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Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards

Sécurité des machines — Protecteurs — Prescriptions générales pour la conception et la construction des protecteurs fixes et mobiles

Reference number
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International Organization for Standardization

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 199, *Safety of machinery*.

This second edition cancels and replaces the first edition (ISO 14120:2002), which has been technically revised. The main changes from the previous edition are as follows.

— Definitions have been brought into line with ISO 12100. The figures showing examples of guards have been updated where appropriate.

— Clause 5 has been updated with new references to ISO 13855 and ISO 14119. Requirements on the removal of guards have been amended. Subclause 5.3.9 describes requirements for the removal of fixed guards only with a tool. In addition, there is a requirement that fixed guards be designed to prevent easy removal. The subclause about impact and ejection resistance (5.4) has been strengthened. Subclauses on Climbing (5.18), Retained fastenings (5.19), Warning signs (5.21), Colour (5.22) and Appearance (5.23) have been added.

— Clause 6 has been amended and updated to better include cover combinations of different guards or of guards with other devices. Selection of guards according to the number and size of the hazards (6.3) has been changed and updated. Subclause 6.4.4.2, where access is required during the working cycle, has been changed and updated.

— Clauses on verification and validation have been introduced (Clause 7). This includes a table which outlines the safety requirements and/or measures by subclause.

— The text of Clause 8 has been updated, including requirements for procedures for removal of guards (use of a tool and the safe working procedure). The subclause for removal of guards (8.5) has changed.

— Two new informative annexes on test methods, one on projectile tests and the other on impact tests, have been added.

— The Bibliography, which contains a list of International and European Standards published or in preparation that can be helpful in the design and commissioning of guards, has been updated.

Introduction

The structure of safety standards in the field of machinery is as follows:

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

b) **type-B standards** (generic safety standards) dealing with one safety aspect or one or more type(s) of safeguard 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 safeguards (e.g. two-hand controls, interlocking devices, pressure-sensitive devices, guards);

c) **type-C standards** (machine safety standards) dealing with detailed safety requirements for a particular machine or group of machines.

This International Standard is a type-B2 standard as stated in ISO 12100.

Guards provide a risk reduction for both protection against unintended access and against ejected parts and substances. The guarding can also give protection against others hazards, e.g. noise, fire, biological hazards, and radiation.

The requirements of this document can be supplemented or modified by a type-C standard.

For machines that are covered by the scope of a type-C standard and that have been designed and built according to the requirements of that standard, the requirements of that type-C standard take precedence.

Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards

1 Scope

This International Standard specifies general requirements for the design, construction, and selection of guards provided to protect persons from mechanical hazards.

This International Standard indicates other hazards that can influence the design and construction of guards.

This International Standard applies to guards for machinery which will be manufactured after it is published.

The requirements are applicable if fixed and movable guards are used. This International Standard does not cover interlocking devices. These are covered in ISO 14119.

This International Standard does not provide requirements for special systems relating specifically to mobility such as ROPS (rollover protective structures), FOPS (falling-object protective structures), and TOPS (tip over protective structures) or to the ability of machinery to lift loads.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13855, *Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body*

ISO 13857, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs*

ISO 14119, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

ISO 14123-1, *Safety of machinery — Reduction of risks to health from hazardous substances emitted by machinery — Part 1: Principles and specifications for machinery manufacturers*

ISO 14159, *Safety of machinery — Hygiene requirements for the design of machinery*

IEC 60204-1:2005, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100 and the following apply.

3.1
guard
physical barrier, designed as part of the machine, to provide protection

Note 1 to entry: A guard may act either

— alone, in which case it is only effective when “closed” (for a movable guard) or “securely held in place” (for a fixed guard), or

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

Note 2 to entry: Depending on its construction, a guard may be described as, for example, casing, shield, cover, screen, door, enclosing guard.

Note 3 to entry: The terms for types of guards are defined in ISO 12100:2010, 3.27.1 to 3.27.6. See also ISO 12100:2010, 6.3.3.2 for types of guards and their requirements.

[SOURCE: ISO 12100:2010, 3.27]

3.2
fixed guard
guard affixed in such a manner (for example, by screws, nuts, and welding) that it can only be opened or removed by the use of tools or by destruction of the means by which the guard is affixed

[SOURCE: ISO 12100:2010, 3.27.1]

3.2.1
enclosing guard
guard which prevents access to the hazard zone from all sides

Note 1 to entry: See Figure 1.

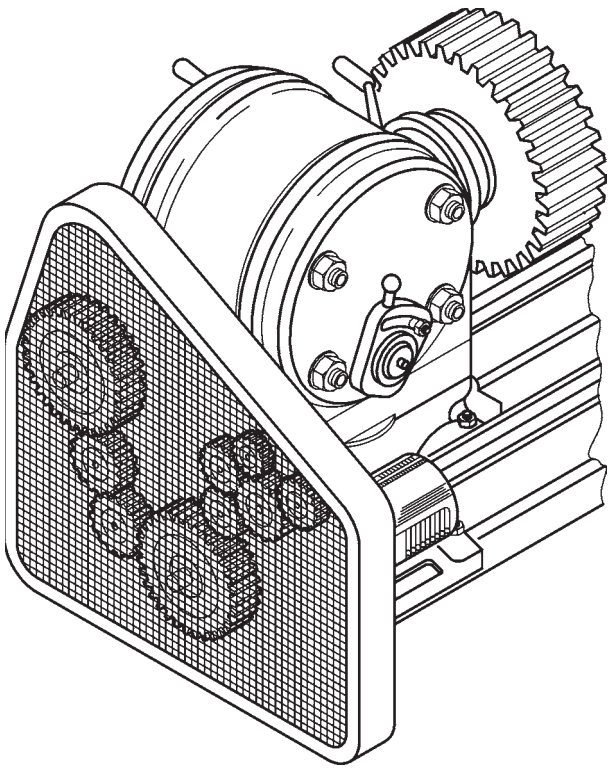


Figure 1 — Example of an enclosing guard totally preventing access to transmission machinery

3.2.2
distance guard
guard which does not completely enclose a hazard zone, but which prevents or reduces access by virtue of its dimensions and its distance from the hazard zone, for example perimeter fence or tunnel guard

Note 1 to entry: A distance guard can be partially or fully surrounding.

Note 2 to entry: See Figures 2 and 3.

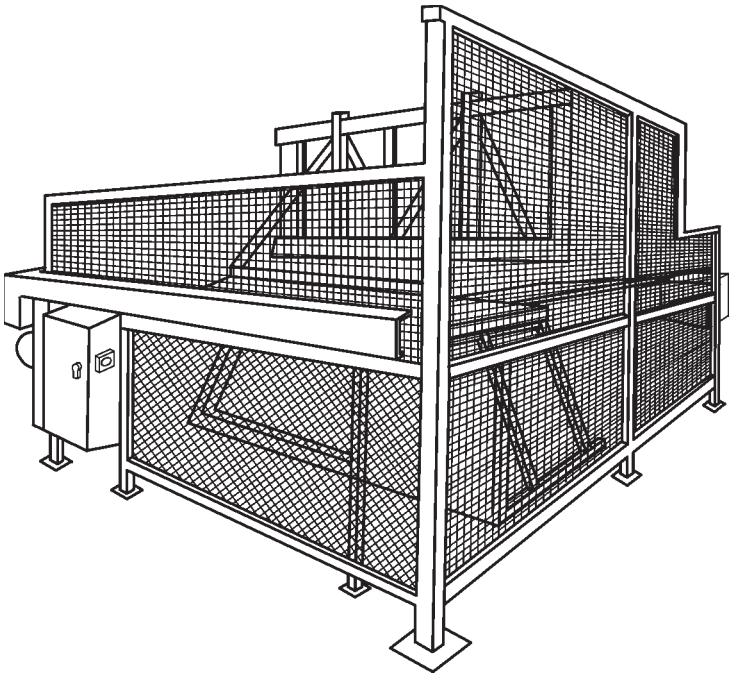


Figure 2 — Example of a distance guard

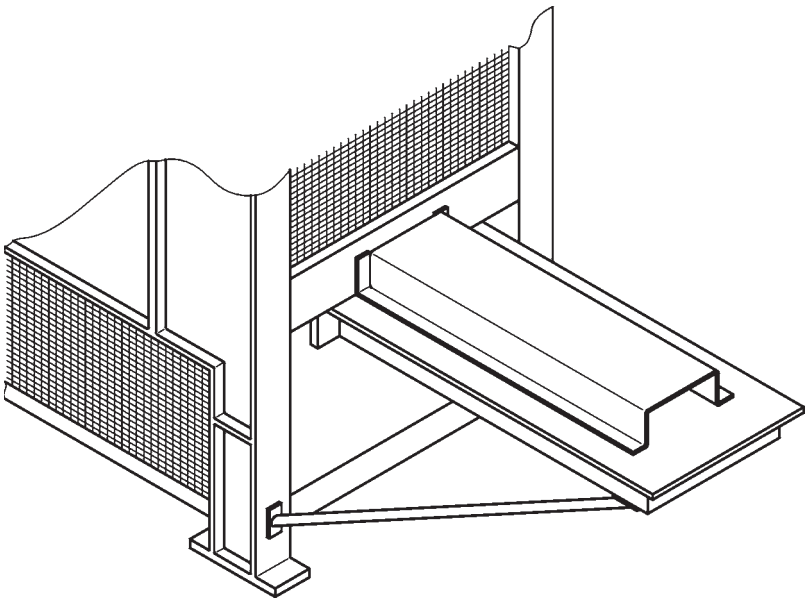


Figure 3 — Example of a distance guard: tunnel guard providing protection at machine feed or discharge area

3.3
movable guard
guard which can be opened without the use of tools

[SOURCE: ISO 12100:2010, 3.27.2]

3.3.1
power-operated guard
movable guard that is operated with the assistance of power from a source other than persons or gravity

3.3.2
self-closing guard
automatically adjustable guard
movable guard operated by a machine element (e.g. moving table) or by the workpiece or a part of the machining jig, so that it allows the workpiece (and the jig) to pass and then automatically returns (by means of gravity, a spring, other external power, etc.) to the closed position as soon as the workpiece has vacated the opening through which it has been allowed to pass

Note 1 to entry: See Figure 4.

