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Industrial fans — Mechanical safety of fans — Guarding

*Ventilateurs industriels — Sécurité mécanique des ventilateurs —
Protecteurs*



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Foreword

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

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

International Standard ISO 12499 was prepared by Technical Committee ISO/TC 117 *Industrial fans*.

Annex A of this International Standard is for information only.

Introduction

This International Standard is intended to provide designers, users and installers with information on the safety aspects of fixed guards for use with industrial fans.

Since fans, by the nature of the function they perform, contain rotating parts, they present a mechanical hazard which has to be minimized or avoided. As a fan does not usually have to be accessible during "normal operation", a fixed guard can be applied. This can be removed during "ancillary operations" as necessary for servicing or maintenance.

As the scope of this International Standard covers a particular form of guarding as well as its design and use for a specific range of products, it is a type C standard, as defined by the European Committee for Standardization.

It complies with ISO/TR 12100-1, ISO/TR 12100-2 and EN 414, as well as ISO 13852.

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Industrial fans — Mechanical safety of fans — Guarding

1 Scope

This International Standard specifies requirements for the mechanical guarding of industrial fans.

The circumstances under which safety measures shall be taken are described and information on how hazards can be reduced or eliminated is given, along with guidance on safety practices and information for use.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3864:1984¹⁾, *Safety colours and safety signs*.

ISO 13349: —²⁾, *Industrial fans — Vocabulary and definitions of categories*.

ISO 13852:1996, *Safety of machinery — Safety distances to prevent danger zones being reached by the upper limbs*.

ISO 14120: —²⁾, *Safety of machinery — General requirements for the design and construction of guards (fixed, movable)*.

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 13349 and the following definitions apply.

3.1

industrial fan

any fan used for industrial purposes, including the ventilation of buildings and mines but excluding ceiling, pedestal and similar circulation type fans such as those commonly used for non- industrial purposes

3.2

normal operation

operation when the fan impeller is rotating and the fan is fulfilling its designed function of moving air

3.3

ancillary operation

operation when the fan impeller is stationary and all power to the fan has been disconnected to allow such activities as maintenance, cleaning, adjustment or troubleshooting to take place

1) To be revised, in parts.

2) To be published.

**3.4
windmilling**

rotation of a fan impeller induced by flow across the impeller

**3.5
hazard**

source of possible injury or damage to health

**3.6
hazardous situation**

any situation in which a person is exposed to a hazard or to hazards

**3.7
personal injury**

hurt caused to or sustained by a person as a result of mechanical hazard

**3.8
risk**

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

**3.9
danger zone
danger point**

any zone or point at or near the fan where a person is exposed to risk of injury or damage to health

**3.10
guard
guarding**

mechanical means whereby mechanical hazards associated with industrial fans are minimized or avoided

**3.10.1
fixed guard**

guard kept in place by means of fasteners, making removal impossible without using tools

**3.10.2
fixed distance guard**

fixed guard which does not completely enclose a danger zone, but which prevents or reduces access by virtue of its physical dimensions and its distance from the hazard

**3.11
safeguarding**

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

**3.12
residual risk**

risk remaining after specified safety measures have been taken during design or by the application of safeguarding

**3.13
safe working practice**

system of working which reduces or eliminates the risk of injury

**3.14
information for use**

safety measures consisting of communication links, such as text, words, signs, signals, symbols or diagrams, used separately or in combination, to convey information to the user

NOTE Information for use is directed to professional and/or nonprofessional users.

