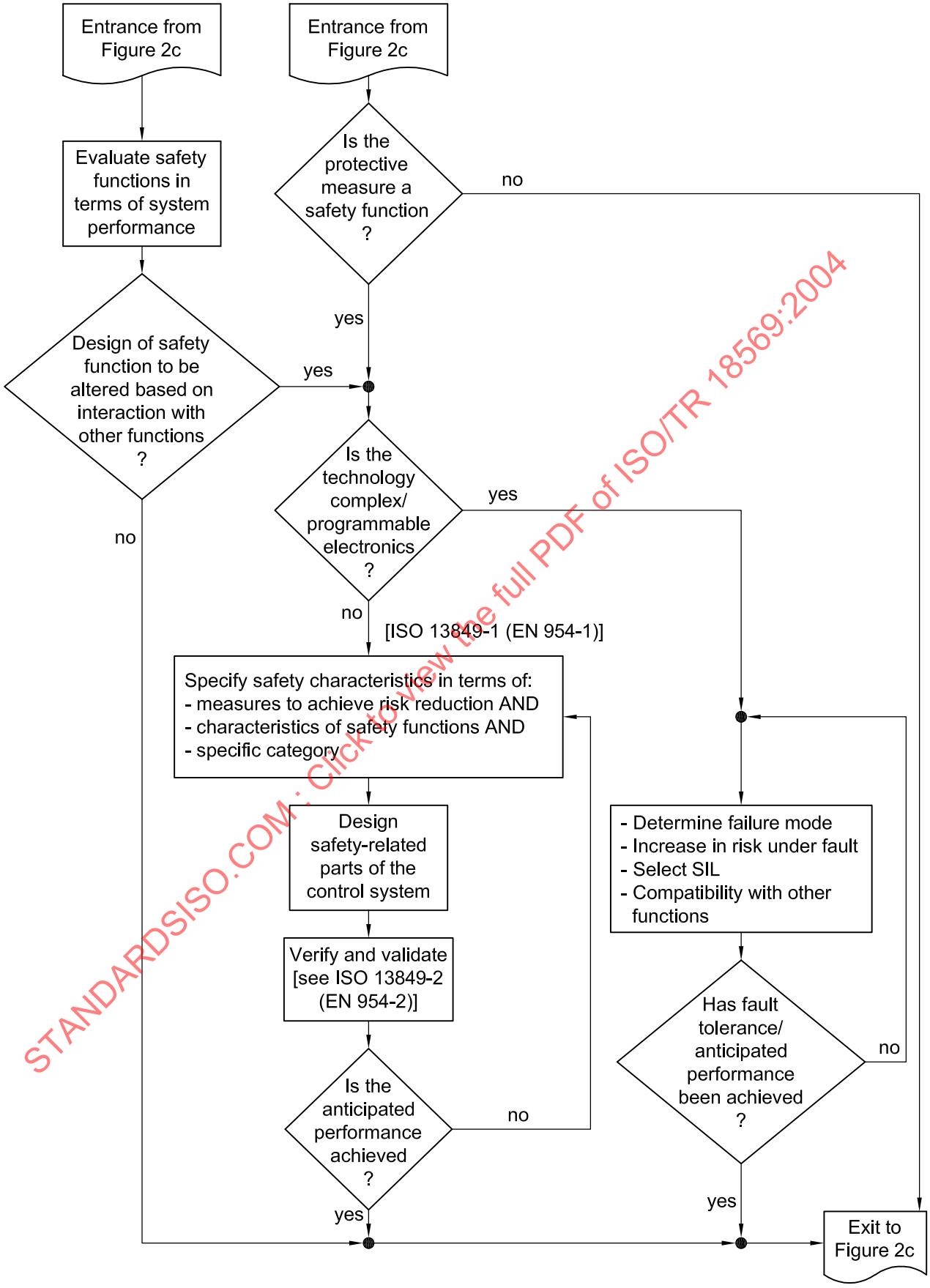


Figure 2d — Overview of the determination and validation of safety functions

4 Safety distances and hand/arm speed

4.1 General

When positioning guards and other safeguarding devices, it may be necessary to determine the distance from the hazard zone to ensure proper effectiveness of the safeguard. This distance is based on approach speed and in general is calculated using the formula given in 4.4.

4.2 Safety distances

a) ISO 13852: Upper limbs (standard to be used in determining reaching values):

   1) Reaching values:

      i) upwards;

      ii) around;

      iii) through openings.

   2) Effects of additional protective structures.

b) ISO 13854: Minimum gaps to prevent crushing of body parts (standard to be used to determine minimum gaps to avoid crushing of body parts):

   Minimum gaps for various parts of the body are given in Table 1 of the standard.

c) ISO 13853: Lower limbs (standard to be used in determining reaching values):

   1) Reaching values:

      i) regular openings;

      ii) irregular openings.

4.3 Hand/arm speed

ISO 13855: Approach speed to determine positioning of protective devices:

a) Methodology [see ISO 13855:2002, Figure 2];

b) Method for calculating minimum distances;

c) Methods for calculating minimum distances for:

   1) electro-sensitive protective systems;

   2) ground-level trip devices (e.g. PSPDs);

   3) hold-to-run controls (e.g. single-hand and two-hand control);

   4) combination of devices.

4.4 Basic formula

The minimum distance from the danger zone is calculated by using the general formula

$$S = (K \times T) + C \quad (1)$$

where

S is the minimum distance, in millimetres, from the danger zone to the detection point, line or plane or zone;

K is a parameter, in millimetres per second, derived from data on approach speeds of the body or parts of the body;

T is the overall system stopping performance [see ISO 13855:2002, 3.2];

C is an additional distance, in millimetres, based on intrusion towards the danger zone prior to actuation of the protective equipment.

5 Guards and interlocking devices

5.1 General

Probably the most common safeguard is a guard. Where it is necessary to be able to “open” a guard during operation or maintenance, the guard is normally interlocked so that the hazardous situation covered by the guard is “stopped” or prevented from “starting”. Where additional protection is required due to either stopping time of the hazardous motion or insufficient distance between the guard and the hazard zone, the use of guard locking may be needed.

5.2 Guards

a) Basic definitions – ISO 12100-1:2003:

1) guard (3.25);

2) fixed (3.25.1);

3) movable (3.25.2);

4) adjustable (3.25.3);

5) interlocking (3.25.4);

6) interlocking with guard locking (3.25.5);

7) control (3.25.6).

b) Selection – ISO 12100-2:2003, Figure 1.

c) Requirements – ISO 12100-2:2003, 4.2.2.

d) Detailed requirements – ISO 14120:2002:

1) definitions (Clause 3);

2) requirements for design and construction (Clauses 5 and 7);

3) selection of types (Clause 6);

4) verification of the safety requirements (Clause 8);

5) instructions for use (Clause 9).

5.3 Interlocking devices

a) Definition – see ISO 12100-1:2003, 3.26.1.

b) Requirements – see ISO 12100-2:2003, 5.2.2, 5.2.3, 5.3.2.3, 5.3.2.5.

c) Detailed requirements – ISO 14119:

1) definitions;

2) operating principles;

3) requirements for design;

4) additional requirements for electrical interlocks;

5) selection.

d) References to interlocking in IEC 60204-1:2000:

1) definition: see 3.29;

2) other references in the text: see 5.3.1, 6.2.2b, 9.2.5.1, 9.2.5.2, 9.3.1, 9.3.3, 9.3.4, 9.4.1, 9.4.2.3.

6 Safety functions

6.1 Emergency stop

There are two standards which deal with the requirements for emergency stop: ISO 13850 and IEC 60204-1. Other requirements are found in ISO 12100-2 and ISO 13849-1.

a) Basic requirements – see ISO 13850:

1) Category 0;

2) Category 1.

b) Emergency stop device:

1) General:

i) ISO 12100-2:2003, 6.1.1;

ii) IEC 60204-1:2000, 10.7;

iii) ISO 13850:1996, 4.3 to 4.5;

iv) IEC 60947-5-5.

2) Control medium “Mechanical”:

   ISO 13850.

3) Control medium “Electrical” (IEC 60204-1:2000):

   i) 5.3.3: Supply disconnecting (isolating) device;

   ii) 9.2.2: Stop functions;

   iii) 9.2.4: Suspension of safeguarding;

   iv) 9.2.5.4: Emergency operations;

   v) 10.2.1: Colours;

   vi) Table 2: Colours for push-button actuators and their meanings;

   vii) Table 3: Colours for indicator lights and their meanings with respect to the condition of the machine;

   viii) 10.4: Illuminated push-buttons;

   ix) 10.7: Devices for emergency stop;

   x) Table F.1: Application options.

4) Control medium “Fluid” (ISO 4413 – Hydraulic; ISO 4414 – Pneumatic):

   Only a reference to ISO 13850.

6.2 Energy isolation and prevention of unexpected start-up

6.2.1 General

Means of reducing the risks from energy sources and unintended or unexpected initiation of hazardous situations.

6.2.2 Energy isolation

a) ISO 14118:2000:

   — Definition: see 3.3;

   — Means for isolation and energy dissipation.

b) IEC 60204-1:2000:

   — References: see 5.3.2.

6.2.3 Prevention of unexpected start-up

a) ISO 14118:2000:

   — Definition: see 3.2;

   — Other means for preventing unexpected start-up: monitoring, 6.4.

b) IEC 60204-1:2000:

— References: see 5.4, 9.4.3.1.

6.3 Mode selection, reduced speed and monitoring

6.3.1 Mode selection

References – see:

— ISO 12100-2:2003, 3.7.9, 3.7.10;

— IEC 60204-1:2000, 9.2.3, 9.2.4.

6.3.2 Reduced speed

Reference – see ISO 12100-2:2003, 4.11.10.

6.3.3 Monitoring

References – see:

— ISO 12100-2:2003, 4.12.1, 4.12.2, 5.3.2.3;

— IEC 60204-1:2000, 7.5 to 7.9, 9.2.5.5, 9.4.3.1.

7 Protective devices

7.1 Enabling and two-hand control devices

7.1.1 Enabling device

a) Definition – see ISO 12100-1:2003, 3.26.2.

b) Requirements – see IEC 60204-1:2000, 9.2.5.8.

