AS 4024.1601—2006

Australian Standard™

Safety of machinery

Part 1601: Design of controls, interlocks and guarding—Guards—General requirements for the design and construction of fixed and movable guards

This Australian Standard was prepared by Committee SF-041, General Principles for the Guarding of Machinery. It was approved on behalf of the Council of Standards Australia on 1 May 2006.
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Australian Chamber of Commerce and Industry
Australian Electrical and Electronic Manufacturers Association
Department for Administration and Information Services, SA
Department of Consumer and Employment Protection, WorkSafe Division, WA
Department of Primary Industries, Mine Safety, NSW
Engineers Australia
Federal Chamber of Automotive Industries
Human Factors and Ergonomics Society of Australia
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Victorian WorkCover Authority

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Part 1601: Design of controls, interlocks and guarding—Guards—General requirements for the design and construction of fixed and movable guards

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PREFACE

This Standard was prepared by the Standards Australia Committee SF-041, General Principles for the Guarding of Machinery, as revision (in part) of AS 4024.1—1996, *Safeguarding of machinery*, Part 1: *General principles*.

During its work, the Committee considered a number of Standards dealing with the safety of machinery originating within the European Community. Many of these European Standards are now being adopted virtually unchanged as International Standards by the International Organization for Standardization (ISO), and the Committee has agreed to continue to use material emanating from both CEN and ISO in this new edition, to maintain consistency with previous editions of AS 4024, and other, machine-specific Australian Standards currently under development.

This edition has been published as a series rather than the single part previously available. In doing this, the Committee has cleared the way for simple revisions in the future. When a new edition of a relevant EN or ISO Standard becomes available, it can be adopted and published within the framework of AS 4024 with a minimum delay, so ensuring continued international alignment.

The term ‘normative’ has been used in this Standard to define the application of the appendix to which it applies. A ‘normative’ appendix is an integral part of a Standard.

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Safety of machinery

Part 1601: Design of controls, interlocks and guarding—Guards—General requirements for the design and construction of fixed and movable guards

1 SCOPE

This Standard specifies general requirements for the design and construction of guards both fixed and moving provided primarily to protect persons from mechanical hazards associated with machinery.

Attention is drawn to the use of guards to minimize exposure to non-mechanical hazards.

The requirements of this Standard are applicable if fixed and movable guards are used. The Standard does not cover those parts of guards which actuate interlocking devices. These are covered in AS 4024.1602.

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

2 OBJECTIVE

The objective of this Standard is to enable designers, manufacturers, suppliers, employers and users of machinery to minimize risks to the health and safety of employees and those working with or otherwise near machinery by providing technical means for the design and construction of guards.

3 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS	
4024	Safety of machinery
4024.1101	Part 1101: Terminology—Terms and definitions
4024.1201	Part 1201: General principles—Basic terminology and methodology
4024.1202	Part 1202: General principles—Technical principles
4024.1301	Part 1301: Risk assessment—Principles for risk assessment
4024.1302	Part 1302: Risk assessment—Reduction of risks to health and safety from hazardous substances emitted by machinery—Principles and specification for machinery manufacturers
4024.1602	Part 1602: Design of controls, interlocks and guarding—Interlocking devices associated with guards—Principles for design and selection
4024.1801	Part 1801: Safety distances and safety gaps—Safety distances to prevent danger zones being reached by upper limits
4024.1802	Part 1802: Safety distances and safety gaps—Safety distances to prevent danger zones being reached by the lower limits
4024.1803	Part 1803: Safety distances and safety gaps—Minimum gaps to avoid crushing of parts of the human body
60204	Safety of machinery—Electrical equipment of machines
60204.1	Part 1: General requirements (IEC 60204-1, Ed.5 (FDIS), MOD)

4 DEFINITIONS

For the purposes of this Standard, the definitions given in AS 4024.1101, AS 4024.1201 and those below apply.

4.1 Frequency of access

Number of occasions on which access is required or foreseeable within the guarded area per unit of time.

4.2 Guard

Part of a machine specifically used to provide protection by means of a physical barrier.

NOTES:

1 Depending on its construction, a guard may be called casing, cover, screen, door, enclosing guard, etc.

2 A guard may act alone, in which case it is only effective when it is closed or in conjunction with an interlocking device with or without guard locking, in which case protection is ensured whatever the position of the guard (see also Clause 4.6).

3 For a fixed guard 'closed' means 'kept in place'.

4.3 Guard positions

4.3.1 *Guard closed*

When performing the function for which it was designed, that is to prevent or reduce access to the danger zone and/or reduce exposure to hazards such as noise, radiation etc., a guard is closed.

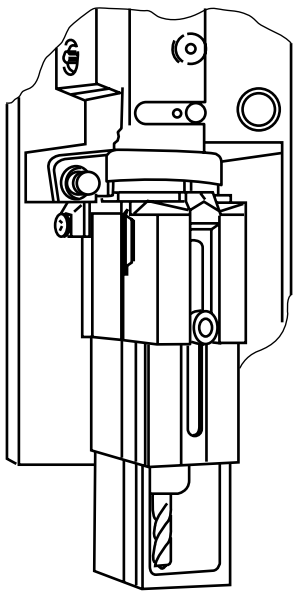
4.3.2 *Guard open*

When it is not in the closed position, a guard is open.

4.4 Guard types

4.4.1 *Adjustable guard*

Fixed or movable guard which is adjustable as a whole or which incorporates adjustable parts. The adjustment remains fixed during a particular operation (see Figure 1).



NOTE: The guard is telescopic to provide ready adjustment to the surface of the workplace.

FIGURE 1 EXAMPLE OF AN ADJUSTABLE GUARD FOR A RADIAL OR PEDESTAL DRILLING MACHINE

4.4.2 *Enclosing guard*

Guard which prevents access to the danger zone from all sides (See Figure 2).