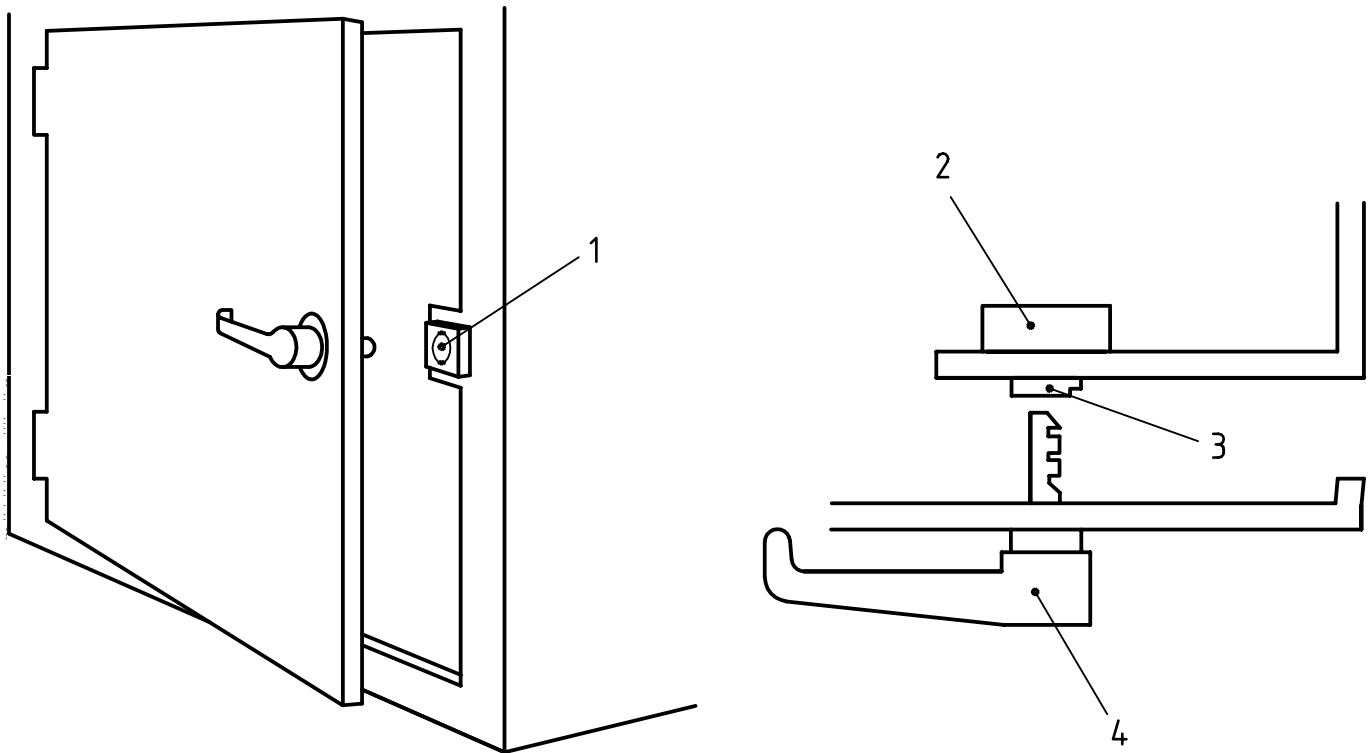
3.15 captive key interlock with timer

combination of a switch, with timer, and a lock secured to a fixed part of the machine with the operating key held captive in the access door

NOTE The sequence of operation is as follows:

- turn handle to switch off,
- after time delay, further turn to unlock access door, and
- open door (key disengages from lock).

A typical example is illustrated in figure 1.



Key

- ① Lock with switch
- ② Switch
- ③ Lock
- ④ Handle containing key

NOTE The captive key interlock ensures that the circuit-breaking element will be opened before the guard can be opened. It can be used when the guard can be removed completely. It is less suitable for sliding guards than for hinged and completely removable ones; it can be combined with a time-delay unit.

Figure 1 — Principle of captive key interlock

4 Hazards from fans

A person may be injured by a fan as a result of:

- a) being trapped between a moving and stationary part, e.g. a fan impeller and casing or other fixed part of a fan;
- b) being trapped between two moving parts, e.g. a belt and pulley;
- c) being drawn into the fan inlet by air movement, resulting in contact with a rotating shaft or impeller;
- d) coming into contact with a moving part, such as an impeller;
- e) object being drawn into the fan inlet and ejected at high velocity at fan discharge or inlet;
- f) structural failure of fan components;
- g) contact with surfaces of the fan at extreme temperatures (i.e. less than -20 °C or greater than $+50\text{ °C}$);
- h) noise emission caused by safeguards;
- i) even when a fan is switched off, the rotating parts can still be caused to windmill by air driven through the fan, either naturally or by fan(s) in other parts of the duct system connected to the fan; this could cause injury as the result of contact with a moving part, such as an impeller;
- j) unauthorized opening of access doors provided in the fan or connecting ductwork, if done whilst the fan is operating, can cause injury as the result of being drawn into the fan inlet by air movement, resulting in contact with a rotating shaft or impeller, or contact with a moving part, such as an impeller.