Where an enabling device is provided as part of the system, it is designed to allow motion or another hazardous situation when actuated in one position only. In any other position, hazardous situations are stopped safely. Operation of the device by itself does not initiate hazardous situations. When an enabling device is required, it is connected to a category 0 or a category 1 stop (see IEC 60204-1:2000, 9.2.2). Enabling devices are designed in compliance with ergonomic principles. A simple defeat is prevented.

c) Types of enabling device:

1) two-position:

i) position 1: off-function of the switch (actuator is not pushed);

ii) position 2: enabling function (actuator is pushed).

2) three-position:

i) position 1: off-function (actuator is not pushed);

ii) position 2: enabling function (actuator is pushed to its mid position);

iii) position 3: off-function (actuator is pushed past its mid position).

When returning from position 3 to position 2, the enabling function should not become active.

7.1.2 Two-hand control device

a) Definition – see:

— ISO 12100-1:2003, 3.26.4;

— ISO 13851:2001, 3.1.

b) Requirements: Three types of two-hand control device are available, the selection of which is determined by the risk assessment. These should have the following features:

1) Type I – This type requires:

i) the provision of two control devices requiring concurrent actuation by both hands;

ii) continuous actuation during the hazardous condition; and

iii) machine operation to cease on release of either control device when hazardous conditions are still present.

2) Type II – A type I control requiring the release of both control devices before machine operation may be reinitiated.

3) Type III – A type II control requiring concurrent actuation of the control devices as follows:

i) it should be necessary to actuate the control devices within a certain time limit of each other (see ISO 13851:2002, Annex B);

ii) where the time limit is exceeded, both control devices should be released before operation may be initiated.

Type III is further classified as IIIA, IIIB, IIIC (see ISO 13851:2002, Table 1 – see also IEC 60204-1:2000, 9.2.5.7).

c) ISO 13851 describes:

1) types of two-hand control device and their selection;

2) characteristics of safety functions;

3) requirements related to categories of control;

4) use of programmable electronic systems;

5) prevention of accidental actuation and of defeat;

6) general requirements;

7) test procedures;

8) information for use;

9) marking.

7.2 Hold-to-run, trip, mechanical restraint, limiting and limited movement devices

7.2.1 Hold-to-run control device

Definition – see ISO 12100-1:2003, 3.26.3.

Requirements – see IEC 60204-1:2000, 9.2.5.6, 10.2; ISO 12100-2, 3.7.8b.

7.2.2 Trip device

Requirements – see ISO 12100-2:2003, 5.2.1, 5.2.2, 5.2.3; IEC 60204-1:2000, 9.4.1, EN 1760.

7.2.3 Mechanical restraint device

Definition – see ISO 12100-1:2003, 3.26.7.

7.2.4 Limiting device

Definition – see:

— ISO 12100-1:2003, 3.26.8;

— IEC 60204-1:2000, 3.30.

Requirements – see ISO 12100-2:2003, 3.8; IEC 60204-1:2000, 9.3.2.

7.2.5 Limited movement control device

Definition – see ISO 12100-1:2003, 3.26.9.

Requirements – see ISO 12100-2:2003, 4.11.10.

7.3 Electro-sensitive protective equipment (ESPE)

a) Definitions:

1) Electro-sensitive protective equipment (ESPE)

A protective trip or presence-sensing system comprising as a minimum:

— a sensing function,

— a system control function,

— output signal switching devices.

[IEC 61496-1:1997, 3.1]

NOTE The safety-related control system associated with the ESPE, or the ESPE itself, may include a final switching device, a secondary switching device, muting functions, stopping performance monitor, etc., in order to assist in the understanding of the inter-relationship of the various major elements of the ESPE and the associated safety-related control systems. Block schematic diagrams are included as Figures A.1 and A.2 of the standard mentioned.

2) Active opto-electronic protective device (AOPD)

A device whose sensing function is performed by opto-electronic emitting and receiving elements detecting the interruption of optical radiations, generated within the device, by an opaque object present in the specified detection zone.

[IEC 61496-2:1997, 3.201]

b) General requirements (IEC 61496-1:1997):

1) Functional and design requirements;

i) Type 2,

ii) Type 4;

2) Testing;

3) Protection against electric shock;

4) Marking for identification and safe use;

5) Information for use;

6) Optional functions of the ESPS (IEC 61496-1:1997, Annex A);

7) Catalogue of single faults (IEC 61496-1:1997, Annex B).

c) Special requirements for AOPDs (IEC 61496-2) (Requirements in addition to those found in IEC 61496-1):

1) Functional and design requirements;

2) Testing;

3) Protection against electric shock;

4) Marking for identification and safe use;

5) Information for use.

7.4 Pressure-sensitive protective devices (PSPDs)

ISO 13856 — *Safety of machinery — Pressure-sensitive protective devices*

a) *Part 1: General principles for the design and testing of pressure-sensitive mats and pressure-sensitive floors*

Requirements for pressure-sensitive mats and floors used as protective devices for persons weighing more than 35 kg and for persons, including children, weighing more than 20 kg:

— shape, size;

— actuating force;

— response time;

— static force;

- number of operations;
- output state of the sensor;
- response of the output signal switching device to the actuating force;
- access;
- adjustments;
- environmental conditions;
- power supply;
- electrical equipment;
- enclosure;
- categories [see also ISO 13849-1 (EN 954-1)];
- sensor fixings;
- tripping;
- surface conditions;
- marking;
- information for use;
- testing.

b) *Part 2: General principles for the design and testing of pressure-sensitive edges and pressure-sensitive bars* (at present European Standard only, ISO standard in preparation)

Requirements for pressure-sensitive edges and bars with and without an external reset facility:

- essential data for the selection of a suitable device;
- operating types;
- effecting sensing field;
- actuating force;
- actuating and overtravel distances;
- forces;
- response times;
- number of operations;
- sensor output;
- reset;

— environmental conditions;

— power supply;

— enclosure;

— categories [see also ISO 13849-1 (EN 954-1)];

— marking;

— information for use;

— testing.

8 Electrical equipment

IEC 60204-1:1997 (EN 60204-1:1997), *Electrical equipment of machines — Part 1: General requirements*, is the base electrical standard. It references 50 other standards and by doing so covers all of the electrical equipment of the machine.

a) IEC 60204-1:1997, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*:

— general requirements (electrical supply, physical environment, handling, transportation);

— incoming supply, disconnecting device;

— protection against electrical shock;

— protection of equipment (overcurrent, overload, abnormal temperature, overspeed);

— equipotential bonding (grounding);

— control circuits, control functions;

— operator interface, machine-mounted control devices;

— electronic equipment;

— controlgear;

— conductors and cables;

— wiring practices;

— electric motors and associated equipment;

— accessories and lighting;

— warning signs and item designations;

— technical documentation;

— testing.

b) Electrical standards relating to machinery/equipment:

- IEC 60034-1, IEC 60034-5, IEC 60034-11: Rotating electrical machines;
- IEC 60072-1, IEC 60072-2: Dimensions and output series for rotating electrical machines;
- IEC 60076-5: Power transformers;
- IEC 60309-1: Plugs, socket-outlets and couplers for industrial purposes;
- IEC 60364-4-41, IEC 60364-4-46, IEC 60364-4-47, IEC 60364-4-473, IEC 60364-5-54: Electrical installations of buildings;
- IEC 60417: Graphical symbols for use on equipment, available in the form of a subscription to an online database;
- IEC 60439-1: Low-voltage switchgear and controlgear assemblies;
- IEC 60445: Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system;
- IEC 60446: Identification of conductors by colours or numerals;
- IEC 60447: Man-machine interface (MMI) — Actuating principles;
- IEC 60529: Degrees of protection provided by enclosures (IP code);
- IEC 60947-2, IEC 60947-3, IEC 60947-4-1, IEC 60947-5-1, IEC 60947-7-1: Low-voltage switchgear and controlgear;
- IEC 61082-1, IEC 61082-2, IEC 61082-3, IEC 61082-4: Preparation of documents used in electrotechnology;
- IEC 61140: Protection against electric shock.

c) IEC 61131: Programmable controllers:

- general information (Part 1);
- equipment requirements and tests (Part 2);
- programming languages (Part 3);
- application guidelines;
- user guidelines;
- fuzzy-control programming (Part 7);
- guidelines for the application and implementation of programming languages (Part 8: Technical Report).

d) IEC 61508-1, *Functional safety of electrical/electronic/programmable electronic safety-related systems — Part 1: General requirements*

9 Fluid power systems and components

a) ISO 4414 (EN 983): Pneumatic power.

b) ISO 4413 (EN 982): Hydraulic power.

1) List of hazards;

2) Basic requirements for design:

i) Cylinders;

ii) Valves;

iii) Energy transmission and conditioning;

iv) System protection;

v) Sequence control;

vi) Control systems with servos/proportional control;

3) Verification;

4) Information for use.

10 Marking, warning devices, signs and symbols, actuating principles

a) General: ISO 12100-2:2003, Clause 6.

b) Marking:

1) ISO 12100-2:2003 (EN ISO 12100-2:2003), 6.4;

2) IEC 60204-1:1997 (EN 60204-1:1997), 3.39 (definition), 5.2, 5.4, 9.1.4, 10.2.2, Clause 17;

3) IEC 61310-2:1995 (EN 61310-2:1995): Requirements for marking:

i) marking for identification and safe use (Clause 4);

ii) application of markings (Clause 5);

iii) marking of connections (Clause 6);

iv) durability of markings and their attachment (Clause 7).