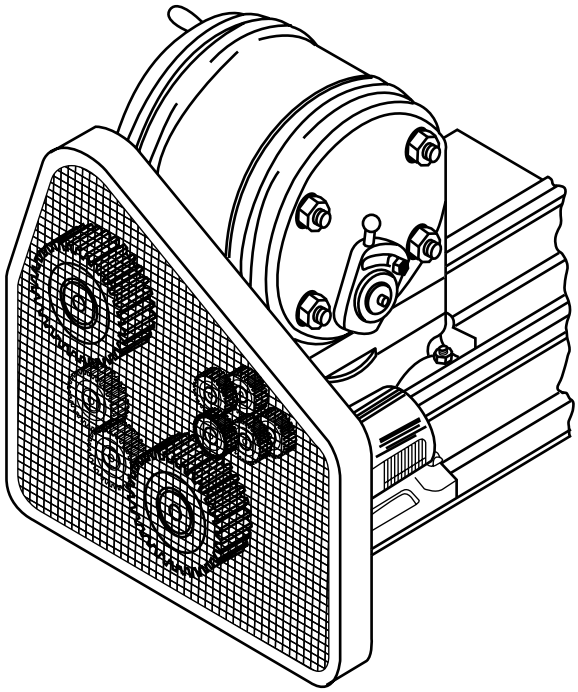


FIGURE 2 EXAMPLE OF AN ENCLOSING GUARD TOTALLY PREVENTING ACCESS TO TRANSMISSION MACHINERY

4.5 Fixed guards

4.5.1 *Fixed guard*

Guard kept in place, that is closed, either permanently (by welding, etc.), or by means of fasteners (screws, nuts, etc.) making removal or opening impossible without using tools.

4.5.2 *Distance guard*

Guard which does not completely enclose a danger zone, but which prevents or reduces access by virtue of its dimensions and its distance from the danger zone, for example perimeter fence or tunnel guard (See Figures 3 and 4).

4.6 Interlocking guards

4.6.1 *Interlocking guards*

Guard associated with an interlocking device so that—

(a) the hazardous machine functions 'covered' by the guard cannot operate until the guard is closed;

(b) if the guard is opened while hazardous machine functions are operating, a stop instruction is given; and

(c) when the guard is closed, the hazardous machine functions 'covered' by the guard can operate, but the closure of the guard does not by itself initiate their operation (see Figures 5 and 6).