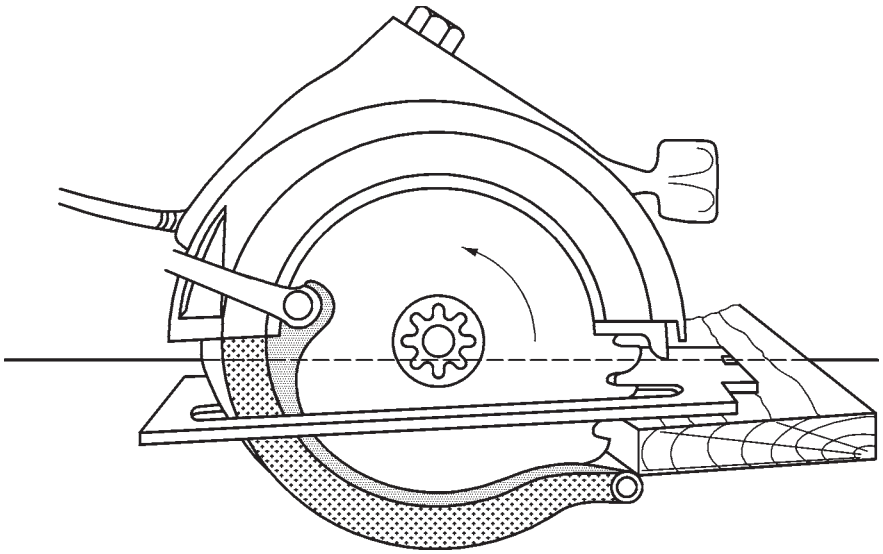


Figure 4 — Example of a self-closing guard

3.4
adjustable guard
guard which is adjustable as a whole or which incorporates adjustable part(s)

[SOURCE: ISO 12100:2010, 3.27.3]

3.4.1
manually adjustable guard
adjustable guard where the adjustment is made manually and the adjustment remains fixed during a particular operation

Note 1 to entry: See Figure 5.

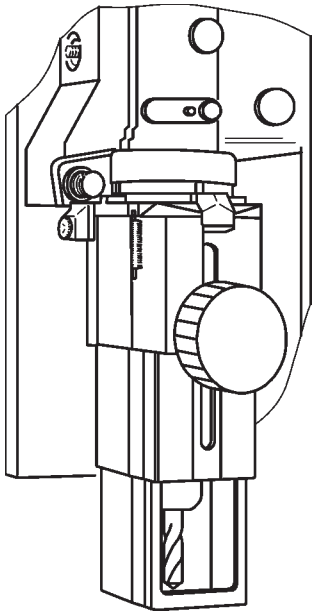


Figure 5 — Example of an adjustable guard for a radial or pedestal drilling machine

3.5
interlocking guard
guard associated with an interlocking device so that, together with the control system of the machine, the following functions are performed:

— the hazardous machine functions “covered” by the guard cannot operate until the guard is closed;

— if the guard is opened while hazardous machine functions are operating, a stop command is given;

— when the guard is closed, the hazardous machine functions “covered” by the guard can operate (the closure of the guard does not, by itself, start the hazardous machine functions)

Note 1 to entry: See Figure 6 and 7.

Note 2 to entry: See ISO 14119 about interlocking devices.

[SOURCE: ISO 12100:2010, 3.27.4]

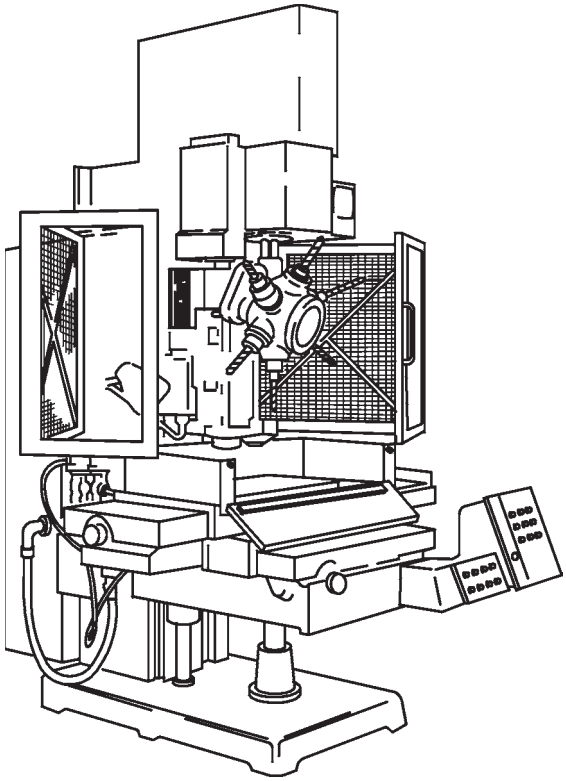


Figure 6 — Example of interlocking hinged guards; these enclose the hazard zone when closed

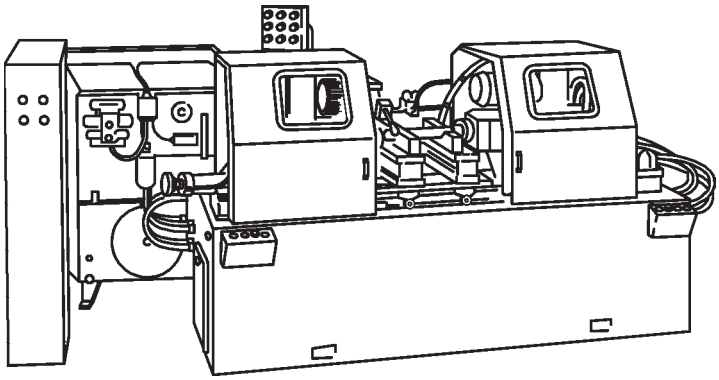


Figure 7 — Example of interlocking sliding guards

3.5.1
interlocking guard with a start function
control guard
special form of interlocking guard which, once it has reached its closed position, gives a command to initiate the hazardous machine function(s) without the use of a separate start control

Note 1 to entry: ISO 12100:2010, 6.3.3.2.5, gives detailed provisions regarding the conditions of use for a control guard (see also 5.3.14).

[SOURCE: ISO 12100:2010, 3.27.6]

3.5.2
interlocking guard with guard locking
guard associated with an interlocking device and a guard locking device so that, together with the control system of the machine, the following functions are performed:

— the hazardous machine functions “covered” by the guard cannot operate until the guard is closed and locked;

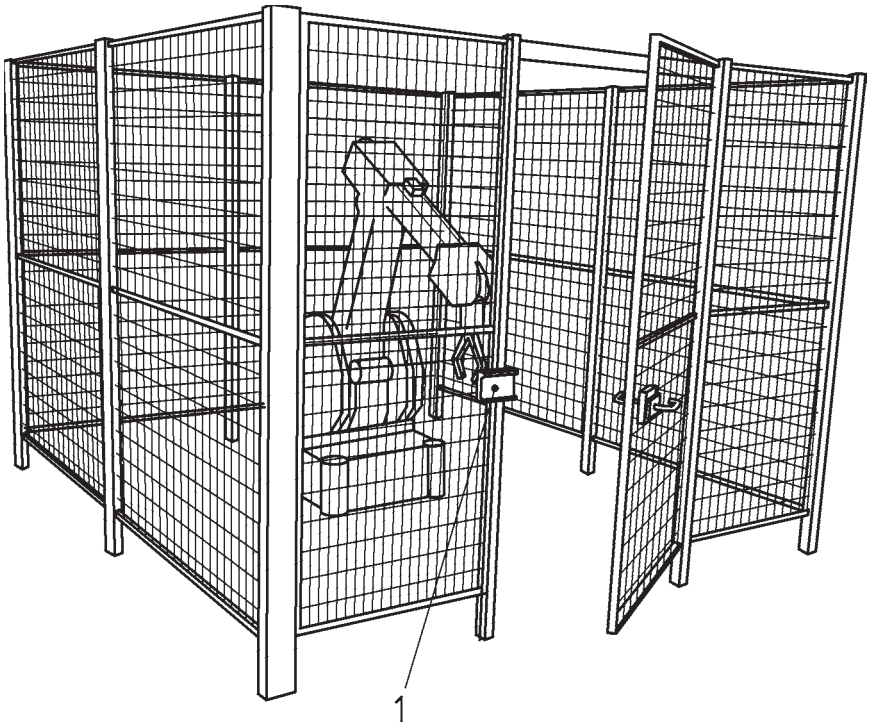
— the guard remains closed and locked until the risk due to the hazardous machine functions “covered” by the guard has disappeared;

— when the guard is closed and locked, the hazardous machine functions “covered” by the guard can operate (the closure and locking of the guard do not, by themselves, start the hazardous machine functions)

Note 1 to entry: See ISO 14119 about interlocking devices.

Note 2 to entry: See Figure 8.

[SOURCE: ISO 12100:2010, 3.27.5]



Key

1 example of guard locking device

Figure 8 — Example of safeguarding using fixed distance guards and interlocking guards with guard locking

3.6
closed position
position of a guard so that it performs the function for which it was designed

Note 1 to entry: The function can be to prevent/reduce access to the hazard zone, and/or prevent ejection of parts of the machine or the workpiece, and/or reduce exposure to hazards such as noise, radiation, etc.