(See also ISO 7000, ISO 3864.)

c) Item designations:

IEC 60204-1:1997 (EN 60204-1:1997), 3.45, 5.2, 18.3 (see also IEC 60757, IEC 61346-1, IEC 61346-2).

d) Warning and information devices:

1) IEC 61310-1:1995 (EN 61310-1:1995): Visual, auditory, tactile signals:

i) presentation of safety-related information (Clause 4);

ii) information coding (Clause 5);

2) IEC 60204-1:1997 (EN 60204-1:1997), 10.8, 18.3.

e) Signs and symbols:

1) ISO 12100-2:2003 (EN ISO 12100-2:2003), 5.3;

2) IEC 61310-1:1995 (EN 61310-1:1995):

i) Graphical symbols related to operation of actuators (Clause 6);

ii) Safety signs (Clause 7);

3) IEC 60204-1:1997 (EN 60204-1:1997), 5.3, 6.2.2, 6.2.4, 18.2;

4) IEC 60073: Coding of indicating devices and actuators by colours and supplementary means;

5) IEC 60417: Graphical symbols for use on equipment, available in the form of a subscription to an online database;

6) ISO 3461-1:1988: General principles for the creation of graphical symbols (same as IEC 60416);

7) ISO 3864:1984: Safety colours and safety signs;

8) ISO 4196:1984: Graphical symbols — Use of arrows;

9) ISO 7000:1989: Graphical symbols for use on equipment — Index and synopsis;

10) ISO 11684: Tractors, machinery for agriculture and forestry, powered lawn and garden equipment — Safety signs and hazard pictorials — General principles.

f) Actuating principles:

1) IEC 60204-1:1997 (EN 60204-1:1997), 5.3.3;

2) IEC 61310-3 (EN 61310-3).

11 Documentation

11.1 Information for use

a) ISO 12100-2:2003 (EN ISO 12100-2:2003), 6.5: Requirements for accompanying documents (e.g. instruction handbook);

b) ISO 12100-1:2003 (EN ISO 12100-1:2003), 5.5: Informing and warning users about residual risks;

c) Relevant standards for special and/or additional requirements.

11.2 Technical documentation

a) General:

Instructions: ISO 12100-2 (EN ISO 12100-2).

b) Electrical:

1) IEC 60027: Letter symbols to be used in electrical technology:

Part 1: General;

Part 2: Telecommunications and electronics;

Part 3: Logarithmic quantities and units;

Part 4: Symbols of quantities to be used for rotating electrical machines.

2) IEC 60204-1:1997 (EN 60204:1997), Clause 18: Electrical documentation.

3) IEC 60617: Graphical symbols for diagrams, available in the form of a subscription to an online database covering the following areas (previously covered by IEC 60617, parts 2 to 11):

— Symbol elements, qualifying symbols and other symbols having general application;

— Conductors and connecting devices;

— Basic passive components;

— Semiconductors and electron tubes;

— Production and conversion of electrical energy;

— Switchgear, controlgear and protective devices;

— Measuring instruments, lamps and signalling devices;

— Telecommunications: Switching and peripheral equipment;

— Telecommunications: Transmission;

— Architectural and topographical installation plans and diagrams.

Also available, separately from the online database, are the following two parts:

Part 12: Binary logic elements;

Part 13: Analogue elements.

4) IEC 61082: Preparation of documents used in electrotechnology:

Part 1: General requirements (documentation principles, general drawing rules);

Part 2: Function-oriented diagrams (overview, function, and circuit diagrams);

Part 3: Connection diagrams, tables and lists;

Part 4: Location and installation documents.

5) IEC 61346-1: Structuring principles and reference designations:

Part 1: Basic rules;

Part 2: Classification of objects and codes for classes.

c) Mechanical:

1) ISO 31: Quantities and units:

   Part 1: Space and time;

   Part 2: Periodic and related phenomena;

   Part 3: Mechanics;

   Part 4: Heat;

   Part 5: Electricity and magnetism;

   Part 6: Light and related electromagnetic radiations;

   Part 7: Acoustics;

   Part 8: Physical chemistry and molecular physics;

   Part 9: Atomic and nuclear physics;

   Part 10: Nuclear reactions and ionizing radiations;

   Part 11: Mathematical signs and symbols for use in the physical sciences and technology;

   Part 12: Characteristic numbers;

   Part 13: Solid state physics.

2) ISO 128: Technical drawings — General principles of presentation.

3) ISO 129: Technical drawings — Dimensioning.

4) ISO 216: Writing paper and certain classes of printed matter — Trimmed sizes — A and B series.

5) ISO 286: ISO system of limits and fits:

   Part 1: Bases of tolerances, deviations and fits;

   Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts.

6) ISO 406: Technical drawings — Tolerancing of linear and angular dimensions.

7) ISO 1000: SI units and recommendations for the use of their multiples and of certain other units.

8) ISO 1101: Technical drawings — Geometrical tolerancing.

9) ISO 1219-1: Fluid power systems and components — Graphical symbols.

10) ISO 2768: General tolerances:

    Part 1: Tolerances for linear and angular dimensions without individual tolerance indications;

    Part 2: Geometrical tolerances for features without individual tolerance indications.

11) ISO 3098: Technical drawings — Lettering:

    Part 0: General requirements;

Part 2: Latin alphabet, numerals and marks;

Part 3: Greek alphabet;

Part 4: Diacritical and particular marks for the Latin alphabet;

Part 5: CAD lettering of the Latin alphabet, numerals and marks;

Part 6: Cyrillic alphabet.

12) ISO 3461-1, IEC 60416: General principles for the creation of graphical symbols.

13) ISO 5455: Technical drawings — Scales.

14) ISO 5457: Technical product documentation — Sizes and layouts of drawing sheets.

15) ISO 5458: Technical product documentation (GPS) — Geometrical tolerancing — Positional tolerancing.

16) ISO 5459: Technical drawings — Geometrical tolerancing — Datums and datum-systems for geometrical tolerances.

d) Signs and symbols:

1) IEC 60417: Graphical symbols for use on equipment:

Part 1: Overview and application;

Part 2: Symbol originals.

2) IEC 61310-1:1995:

i) Graphic symbols related to operation of actuators (Clause 6);

ii) Safety signs (Clause 7).

3) ISO 3461-1, General principles for the creation of graphical symbols.

4) ISO 3864, Safety colours and safety signs.

5) ISO 4196, Graphical symbols — Use of arrows.

6) ISO 7000, Graphical symbols for use on equipment — Index and synopsis.

12 Ergonomics

12.1 Terminology, general principles

EN 614-1, *Ergonomic design principles — Terminology and general principles*.

12.2 Human body dimensions

1) ISO 15534 (EN 547), *Ergonomic design for the safety of machinery*:

Part 1: Principles for determining the dimensions required for openings for whole-body access into machinery;

Part 2: Principles for determining the dimensions required for access openings;

Part 3: Anthropometric data.

2) ISO 7250 (EN ISO 7250), *Basic human body measurements for technological design.*

3) ISO 14738, *Safety of machinery — Anthropometric requirements for the design of workstations at machinery.*

12.3 Touchable surfaces

EN 563, *Temperature of touchable surfaces — Ergonomic data to establish temperature limit values for hot surfaces*.

12.4 Displays, control actuators

ISO 9355 (EN 894), *(Safety of machinery —) Ergonomic requirements for the design of displays and control actuators:*

a) *Part 1: Human interactions with displays and control actuators;*

b) *Part 2: Displays*.

EN 894-3, *Safety of machinery — Ergonomics requirements for the design of displays and control actuators — Part 3: Control actuators.*

12.5 Visual danger signals

ISO 11428 (EN 842), *(Safety of machinery —) Ergonomics — Visual danger signals — General requirements, design and testing.*

12.6 Auditory and visual signals, speech communication

For danger, warning and information auditory signals [ISO 7731 (EN 457)], visual signals [ISO 11428 (EN 842)] and speech communication [ISO 9921 (EN ISO 9921)] have to be so designed that signals and speech are quickly and clearly recognizable [ISO 11429 (EN 981)].

12.7 Human physical performance

1) ISO 11226 (EN 1005-4), *Ergonomics — Evaluation of static working postures (EN title: Safety of machinery — Human physical performance — Part 4: Evaluation of working postures and movements in relation to machinery)*;

2) ISO 11228-1 (EN 1005-2), *Ergonomics — Manual handling — Part 1: Lifting and carrying (EN title: Safety of machinery — Human physical performance — Part 2: Manual handling of machinery and component parts of machinery)*;

3) EN 1005, *Human physical performance*:

Part 1: Terms and definitions;

Part 3: Recommended force limits for machinery operation.

12.8 Application of ergonomics standards

EN 13861, *Safety of machinery — Guidance for the application of ergonomics standards in the design of machinery*.

13 Hazardous substances and airborne emissions

13.1 Hazardous substances

a) ISO 14123-1 (EN 626-1): Principles and specifications for machinery manufacturers:

   1) Hazardous substances;

   2) Risk assessment;

   3) Types of emission:

      i) Airborne;

      ii) Non-airborne;

   4) Requirements and/or measures for elimination or reduction of risk;

   5) Information for use and maintenance.

b) ISO 14123-2 (EN 626-2): Methods leading to verification procedures:

   1) Methodology:

      i) Identification of hazardous substances;

      ii) Characteristics;

      iii) Identification of critical factors;

      iv) Specification of indicative parameters;

   2) Verification.

13.2 Airborne emissions

Evaluation of the emission of airborne hazardous substances.

a) EN 1093-1, Selection of test methods

   Defines parameters which may be used for the evaluation of emissions of hazardous substances from machines and provides the basis for selection of appropriate test methods:

   1) Assessment parameters;

   2) Types of test method;

   3) Basis of selection (of test methods).

b) EN 1093-3, Measurement of the emission rate of a specified pollutant using the real pollutant — Bench test method.

   Bench test method for the measurement of the emission rate of a specified airborne hazardous substance from machines using a test rig under specified operating conditions of the machine.

c) EN 1093-4, Measurement of the capture efficiency using a tracer material method.

A method for the measurement of the capture efficiency of an exhaust system installed on a machine. This method is based on a tracer technique and may be operated in all types of test environment (bench, room and field — see EN 1093-1).

d) EN 1093-6, Separation efficiency by mass, unducted outlet.

e) EN 1093-7, Separation efficiency by mass, ducted outlet.

f) EN 1093-8, Pollutant concentration parameter — Test bench method.

g) EN 1093-9, Pollutant concentration parameter — Room method.

h) EN 1093-11, Decontamination index.