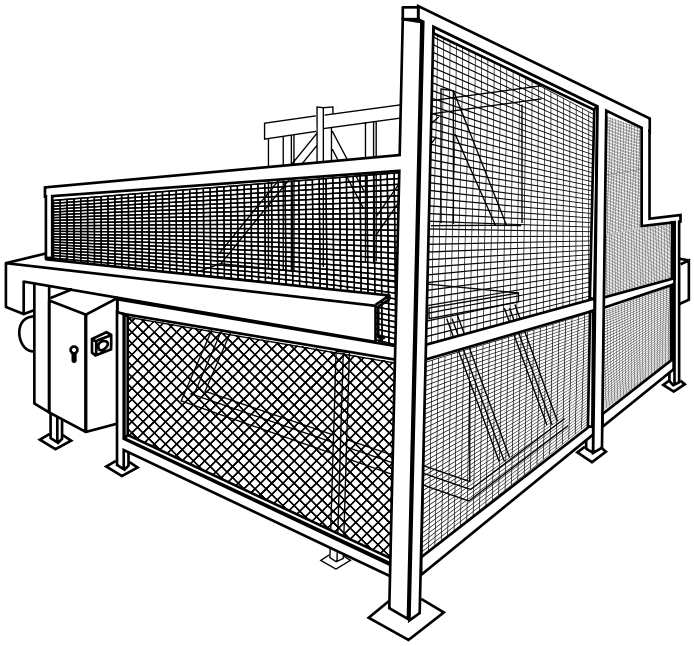


FIGURE 3 EXAMPLE OF A DISTANCE GUARD

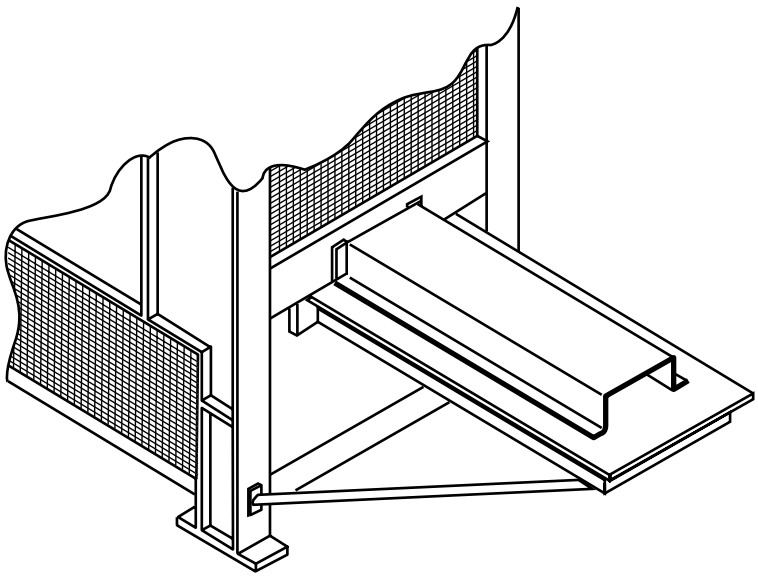


FIGURE 4 EXAMPLE OF A DISTANCE GUARD: TUNNEL GUARD PROVIDING PROTECTION AT MACHINE FEED OR DISCHARGE AREA

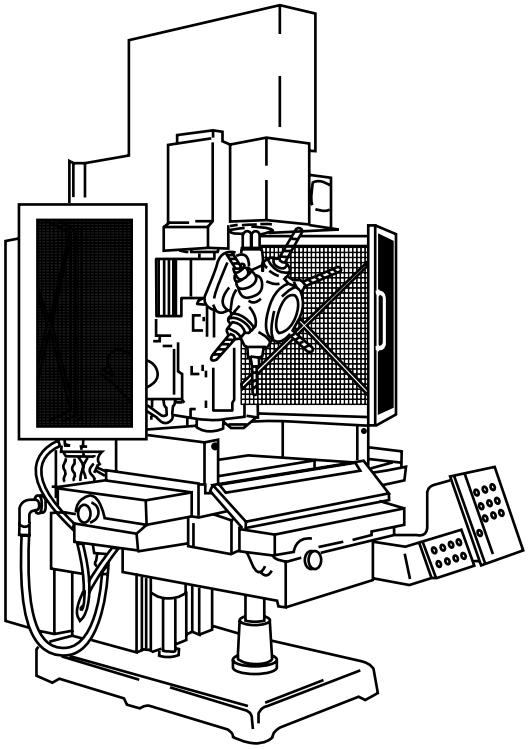


FIGURE 5 EXAMPLE OF INTERLOCKING HINGED GUARDS; WHICH ENCLOSE THE DANGER ZONE WHEN CLOSED

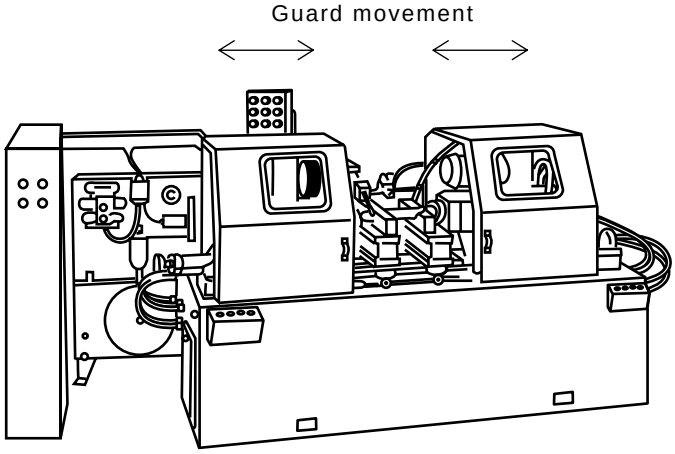


FIGURE 6 EXAMPLE OF INTERLOCKING SLIDING GUARDS

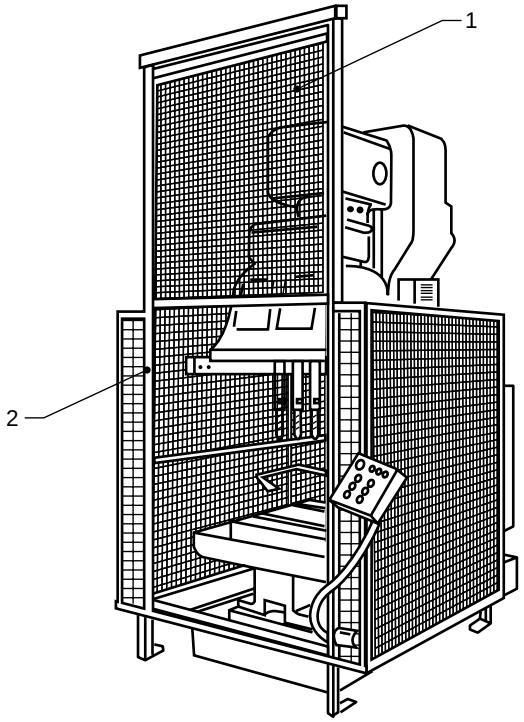
4.6.2 *Interlocking guard with guard locking*

Guard associated with an interlocking device and a guard locking device so that—

(a) the hazardous machine functions 'covered' by the guard cannot operate until the guard is closed and locked;

(b) the guard remains closed and locked until the risk of injury from the hazardous machine functions has passed; and

(c) when the guard is closed and locked, the hazardous machine function 'covered' by the guard can operate, but the closure and locking of the guard do not by themselves initiate their operation (see Figure 7).



LEGEND:
1 = Interlocking guard
2 = Fixed guard

FIGURE 7 EXAMPLE OF SAFEGUARDING OF DRILLING MACHINE USING INTERLOCKING GUARDS AND FIXED GUARDS

4.7 Movable guards

4.7.1 *Movable guard*

Guard generally connected by mechanical means, for example with hinges or slides, to the machine frame or an adjacent fixed element and which can be opened without the use of tools.

4.7.2 *Control guard*

Movable guard associated with an interlocking device so that—

(a) the hazardous machine functions 'covered' by the guard cannot operate until the guard is closed; and

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

NOTE: The use of control guards is subject to certain conditions (see Clause 6.4.10).

4.7.3 *Power-operated guard*

Movable guard that is operated with the assistance of power from a source other than persons or gravity.

4.7.4 *Self-closing guard*

Movable guard operated by a machine element (for example a 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 (See Figure 8).

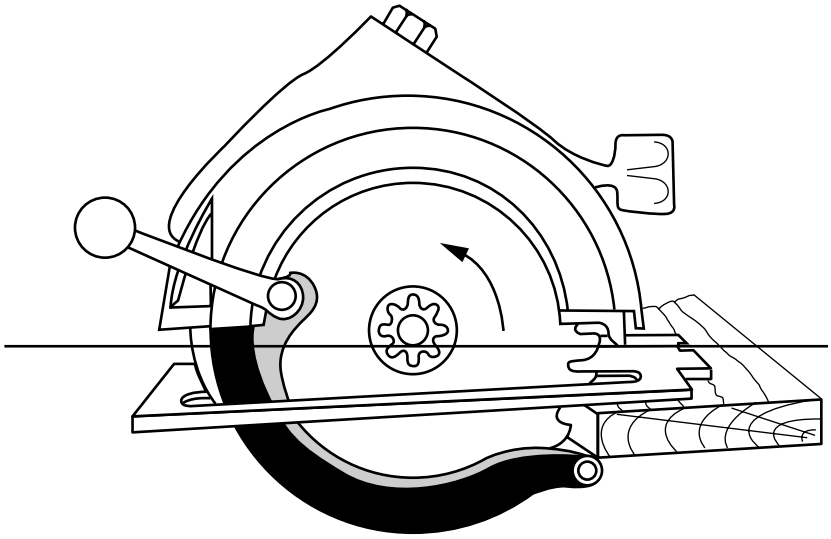


FIGURE 8 EXAMPLE OF A SELF-CLOSING GUARD

4.8 Tool

Implement such as a key or wrench designed to operate a fastener. An improvised implement such as a coin or a nail file cannot be considered as a tool.