Note 2 to entry: Open guard — guard which is not in closed position.

3.7
tool
implement such as a key or wrench designed to open and close a fastener

Note 1 to entry: An improvised implement, such as a coin or a nail-file, cannot be considered as a tool.

3.8
use of a tool
action by a person under known and predetermined circumstances as part of a safe working procedure

3.9
frequency of access
number of occasions on which access is required or foreseeable within the guarded area per unit of time

4 Risk assessment

In order to select and design types of guards appropriate to particular machinery, it is important to assess the risk arising from the various hazards present at that machinery and the foreseeable categories of persons who can be exposed to the hazard(s) (see ISO 12100:2010, Clause 5).

5 General requirements for the design and construction of guards

5.1 Machine aspects

5.1.1 General

Proper consideration of foreseeable aspects of the machine environment and operation throughout the foreseeable life of the machine is necessary in the design and application of guards. Inadequate consideration of these aspects can lead to hazardous situations where machinery operation is hindered. This can lead to persons defeating the guards provided, thus, exposing them to greater risk.

5.1.2 Access to hazard zones

To minimize access to hazard zones where practicable, guards and machinery shall be so designed as to enable routine adjustments, lubrication, and maintenance to be carried out without opening or removing the guards.

Where access is required within the guarded area, this shall be as free and unobstructed as practicable. The following are examples of reasons for access:

— loading and unloading;

— tool changing and setting;

— measurement, gauging, and sampling;

— maintenance and repair;

— lubrication;

— removal of waste material (for example scrap, swarf, spillage);

— obstruction removal;

— cleaning and hygiene.

5.1.3 Containment of ejected parts and other impacts

Where there is a foreseeable risk of

— ejection of parts (for example workpiece or broken tooling) from the machine,

— impacts from parts of machinery, or

— impacts from the operator,

the guard shall, as far as practicable, be designed and constructed so as to contain and withstand such ejections and impacts. See Annexes B and C for options.

5.1.4 Containment of hazardous substances

Where there is a foreseeable risk of emission from the machine of hazardous substances (for example coolant, vapours, gases, swarf, sparks, hot or molten material, dust, solid, or fluid matter), the guard shall be designed according to ISO 14123-1 to contain these substances as far as practicable.

If a guard forms part of an extraction system, this function shall be considered in the design, selection of materials, construction, and positioning of the guard.

5.1.5 Noise

Where a requirement has been established to reduce machine noise, guards shall be designed and constructed which will give the required noise reduction as well as providing protection against the other hazards present at the machine (see also ISO 11200). Guards acting as acoustic enclosures shall have adequately sealed joints to reduce the emission of noise.

NOTE More information can be found in ISO/TR 11688.

5.1.6 Radiation

Where there is a foreseeable risk of exposure to hazardous radiation, guards shall be designed and appropriate materials shall be used in their construction to protect persons from the hazard, see EN 12198-3. Examples include the use of darkened glazing (see ISO 25980 and EN 12254) to protect from the effects of weld flash or the elimination of openings in a guard around a laser.

5.1.7 Potentially explosive atmosphere

Where there is foreseeable risk of explosion, guards shall be designed to contain or dissipate the released energy in a safe manner and direction (for example by use of “explosion relief” panels) (see also EN 1127-1).

A guard shall not be an ignition source. To prevent the guard from becoming an ignition source, these aspects shall be considered (e.g. hot surfaces, mechanically generated sparks, electricity, static electricity, electromagnetic waves, and ultrasonic).

NOTE Where a guard is designed to protect against fire additional information is given in ISO 19353.

5.2 Human aspects

5.2.1 General

Reasonably foreseeable aspects of human interaction with machinery (for example when loading, maintaining or lubricating) shall be given proper consideration in the design and construction of guards.

5.2.2 Safety distances

Guards intended for preventing access to hazard zones shall be designed, constructed, and positioned to prevent parts of the body from reaching hazard zones according to ISO 13857. For interlocked movable guards, safety distances according to ISO 13855 shall also be fulfilled.

5.2.3 Control of access to the hazard zone

Movable guards shall be designed and positioned such that during normal operation they are prevented from closing with persons in the hazard zone. Where this is not practicable, other means shall be used to prevent persons from remaining undetected within the hazard zone. See ISO 12100:2010, 6.3.3.2.3.

5.2.4 Viewing

Where viewing of the process is required, guards shall be designed and constructed to offer adequate viewing. This can eliminate the need for defeating them. See also 5.9.

5.2.5 Ergonomic aspects

5.2.5.1 General

Guards shall be designed and constructed taking into account ergonomic principles [see also ISO 12100:2010, 6.2.8 a) and c)].

5.2.5.2 Size, weight, and design

Removable sections of guards shall be designed to be of a suitable size, weight, and design to permit ease of handling. Guards which cannot readily be moved or transported by hand shall be provided or be capable of being provided with suitable attachment devices for transport by means of a lifting device.

The attachments or provisions can be, for instance,

— standard lifting appliances with slings, hooks, eyebolts, or simply tapped holes for appliance fixing,

— appliances for automatic grabbing with a lifting hook, when securing is not possible from the ground, or

— lifting gear and appliances integrated into the guard.

When the mass of the guard or removable parts is sufficient to require the use of general lifting machinery, an indication, on the guard itself and removable parts or in the information for use, of the value of their mass expressed in kilograms (kg).

NOTE Where removable sections of guards are intended to be moved or transported by hand, see EN 1005–2.

5.2.5.3 Operating force

Movable guards or removable sections of guards shall be designed to permit ease of operation.

The observance of ergonomic principles in designing guards contributes to increasing safety by reducing stress and the physical effort of the operator. This improves the performance and reliability of the operation, thereby reducing the probability of errors at all stages of machine use (see ISO 12100).

Operating forces can be reduced by the use of devices such as springs, counterbalances, or gas struts.

5.2.5.4 Power operated guards

Where guards are power operated, they shall not be capable of causing injury (for example, from contact pressure, force, speed, sharp edges). Where a guard is fitted with a protective device which automatically initiates re-opening of the guard, the closing force shall not exceed 150 N and the kinetic energy of the guard shall not exceed 10 J. Where no such protective device is fitted, these values shall be reduced to 75 N and 4 J respectively.

These values are only applicable when a wide closing edge is used and no hazards from cutting or shearing are present.

5.2.6 Intended use

Guards shall be designed to take into account foreseeable use and reasonably foreseeable misuse (see ISO 12100:2010, 3.23 to 3.24 and Clause 5).

5.3 Guard design and construction aspects

5.3.1 General

All foreseeable aspects of guard operation shall be given proper consideration at the design stage to ensure that the design and construction of the guard itself does not create further hazard.

5.3.2 Crushing or trapping points

Guards shall be designed so as not to cause hazardous crushing or trapping points with parts of the machine or other guards (see also ISO 13854).

5.3.3 Durability

Guards shall be designed to perform their function properly throughout the foreseeable life of the machine. When this is not practicable, degradable parts shall be replaceable.

NOTE Decreased durability can be caused, e.g. by environmental influences such as varying temperatures, light, oxygen, or chemicals (e.g. cleaning agents).

5.3.4 Hygiene

Where applicable, guards shall be designed so as not to create hazards to hygiene by trapping items or material, for example food particles, or stagnant fluids (see also ISO 14159).

5.3.5 Cleaning

Where it is a requirement of the process, notably for the processing of food and pharmaceuticals, guards shall be so designed that they are not only safe to use but can also be easily cleaned.

5.3.6 Exclusion of contaminants

Where it is a requirement of the process, guards shall be designed to exclude contaminants from the process, for example in the food, pharmaceutical, electronic, and related industries.

5.3.7 Sharp edges, etc.

Guards shall be designed and constructed so as not to have exposed sharp edges and corners or other hazardous projections.

5.3.8 Integrity of joints

Welded, bonded, or mechanically fastened joints shall be of sufficient strength to suit reasonably foreseeable loading. Where bonding agents are used, these shall be compatible with the process and materials being used. Where mechanical fastenings are used, their strength, number, and spacing shall be sufficient to ensure the stability and rigidity of the guard.

5.3.9 Removal of fixed guards

Demountable fixed parts of guards shall only be removable with the use of a tool (see 3.8). See also 8.5 and 8.6.

— Fixed guards shall be designed to prevent easy removal.

NOTE 1 This is because operators can prefer to use an easily removable fixed guard instead of using an interlocked movable guard.

— Quick release fasteners such as self-clinching fasteners shall not be used to secure fixed guards from outside the guarded area.

NOTE 2 The use of fastenings that can be released quickly from the inside of the guarded area should not be regarded as an alternative to providing an emergency exit. The emergency release of guards with interlocking/guard locking is dealt with in ISO 14119. See also Clause 6.

5.3.10 Mounting of removable fixed guards

Fixed guards which are removable shall, where practicable, be unable to remain in place without their fixings.

5.3.11 Adjustable guards

Adjustable guards shall be designed and constructed to restrict the opening to a minimum, consistent with the passage of material.

Both manually adjusted and automatically adjusted (self-closing) guards can be used in conjunction with fixed guards.

Manually adjustable guards shall

— be designed and constructed so that the adjustment remains fixed during a given operation, and

— be easily adjustable without the use of a tool.

Automatically adjustable guards shall

— be designed and constructed so that the gap between the guard and the material is always limited to the minimum that is necessary for the work, and

— as far as practicable, be designed to prevent the automatic adjustment being defeated.