NOTE Figure 2 illustrates typical mechanical hazards referred to in a) to d).

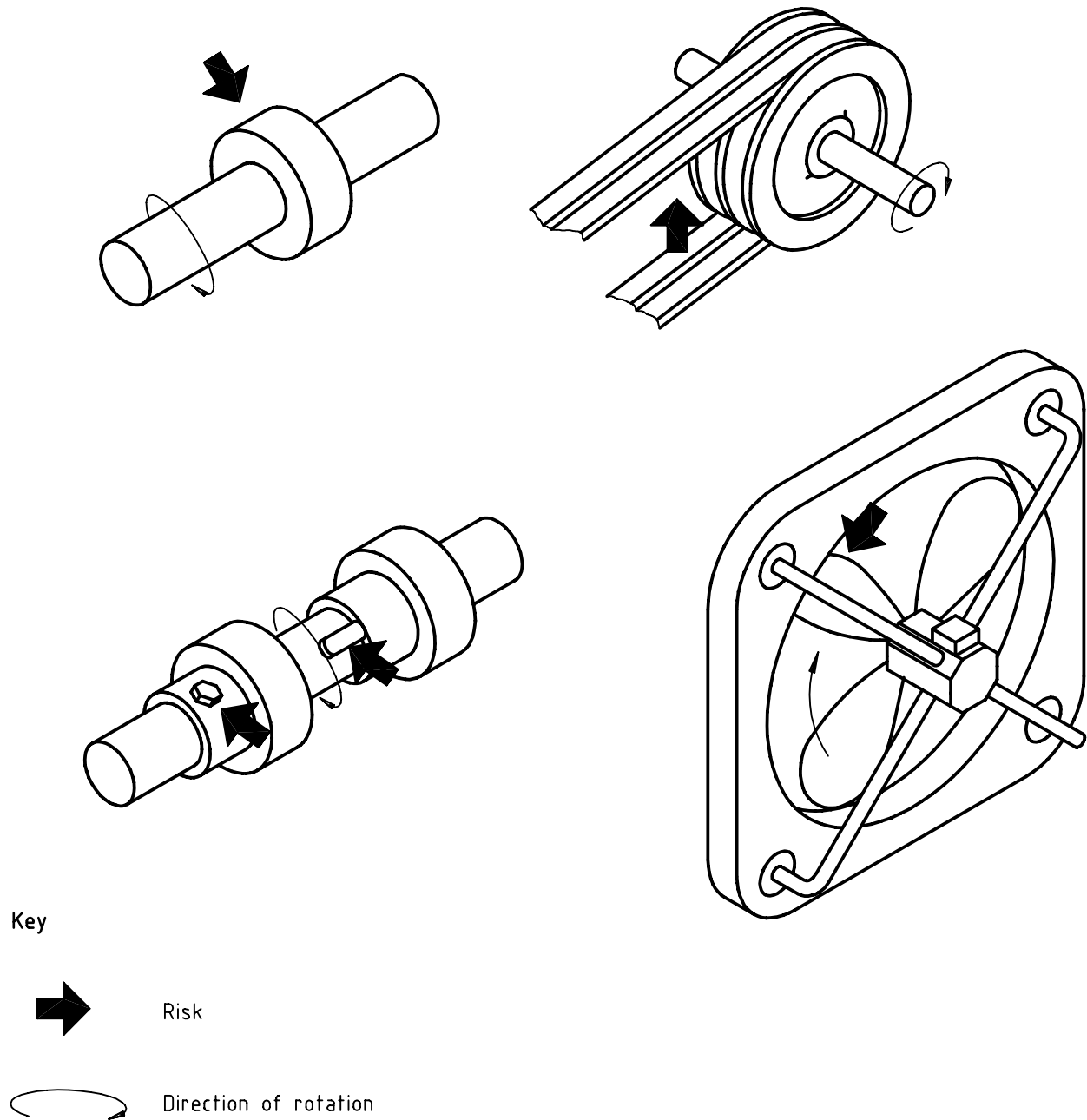


Figure 2 — Typical mechanical hazards from fans

5 Risk assessment

A qualitative assessment of the risk of injury from fans indicates that if no safeguarding measures are undertaken, this risk can be considerable and unacceptable.

Depending upon the power of the fan and the hazard involved, injury can be severe or even fatal.

Hazards in clause 4 a) to f) are judged to be those having the greatest potential for injury.

The conclusion is that safeguarding measures shall be undertaken to minimize the risk.

Where there is a residual risk, "safe working practices" shall be followed and the safety aspects of "information for use" shall receive particular attention.

6 Reduction of risk

The basic principles for reducing the risk of injury, which may be applied to fans, are :

- a) identification or knowledge of the hazard(s); (where the hazard is not visible or evident, such as at access doors, a suitable warning label in accordance with ISO 3864 shall be fixed to the door in a clearly visible position),
- b) elimination or avoidance of the hazard(s), including measures to reduce the scale of possible injury,
- c) use of physical safeguards,
- d) use of "safe working practices",
- e) emphasis on the safety aspects of "information for use".

One other method of eliminating or reducing risks caused by fans is to make use of safety distances preventing danger zones from being reached by the upper limbs, as detailed in ISO 13852.

It is not always possible for the fan manufacturer to be certain that a fan is safe by virtue of its position. Where access and consequent injury is reasonably foreseeable, safeguards shall be provided by the installer or fan user.

This means that protective guards shall be fitted in accordance with the requirements of 7.1.

The necessity of access to the fan for the purposes of inspection or cleaning make it impossible to exclude removable guards or inspection covers. These therefore shall be removed only by qualified persons as defined in 7.3.3.

Certain safety measures are more reliable than others. The order of priority is determined by reliability and therefore safeguards shall be considered and applied in preference before safe working practices.

7 Types of safeguard

7.1 Fixed guard (see figures 3 and 4)

Fans are designed to be used with four different ductwork connections. These are :

- a) no duct connection at inlet and outlet,
- b) no duct connection at inlet, duct connection at outlet,
- c) duct connection at inlet, no duct connection at outlet,
- d) duct connection at inlet and outlet.