14 Risks arising from radiation

EN 12198-1, *Safety of machinery — Assessment and reduction of risks arising from radiation emitted by machinery — Part 1: General principles.*

EN 12198-2, *Safety of machinery — Assessment and reduction of risks arising from radiation emitted by machinery — Part 2: Radiation emission measurement procedure.*

EN 12198-3, *Safety of machinery — Assessment and reduction of risks arising from radiation emitted by machinery — Part 3: Reduction of radiation by attenuation or screening.*

a) Definitions:

   1) Functional radiation (EN 12198-1:2000, 3.1);

   2) Undesirable radiation (EN 12198-1:2000, 3.2);

b) Types of radiation (EN 12198-1:2000, Table 1):

   1) Electric and magnetic fields: static; low-frequency;

   2) Electromagnetic waves: radio frequency, infra-red, visible, ultra-violet, X-rays, γ-rays;

c) Characteristics of radiation emissions;

d) Risk assessment;

e) Classification of machines due to radiation emission levels;

f) Protective measures;

g) Verification of compliance;

h) Information for use.

NOTE The scope of EN 12198 is limited to non-ionizing radiation.

15 Permanent means of access

EN ISO 14122, *Safety of machinery — Permanent means of access to machinery:*

Part 1: Choice of means of access between two levels

a) Basic parameters and means of access:

   1) ladder;

   2) stepladder;

   3) stairway;

   4) ramp.

b) Requirements for the selection of fixed means of access.

Part 2: Working platforms and gangways

a) Definitions.

b) Requirements for platforms and walkways.

Part 3: Stairways, stepladders and guard-rails

a) Definitions.

b) General safety requirements and/or measures concerning materials and dimensioning.

c) Safety requirements and/or measures applicable to:

   1) stairways;

   2) stepladders;

   3) guard-rails.

d) Verification of safety requirements and/or measures.

Part 4: Fixed ladders

a) Definitions.

b) Safety requirements and/or measures.

c) Verification.

16 Fire and explosion

a) EN 1127-1:

   — Basic hazards;

   — Minimization of risk;

   — Classification of hazardous areas;

   — Avoidance of ignition sources;

   — Requirements to reduce explosion effects;

   — Instrumentation;

— Information for use.

b) Application (see 16.2 for classification):

— Equipment group I: Mining;

— Equipment group II: Other equipment.

c) Compliance is presumed if:

— equipment conforms to transposed harmonized standards or lacking European Standards;

— relevant national standards.

Equipment judged to be non-compliant has to be withdrawn from the market.

17 Acoustics

17.1 Objectives

a) Noise emission values are the basic data for the risk assessment. The criterion for assessing the efficiency of the noise reduction measures [see b)] is the actual noise emission values [see c)] from the machine in relation to other machines of the same family [see d)] and not the nature of the reduction measures themselves.

b) Noise reduction at machine [ISO/TR 11688-1 (EN ISO 11688-1), EN 1746]:

— noise reduction at source by design,

— noise reduction by protective devices,

— noise control by information

should lead to low noise emission by the machine.

c) Determination and declaration of noise emission [ISO 3740 (EN ISO 3740), ISO 4871 (EN ISO 4871), ISO 11200 (EN ISO 11200), ISO 12001 (EN ISO 12001)].

d) Collection and presentation of comparative emission data using noise emission values [ISO 12001 (EN ISO 12001), ISO 11689 (EN ISO 11689)].

17.2 Relevant standards

ISO 3740 (EN ISO 3740), *Acoustics — Determination of sound power levels of noise sources*.

ISO 4871 (EN ISO 4871), *Acoustics — Noise labelling of machinery and equipment*.

See Table 3 for further details.

Table 3 — Standards which are related to acoustical noise

International Standard	Equivalent European Standard	Title
—	EN 1746	*Safety of machinery — Guidance for the drafting of the noise clauses of safety standards*
ISO 1999	—	*Acoustics — Determination of occupational noise exposure and estimation of noise-induced hearing impairment*
ISO 3740	EN ISO 3740	*Acoustics — Determination of sound power levels of noise sources — Guidelines for the use of basic standards*
ISO 4871	EN ISO 4871	*Acoustics — Declaration and verification of noise emission values of machinery and equipment*
ISO 7574-1	EN 27574-1	*Acoustics — Statistical methods for determining and verifying stated noise emission values of machinery and equipment — Part 1: General considerations and definitions*
ISO 7574-2	EN 27574-2	*Acoustics — Statistical methods for determining and verifying stated noise emission values of machinery and equipment — Part 2: Methods for stated values for individual machines*
ISO 7574-3	EN 27574-3	*Acoustics — Statistical methods for determining and verifying stated noise emission values of machinery and equipment — Part 3: Simple (transition) method for stated values for batches of machines*
ISO 7574-4	EN 27574-4	*Acoustics — Statistical methods for determining and verifying stated noise emission values of machinery and equipment — Part 4: Methods for stated values for batches of machines*
ISO 11200	EN ISO 11200	*Acoustics — Noise emitted by machinery and equipment — Guidelines for the use of basic standards for the determination of emission sound pressure levels at a work station and at other specified positions*
ISO 11201	EN ISO 11201	*Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Engineering method in an essentially free field over a reflecting plane*
ISO 11202	EN ISO 11202	*Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Survey method* in situ
ISO 11203	EN ISO 11203	*Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions from the sound power level*
ISO 11204	EN ISO 11204	*Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Method requiring environmental corrections*
ISO/TR 11688-1	EN ISO 11688-1	*Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning*
ISO 11690-1	EN ISO 11690-1	*Acoustics — Recommended practice for the design of low-noise workplaces containing machinery — Part 1: Noise control strategies*
ISO 11690-2	EN ISO 11690-2	*Acoustics — Recommended practice for the design of low-noise workplaces containing machinery — Part 2: Noise control measures*
ISO 12001	EN ISO 12001	*Acoustics — Noise emitted by machinery and equipment — Rules for the drafting and presentation of a noise test code*

18 Mechanical vibration

18.1 General considerations

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

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

18.2 Types of vibration

18.2.1 Whole body

ISO 2631-1, EN 1032:

a) Characterization (direction);

b) Location of measurement;

c) Magnitude;

d) Measuring equipment;

e) Weighting functions;

f) Testing:

   1) Instrumentation;

   2) Measuring directions;

   3) Testing conditions;

g) Vibration measurement and analysis;

h) Measurement report;

i) The instructions should indicate:

   — the weighted root square acceleration value to which the body (feet or posterior) is subjected, if it exceeds 0,5 m/s^2;

   — that the acceleration does not exceed 0,5 m/s^2, if this is the case.

18.2.2 Hand-held

ISO 5349-1 (EN ISO 5349-1), ISO 5349-2 (EN ISO 5349-2),

ISO 8662-1 (EN 28662-1), ISO 8662-2 (EN 28662-2),

ISO 8662-3 (EN 28662-3), ISO 8662-4 (EN ISO 8662-4),

ISO 8662-5 (EN 28662-5), ISO 8662-6 (EN ISO 8662-6),

ISO 8662-7 (EN ISO 8662-7), ISO 8662-8 (EN ISO 8662-8),

ISO 8662-9 (EN ISO 8662-9), ISO 8662-10 (EN ISO 8662-10),

ISO 8662-11, ISO 8662-12 (EN ISO 8662-12),

ISO 8662-13 (EN ISO 8662-13), ISO 8662-14 (EN ISO 8662-14).

The instructions should indicate:

— the weighted root mean square acceleration value to which the arms are subjected, if it exceeds 2,5 m/s^2, determined by the appropriate test code;

— that the acceleration does not exceed 2,5 m/s^2, if this is the case.

19 Electromagnetic compatibility

a) Basis: Directive 89/336/EC, *Council Directive: Electromagnetic Compatibility (EMC)*.

b) Implementation: 1 January 1996 (Grace period: 1 January 1992 until 31 December 1995).

c) Application (see Annex III):

1) Equipment which can cause interference in telecommunications equipment;

2) Equipment which is susceptible to electromagnetic interference.

d) Compliance:

Compliance is presumed if:

1) equipment conforms to transposed harmonized standards or lacking European Standards;

2) relevant national standards, duly qualified.

Equipment judged to be non-compliant should be withdrawn from the market.

e) Conformity:

1) Where equipment is in compliance with the above requirements, the manufacturer or authorized representative issues a Declaration of Conformity. The Declaration of Conformity should be available for 10 years.

2) Where equipment is in compliance with the above requirements, the manufacturer or authorized representative should create a Technical Construction File which:

i) describes the equipment;

ii) sets out procedures used to ensure conformity;

iii) includes a report or certificate from the notified body.

The Technical Construction File should be available for 10 years after the equipment is placed on the market. The supplier should issue a Declaration of Conformity.

f) CE marking (see Annex I).

See also Directive 98/37/EC and relevant European Standards.