NOTE It will not be possible in all cases to prevent automatically adjustable guards from being defeated, bypassed, or rendered non-operational in an easy way.

5.3.12 Movable guards

The opening of movable guards shall require deliberate action.

Where possible, movable guards shall be attached to the machine or adjacent fixed elements so that they are retained, for example by hinges or slides, even when open. Such attachments shall only be removable with the use of a tool (see 3.8). Interlocked moveable guards shall be positioned relative to the hazard zone in accordance with ISO 13855.

5.3.13 Closed position of movable guards

The closed position of movable guards shall be unambiguous and distinct. The guard shall be held in position against a stop by means of gravity, a spring, catch, or other means.

5.3.14 Interlocking guards with a start function (control guards)

Interlocking guards with a start function can be used only if ISO 12100:2010, 6.3.3.2.5 and all the following are fulfilled:

— the dimensions and shape of the machine allow for the operator or any person having to intervene on the machine to have a global view of the whole machine/process;

— where starting the machine with an interlocking guard with a start function is one of the possible control modes of the machine, mode selection shall be ensured according to ISO 12100:2010, 6.2.11.10.

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

5.4 Materials, rigidity, and impact requirements

5.4.1 General

The following aspects shall be considered in the selection of suitable materials for the construction of guards. These properties shall be maintained throughout the foreseeable life of the guard.

5.4.2 Impact and ejection resistance

Guards shall, as far as practicable, be designed and the material selected to withstand and contain reasonably foreseeable impacts and ejections according to 5.1.3.

Materials for viewing panels shall be selected with properties suited to resist the mass and velocity of the ejected object or material. Where guards are fitted with viewing panels, special consideration shall be given to the selection of materials and method of fixing them. Guards shall resist static and dynamic forces (pressure, impacts) according to the risk assessment.

NOTE The impact resistance depends, e.g. on the properties of the material being used, its strength, the fixing, and its ageing.

5.4.3 Rigidity

Support posts, guard frames, mountings, and infill materials shall be selected and arranged to provide a rigid and stable structure and to resist deformation. This is especially important where deformation of material could be detrimental to maintaining safety distances.

5.4.4 Secure fixing

Guards or parts of guards shall be secured by fixing points of adequate strength, spacing, and number to remain secure under any foreseeable loading or impact. Fixing can be by means of mechanical fasteners or clamps, welded or bonded joints, or other means suited to the application. See also 5.3.8.

5.4.5 Reliability of moving parts

Moving parts, for example hinges, slides, handles, and catches, shall be selected to ensure reliable operation given their foreseeable usage and working environment.

5.5 Containment

Harmful substances, for example fluids, swarf, dust, and fumes, which can reasonably be foreseen, shall be contained within the guard by a suitable impermeable material according to ISO 14123-1.

5.6 Resistance to corrosion

Materials shall be selected which are resistant to foreseeable oxidation and corrosion arising from the product, process or environment (e.g. from cutting fluids in machining operations or cleaning, sterilizing agents in food processing machinery). This can be achieved by the application of suitable protective coatings.

5.7 Resistance to microorganisms

Where there is a foreseeable risk to health from bacterial and fungal growth, materials that inhibit this growth and can be easily cleaned and, if necessary, disinfected are used in the construction of guards and shall be selected according to ISO 14159.

Examples are machines in the food, pharmaceutical and related industries, and catering in hospitals or hotels.

5.8 Non-toxicity

Materials and finishes used shall be non-toxic in all foreseeable conditions of use and compatible with the process involved especially in food, pharmaceutical, and related industries according to ISO 14123-1.

5.9 Machine viewing

Where viewing of machine operation is required through the guard, materials shall be selected with suitable properties. If perforate material or wire mesh is used, this should be of adequate open area and suitable colour to permit viewing. Viewing will be enhanced if the perforate material is darker than the area observed. See also 5.22.

5.10 Transparency

Materials used for viewing machine operation shall, as far as practicable, be selected from amongst those which retain their transparency despite age and use. Guards shall be designed to make provision for the replacement of degraded materials.

Certain applications can require the selection of materials or combinations of materials that are resistant to abrasion, chemical attack, degradation by radiation, dust attraction by static electrical charge, or surface wetting by fluids which impair transparency.

5.11 Shadows and stroboscopic effects

Guards shall be designed and constructed so as to minimize shadows and stroboscopic effects which can cause a risk.

NOTE See ISO 12100:2010, 6.2.8 e).

5.12 Electrostatic properties

Materials of the guard that enclose or is placed in an environment containing dust, fibres, or particles shall be selected to prevent accumulation. If there is a risk of static charge to a hazardous level, guards shall be designed in material with an electrical conductance high enough to avoid build-up of static charge or by other measures to prevent hazardous static charge.

For consideration of ignition sources, see 5.1.7.

NOTE IEC/TR 61340–1 gives guidance on electrostatic problems and hazards.

5.13 Guards with electrically conductive parts

Where guards are made of electrically conductive material and used in electrically powered machines, they might need to be considered as “extraneous conductive parts of the machine” according to IEC 60204-1:2005, Clause 8.

5.14 Thermal stability

Materials shall be selected which do not degrade when exposed to the range of foreseeable temperature variations or sudden changes in temperatures. Examples are materials which are not prone to brittle fracture, excessive deformation, or emission of toxic or flammable fumes.

Materials selected shall retain their properties in foreseeable climatic and workplace conditions.

5.15 Fire and flammability

Where there is a foreseeable risk of fire (see ISO 19353), materials selected shall be spark resistant and fire retardant and shall not absorb or emit flammable fluid, fumes, etc.

5.16 Noise and vibration reduction

Where necessary, materials shall be selected to provide noise and vibration reduction. This can be achieved by means of insulation (putting an acoustic barrier in the path of the noise), and/or absorption (lining guards with appropriate acoustically absorbent materials) or by a combination of both. Guard panels might also need to be suitably damp to minimize effects of resonance which can transmit or amplify noise.

5.17 Radiation protection

In certain applications, such as welding or the use of lasers, materials shall be selected that protect persons from harmful radiation.

NOTE In welding applications, for example, this protection can be by means of a suitably tinted transparent screen which permits viewing but eliminates harmful radiation.

5.18 Climbing

Climbing on guards shall, as far as practicable, be inhibited by design. Consideration shall be given to this possibility in their construction and the selection of materials and shapes. For example, by eliminating horizontal structural members and the horizontal component of mesh fabric from the outside surface of the guard, climbing is made more difficult.

5.19 Retained fastenings

When it is foreseen, e.g. maintenance, that the fixed guard will be removed, the fastenings shall remain attached to the guard or to the machinery.

The requirement does not necessarily apply to fixed guards that are only liable to be removed, for example, when the machinery is completely overhauled, is subject to major repairs, or is dismantled for transfer to another site.

For the same reason, it might not be necessary to apply the requirement for retained fastenings to removable covers provided for access (e.g. for inspection) in casings of machinery if

— the manufacturer's instructions specify that the repairs requiring removal of these casings are only to be carried out in a specialist repair workshop, and

— fastenings shall only be removable by the use of a tool.

See Annex A for examples of retained fastenings.

NOTE This requirement aims to reduce risks due to loss of one or more of the fastenings when guards are removed, for example, for maintenance purposes. This can lead to the guards not being replaced, only partially fixed in place or fixed with replacement fixings that do not have adequate strength, so that the guard cannot adequately perform its protective function, for example, where containment of ejected parts is necessary.

5.20 Vibration resistance

Where necessary, to prevent loosening and maintain attachment to the guard, fastenings shall to be fitted with lock nuts, spring washers, etc.

5.21 Warning signs

Where access within the guarded area can expose persons to residual risks (e.g. radiation), appropriate warning signs shall be placed at access points.

5.22 Colour

Attention can be drawn to the hazard while the guard is opened or left off by highlighting the hazard by the use of suitable colours. For example, if a guard is painted the same colour as the machine, the hazardous parts are painted a contrasting bright colour.

Care should be taken in the selection and combination of colours to avoid confusion, e.g. red and yellow, in combination is normally used for emergency stop.

When observation of the process is required, guards of perforate material should not be painted in bright colours, e.g. yellow, that might interfere with the viewing of the process.

NOTE For further information see EN 614–1.

5.23 Appearance

Guards shall be designed so that they do not add adverse physiological and psychological effects.

NOTE See ISO 12100:2010, 6.2.8.

6 Selection of types of guards

6.1 General

Types of guards shall be selected in accordance with the following (see also ISO 12100:2010, 6.3.2).

In selecting suitable guards, the phases of the life of the machinery (as defined in ISO 12100) shall be considered.

The most important selection criteria are the following:

— probability and foreseeable severity of any injury as indicated by the risk assessment;

— intended use of the machine as defined in ISO 12100;

— foreseeable misuse and defeat of the guards;

— hazards present at the machine;

— nature and frequency of access.