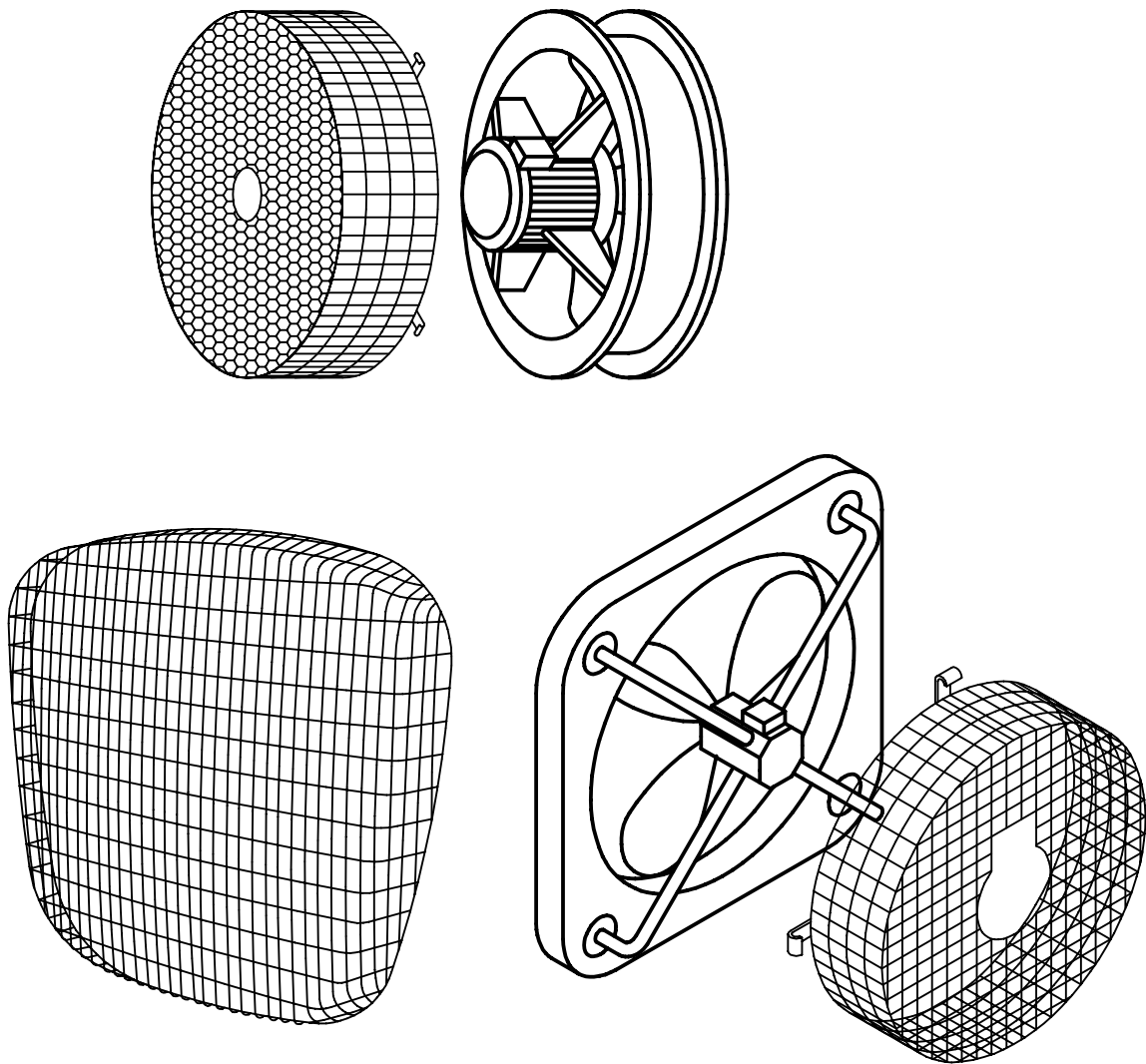
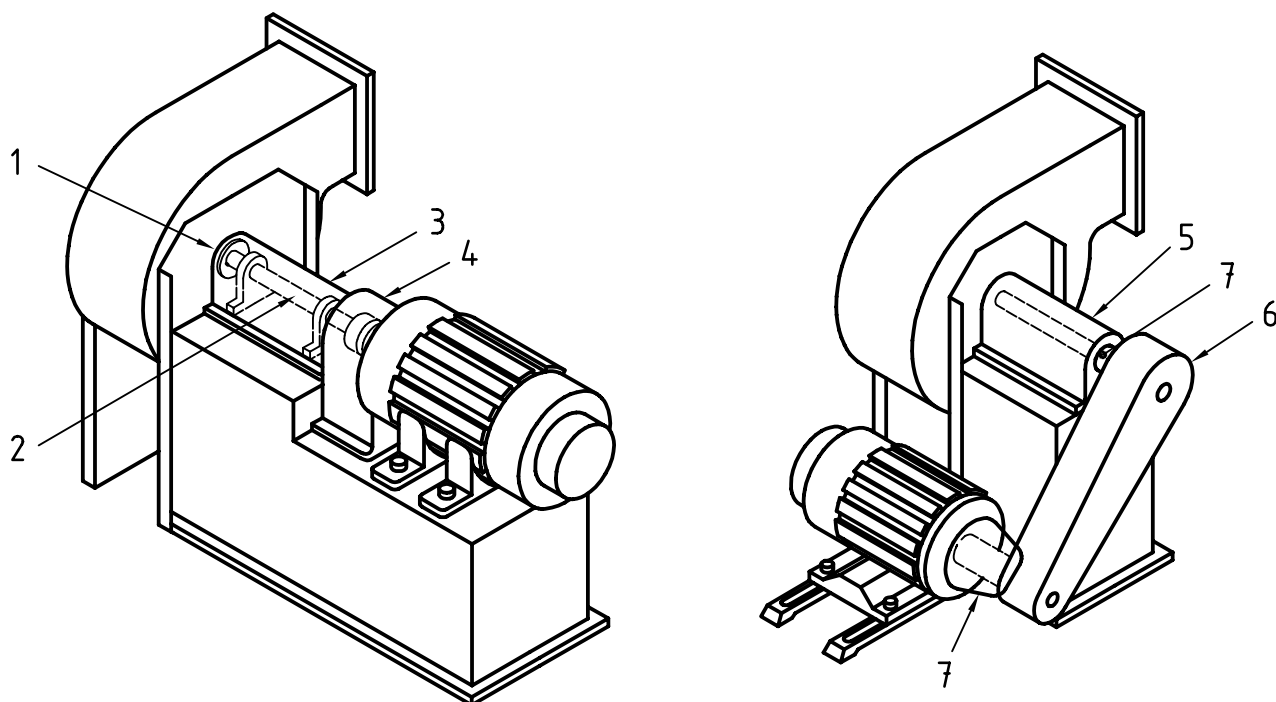
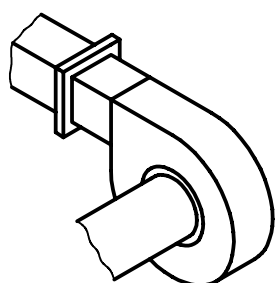