Annex A

Relationship of standards to various European Directives related to machinery

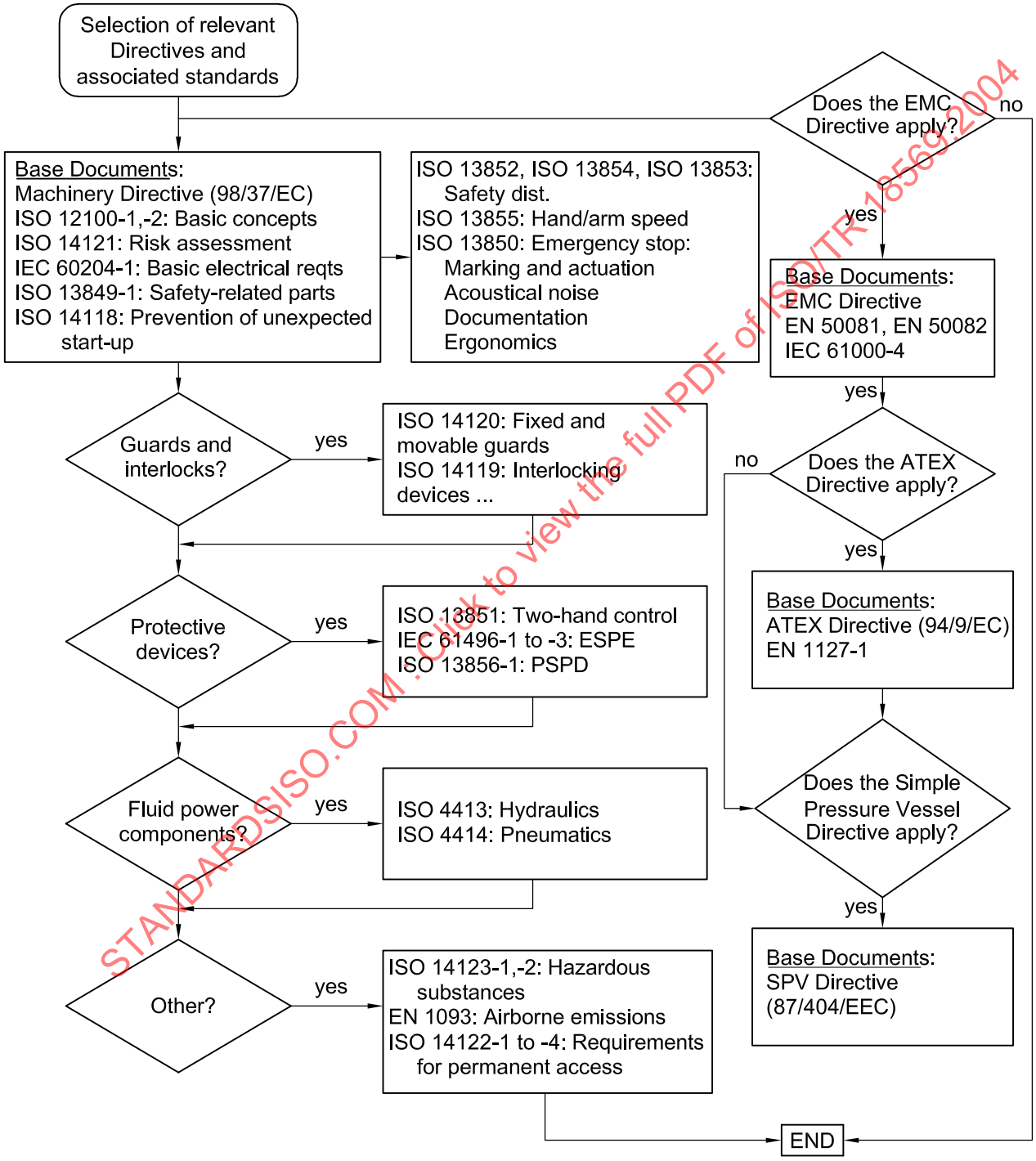


Figure A.1 — Relationship of machinery safety standards to various European Directives

Annex B

Ergonomic considerations

B.1 Referenced standards

Number	Title
ISO 7250 (EN ISO 7250)	*Basic human body measurements for technological design*
ISO 7731 (EN 457)	*Ergonomics — Danger signals for public and work areas — Auditory danger signals*
ISO 9355-1 (EN 894-1)	*Ergonomic requirements for the design of displays and control actuators — Part 1: Human interactions with display and control actuators*
ISO 9355-2 (EN 894-2)	*Ergonomic requirements for the design of displays and control actuators — Part 2: Displays*
ISO 11226 (EN 1005-4)	*Ergonomics — Evaluation of static working postures* (EN title: *Safety of machinery — Human physical performance — Part 4: Evaluation of working postures and movements in relation to machinery*)
ISO 11228-1 (EN 1005-2)	*Ergonomics — Manual handling — Part 1: Lifting and carrying* (EN title: *Safety of machinery — Human physical performance — Part 2: Manual handling of machinery and component parts of machinery*)
ISO 11428 (EN 842)	*Ergonomics — Visual danger signals — General requirements, design and testing*
ISO 11429 (EN 981)	*Ergonomics — System of auditory and visual danger and information signals*
ISO 15534-1 (EN 547-1)	*Ergonomic design for the safety of machinery — Part 1: Principles for determining the dimensions required for openings for whole-body access into machinery* (EN title: *Safety of machinery — Human body measurements — Part 1: Principles for determining the dimensions required for openings for whole body access into machinery*)
ISO 15534-2 (EN 547-2)	*Ergonomic design for the safety of machinery — Part 2: Principles for determining the dimensions required for access openings* (EN title: *Safety of machinery — Human body measurements — Part 2: Principles for determining the dimensions required for access openings*)
ISO 15534-3 (EN 547-3)	*Ergonomic design for the safety of machinery — Part 3: Anthropometric data* (EN title: *Safety of machinery — Human body measurements — Part 3: Anthropometric data*)
IEC 61310-1 (EN 61310-1)	*Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, auditory and tactile signals*
IEC 61310-2 (EN 61310-2)	*Safety of machinery — Indication, marking and actuation — Part 2: Requirements for marking*
IEC 61310-3 (EN 61310-3)	*Safety of machinery — Indication, marking and actuation — Part 3: Requirements for the location and operation of actuators*
EN 563	*Safety of machinery — Temperatures of touchable surfaces — Ergonomics data to establish temperature limit values for hot surfaces*
EN 614-1	*Safety of machinery — Ergonomic design principles — Terminology and general principles*
EN 894-3	*Safety of machinery — Ergonomics requirements for the design of displays and control actuators — Part 3: Control actuators*
EN 1005-1	*Safety of machinery — Human physical performance — Part 1: Terms and definitions*
EN 1005-3	*Safety of machinery — Human physical performance — Part 3: Recommended force limits for machinery operation*
ANSI B11.TR.1 [a]	*Ergonomic Guidelines for the Design, Installation and Use of Machine Tools*

[a] This document can be obtained from the Association For Manufacturing Technology, Safety Department (+01-703-827-5212).

B.2 Basic ergonomic design principles

The standards listed above provide information and guidance on ergonomic design principles. As a start, the designer should review EN 614 and ANSI B11.TR.1 which provide a general understanding of various aspects of ergonomic design.

EN 614-1 covers the following topics:

a) Design considering anthropometry and biomechanics (body dimensions, posture, movements, strength);

b) Cognitive factors (human information reception and processing);

c) Design of displays, signals, control actuators;

d) Emissions from work equipment (noise, thermal, illumination, hazardous material);

e) Interactions in the work place;

f) Incorporating ergonomic principles into the design process including ergonomic tasks to be performed:

   1) development and clarification of specifications;

   2) the preparation of design outline(s);

   3) the preparation of the detailed design;

   4) implementation.

B.3 Basic considerations for man-machine interface when designing and constructing a machine

a) What does the individual have to do to operate the machine?

   This includes such tasks as reaching, stretching, bending, stooping, lifting, and twisting along with frequent repetitive hand/arm or foot/leg motions. The designer needs to consider various anthropometric data for both males and females as well as possible ethnic deviations. It is also important (where possible) for the manufacturer (or supplier) to review environmental conditions with the user for possible conditions which can affect the relationship of the operator with the machine. The designer should try to ensure accommodation, compatibility, operability and maintainability by matching the configuration and orientation of various machine components to the body dimensions of the anticipated operator population. Operator training in the proper use and maintenance of the machine is another prime aspect to ensure good health.

   ANSI B11.TR.1 provides a detailed outline of the various considerations which go into ergonomic design as well as anthropometric data for the following:

   — selected body dimensions for males and females (inches and cm);

   — horizontal reach and grasp dimensions;

   — lifting, lowering, pushing, pulling and carrying guidelines (males and females);

   — standing work task height guidelines;

   — direction of control movement and repetitive operation.

   Further information can be found in ISO 11226, ISO 11228-1, EN 1005-1, EN 1005-3 and EN 1005-4 which provide:

   — information regarding human motion from various body positions (e.g. sitting, standing, lying down);

— derived SI units which relate to human body dimensions and movements;

— manual handling of objects (lifting, carrying) for males and females;

— recommended force limits for machinery operation (hand/arm, foot/leg).

ISO 7250 (EN ISO 7250) provides descriptions on basic anthropometric measurements (55 different measurements).

b) Are the controls placed in such a position that allow an operator to have easy access while still being able to view the operation of the machine? Are their functions clear and unambiguous?

IEC 61310-1 (EN 61310-1) to IEC 61310-3 (EN 61310-3) provide guidance in the following areas:

— actuation;

— grouping of functions;

— operating sequence;

— actions and effects;

— requirements for identification;

— requirements for special kinds and particular use of actuators;

— classification of and correlation between actions and their resulting final effects.

ISO 9355-1 (EN 894-1) and EN 894-3 provide guidance on task requirements for control actuators including:

— continuity of movement;

— operating force;

— operating speed;

— discrete manual control actuator movements.

c) Does production operation require frequent manual operations (e.g. start/initiate, part load, scrap removal) which may result in physical or mental stress?

d) Is the display easy to read and understand?

— ISO 9355-1 (EN 894-1) and ISO 9355-2 (EN 894-2) provide information on the design and placement of displays in order to increase the attention of the operator and the retention of information.

— Some guidance is found in ISO 11429 (EN 981).

e) When it is necessary to manually load and/or unload the machine, how easy is it to perform this task?

f) Is there sufficient space to perform maintenance effectively? Is the operator required to access part of the machine (whole body, body part) during production?

ISO 15534-1 (EN 547-1) provides guidance for whole-body access for various passage openings (e.g. upright as through a door, up a ladder, circular openings). ISO 15534-2 (EN 547-2) provides guidance for access openings when only a portion of the body (hand/arm, foot/leg, head) requires entrance.

g) Can machine 'jams' be effectively removed without undue risk?

h) How is the machine set up to be handled?

i) Are there areas of the machine which present a potential of thermal burn?

EN 563 provides surface temperature data for burn thresholds. It is presented in a series of graphs relating time of skin contact vs. the type (e.g. plastics, ceramics, glass, metal, wood) and texture of material (e.g. smooth, rough, coated or uncoated).

Annex C

Outline of electrical requirements

Basic requirements (IEC 60204–1)

a) Scope:

Applies to applications of electrical and electronic components and systems to machines (currently industrial machines), not portable by hand while working but including a group of machines working together in a coordinated manner.