6.2 Combination of different guards or of guards with other devices

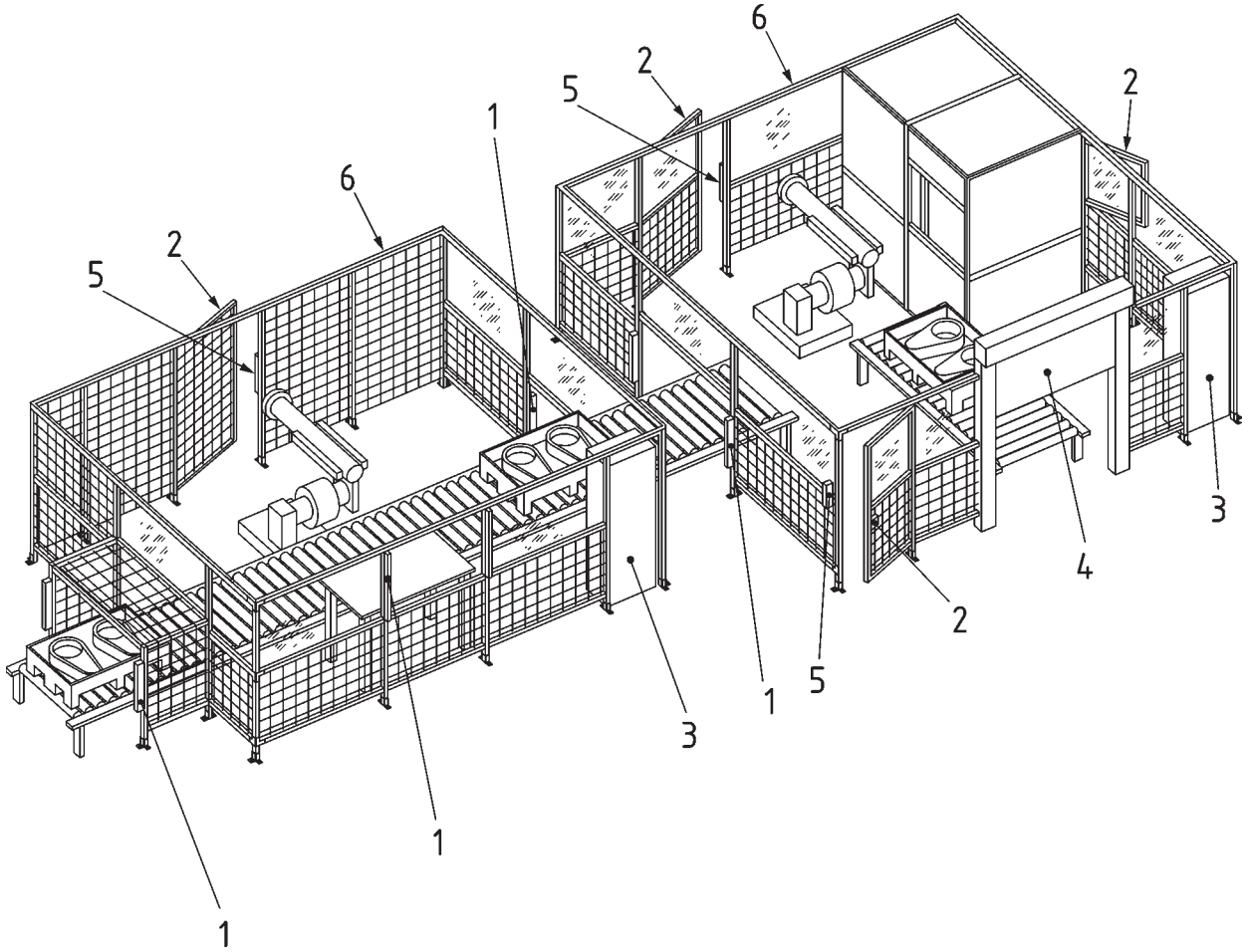
It can be appropriate to use a combination of different types of guards. For example:

— if a machine has several hazard zones and access is required to one of them during the operating phase, the guards can consist of a fixed guard combined with an interlocking movable guard;

— if a perimeter fence is used to prevent access to the hazard zones of a machine, an interlocked gate would normally be required to provide safe access.

In a similar way, a combination of protective devices and guards can sometimes be required (see Figure 9).

EXAMPLE Where a mechanical feed device is used in conjunction with a fixed guard to feed workpieces into a machine (thereby removing the need for access to the hazard zone), a sensing protective device (see ISO 12100:2010, 3.28.5) can be required to protect against a secondary trapping or shearing hazard between the mechanical feed device and the fixed guard.



Key

1 active optoelectronic protective device (AOPD)
2 interlocking guard
3 electrical cabinet
4 interlocked movable guard with pressure-sensitive edge
5 reset device
6 distance guard

Figure 9 — Example of combination of different guards and protective devices

6.3 Selection of guards according to the number and size of the hazards

Where practicable, hazards shall be guarded by enclosing guards.

When enclosing guards are not practicable, guards of the most appropriate type should be selected, e.g. fixed guards (distance or perimeter), movable guards, adjustable guards (automatic or manual) (see 6.4).

It is possible for a guard to protect multiple hazards and/or hazardous zones e.g. perimeter guarding with an interlocked access gate around an assembly of machines. If a guard protects multiple hazards, then the guarding shall be appropriate for all the hazards.

When a hazardous area is separated into different zones to allow access to stationary machinery in one zone when machinery is operating on other zones, access to a zone still in operation by accessing a safe zone shall be prevented by the use of appropriate safeguarding.

NOTE Other safeguarding measures outside of the scope of this International Standard might be more suited to the hazard(s) identified and the intended operation of the machine.

It can be beneficial to the production process to divide a guarded area into different zones, to enable actions (for example checking, adjustment) in one zone to be carried out without affecting machine operation in another zone. In this case, the guarding for each zone shall be in accordance with all the requirements of this International Standard.

6.4 Selection of guards according to the nature and frequency of access required

6.4.1 General

ISO 12100 provides requirements and guidance on the selection of guards, see ISO 12100:2010, 6.3.2 and Figure 4.

6.4.2 Moving transmission parts

Guards to protect against hazards generated by moving transmission parts, e.g. pulleys, belts, gears, rack, and pinions, shafts shall be either fixed guards (see Figure 1) or interlocked movable guards.

Selection of fixed or interlocked movable guard shall be done according to 6.4.4.1.

6.4.3 Where access is not required during use

Fixed guards should be used on account of their simplicity and reliability.

6.4.4 Where access is required during use

6.4.4.1 Where access is required for machine setting, process correction or maintenance

The following types of guard should be used:

a) Movable guard, if the foreseeable frequency of access is high (e.g. more than once per week) or if removal or replacement of a fixed guard would be difficult. Movable guards shall be associated with an interlock or an interlock with guard locking (see ISO 14119);

b) Fixed guard only, if the foreseeable frequency of access is low (e.g. less than once per week), its replacement is easy and its removal and replacement are carried out under a safe system of work.

6.4.4.2 Where access is required during the working cycle

The following types of guard should be used:

a) Movable guard with interlock or with interlock with guard locking (see ISO 14119);

b) Power-operated interlocking movable guards may be preferable, where there is a very short working cycle or ergonomic reasons, e.g. heavy guards, hot process;

c) Interlocking guards with a start function (control guards), where the special conditions are met for use (see 5.3.14).

NOTE When frequent access is required during the working cycle, other types of protective devices (e.g. light curtain) can be more practical. They are not in the scope of this International Standard.

6.4.4.3 Where, due to the nature of the operation, access to the hazard zone cannot be totally prevented

When tools, for example saw blades, need to be partially exposed, the following guards are appropriate:

a) self-closing guard (see 5.3.11);

b) adjustable guard (see 5.3.11 and also ISO 12100).

7 Verification of the safety requirements for guards

7.1 General

The aspects of guard design and construction shall be subject to verification by examination, inspection, testing, or calculation. Where practicable, verification shall be carried out with the guard in its working situation.

NOTE 1 For certain type of guards or for machines as specified in the Type-C standards, type testing of the guard is mandatory. In some instances, this might need to be carried out away from the machine, for example power take-off guards and guards for abrasive wheels.

NOTE 2 Some test methods mentioned in the informative Annexes B and C contain optional requirements but, unless a Type-C standard specifies these requirements for certain machines, there is no need to comply with these optional requirements to claim compliance with this International Standard.

7.2 Verification and validation methods

Verification and validation can be satisfied by methods including but not limited to the following:

— visual inspection (A);

— practical tests (B);

— measurement (C);

— observation during operation (D);

— review of task-based risk assessment (E);

— review of specifications, layout, and documentation (F).

7.3 Required verification and validation

Table 1 lists specific requirements that are identified as essential for the design, construction, and selection of guards provided to protect persons from mechanical hazards. For each requirement, Table 1 indicates the means by which compliance with the requirement shall be verified.

Table 1 — Means of verification and/or validation of the safety requirements and/or measures

Subclause	Safety requirements and/or measures	Verification and/or validation methods					
		A	B	C	D	E	F
5.1	Machine aspects						
5.1.1	General						
5.1.2	Access to hazard zones is minimized by e.g. enabling routine adjustments without opening or removing the guards.	X	X		X	X	
5.1.3	The guard is designed to contain and withstand ejected parts from workpiece, machinery, or tools.		X			X	X