Figure 3 — Guards for axial flow and propeller fans

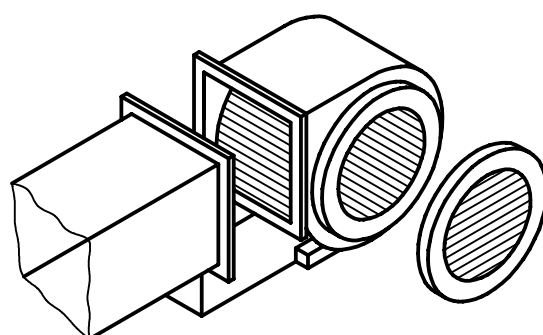


Key

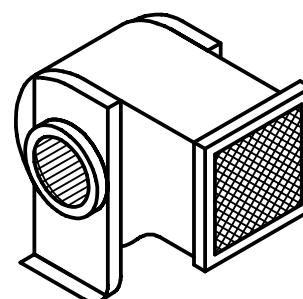
- ① Cooling disc
- ② Shaft
- ③ Combined shaft, bearing and cooling disc guard
- ④ Coupling guard
- ⑤ Shaft and bearing guard
- ⑥ Fully enclosed drive
- ⑦ Protection of exposed shaft



Fan protected by ductwork



Ducting at outlet, guard at inlet



Inlet and outlet guard

Figure 4 — Typical guards for centrifugal fans

Guards, fitted to fan, shall be requested in accordance with the ductwork connection as follows :

- a) guards fitted on the inlet and outlet sides unless one side is inaccessible by virtue of its installation (for example a fan fitted to a cooler would have no access on the coil side);
- b) guard fitted on the inlet side only;
- c) guard fitted on the outlet side;
- d) no guard fitted.

The fan user or installer shall ensure that the duct system is equipped with guards according to the ductwork connections as follows :

- a) no guard;
- b) guard fitted at the duct system outlet;
- c) guard fitted at the duct system inlet;
- d) guards fitted at the duct system inlet and outlet.

Guards at the end of duct systems shall not be mandatory if the maximum cross-section dimension does not exceed 400 mm and the hazard is more than 1 000 mm from the duct system opening or access is prevented by the presence of a duct fitting such as a damper or a louvre.

The guard shall, by its design, prevent access to the dangerous parts of the fan and associated equipment. It shall be of robust construction, sufficient to withstand the stresses generated by operation of the fan and the environmental conditions. It shall be securely fixed in position using fixings which cannot be loosened by vibration.