4.9 Use of a tool

Use of a tool by an authorized person under known and predetermined circumstances as part of a safe system of work.

5 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 at risk (see AS 4024.1201 and AS 4024.1301).

6 PRINCIPAL REQUIREMENTS FOR THE DESIGN AND CONSTRUCTION OF GUARDS

6.1 Machine aspects

6.1.1 *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 unsafe or inoperable machinery. This in turn can lead persons to defeat the guards provided, thus exposing them to greater risk.

6.1.2 *Access to danger zones*

To minimize access to danger zones, 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 technically possible. The following are examples of reasons for access:

(a) Loading and unloading.

(b) Tool changing and setting.

(c) Measurement, gauging and sampling.

(d) Process observation.

(e) Maintenance and repair.

(f) Lubrication.

(g) Removal of waste material (e.g. scrap, swarf, spillage).

(h) Obstruction removal.

(i) Cleaning and hygiene.

6.1.3 *Containment of ejected parts*

Where there is a foreseeable risk of ejection of parts (for example broken tooling or the workpiece) from the machine, the guard shall, as far as technically possible, be designed and constructed from appropriate materials selected to contain such ejections.

6.1.4 *Containment of hazardous substances*

Where there is a foreseeable risk of emission from the machine of hazardous substances (e.g. coolant, vapours, gases, swarf, sparks, hot or molten material, dust), the guard shall be designed to contain these substances as far as technically possible and suitable extraction equipment may be needed (see AS 4024.1302).

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.

6.1.5 *Noise*

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

6.1.6 *Radiation*

Where there is a foreseeable risk of exposure to hazardous radiation, guards shall be designed and appropriate materials selected to protect persons from the hazard. Examples include the use of darkened glazing to prevent weldflash or the elimination of openings in a guard around a laser.

6.1.7 *Explosion*

Where there is foreseeable risk of explosion, guards shall be designed to contain or dissipate the released energy in a safe manner and direction (e.g. by use of ‘explosion relief’ panels).

6.2 Ergonomics aspects

6.2.1 *General*

Foreseeable aspects of human interaction with machinery (e.g. when loading, maintaining or lubricating) shall be given proper consideration in the design and construction of guards.

Guards shall be designed and constructed taking into account ergonomic principles (see also AS 4024.1202).

6.2.2 *Safety distances*

Guards intended for preventing access to danger zones shall be designed, constructed and positioned to prevent parts of the body from reaching danger zones (see also AS 4024.1801 and AS 4024.1802).

6.2.3 *Control of access to the danger zone*

As far as is possible, movable guards shall be designed and positioned such that during normal operation they are prevented from closing with persons in the danger zone. Where this is not possible, other means shall be used to prevent persons from remaining undetected within the danger zone.

6.2.4 *Viewing*

To minimize the need to remove them, guards shall be designed and constructed to offer adequate viewing of the process.

6.2.5 *Size and weight*

Removable sections of guards shall be designed to be of a suitable size and weight 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 gear.

The attachments or provisions can be, for example—

(a) standard lifting appliances with slings, hooks, eyebolts or simply tapped holes for appliance fixing;

(b) appliances for automatic grabbing with a lifting hook, when securing is not possible from the ground;

(c) lifting gear and appliances integrated into the guard; or

(d) an indication, on the guard itself and on some of its removable parts or in the information for use, of the value of their mass expressed in kilograms (kg).

6.2.6 *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 AS 4024.1201).

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

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 force to prevent the guard closing shall not exceed 150 N. 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.

6.2.7 *Intended use*

Guards shall be designed so far as is practicable to take into account foreseeable use and reasonably foreseeable misuse (see AS 4024.1201).

6.3 Guard design aspects

6.3.1 *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 a further hazard.

6.3.2 *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 AS 4024.1803).

6.3.3 *Durability*

Guards shall be designed to perform their function properly throughout the foreseeable life of the machine, otherwise provision shall be made for the replacement of degradable parts.

6.3.4 *Hygiene*

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

6.3.5 *Cleaning*

Guards used in certain applications, notably for the processing of food and pharmaceuticals, shall be so designed that they are not only safe to use but can also be easily cleaned.

6.3.6 *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.

6.4 Guard construction aspects

6.4.1 *General*

The following aspects shall be considered in determining the methods to be used for the construction of guards.

6.4.2 *Sharp edges*

Guards shall be constructed so as to be free of exposed sharp edges, corners or other hazardous projections.

6.4.3 *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.

6.4.4 *Removal only by tool*

Demountable parts of guards shall only be removable with the use of a tool not normally available to an operator (see Clauses 4.8 and 4.9).

6.4.5 *Positive location of removable guards*

Where technically possible, removable guards shall be unable to remain in place without their fixings. This does not preclude the use of locating or supporting features that assist during assembly or disassembly.

6.4.6 *Positive closing of movable guards*

The closed position of movable guards shall be determined positively. The guard shall be held in position against a stop by means of gravity, a spring, catch, guard locking device or other means.

6.4.7 *Self-closing guards*

The self-closing guard opening shall be limited to no more than that required for the passage of the workpiece. It shall not be possible to block the guard in its open position. These guards can be used in conjunction with fixed distance guards.

6.4.8 *Adjustable guards*

Adjustable parts shall be such as to enable the opening to be restricted to a minimum consistent with the passage of material, and be easily adjustable without the use of a tool.

6.4.9 *Movable guards*

The opening of movable guards shall require positive action and, where practicable, 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 Clauses 4.8 and 4.9).

6.4.10 *Control guards*

Control guards (see Clause 4.7.2 and AS 4024.1202) may be used only if all of the following conditions are fulfilled:

(a) There is no possibility of an operator or a part of the operator's body remaining in the danger zone or between the danger zone and the guard while the guard is closed.