Table 1 *(continued)*

Subclause	Safety requirements and/or measures	Verification and/or validation methods					
		A	B	C	D	E	F
5.1.4	The guard is designed for containment of hazardous substances.			X		X	X
5.1.4	The guard is designed to form a part of the extraction system.			X		X	X
5.1.5	The guard is designed to reduce noise.			X		X	
5.1.5	The guard have adequately sealed joint to reduce emission.			X		X	
5.1.6	The guard is designed to protect from radiation.			X		X	
5.1.7	The guard is designed to contain and dissipate released energy in case of an explosion					X	X
5.1.7	All potential ignition sources have been considered in order to protect the guard from being an ignition source.					X	X
5.2	Human aspects						
5.2.1	Reasonably foreseeable aspects of human interaction with machinery have been considered.		X	X		X	X
5.2.2	The guard is positioned according to ISO 13857.			X		X	X
5.2.3	The movable guard is designed and positioned to prevent it from closing when persons are in the hazard zone.		X			X	X
5.2.3	Other means are used in to prevent persons from remaining undetected in the hazard zone.		X			X	X
5.2.4	The guard is designed and constructed to offer adequate viewing of the process.	X				X	X
5.2.5	Ergonomic aspects						
5.2.5.1	Ergonomic principles have been taken into account.					X	X
5.2.5.2	Removable sections of guards are designed to be of a suitable size, weight, and design to permit ease of handling.		X	X		X	X
5.2.5.2	Removable sections of guards are provided with suitable attachment devices for transport by means of a lifting device.	X				X	X
5.2.5.3	Movable guards or removable sections of guards are designed to permit ease of operation.		X			X	X
5.2.5.4	The power operated guards is not capable of causing injury.	X		X		X	X
5.2.6	The guard is designed to take into account foreseeable use and reasonably foreseeable misuse.	X	X			X	X
5.3	Guard design and construction aspects						
5.3.1	The guard shall not create a further hazard.					X	X
5.3.2	The guard is designed so as not to cause hazardous crushing or trapping points with parts of the machine or other guards.	X		X		X	X
5.3.3	The guard is designed to perform its function properly throughout the foreseeable life of the machine.				X	X	X
5.3.4	The guard is designed so as not to create hazards to hygiene by trapping items or material.	X				X	X

Table 1 *(continued)*

Subclause	Safety requirements and/or measures	Verification and/or validation methods					
		A	B	C	D	E	F
5.3.5	The guard can be easily cleaned.		X			X	X
5.3.6	The guard is designed to exclude contaminants.			X		X	X
5.3.7	The guard does not have sharp edges, corners, or other hazardous projections.	X				X	X
5.3.8	Welded, bonded, or mechanically fastened joints have sufficient strength.		X			X	X
5.3.8	The mechanical fastenings have sufficient strength, number, and spacing.		X			X	X
5.3.9	Demountable parts are only removable with the use of a tool.		X			X	X
5.3.10	The fixed removable guard is unable to remain in place without its fixings.		X				X
5.3.11	The adjustable guard is designed and constructed to restrict the opening to a minimum.	X				X	X
5.3.11	The manually adjustable guard is designed so the adjustment remains fixed during the given operation.		X			X	X
5.3.11	The manually adjustable guard is designed so it is easily adjustable without the use of a tool.		X	X			X
5.3.11	The automatically adjustable guard is designed so the gap between the guard and material is limited to a minimum.		X			X	X
5.3.11	The automatically adjustable guard is designed to prevent the automatic adjustment to be defeated.		X			X	X
5.3.12	The opening of the movable guard requires deliberate action.		X				X
5.3.13	The closed position of the movable guard is unambiguous and distinct.		X				X
5.3.13	The guard is held in position against a stop by means of gravity, a spring, catch, guard locking device, or other means.		X				X
5.3.14	For the interlocking guards with a start function all the following is fulfilled: -dimensions of the machine allows for the operator to have a global view of the machine.		X			X	X
5.4	Materials, rigidity, and impact requirements						
5.4.1	General						
5.4.2	The guard is designed to resist static and dynamic forces.		X	X		X	X
5.4.3	Support posts, guard frames, mountings, and infill materials shall be selected and arranged to provide a rigid and stable structure and to resist deformation. This is especially important where deformation of material could be detrimental to maintaining safety distances.		X	X		X	X
5.4.4	The guards or parts of guards is secured by fixing points of adequate strength, spacing and number to remain secure under any foreseeable loading.		X	X		X	X

Table 1 *(continued)*

Subclause	Safety requirements and/or measures	Verification and/or validation methods					
		A	B	C	D	E	F
5.4.5	Moving parts, for example hinges, slides, handles, catches, selected to ensure reliable operation given their foreseeable usage and working environment.		X	X		X	X
5.5	Harmful substances, for example fluids, swarf, dust, fumes, are contained within the guard by a suitable impermeable material.		X	X		X	X
5.6	Materials shall be selected which are resistant to foreseeable oxidation and corrosion from the product, process, or environmental factors.					X	X
5.7	Materials used in the construction of guards are selected that inhibit growth of microorganisms and can be easily cleaned and, if necessary, disinfected.					X	X
5.8	Materials and finishes used is non-toxic in all foreseeable conditions of use and compatible with the process.					X	X
5.9	Materials are selected to permit viewing.	X				X	X
5.10	Materials used for viewing machine operation are selected from amongst those which retain their transparency despite age and use.	X					X
5.10	The guards are designed to make provision for the replacement of degraded materials.					X	X
5.11	Guards are designed and constructed so as to minimize shadows and stroboscopic effects which can cause a risk.	X				X	X
5.12	Materials of the guards are selected to prevent accumulation of dust fibres, etc.			X		X	X
5.12	The guards are designed in a material with an electrical conductance high enough to avoid build-up of static charge, or by other measures to prevent hazardous static charge.			X		X	X
5.13	The guards are provided with terminations for earthing conductors.					X	X
5.14	The materials selected do not degrade when exposed to the range of foreseeable temperature variations or sudden changes in temperatures.			X		X	X
5.15	Materials selected are spark resistant and fire retardant and not absorbing or emitting flammable fluid, fumes, etc.			X		X	X
5.16	Materials are selected to provide noise and vibration reduction.			X		X	X
5.17	Materials are selected that protect persons from harmful radiation.			X		X	X
5.18	Climbing on guards is inhibited by design.	X	X			X	X
5.19	The fastenings are remaining attached to the guard or to the machinery.	X	X			X	X
5.20	Fastenings can be fitted with lock nuts, spring washers, etc., to ensure that they remain attached to the guard.	X	X			X	X

Table 1 *(continued)*

Subclause	Safety requirements and/or measures	Verification and/or validation methods					
		A	B	C	D	E	F
5.21	Warning signs are placed at access points.	X				X	X
5.22	Attention is drawn to the hazard while the guard is opened or left off by highlighting the hazard by the use of suitable colours.	X				X	X
5.23	Guards are designed so that they do not add adverse physiological and psychological effects.	X	X		X	X	X

8 Information for use

8.1 General

The instructions for use shall contain the required information about guards, their safety parameters, and their functions (e.g. vertical or horizontal orientation), including installation and maintenance (see ISO 12100:2010, 6.4).

8.2 Guard hazards

Information shall be provided for any hazards associated with the guards themselves, for example mechanical hazards or flammability of materials and relevant test results.

8.3 Installation

Instructions shall be supplied for the correct installation of guards and associated equipment.

When guards are to be attached to a structure, the instructions shall include requirements for fixing. This includes, but is not limited to, the following:

— fixing to a floor;

— assembling of movable guards;

— number and types of fixings;

— compliance with other relevant standards, e.g. ISO 13857 and ISO 14119.

NOTE When guards are designed to be fixed to a concrete floor, instructions for installation can refer to concrete classification. See for example EN 206–1 with classes C20/25 to C50/60 for compressive strength.

8.4 Operation

Instructions shall be provided directing the user to the correct operation of the guards, and the related interlocks if they are supplied with the guard. Warnings against reasonably foreseeable misuse shall be given (see ISO 12100).

8.5 Removal of guards

Information shall be provided indicating actions to be taken before guards are removed, for example machine power isolation, dissipation of stored energy, and procedures for the removal of guards.

The information shall also prescribe requirements on procedures for the removal of guards, including

— appropriate use of a tool (see 3.7 and 3.8) and

— safe working procedure.

NOTE See also ISO 14118 and IEC 60204–1:2005, 5.3 and 5.4.

8.6 Inspection and maintenance

Details shall be provided of inspections required to identify defects and the maintenance required. This shall include the following, as appropriate:

— loss of or damage to any part of the guard, especially where this leads to deterioration of safety performance, for example reduction of impact resistance from scratches to glazing materials;

— deformed or damaged part to be repaired or replaced if the damage has negative influence on safety;

— replacement of wearing parts;

— correct operation of interlocks;

— degradation of jointing or fixing points;

— degradation by corrosion, temperature change, embrittlement, or chemical attack;

— satisfactory operation and lubrication, if necessary, of moving parts;

— modification of safety distances and aperture sizes;

— degradation of acoustic performance, if applicable.

The information for use shall include a warning that fixings for guards (e.g. bolts, screws) should only be replaced with fixings of the same or an equivalent type, e.g. fixing requiring the use of a tool (see 3.7 and 3.8).

Annex A
(informative)

Example of retained fastening

See Figure A.1.