Commences at the point of connection to the electrical supply which can be up to and including 1 000 V a.c. and 1 500 V d.c.

b) General requirements:

1) Concept of risk assessment and risk reduction.

2) Base hazards: electrical shock, electrical burn, faults/failures resulting in malfunctions, disturbances/disruptions in power sources resulting in malfunctions, stored energy, audible noise.

3) Conditions of electrical supply.

4) Physical environment:

i) Protection against electromagnetic interference (EMC), both emission and immunity;

ii) Ambient temperature, humidity, altitude, contaminants, vibration/shock.

c) Incoming supply conductor terminations, disconnecting means [see also ISO 14118 (EN 1037)]:

1) Recommend direct connection to disconnecting (isolating) device which is hand operated;

2) Disconnecting device in accordance with relevant IEC standard;

3) Handle between 0,6 m and 1,9 m from the floor;

4) Required isolation feature;

5) Provision for a separate earthing (grounding) terminal (PE terminal); where colour is used, internal earthing conductor has to be GREEN AND YELLOW.

d) Protection against electrical shock:

1) Protection against direct contact: enclosures, isolation of live parts, residual voltages, separation (IP 2XB – recessed terminals, the 'finger test');

2) Protection against indirect contact: automatic disconnection of the supply, use of class II equipment, physical separation (creepage and clearance distances);

3) Protection by the use of protective extra-low voltage (PELV) circuits (25 V a.c. or 60 V d.c.).

e) Protection of equipment:

1) Overcurrent;

2) Overload of motors;

3) Abnormal temperature;

4) Power supply fluctuation/interruption;

5) Motor overspeed;

6) Earth faults/residual current.

f) Equipotential bonding (grounding):

1) Protective bonding circuit: PE terminal, conductive structural parts, protective conductors;

2) Protective conductors: recommend copper, GREEN AND YELLOW colour;

3) All exposed conductive parts have to be connected to the protective bonding circuit;

4) Switching devices excluded.

g) Control circuits and control functions:

1) Control voltage supply: use of isolating transformer (exception for small machines); should not exceed 250 V/50 Hz or 277 V/60 Hz;

2) Control functions:

i) start functions;

ii) stop functions: categories 0, 1, 2;

iii) emergency stop (see 6.1 and ISO 13850);

iv) operating mode(s);

v) suspension of safeguards: use of alternate method;

vi) devices used in 'safety' functions: two-hand control, enabling, hold-to-run;

3) Protective interlocks [see also ISO 14119 (EN 1088)];

4) Control functions in case of failure (see also ISO 13849-1, IEC 61508-1):

i) use of well-tried components, proven techniques;

ii) monitoring;

iii) redundancy/diversity;

iv) one or more in combination;

5) Protection against malfunction due to:

i) earth faults;

ii) voltage interruptions;

iii) circuit continuity.

h) Operator interface, machine-mounted control devices:

1) Location and mounting: readily accessible, mounted to minimize the possibility of damage;

2) Be able to withstand the stresses of expected use;

3) Pushbuttons (see IEC 60204-1:1997, Table 2):

i) RED – Emergency (may be used for stop but BLACK is preferred);

ii) GREEN – Safe or normal (may be used for START but WHITE is preferred);

iii) YELLOW – caution or abnormal;

iv) BLUE – function of mandatory significance;

v) use of IEC 60417 symbols;

4) Indicator lights and displays (see IEC 60204-1:1997, Table 3);

5) Illuminated pushbuttons;

6) Emergency stop devices:

i) mushroom head, foot switch, pull cord;

ii) mechanical latching means (rotate and lock, detent);

iii) should be manually reset;

iv) positive opening operation of contacts (see also IEC 60947-5-1);

v) RED actuator with YELLOW background (where possible).

i) Electronic equipment: (see also ISO 13849-1, IEC 61131, IEC 61508-1).

j) Controlgear:

1) Location and mounting:

i) easily accessible from the front;

ii) where adjustment is required, device located 0,2 m to 6,0 m above floor;

iii) non-electrical parts should not be located in enclosures containing controlgear;

iv) controlgear (devices, terminal blocks) connected to supply or control and supply voltages have to be mounted separately from controlgear connected to control voltages only;

2) Degrees of protection (IP rating): Currently is IP 54 (with exceptions);

3) Enclosures, doors, openings.

k) Conductors and cables: (see also IEC 60204-1:1997, Annex C);

l) Wiring practices:

1) General requirements;

2) Identification by colour:

i) GREEN AND YELLOW: Protective conductor;

ii) LIGHT BLUE: Current-carrying neutral;

iii) BLACK: a.c. and d.c power circuits;

iv) RED: a.c. control circuits;

v) BLUE: d.c. control circuits;

vi) ORANGE: Interlock control circuits supplied from an external power source;

3) Wiring inside and outside enclosures;

4) Ducts, connection and junction boxes.

m) Electric motors and associated equipment:

1) Compliance with IEC 60034;

2) Compliance with IEC 60072-1 and IEC 60072-2;

3) Criteria for selection.

n) Accessories and lighting.

o) Warning signs and item designation:

1) Use of symbol 13 of ISO 3864;

2) Correspondence between part identification and drawings.

p) Technical documentation: compliance with IEC 61082-1 (EN 61082-1) to IEC 61082-4 (EN 61082-4).

q) Testing:

1) Verification that the electrical equipment is in compliance with the technical documentation;

2) Continuity of the protective bonding circuit [see IEC 60204-1:1997 (EN 60204-1:1997), 19.2];

3) Insulation resistance tests [see IEC 60204-1:1997 (EN 60204-1:1997), 19.3];

4) Voltage tests [see IEC 60204-1:1997 (EN 60204-1:1997), 19.4];

5) Protection against residual voltages [see IEC 60204-1:1997 (EN 60204-1:1997), 19.5];

6) Functional tests [see IEC 60204-1:1997 (EN 60204-1:1997), 19.6];

7) Retesting [see IEC 60204-1:1997 (EN 60204-1:1997), 19.7].

Annex D

Outline of standards related to electrical documentation

D.1 IEC 61082, *Preparation of documents used in electrotechnology*

Part 1 (1991): General requirements[1)]

Classification of documents	Part 1 ref.	Example	Ref. in IEC 61082	Ref. in IEC 60204-1
Section 2 – Function-oriented documents			IEC 61082-2	
– overview diagram	2.2.1.1	Figures 14, 15	IEC 61082-2	
– block diagram	2.2.1.2			
– network map	2.2.1.3	Figure 18		
– function diagram	2.2.1.4	Figure 16	IEC 61082-2	18.6
– logic function diagram	2.2.1.5			
– equivalent-circuit diagram	2.2.1.6			
– function chart	2.2.1.7			
– sequence chart (table)	2.2.1.8	Figure 8		
– time sequence chart	2.2.1.9			
– circuit diagram	2.2.1.10	Figures 4, 5, 7	IEC 61082-2	18.7
– terminal-function diagram	2.2.1.11	Figures 19, 20		
– programme diagram (table, list)	2.2.1.12	Figure 22		
Location documents				
– site plan	2.2.2.1	Figure 24		
– installation drawing (plan)	2.2.2.2	Figures 17, 23, 25, 26		
– installation diagram	2.2.2.3	Figure 17		
– assembly drawing	2.2.2.4			
– arrangement drawing	2.2.2.5	Figures 27, 30		

1) IEC 61082 cancels and replaces IEC 113. There is no exact correspondence between the parts of IEC 61082 and IEC 113 but the following gives an approximation:

— IEC 61082-1 –> IEC 113-1, IEC 113-3 and parts of IEC 113-7 and IEC 113-8;

— IEC 61082-2 –> IEC 113-4 and parts of IEC 113-7 and IEC 113-8;

— IEC 61082-3 –> IEC 113-5, IEC 113-6.

Connection diagrams			
– connection diagram (table)	2.2.3.1		
– unit connection diagram (table)	2.2.3.2	Figure 28	IEC 61082-3
– interconnection diagram	2.2.3.3	Figure 29	IEC 61082-3
– terminal connection diagram (table)	2.2.3.4	Figure 31	IEC 61082-3
– cable diagram (table, list)	2.2.3.5	Figure 32	IEC 61082-3
Item lists			
– parts list	2.2.4.1	Figure 33	
– spare-parts list	2.2.4.2		
Installation-specific documents	2.2.5		
Commissioning-specific documents	2.2.6		
Operation-specific documents	2.2.7		
Maintenance-specific documents	2.2.8		
Reliability- and maintainability-specific documents	2.2.9		
Other documents Examples: drawing references, dimensioning (including tolerancing), drafting techniques	2.2.10		

The remainder of the document provides numerous examples and general drawing rules (see Annex A).

Part 2: Function-oriented diagrams	*Example*	*Ref. in IEC 60204-1*
Section 2 – Common rules for function-oriented diagrams	Figures 1 to 43	
Graphical symbols	2.4.2	
Logic conventions	2.7.2	
Section 3 – Overview diagrams	Figures 44 to 54	18.6
Section 4 – Function diagrams	Figures 55 to 57	18.6
Section 5 – Circuit diagrams	Figures 58 to 72 Tables 1 to 5	18.7

Part 3: Connection diagrams, tables and lists	*Example*	*Ref. in IEC 60204-1*
Section 2 – Common rules for connection diagrams, tables and lists		
Section 3 – Unit connection diagram (table)	Figures 1 to 7	
Section 4 – Interconnection diagram	Figures 8 to 12	18.5
Section 5 – Terminal connection diagram	Figures 13 to 18	
Section 6 – Cable diagram (table, list)	Figures 19 to 21	

Part 4: Location and installation documents	*Example*	*Ref. in IEC 60204-1*
Section 3 – Electrical installations, documents and information		18.5
Section 4 – Common rules for the presentation of location documents		
Section 5 – Different kinds of location documents		

— Requirements on basic documents (site plans, building drawings, mechanical components);

— Documents for location of equipment on site (arrangement/installation drawing, installation diagram, cable routing diagram, earthing plan);

— Documents for location of equipment in buildings and in other objects [arrangement drawing, installation diagram, cable routing drawing, earthing drawing (diagram)];

— Documents for location of items in or on equipment (assembly drawing, arrangement drawing).