(b) 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.

(c) Opening the control guard or an interlocking guard is the only way to enter the danger zone.

(d) The interlocking device associated with the control guard is of the highest possible reliability (as its failure can lead to an unintended/unexpected start-up).

(e) Where starting the machine with a control guard is one of the possible control modes of the machine, mode selection shall be ensured according to AS 4024.1202.

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

6.5 Selection of materials

6.5.1 *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 intended life of the guard.

6.5.2 *Impact resistance*

Guards shall be designed to withstand impacts from parts of the machine, workpiece, broken tooling, ejected solid or fluid matter and impact by the operator. Where guards are fitted with viewing panels, special consideration shall be given to the selection of materials and method of fixing them. Materials shall be selected with properties suited to resist the mass and velocity of the ejected object or material.

6.5.3 *Rigidity*

Support posts, guard frames 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.

6.5.4 *Secure fixing*

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

6.5.5 *Reliability of moving parts*

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

6.6 Containment

Harmful substances, for example fluids, swarf, dust or fumes shall be contained within the guard by a suitable impermeable material.

6.7 Resistance to corrosion

Materials shall be selected which are resistant to oxidation and corrosion from the product, process or environmental factors, for example from cutting fluids in machining operations or cleaning and sterilizing agents in food processing machinery. This can be achieved by the application of suitable protective coatings.

6.8 Resistance to micro-organisms

Where there is a foreseeable risk to health from bacterial and fungal growth, such as in the food, pharmaceutical and related industries, materials used in the construction of guards shall be selected that inhibit this growth and can be easily cleaned and, if necessary, disinfected.

6.9 Non-toxicity

Materials and finishes used shall be non-toxic during use and be compatible with the process involved particularly in the food, pharmaceutical and related industries.

6.10 Machine viewing

Where it is necessary to view machine operation through the guard, materials with suitable properties shall be selected, for example if perforated 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 perforated material is darker than the area to be observed.

6.11 Transparency

As far as is technically possible, materials used for viewing machine operation shall 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 may require the selection of materials or combinations of materials that are resistant to abrasion, chemical attack, degradation by ultraviolet radiation, dust attraction by static electrical charge, or surface wetting by fluids which impair transparency.

6.12 Stroboscopic effects

Where there is a hazard from stroboscopic effects, guard design, materials and lighting shall be selected to minimize this occurrence. Sources of stroboscopic and similar hazards include fluorescent lighting and segmented or faceted rotating objects that interrupt the view of a light source or reflect light toward the operator.

6.13 Electrostatic properties

Certain applications may require the selection of materials that do not retain an electrostatic charge, in order to avoid an accumulation of dust and particles as well as sudden electrical discharge with the associated risks of fire or explosion.

Guards may need to be earthed to avoid build up of static charge to a hazardous level (see AS 60204.1).

6.14 Thermal stability

Materials shall be selected which do not degrade, that is which are not subject to brittle fracture, excessive deformation or emission of toxic or flammable fumes when exposed to the range of temperature variations or sudden changes in temperatures which can be experienced during operation.

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

6.15 Flammability

Where there is a risk of fire, materials selected shall be spark resistant and fire retardent and shall not absorb or emit flammable fluid or fumes.

6.16 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), or absorption (lining guards with appropriate acoustically absorbent materials) or by a combination of both. Guard panels may also need to be suitably damped to minimize the effects of resonance which can transmit or amplify noise.

6.17 Radiation protection

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

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

7 SELECTION OF TYPES OF GUARDS

7.1 General

If the risk assessment has established a requirement for guards, they shall be selected in accordance with Clause 7 and Appendix A (see also AS 4024.1202).

In selecting suitable guards, the appropriate phases of the life of the machinery (as defined in AS 4024.1201) shall be considered.

The most important selection criteria are—

(a) the probability of occurrence and likely severity of any injury as indicated by the risk assessment;

(b) the intended use of the machine as defined in AS 4024.1201;

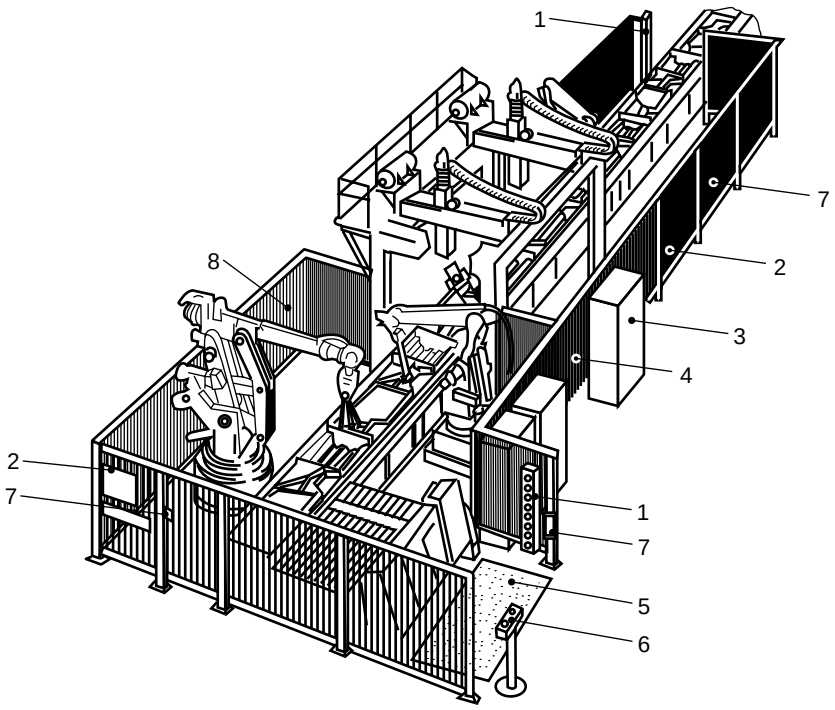
(c) the hazards present at the machine (see AS 4024.1201); and

(d) the nature and frequency of access.