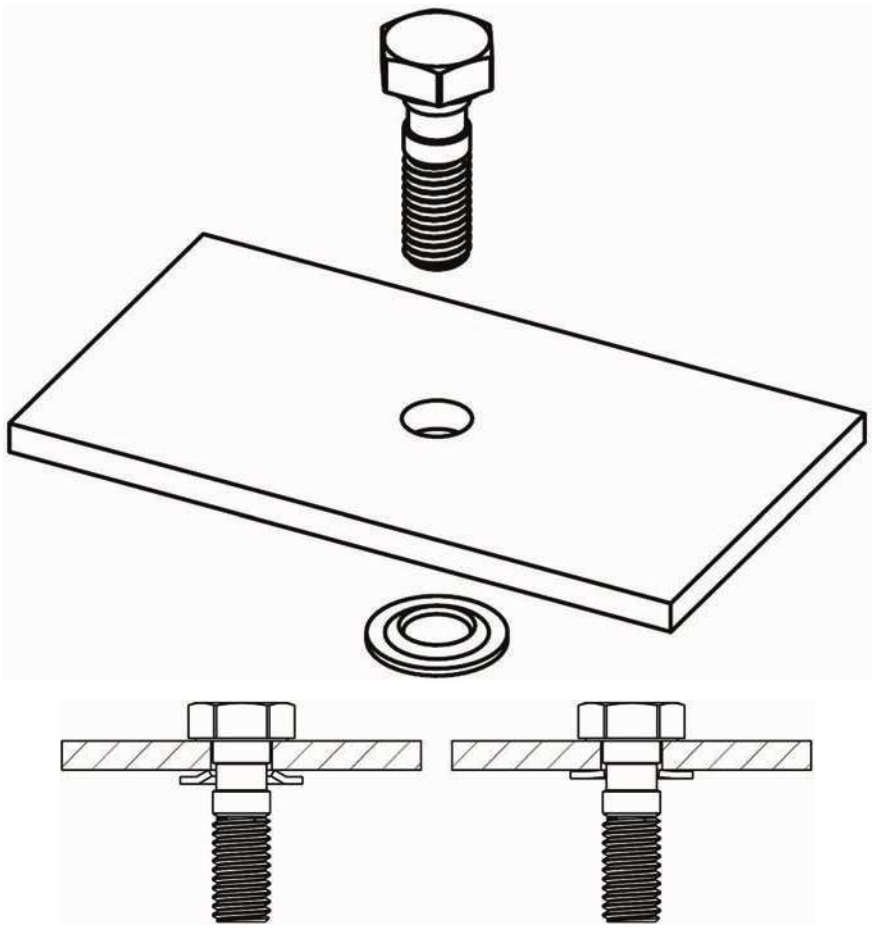


Figure A.1 — Example of a retained fastening using captive screw

Annex B
(informative)

Example of projectile test method for mechanically testing guards

B.1 General information

The method given in Annex B is optional, but if used has to be followed as given.

A guard typically performs two functions, to prevent persons gaining access to the hazard zone and to contain parts of the machine, (e.g. work piece) within the guarded zone. This annex offers guidance for the case of containing parts of the machine and work pieces, except fluid and fumes.

The guidance in this annex is relevant only when an impact hazard exists.

Annex B also gives basic information about the mechanical testing of guards and shows an example of a test method for guards used on machines in order to minimize risks of impact of parts or of work pieces coming from inside the hazard zone. This annex applies to guard materials. The test method gives guidance for small projectiles with high velocity (e.g. for ejected parts of the machinery).

B.2 Projectile test

B.2.1 General

The projectile test method should be used only to test the resistance of guards against impacts from inside the hazard zone. The aim of this test is to simulate the hazard that occurs when broken parts of the machine, of the work piece, or parts of tools are ejected. It shows the resistance and/or strength of guard materials to penetration by ejected parts of the machine in fault conditions.

This test method is based upon machines equipped with rotating parts up to a circumferential speed given by the following equation:

$$V_c = B \times \pi \times n \qquad \text{(B.1)}$$

where

V_c is the circumferential speed [m/s];

B is the maximum diameter of the rotating element [m];

n is the rotary speed [s^{-1}].

This test method can also be used for machinery with other high-speed ejection hazards.

B.2.2 Test equipment

B.2.2.1 General

The test equipment comprises a projectile, a means to propel the projectile to the required impact speed (e.g. a propulsion device) and a support for the test object.

B.2.2.2 Projectile

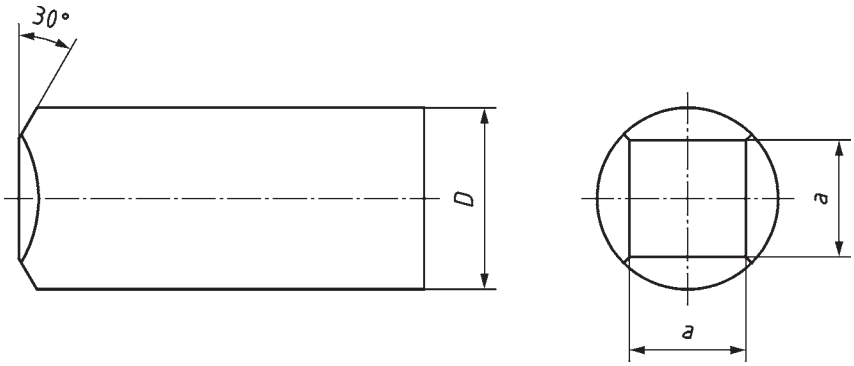
Examples for shape, mass, and dimensions of projectiles are given in Figure B.1 and Table B.1.

Projectiles are to be made from steel with the following mechanical properties:

— Tensile strength R = 560 N/mm^2 to 690 N/mm^2

— Yield strength $R0{,}2 \geq 330$ N/mm^2

— Elongation at rupture A = 20 %



NOTE Hardened to 56^{+4} HRC over depth of at least 0,5 mm.

Figure B.1 — Projectile

Table B.1 — Projectile, mass, and dimensions

Projectile		
M **mass** **kg**	D **diameter** **mm**	$a \times a$ **impact face** **mm × mm**
0,100	20	10 × 10
0,625	30	19 × 19
1,25	40	25 × 25
2,5	50	30 × 30

B.2.2.3 Speed measurements

The speed of the projectile shall be measured at a point where it is no longer subject to acceleration (i.e. after exiting the barrel or in the barrel beyond suitable pressure relief, see Figure B.2). The speed needs to be measured over a fixed distance using proximity sensors, photoelectric cells, or other appropriate means.

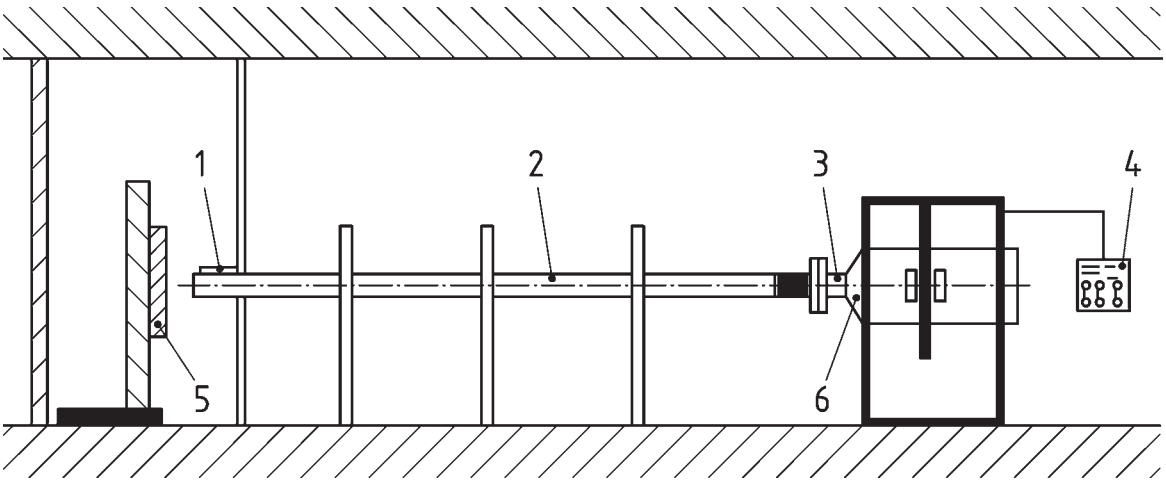
B.2.2.4 Supporting the guard under test

The test is carried out with the guard and/or a sample of the guard material. The guard support shall be equivalent to the guard mounting on the machine. For testing guard materials, samples can be used fixed on a frame with an inner opening of 450 mm × 450 mm. The frame shall be sufficiently rigid. The sample shall be mounted in an equivalent way to the material in the guard.

B.2.2.5 Gun

The gun consists of a compressed air vessel with flanged gun barrel (see Figure B.2). Compressed air can be released by a valve to accelerate the projectile toward the test object.

The air gun is fed by an air compressor. The speed of the projectile can be controlled by the pressure of the air.



Key

1	velocimeter	4	control panel
2	gun barrel	5	test object
3	projectile	6	compressed-air vessel

Figure B.2 — Equipment for projectile test

B.2.3 Test method

The measured impact speed shall not be less than the calculated speed V_c (see Formula B.1).

Impact shall be as square to the surface as possible. The targets for the projectiles shall be the weakest and most unfavourable spots on the material sample or on the guard.

B.2.4 Results and test report

B.2.4.1 Results

After the test, the damage found on the test object should be assessed.

Types of damage can consist of the following:

— buckling/bulging (permanent deformation without crack);

— incipient crack (visible only on one surface);

— through crack (crack visible from one surface to the other);

— penetration (projectile penetrating the test object);

— guard window or infill material loosened from its fixing;

— guard loosened from guard support.

The test has failed if the projectile has passed through the test object (e.g. material sample, guard). Additional criteria can be used if the safety-performance of the guard would otherwise be compromised.

NOTE The conclusion can be done as an evaluation from the total number of tests required.

B.2.4.2 Test report

The test report should give the following minimum information:

— date, place of the test, and name of the testing company or organization;

— projectile mass, dimensions, speed;

— machine manufacturer, type;

— design, material, and dimensions of the test sample;

— clamping or fixing of the test sample;

— direction of shock, point of impact of the projectile;

— test results.

It should be noted that the results are valid only for the test object. The conclusions for use of the guard in a specific application are made by the machine designer.

Annex C
(informative)

Example of pendulum test method for mechanically testing guards

C.1 General information

The method given in Annex C is optional, but if used has to be followed as given.

A guard typically performs two functions, to prevent persons gaining access to the hazard zone and to contain parts of the machine (e.g. work piece) within the guarded zone. This annex gives guidance for both cases.

The guidance given in this annex is relevant only when an impact hazard exists.

Annex C also gives basic information about the mechanical testing of guards and shows examples of test methods for guards used on machines in order to minimize risks of impact of the human body coming from outside the protected hazard zone as well as to minimize risks of impact of parts or of work pieces coming from inside the hazard zone. The annex applies to guard materials as well as to complete guards for machines, e.g. protective fences.