Section 6 – Examples	Figures 1 to 17

D.2 IEC 61346–1, *Structuring principles and reference designations — Part 1: Basic rules*

a) Introduction

In connection with the design, engineering, realization, operation, maintenance and demolition, i.e. the life-cycle of a system, it is necessary to employ a number of identification systems for different purposes, for example:

1) product (article) numbering system used for identification of types of products;

2) serial number system used for identification of product individuals;

3) order number system used for identification of orders/contracts;

4) reference designation system used for identification of objects within a system/plant.

This part of IEC 61346 deals only with the reference designation system.

Table D.1 relates the identification systems to their contexts. The shaded areas show the context of the reference designation system and the classification provided by the letter codes. The reference designation system is also used in manufacturing or operating companies for identification of occurrences of types.

Table D.1 — Identifications and their contexts

Context	Type [a]	Occurrence of types [b]	Individuals [c]
The technical area in general	Letter codes for generic types	Not applicable	Not applicable
Manufacturing company	Type designations, article (part) number	Reference designation	Serial number
Plants/systems project	Identity number of typical class of objects	Reference designation	Serial number, Order number, Inventory number
Operating company	Internal part number	Reference designation	Inventory number (serial number)

[a] Type: a class of objects having the same set of characteristics.

[b] Occurrence: the use of a type in a specific position in a plant or system.

[c] Individual: one specimen of a type irrespective of where it is being used.

It should be noted that this standard provides a number of possibilities for the construction of reference designations. For most applications, however, only a subset of the possibilities given need be used.

The basic requirements and the required properties of a reference designation system that form the basis for the reference designation system described in this standard are given in Annex A. It is recommended to study this annex before reading the normative clauses of this standard. The annex contains a description of the properties of the reference designation system of this standard in a comparison with the required properties. A more comprehensive discussion of the basic concepts of the reference designation system can be found in IEC 61346-4.

b) Structuring principles

1) function-oriented;

2) product-oriented;

3) location-oriented;

4) object description and object occurrence in forming structures.

c) Construction of reference designation

1) format of reference designations;

2) additional aspects of the same type;

3) identifying objects using different aspects;

4) reference designation set;

5) reference designation group.

d) Location designation

Annex A – Basic requirements and required properties of the reference designation system

Annex B – Examples of transitions from one aspect to another aspect

Annex C – Example of transition from one aspect to another aspect where the latter aspect has independent representations

Annex D – Examples of reference designations

Annex E – Letter codes for items – alphabetic listing [IEC 61346-2:2000 (EN 61346-2), Table 1] (see Table D.2)

Annex F – Differences and similarities between the designation system defined in this standard, ISO 1219-2, ISO 3511-1 to ISO 3511-4 and IEC 61346-1 (EN 61346-1)

Annex G – Bibliography

Table D.2 — One-letter code for items – Alphabetic listing

Items	Code	Examples of mechanical or fluid items	Examples of electrical or electromechanical items
Consisting of sub-items in those cases where none of the other letter codes applies	A	Constructional or functional unit Functional group	Constructional or functional unit Functional group
For conversion of a measured quantity in a flow path to another quantity in a measuring flow path	B	Measuring transducer Sensor	Measuring transducer Sensor-instrument (measuring) transformer Tachometer generator
For storage of material or energy	C	Cistern, tank Container Barrel	Capacitor (bank) Accumulator (battery)
For digital processing of signals	D	Combinative element Monostable element Bistable element Memory	Combinative element Monostable element Bistable element Register Memory Integrated circuit
For production or treatment of heat (cold), light, or chemical energy	E	Boiler Heat exchanger Nuclear reactor Gas lamp	Boiler Heater, heating element Lamp bulb Luminaire
For direct-acting protection	F	Safety valve Rupturing disk	Fuse 'Miniature circuit-breaker' Surge diverter
For generation of flow or propagation	G	Pump Compressor Fan Stirrer	Power or signal generator* Oscillator Astable element Induction pump Induction stirrer * Tachometer generator, see letter code B
For transport or handling of material	H	Conveyor Lift car Truck Robot	—
For software	J	—	Programme Programme module
For relaying	K	Fluidistor Pilot valve operated by control signal	All-or-nothing relay Contactor relay Timing relay Measuring relay
For damping	L	Damper Shock absorber Spring damping device	Inductor, reactor Ferrite bead Permanent magnet
For conversion of potential, kinetic, chemical, heat or electric energy to achieve motion	M	Motor (also oscillating) Water/wind turbine Steam turbine Combustion engine Fluid cylinder	Motor (also linear)
For analogue processing of signals	N	Amplifier Feedback controller	Amplifier Feedback controller

Table D.2 (*continued*)

Items	Code	Examples of mechanical or fluid items	Examples of electrical or electromechanical items
For presentation of information	P	Measuring instrument Indicator Sight-glass	Measuring instrument Clock, timer Indicator Signal lamp Character display unit Video display unit Printer Event recorder Siren, bell Loudspeaker
For switching of mechanical items and electric power circuits	Q	Railway points	Circuit-breaker Switch (mechanical) Contactor Disconnector Switch-fuse Starter
For restriction of flow	R	Orifice plate	Resistor Varistor
For switching of control circuits	S	Pilot valve operated by hand or directly by process	Control switch operated by hand or process condition
For change of pressure torque or voltage in a flow path	T	Pressure intensifier Torque converter	Power or signal transformer* DC/DC converter * Instrument transformer, see letter code B
For change of other characteristics than those covered by letter code T in a flow path	U	Crusher Mixer Vibrator Rollstand Milling machine Fractionating column	Rectifier* Inverter* Frequency changer* A/D- or D/A-converter Modulator, demodulator * Rotating or static
Mechanical: for switching or control of fluid flow *Electrical:* for control of electric flow	V	Shut-off valve Non-return valve Control valve Clutch Brake	Electronic valve Electronic tube Semi-conductor element
For conduction or transport of material or energy (flow paths)	W	Pipe Duct Hose Shaft Link	Conductor Waveguide, e.g. optical fibre Cable Busbar Information bus Antenna Earthing plate
For connecting	X	Terminal block Connector Terminal box Junction box	Terminal block Connector Cable box Through-bushing Terminal box Junction box
For actuating mechanical or electromechanical elements or devices	Y	Fluid or manual actuator Latching device Blocking device	Operating coil Actuator Latching device Blocking device Overcurrent release Under-voltage release
For passive treatment of flow not covered by letter codes R and L	Z	Filter Strainer, sieve Steam trap Delay element	Filter Power line trap Limiter Delay element (line)

Table D.3 — Graphical symbols for diagrams

IEC 60617 Part	Date	Graphical symbols for diagrams (Note that, except for parts 12 and 13, IEC 60617 is no longer available as separate parts but as an online database accessible on a subscription basis. The structure of the withdrawn multi-part standard is given here, however, to indicate the contents of the database.)
1	1985	*General information, general index, cross-reference tables* – Terminology – Presentation of symbols – Numbering of symbols – Use of symbols – Adaptation of symbols to computer-aided drafting systems – General index
2	1996	*Symbol elements, qualifying symbols and other symbols having general application* – 1 Outlines and enclosures – 2 Kind of current and voltage – 3 Adjustability, variability and automatic control – 4 Direction of force or motion – 5 Direction of flow – 6 Operational – 7 Types of material – 8 Effect or dependence – 9 Radiation – 10 Signal waveforms – 11 Printing, perforating and facsimile – 12 Mechanical and other controls – 13 Actuators, Set 1 – 14 Actuators, Set 2 – 15 Earth and frame connections, equipotentially – 16 Ideal current elements – 17 Miscellaneous – Annex A – Other symbols
3	1996	*Conductors and connecting devices* – 1 Connections – 2 Junctions, terminals and branchings – 3 Connection devices – 4 Cable fittings – Annex A – Older symbols

Table D.3 (*continued*)

IEC 60617 Part	Date	Graphical symbols for diagrams (Note that, except for parts 12 and 13, IEC 60617 is no longer available as separate parts but as an online database accessible on a subscription basis. The structure of the withdrawn multi-part standard is given here, however, to indicate the contents of the database.)
4	1996	*Basic passive components* – 1 Resistors – 2 Capacitors – 3 Inductors – 4 Symbol elements – 5 Ferrite cores – 6 Magnetic storage matrices (topographical representation) – 7 Piezoelectric crystals – 8 Delay lines – 9 Block symbols for delay lines and elements – Annex A – Older symbols
5	1996	*Semiconductors and electron tubes* – 1 Symbol elements – semiconductor devices – 2 Qualifying symbols particular to semiconductor devices – 3 Examples of semiconductor diodes – 4 Examples of thyristors – 5 Examples of transistors – 6 Examples of photo-sensitive and magnetic field sensitive devices – 7 Symbol elements, general – electron tubes – 8 Symbol elements mainly applicable to cathode-ray tubes and television camera tubes – 9 Symbol elements applicable to microwave tubes – 10 Symbol elements mainly applicable to miscellaneous tubes including mercury arc rectifiers – 11 Examples of electron tubes – 12 Examples of cathode-ray tubes – 13 Examples of microwave tubes – 14 Examples of miscellaneous tubes including mercury arc rectifiers – 15 Examples of ionizing radiation detectors – 16 Electrochemical devices – Annex A – Older symbols

Table D.3 (*continued*)

IEC 60617 Part	Date	Graphical symbols for diagrams (Note that, except for parts 12 and 13, IEC 60617 is no longer available as separate parts but as an online database accessible on a subscription basis. The structure of the withdrawn multi-part standard is given here, however, to indicate the contents of the database.)
6	1996	*Production and conversion of electrical energy* – 1 Winding interconnections – separate windings – 2 Internally connected windings – 3 Examples of machines – 4 Types of machines – 5 Examples of direct current machines – 6 Examples of alternating current commutator machines – 7 Examples of synchronous machines – 8 Examples of induction type (asynchronous) machines – 9 General symbols for transformers and reactors – 10 Examples of transformers with separate windings – 11 Examples of auto-transformers – 12 Examples of induction regulators – 13 Examples of measuring transformers and pulse transformers – 14 Block symbols for power converters – 15 Primary and secondary cells (batteries) – 16 General symbols for non-rotary power generators – 17 Heat sources – 18 Examples of power generators – 19 Closed-loop controllers – Annex A – Older symbols