7.2 Combination of different guards or of guards with other devices

It may be appropriate to use a combination of different types of guard. For example, if a machine has several danger zones and access is required to one of them during the operating phase, the guards may consist of a fixed guard combined with an interlocking movable guard.

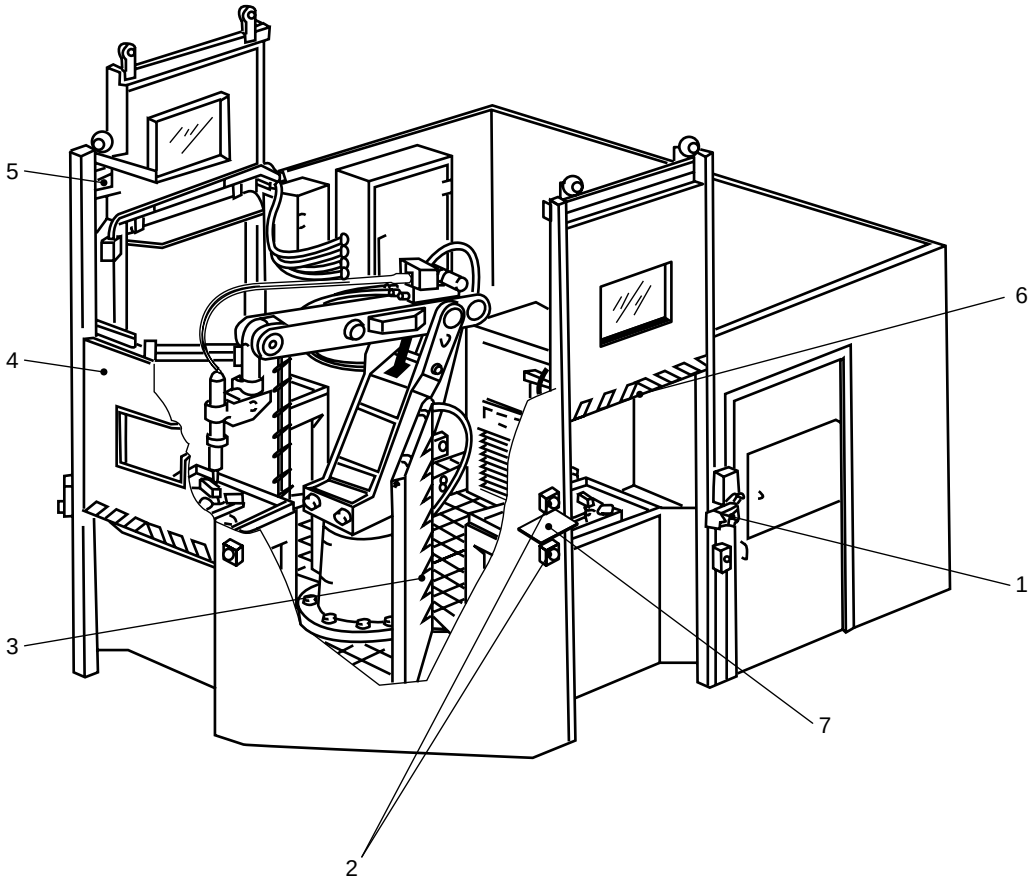
In a similar way, a combination of protective devices and guards may sometimes be required. For example, where a mechanical feed device is used in conjunction with a fixed guard to feed workpieces into a machine (thereby removing the need for access to the danger zone), a trip device (see AS 4024.1201) may be required to protect against a secondary trapping or shearing hazard between the mechanical feed device and the fixed guard (see Figures 9 and 10).



LEGEND:

1 = Optoelectronic curtain
2 = Interlocking guard
3 = Electrical cabinet
4 = Internal fence allowing sectional access
5 = Pressure sensitive mat
6 = Two-hand control device
7 = Reset actuator
8 = Distance guard

FIGURE 9 EXAMPLE 1 OF COMBINATION OF DIFFERENT GUARDS AND GUARDS WITH OTHER PROTECTIVE DEVICES



LEGEND:

1 = Trapped key system	4 = Interlocking guard
2 = Two-hand control device	5 = Guard locking device
3 = Screen between stations	6 = Pressure-sensitive edge

FIGURE 10 EXAMPLE 2 OF COMBINATION OF DIFFERENT GUARDS AND GUARDS WITH OTHER PROTECTIVE DEVICES

7.3 Selection of guards according to the number and location of the hazards

Guards shall be selected from the following in the order of priority given:

(a) Local guards enclosing individual danger zones if the number of danger zones to protect is low. This can provide an acceptable residual risk and permits access to non-hazardous machine parts for maintenance and setting.

(b) A guard enclosing all the danger zones if the number or size of the danger zones is high. In this case, setting and maintenance points shall, as far as possible, be located outside the guarded area.

(c) Partial distance guard if the use of an enclosing guard is not technically possible and the number of danger zones to protect is low.

(d) Fully surrounding distance guard if the use of an enclosing guard is not technically possible and the number or size of the danger zones are high.

The flow chart in Appendix B illustrates this procedure.

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

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

7.4.1 *General*

A flow chart depicting the selection of guards according to the nature and frequency of access are illustrated in Appendix A.

7.4.2 *Moving transmission parts*

Guards to protect against hazards generated by moving transmission parts, for example pulleys, belts, gears, racks and pinions, shafts, shall be either fixed guards (see Figure 1) or movable interlocking guards.

7.4.3 *Where access is not required during use*

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

7.4.4 *Where access is required during use*

7.4.4.1 *Where access is required only for machine setting, process correction or maintenance*

The following types of guard shall be used:

(a) Movable guard if the foreseeable frequency of access is high (for example more than once per shift), 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 AS 4024.1602).

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

7.4.4.2 *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 AS 4024.1602). If access is required for a very short working cycle, it may be preferable to use a power-operated movable guard.

(b) Control guard where the special conditions are met for use (see Clause 6.4.10).

7.4.4.3 *Where, due to the nature of the operation, access to the danger zone cannot be totally prohibited*

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

(a) Self-closing guard (see Clause 6.4.7);

(b) Adjustable guard (see Clause 6.4.8 and AS 4024.1202).