The test method gives guidance for soft and hard pendulums which represent impacts at lower velocity (e.g. contacts by humans, movable parts of machinery) rather than high velocity impact by ejected parts of machinery or materials.

C.2 Pendulum test

C.2.1 General

The pendulum test method can be used to test the resistance of guards against impacts from outside the protected hazard zone and from inside the hazard zone.

The test method is based upon the impact of a “body”, which might be a human body (soft body) or a part of a machine (hard body) falling under the effect of gravity to simulate contact by the human body with the guard or by part of the machine with the guard.

The test was developed for vertical guards. However, it might be applicable to horizontally mounted guards (e.g. guard in the form of a cover) if the application of the test load is compatible with the loading foreseeable in use (e.g. falling objects).

C.2.2 Test equipment

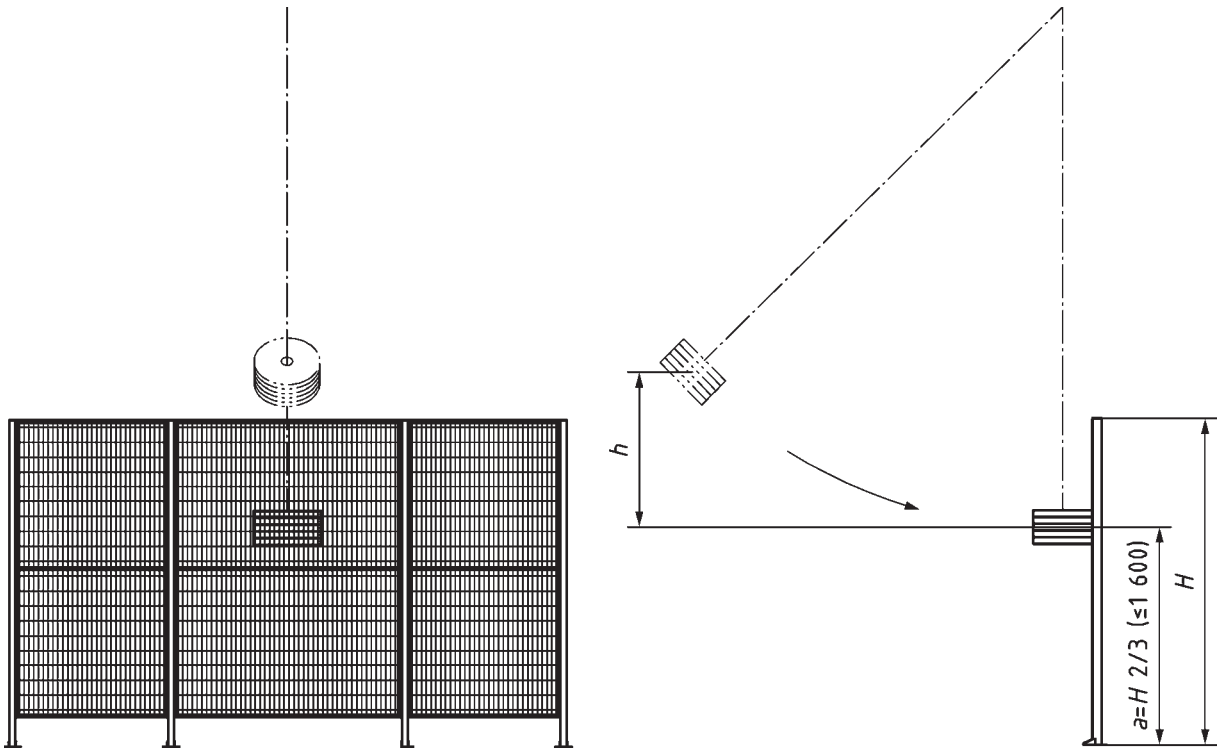
C.2.2.1 General

The test object shall be mounted in the test rig in accordance with the foreseeable application.

If no specific values exist, the test object shall be mounted in the test rig between two posts. The test object shall be at least 1 000 mm wide between the posts. The posts shall be fixed to a solid base. The pendulum is adjusted so that the impact hits the test object at 2/3 of the total guard height above the floor or corresponding plane, but not higher than 1 600 mm.

The rig shall be designed such that friction of the pendulum pivot is negligible.

See Figure C.1.



Key

H guard height

h falling down height

a height of point of impact, which shall not be higher than 1 600 mm

Figure C.1 — Principle of pendulum test

NOTE Calculations to achieve certain energy values are given in C.2.5.

C.2.2.2 Test object

The test equipment is composed of a soft or hard body, a means to bring the body to the required impact speed, and a support for the test object.

C.2.3 Test impact energies

Test impact energies depend on the machine itself and shall be calculated by using the basic formulae for energy:

$$E = ½\ m \times v^2 \quad \text{(C.1)}$$

where

E is the Energy [J] or [Nm];

m is the mass of the pendulum [kg];

v is the velocity of the pendulum [m/s].

or

$$E = m \times g \times h \quad \text{(C.2)}$$

where

m is the mass of the pendulum [kg];

g is 9,81 m/s^2 (constant);

h is the height of the mass falling down [m].

NOTE The energy calculated represents the energy just before impact.

C.2.4 Supporting the guard under test

The test shall be carried out with the guard and/or a sample of the guard material. The guard support shall be equivalent to the guard mounting on the machine. For testing guard materials, samples may be used, fixed on a frame. The frame shall be sufficiently rigid. The sample shall be mounted in an equivalent way to the material in the guard.

C.2.5 Test method

C.2.5.1 Resistance of guards against impact from outside the hazard zone

Basis values for resistance of guards against impacts from outside the protected hazard zone should simulate a human body with a minimum overall weight of 90 kg crashing unconsciously from outside the protected zone into the guard. The speed of such person should be set to 1,6 m/s as a minimum. See energy formulas in C.2.3 resulting in an energy of impact at minimum E = 115 J.

NOTE 1 See ISO 13855.

NOTE 2 The energy calculated represents the energy just before impact.

C.2.5.2 Resistance of guards against impacts from inside the hazard zone — Hard body

The hard body should be a cylindrical or spherical item that represents the foreseeable part making contact with the guard. It should be made of rigid material such as steel and have a mass representative of the foreseeable impact. The impact area should be concentrated, see Figure C.2. The length and/or diameter of the cylinder/sphere depend on the mass.

Figure C.2 — Sample of hard bodies showing impact area

C.2.6 Results and test report

C.2.6.1 Results

After the test, the damages found on the guard or material should be assessed.

The damages can consist of the following:

a) buckling/bulging (permanent deformation without crack);

b) incipient crack (visible only on one surface);

c) through crack (crack visible from one surface to the other);

d) penetration (hard or soft body penetrating the material);

e) guard window or infill material being loosened from its fixing;

f) guard loosened from guard support.

The test is passed if

— the deformations or cracks do not exceed values specified to avoid harm,

— there is no penetration, and

— damages e) and f) above are not observed.

C.2.6.2 Test report

The test report should give the following minimum information:

— date, place of the test, and name of the testing company or organization;

— machine manufacturer, type;

— design, material, and dimensions of the test object;

— clamping or fixing of the test object;

— direction of shock, point of impact of the pendulum;

— test results.

It should be noted that the results are valid only for the test object. The conclusions for use of the guard in a specific application are made by the machine designer.

Annex D
(informative)

Relationship between International Standards referenced in Clause 2 and corresponding European Standards

Table D.1 shows the relationship between International Standards referenced in Clause 2 and corresponding European Standards.

Table D.1 — Relationship between International and corresponding European Standards

International Standard	European Standard
ISO 12100:2010	EN ISO 12100:2010[a]
ISO 13854:1996	EN 349:1993+A1:2008[a]
ISO 13857:2008	EN ISO 13857:2008[a]
ISO 14119:2013	EN ISO 14119:2013[a]
ISO 14123-1:1998	EN 626–1:1994+A1:2008[a]
IEC 60204–1:2005	EN 60204–1:2007[a]
[a] Harmonized standard under the Machinery Directive (2006/42/EC) of the European Community.	

Bibliography

International Standards and Technical Reports

[1] 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*

[2] ISO 11428, *Ergonomics — Visual danger signals — General requirements, design and testing*

[3] ISO 11429, *Ergonomics — System of auditory and visual danger and information signals*

[4] ISO 13854, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

[5] ISO 14118, *Safety of machinery — Prevention of unexpected start-up*

[6] ISO 14159, *Safety of machinery — Hygiene requirements for the design of machinery*

[7] ISO 14738, *Safety of machinery — Anthropometric requirements for the design of workstations at machinery*

[8] ISO 19353, *Safety of machinery — Fire prevention and protection*

[9] ISO 25980, *Health and safety in welding and allied processes — Transparent welding curtains, strips and screens for arc welding processes*

[10] IEC/TR 61340-1, *Electrostatics — Part 1: Electrostatic phenomena — Principles and measurements*

European Standards

[11] EN 614-1, *Safety of machinery — Ergonomic design principles — Part 1: Terminology and general principles*

[12] EN 614-2, *Safety of machinery — Ergonomic design principles — Part 2: Interactions between the design of machinery and work tasks*

[13] EN 1005-2, *Safety of machinery — Human physical performance — Part 2: Manual handling of machinery and component parts of machinery*

[14] EN 1005-3, *Safety of machinery — Human physical performance — Part 3: Recommended force limits for machinery operation*

[15] EN 1127-1, *Explosive atmospheres — Explosion prevention and protection — Part 1: Basic concepts and methodology*

[16] EN 12254, *Screens for laser working places — Safety requirements and testing*

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