Table D.3 (*continued*)

IEC 60617 Part	Date	Graphical symbols for diagrams (Note that, except for parts 12 and 13, IEC 60617 is no longer available as separate parts but as an online database accessible on a subscription basis. The structure of the withdrawn multi-part standard is given here, however, to indicate the contents of the database.)
7	1996	*Switchgear, controlgear and protective devices* – 1 Qualifying symbols – 2 Contacts with two or three positions – 3 Passing contacts with 2 positions – 4 Early and late opening contacts – 5 Contacts with delayed operation – 6 Automatic return and non-automatic return contacts – 7 Single-pole switches – 8 Position switches – 9 Temperature sensitive switches – 10 Speed change sensitive contacts – Mercury and levelling contacts (transferred to A.1 of Annex A) – 11 Examples of multi-position switches including control switches – 12 Block switches for complex switches – 13 Power-switching devices – 14 Block symbols for motor starters (see also A.2 of Annex A)) – 15 Operating devices (ALL–OR–NOTHING RELAYS) – 16 Block symbols and qualifying symbols (Measuring relays and related devices) – 17 Examples of measuring relays – 18 Other devices – 19 Sensors and detectors (Proximity and touch sensitive devices) – 20 Switches – 21 Fuses and fuse switches (Protective devices) – 22 Spark gaps and arresters – 23 Fire extinguishers (transferred to A.3 of Annex A) – 24 Ignighters and flag indicators (transferred to A.4 of Annex A) – 25 Static switches – 26 Static switching devices – 27 Coupling devices and static relays, block symbols – Annex A – Older devices

Table D.3 (*continued*)

IEC 60617 Part	Date	Graphical symbols for diagrams (Note that, except for parts 12 and 13, IEC 60617 is no longer available as separate parts but as an online database accessible on a subscription basis. The structure of the withdrawn multi-part standard is given here, however, to indicate the contents of the database.)
8	1996	*Measuring instruments, lamps and signaling devices* – 1 Indicating, recording and integrating instruments, general symbols – 2 Examples of indicating instruments – 3 Examples of recording instruments – 4 Examples of integrating instruments – 5 Counting devices – 6 Thermocouples – 7 Telemetering devices – 8 Electric clocks – 9 Miscellaneous measuring elements and instruments – 10 Lamps and signaling devices – Annex A, Older devices
9	1996	*Telecommunications: Switching and peripheral equipment* – 1 Switching systems – 2 Block symbols for switching equipment – 3 Elements of selectors – 4 Selectors – 5 Telephone sets – 6 Telegraph and data apparatus – 7 Telegraph repeaters – 8 Qualifying symbols specific to transducers, recorders and reproducers – 9 Transducers – 10 Recorders and reproducers – Annex A – Older symbols

Table D.3 (*continued*)

IEC 60617 Part	Date	Graphical symbols for diagrams (Note that, except for parts 12 and 13, IEC 60617 is no longer available as separate parts but as an online database accessible on a subscription basis. The structure of the withdrawn multi-part standard is given here, however, to indicate the contents of the database.)
10	1996	*Telecommunications: Transmission* – 1 Telecommunication lines and circuit usage – 2 Amplified circuits – 3 Antennas and radio stations – qualifying symbols – 4 General symbol and examples of use – 5 Specific types of antennas and parts of antennas – 6 Radio stations – 7 Microwave technology – transmission paths – 8 One- and two-port devices – 9 Multiport devices – 10 Couplers and probes – 11 Masers and lasers – 12 Qualifying symbols for the types of pulse-modulation – 13 Signal converters – 14 Converters – 15 Amplifiers – 16 Networks with several pairs of terminals – 17 Limiters – 18 Terminating sets and hybrid transformers – 19 Modulators, demodulators, discriminators – 20 Concentrators, multiplexers – 21 Symbol elements of frequency spectrum diagrams – 22 Examples of frequency spectrum diagrams – 23 Fibre optics – transmission lines – 24 Fibre optics – transmission devices

Table D.3 (*continued*)

IEC 60617 Part	Date	Graphical symbols for diagrams (Note that, except for parts 12 and 13, IEC 60617 is no longer available as separate parts but as an online database accessible on a subscription basis. The structure of the withdrawn multi-part standard is given here, however, to indicate the contents of the database.)
11	1996	*Architectural and topographical installation plans and diagrams* – 1 General symbols for generating stations and substations – 2 Specific types of generating stations and substations – 3 Networks – lines – 4 Networks – miscellaneous items – 5 Cabled distribution systems – Sound and TV – Head ends – 6 Amplifiers – 7 Splitters and directional couplers – 8 Tap-off and system outlets – 9 Equalizers and attenuators – 10 Power feeding devices – 11 Installations in buildings – identification of specific conductors – 12 Wiring – 13 Socket outlets – 14 Switches – 15 Lighting outlets and fittings – 16 Miscellaneous – 17 Trunking systems – 18 Airport navigation lights and indicators

Table D.3 (*continued*)

IEC 60617 Part	Date	Graphical symbols for diagrams (Note that, except for parts 12 and 13, IEC 60617 is no longer available as separate parts but as an online database accessible on a subscription basis. The structure of the withdrawn multi-part standard is given here, however, to indicate the contents of the database.)
12	1997	*Binary logic elements* – 1 Introduction – 2 General notes – 3 Explanation of terms – 4 Symbol construction – Composition of the symbol – 5 Outlines – 6 Use and combination of outlines – 7 Qualifying symbols – Negation, logic polarity, dynamic input – 8 Internal connections – 9 Symbols inside the outline – 10 Non-logic connections and signal-flow indicators – 11 Dependency notation – General explanation – 12 Convention – 13 Types of dependency – 14 AND dependency – 15 OR dependency – 16 NEGATE dependency – 17 INTERCONNECTION dependency – 17A TRANSMISSION dependency – 18 CONTROL dependency – 19 SET and RESET dependency – 20 ENABLE dependency – 21 MODE dependency – 22 Comparison of C-, EN-, and M-effects on inputs – 23 ADDRESS dependency – 24 Special techniques used in dependency notation – 25 The ordering of labels associated with inputs and with outputs – 26 Combinative and sequential elements – General notes – 27 Combinative elements – 28 Examples of combinative elements – 29 Examples of buffers, drivers, receivers, and bi-directional switches

Table D.3 (*continued*)

IEC 60617 Part	Date	Graphical symbols for diagrams (Note that, except for parts 12 and 13, IEC 60617 is no longer available as separate parts but as an online database accessible on a subscription basis. The structure of the withdrawn multi-part standard is given here, however, to indicate the contents of the database.)
12 (continued)		– 30 Elements with hysteresis – 31 Examples of elements with hysteresis – 32 Coders, code converters – 33 Examples of code converters – 34 Signal level converters with or without electrical isolation – 35 Examples of signal level converters – 36 Multiplexers and demultiplexers – 37 Examples of multiplexers and demultiplexers – 38 Arithmetic elements – 39 Examples of arithmetic elements – 40 Binary delay elements – 41 Bistable elements – 42 Examples of bistable elements – 43 Indication of special switching properties of bistable elements – 44 Monostable elements – 45 Examples of monostable elements – 46 Astable elements – 47 Examples of astable elements – 48 Shift registers and counters – 49 Examples of shift registers and counters – 50 Memories – 51 Examples of memories – 52 Display elements – 53 Examples of display elements – 54 Complex-function elements – General symbol and basic rules – 55 Bus indicators and data path representation – 56 Examples of complex function elements – Indexes– English, French. Devices for which symbols are shown

Table D.3 (*continued*)

IEC 60617 Part	Date	Graphical symbols for diagrams (Note that, except for parts 12 and 13, IEC 60617 is no longer available as separate parts but as an online database accessible on a subscription basis. The structure of the withdrawn multi-part standard is given here, however, to indicate the contents of the database.)
13	1993	*Analogue elements* – 3 General notes – 4 Qualifying symbols indicating the type of signal – 5 Qualifying symbols indicating the function of inputs, outputs and other connections – 6 Elements performing mathematical functions – General – 7 Examples of elements performing mathematical functions – 8 Amplifiers – 9 Examples of amplifiers – 10 Converters – General – 11 Examples of converters – 12 Voltage regulators – 13 Examples of voltage regulators – 14 Comparitors – 15 Examples of comparitors – 16 Examples of complex function elements – 17 Examples of electronic switches – 18 Other devices – Indexes – English, French. Devices for which symbols are shown

Table D.4 — EU Directives and machine design actions

	Action	Reference	Compliance with Directive(s)	Reference
1	Define the “intended use of the machine”, including “reasonably foreseeable misuse” and limits of machinery.	ISO 12100-2003 (EN ISO 12100-1:2003), 3.22, 3.23		
2			Become familiar with Machinery Directive. NOTE The Directive is the law; the product in question has to comply with its requirements.	98/37/EC
3			Is the product in question listed in Annex IV of the Directive? If yes, select 'notified body' who will conduct certification or examination (see below for further information). (*Certification:* submit technical construction file to notified body for review *Examination:* submit technical construction file *and* a 'sample' of the product to a notified body for review)	98/37/EC, Annex IV
4			Determine if other Directives are applicable (e.g. EMC, ATEX). Also review Product Liability Directive (85/374/EEC).	89/336/EEC 94/9/EC
5			Begin to develop “Technical Construction File” (TCF) — Accident history of product or similar products — Technical documentation (e.g. manuals, drawings, parts lists). (Add to the TCF as required items become available.)	98/37/EC, Annex V
6			For manufacturers located outside the European Community, consider establishing an authorized representative (i.e. a person or entity who acts as an agent; legally empowered to act on behalf of the manufacturer).	98/37/EC
7	Review and become familiar with basic terms and concepts.	ISO 12100-1 (EN ISO 12100-1) ISO 12100-2 (EN ISO 12100-2) IEC 60204-1 (EN 60204-1)		