8 ADDITIONAL DESIGN AND CONSTRUCTION CONSIDERATIONS

8.1 Climbing

Climbing on guards shall where possible 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.

8.2 Retained fastenings

Where possible, guard fastenings shall remain attached to the guard, as this reduces the likelihood of their being lost and not replaced (see Figure 11).

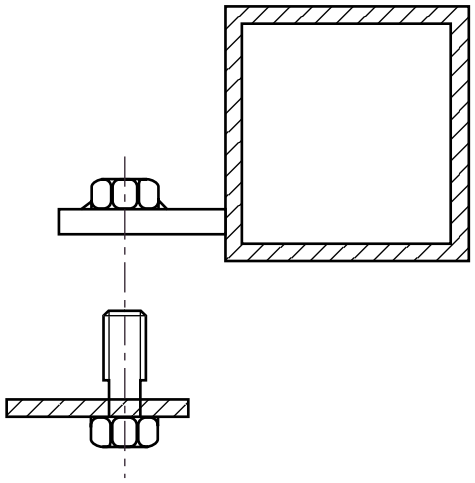


FIGURE 11 EXAMPLE OF A RETAINED FASTENING

8.3 Vibration resistance

Fastenings can need to be fitted with lock nuts, spring washers etc., to ensure that they remain attached to the guard.

8.4 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.

8.5 Colour

Hazards may be highlighted by the use of suitable colours. For example, if a guard is painted the same colour as the machine and the hazardous parts painted a contrasting bright colour, attention is drawn to the hazard when the guard is opened or left off.

8.6 Aesthetics

As far as is possible, guards shall be designed so as to minimize adverse psychological effects.

9 VERIFICATION OF THE SAFETY REQUIREMENTS FOR GUARDS

9.1 General

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

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

9.2 Impact strength

Verification may be required for the resistance of guards to impact from persons, parts of tools, high pressure liquids, etc. Before carrying out this verification, it is necessary to identify the impact hazard to which the guard can be subjected, for example low velocity impacts from persons, high velocity impacts from broken parts of tools, impact from high pressure fluids.

When verifying the impact strength of a guard, it is necessary to take account of the properties of the materials from which the guard is constructed. This shall include the strength of joints used and the strength of fixing points, slides, etc., by which the guard is attached to the machine or other structure.

9.3 Safety distances

Verification that guards comply with the required safety distances shall be by measurement (see AS 4024.1801 and AS 4024.1802).

9.4 Containment

Where guards are designed for containment of hazardous substances (see Clause 6.1.4), the performance of this function shall be verified. Where leakage is readily seen, visual inspection can be adequate. Where leakage cannot be seen, for example leakage of gas or vapour, an alternative verification method such as air sampling is required.

9.5 Noise

Where a guard is designed to reduce noise, its acoustic performance shall be verified by taking noise readings.

9.6 Guard operating forces

Where normal usage of a guard involves the application of physical force, for example to open movable guards or to remove fixed guards, it may be necessary to verify that these forces are not excessive.

9.7 Visibility

Where continued visibility through the guard is essential to the proper functioning of the guard, this shall be verified under normal operating conditions by means of a visual check.

10 INFORMATION FOR USE

10.1 General

The instructions for use shall contain the required information about guards and their functions, including installation and maintenance (see AS 4024.1202).

10.2 Guard hazards

Information shall be provided of any hazards associated with the guards themselves, for example flammability of materials used.

10.3 Installation

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

10.4 Operation

Instructions shall be provided directing the user to the correct operation of the guards, their interlocks, etc. Warnings against reasonably foreseeable misuse shall be given (see AS 4024.1201).

10.5 Removal of guards

Information shall be provided indicating any actions to be taken before guards may be removed safely, (e.g. machine power isolation or dissipation of stored energy).

10.6 Inspection and maintenance

Details shall be provided of inspections to be carried out and maintenance required for, for example—

(a) 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;

(b) replacement of wearing parts;

(c) correct operation of interlocks;

(d) degradation of jointing or fixing points;

(e) degradation by corrosion, temperature change or chemical attack;

(f) satisfactory operation and lubrication, if necessary, of moving parts;