7.2 Fixed distance guard

A distance guard shall be designed and constructed in relation to the hazard, with the object of preventing any part of the body from reaching a danger point or zone. It shall take the form of a fixed barrier or fence designed to prevent access to a danger point or zone. The use of, and values for, safety distances are given in ISO 13852:1996 (see especially table 2).

7.3 Removal of guards

In general fixed guards shall be removable in order to give access to the interior of the fan for inspection and cleaning. The user and installer shall clearly understand and respect the following rules:

- a) the guard shall not be opened or removed whilst the fan is energized;
- b) a lockable isolating switch or power breaker shall be installed in the vicinity of the fan;
- c) only personnel properly instructed in the hazards and risks associated with installing, operating and maintaining fans shall be employed.

8 Guard construction

8.1 Selection of materials

In selecting the materials for the construction of guards, consideration shall be given to mass and size, and the need for removal and replacement during ancillary operations. Guards shall comply with the requirements of ISO 14120.

Similarly, attention shall be paid to the likely environmental conditions, with particular reference to corrosion. Corrosion-resistant materials or corrosion-resistant surface coatings shall be used, where appropriate, to ensure that the guard has a life comparable to that of the fan.

Whatever guard is selected, it shall not of itself present a hazard, such as trapping or shear points, splinters, rough or sharp edges, or be made from material likely to shatter, for example, due to the effects of UV exposure. In addition, the guard shall not itself generate unnecessary noise due to vibration or rattling-inadequate structural rigidity or the creation of pure tones-whistling.

8.2 Sheet material

Guards or areas of guards made from transparent material such as toughened glass or rigid plastic shall be considered where it is an advantage to be able to see the working parts.

NOTE Sheet material has the advantage of strength and rigidity and is particularly suitable for guarding transmission systems where adjustments are rarely needed.

8.3 Perforated or mesh material

Perforated material used for the manufacture of guards shall be perforated metal, woven mesh, welded wire, metal lattice or similar. The mesh size and distance of the guard from the danger point or zone shall be sufficient to prevent contact and shall be in accordance with the requirements of ISO 13852:1996 (see especially table 4).

Where removable parts of guards are provided, for example for checking belt tension, these shall be designed and maintained in accordance with the rules given in this International Standard. If there is a need to measure operational parameters of a fan, such as speed, bearing temperature or vibration, using portable instrumentation, suitable facilities shall be provided which allow the safety guards to remain in position.

8.4 Guard supports

Removable guards shall be fastened to independent supports or part of the fan itself such that they can be removed or replaced without affecting the fan structure. The number, spacing and rigidity of the supports shall be adequate to ensure stability of the guard.

8.5 Access to bearings

Shaft guards, provided they prevent physical contact with the moving parts, need not be extended over the bearing housing. This will facilitate measurement of bearing temperature and vibration and may simplify lubrication.

8.6 Electrical supplies

Where a fan impeller is mounted directly on a motor shaft and a fixed guard is necessary on the motor side of the fan, difficulties can arise with electrical supply cabling. It is preferred that the integrated design of the fan and guard is such that the guard can be completely removed for ancillary operations without disturbing the electrical supply connections. If this is not possible, the alternative arrangements shall be such that the electrical supply cabling does not have to pass through the guard mesh.

9 Design of fixed guards and fixed distance guards

9.1 Guards for rotating components

Guards for rotating impellers, shafts, pulleys, belts, spindles and couplings shall be of substantial construction to avoid accidental contact between the guard and the rotating components. In selecting sheet material, care shall be taken to allow for adequate cooling of drive components and, when on the pressure side of a fan, adequate sealing to prevent leakage. Mesh details and other openings or access to rotating parts shall be in accordance with the requirements of ISO 13852:1996 (see especially table 4).

9.2 Airflow resistance and noise generation

Consideration shall be given to the airflow resistance of guards installed in an airstream. Resistance can be minimised by using round wires in the construction and placing the guard as far away as is practicable from the hazard in order to maximize the mesh size. If these measures are implemented, noise generated by the guard will also be minimized.