(g) modification of safety distances and aperture sizes; and

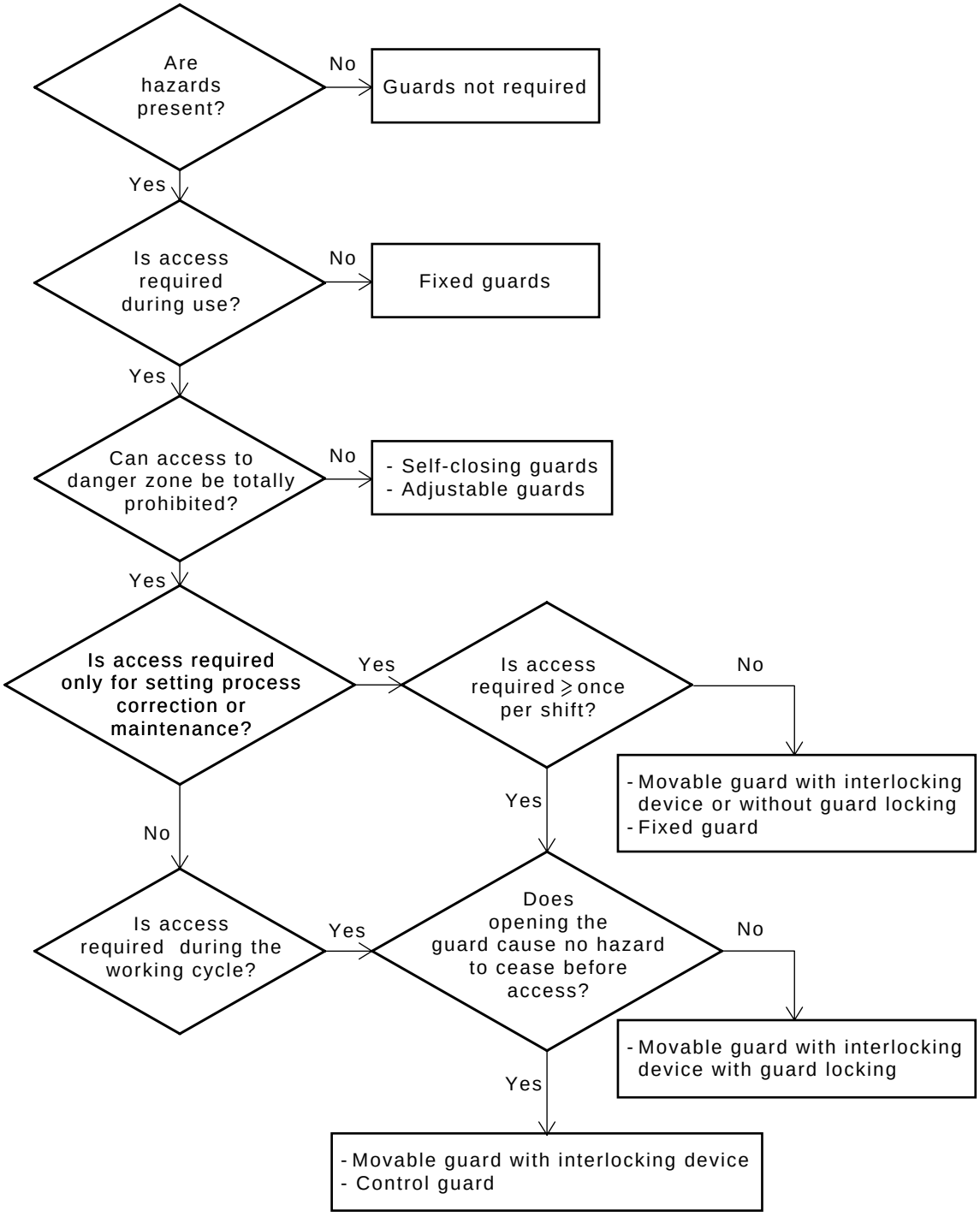
(h) degradation of acoustic performance, if applicable.

APPENDIX A

SELECTION OF GUARDS AGAINST HAZARDS GENERATED BY MOVING PARTS

(Normative)

The chart shown in Figure A1 shall be used in conjunction with Clauses 5 and 7. This Appendix does not take the application of other protective devices, two-hand control devices etc. into account.



NOTE: The use of control guards is subject to the conditions given in Clause 6.4.10.

FIGURE A1 CHART FOR THE SELECTION OF GUARDS AGAINST HAZARDS GENERATED BY MOVING PARTS

APPENDIX B

SELECTION OF GUARDS ACCORDING TO THE NUMBER AND LOCATION OF HAZARDS

(Normative)

The chart shown in Figure B1 shall be used in conjunction with Clauses 5 and 7.3.

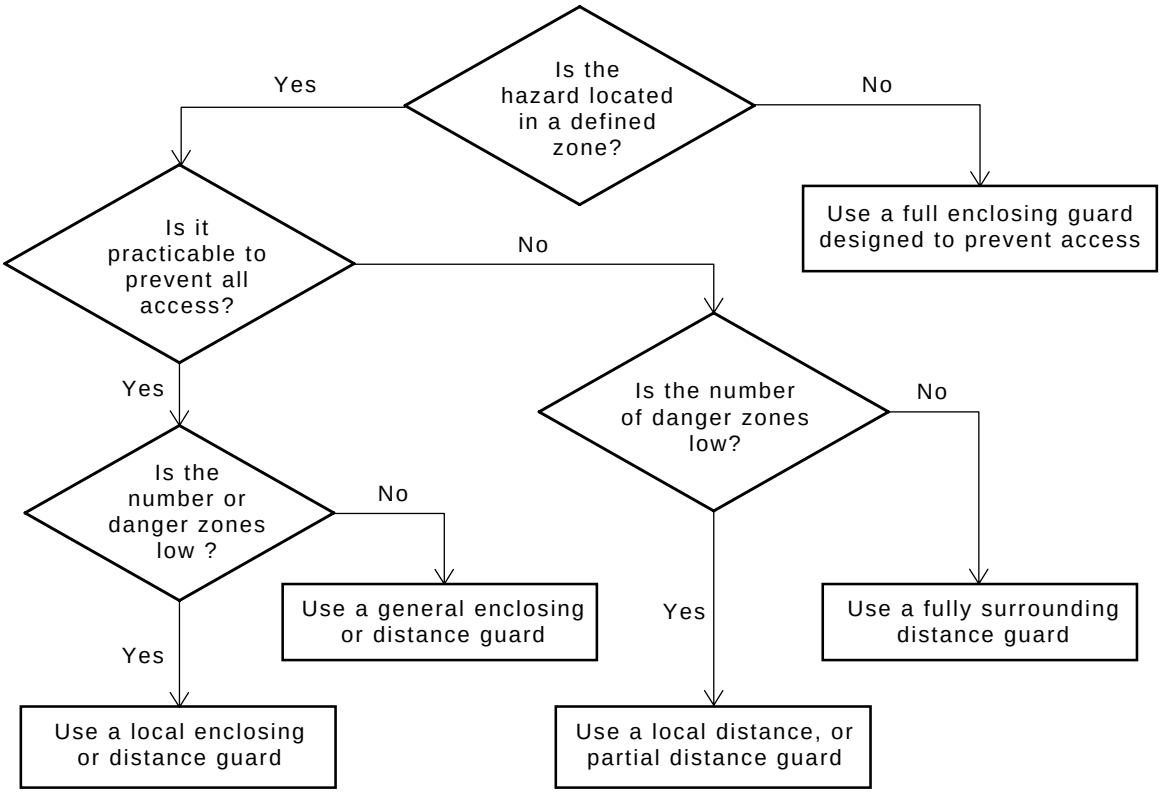


FIGURE B1 CHART FOR THE SELECTION OF GUARDS ACCORDING TO THE NUMBER AND LOCATION OF HAZARDS

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