9.3 Fixed distance guards

The construction of a fixed distance guard shall be rigid enough to withstand a person leaning against it without causing undue distortion or allowing the person to reach a danger point or zone. If a solid barrier would be likely to distort or obstruct the airflow into the fan entry, such as in a large plant room, then a mesh construction shall be used.

10 Noise

The noise generated by the guard itself and the airflow across it shall be minimized by implementing the measures described in 8.1 and 9.2.

11 Fans enclosed within units

11.1 General

Fans may be contained within machinery such as, but not limited to, condensing units, dust collection equipment, cooling towers and air-handling units. Under normal operations, such equipment is enclosed, effectively, inside a barrier. Thus the danger points/zones are inaccessible. However, the fan sections, and any adjacent downstream plenum, are sometimes provided with access doors to allow ancillary operations to take place as required. It is, therefore, necessary to ensure that safe working practices are employed during these activities (see 12.2).

If walk-in access is required to the fan plenum whilst the fan is operating, for example to assist with commissioning or condition monitoring, then fixed guards to prevent contact with transmission components, exposed shaft ends and the impeller shall be fitted. In the case of a double-inlet fan, both inlets shall be protected. It is important that inlet guards are fitted, even on direct-drive fans, to eliminate the danger of entrainment.

If access is not required whilst the fan is operating, although still possible, then fixed guards need not be fitted provided access can be gained only by the use of a key.

NOTE A captive key interlock, with timer, is preferred wherever regular access is necessary. The timer should allow the fan impeller to come to rest before access is possible.

Fan discharge plenums are sometimes fitted with access doors. Unauthorized opening of such doors can cause a hazard, as the door is on the pressure side of the fan and can, if released, blow open and cause injury. Access doors on fan discharge chambers should, therefore, have an appropriate warning notice, in accordance with ISO 3864, advising that the door shall not be opened without first isolating the electrical supply and allowing the fan impeller to come to rest.

11.2 Fan electrical supply isolation

Concerning the fan plenum, the same rules relating to isolating the electrical supply as given in 12.2 apply. In addition, the same warning notice as described in 11.1 shall be affixed to the access door.

12 Safe working practices

12.1 General

Fixed guards should always be used as the most reliable method of reducing risk. However, a residual risk of injury will always remain, particularly during ancillary operations, and safe working practices should be adopted to minimize this residual risk.

12.2 Safe working practices

The manufacturers' instructions with respect to the safe installation, operating and maintenance of the equipment, shall be strictly followed. Particular regard shall be paid to the proper maintenance of the guard(s), especially when these have to be removed to carry out ancillary operations and then replaced.

If guards have to be removed to carry out ancillary operations, a positive means of isolating the electrical supply shall be provided. In these circumstances an isolating switch shall be sited close to the fan such that maintenance personnel have direct control over the electrical supply to the fan.

13 Information for use

13.1 Safety, installation and maintenance instructions

Usually safety, installation and maintenance instructions are the only documents giving instructions for use which are available to the user. Therefore, in addition to the information relating to the fan, the instruction manual shall provide information on the safe installation and use of the safeguards and any procedures necessary to ensure the safety of ancillary operations.

13.2 Safety labels

Safety labels warning the user of a potential mechanical or electrical hazard shall be applied to the fan in an easily visible position. The symbols and colours used on the labels shall comply with ISO 3864 and internationally recognized pictograms shall be used wherever possible.

Where this is not possible, then any text on the label shall be in the language(s) of the country(ies) of use.

To cater for the circumstance in which the instruction manual does not reach the installer or user, a suitable label should be applied to the fan. This label shall take the form of a "mandatory instruction" (see ISO 3864) advising the reader that the instructions contained in the manual shall be followed and, if the manual is not available, where it can be obtained.

Annex A (informative)

Bibliography

- [1] ISO/TR 12100-1:1992, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology.*
- [2] ISO/TR 12100-2:1992, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles and specifications.*
- [3] EN 414:1992, *Safety of machinery — Rules for the drafting and presentation of safety standards.*

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