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Earth-moving machinery — Guards — Definitions and requirements

Engins de terrassement — Protecteurs — Définitions et exigences

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Foreword

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

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

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

ISO 3457 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety requirements and human factors*.

This fourth edition cancels and replaces the third edition (ISO 3457:1986), which has been technically revised.

Introduction

This International Standard provides performance requirements for guards and other means of protecting personnel from unintentional contact with common mechanical, fluid or thermal hazards on earthmoving machinery during normal machine operation and routine maintenance. Relationships between the distance separating a guard from a hazardous component and the guard opening size based on anthropometric data are included.

Some factors having a significant effect upon personnel protection, such as operator and service personnel training, experience and careful practice, are outside the scope of this International Standard.

Deviations from these requirements to allow technological advances in machine systems and designs are permissible. In complying with this International Standard, the following three safety principles are to be considered, in the order given, based on feasibility:

a) eliminate potential hazards by machine design;

b) guard against contact with sources of potential safety hazards if elimination by design is not feasible;

c) warn of potential safety hazards where neither a) nor b) is feasible.

Earth-moving machinery — Guards — Definitions and requirements

1 Scope

This International Standard defines principal terms and specifies requirements for, and characteristics of, guards and other means of protecting personnel from mechanical, fluid or thermal hazards associated with the operation and routine maintenance of earth-moving machinery as defined in ISO 6165, when used as intended by the manufacturer.

2 Normative references

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

ISO 2867, *Earth-moving machinery — Access systems*

ISO 3411, *Earth-moving machinery — Human physical dimensions of operators and minimum operator space envelope*

ISO 6165, *Earth-moving machinery — Basic types — Vocabulary*

ISO 6682, *Earth-moving machinery — Zones of comfort and reach for controls*

ISO 9244, *Earth-moving machinery — Safety signs and hazard pictorials — General principles*

ISO 12508, *Earth-moving machinery — Operator station and maintenance areas — Bluntness of edges*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
guard
protective device, alone or combined with other parts of the machine, designed and fitted to minimize the possibility of contact with a potentially hazardous machine component

3.1.1
barrier guard
guard that restricts the movement of a person's body or a part of it, in order to avoid its contact with a machine component or exposure to other, similar hazards

EXAMPLE Rail, frame, cover or enclosure.

3.1.2
fender
guard partially covering the wheels or tracks of a machine which restricts material that may be thrown by the wheels or tracks, and which can also be used to limit the operator's contact with moving parts

3.1.3
fan guard
structure covering the engine cooling fan to protect against inadvertent contact with the rotating fan

3.1.4
thermal guard
guard that protects persons from contact with hot parts of the machine, and which can also be used to provide a heat barrier between the hot part and flammable materials

3.1.5
hose guard
guard that provides protection from potential harmful fluid spray in the event of a hose failure

3.2
distance guarding
means of providing protection by which the possibility of inadvertent contact with a hazardous component is minimized by the combination of the guard configuration (including openings) and the distance (safety distance) between the guard and the component, and, additionally, separation distances (minimum gap) of crush points in relation to body parts

3.3
routine maintenance
action recommended by the manufacturer to be performed daily to maintain proper performance of a machine

EXAMPLE Lubrication, refueling, adjustments, preventive maintenance, cleaning and inspections.

4 General requirements

4.1 If a significant risk of injury exists from moving parts, hot parts or parts containing fluid, such hazards shall be addressed by design, by guarding, by locating beyond safety distances or by warning. Where it is necessary for machine components to be exposed in order for them to perform their intended function, guarding shall be provided to the extent permitted by proper operation or use. When guarding cannot eliminate the hazard associated with operating conditions as specified by the machine manufacturer, appropriate safety warnings in accordance with ISO 9244 shall be applied.

4.2 Guards shall be attached to the machine with common fasteners or other effective means. Access doors and guards which need to be opened for routine or daily maintenance, inspection or cleaning

— shall be easy to open and close,

— shall remain attached by a hinge, tether, or other suitable means,

— shall include means to keep them closed and, when required, open, and,

— if they need to be removed and exceed 20 kg, shall be provided with hand holds or lift points or both.

4.3 Guards which need to be opened for maintenance shall be free of sharp edges and corners (see ISO 12508) and projections, and have sufficient strength under expected climatic and operational conditions for their intended use.

4.4 Each guard (excluding hose guards) shall be sufficiently rigid to avoid deflection into the hazardous component and to avoid detrimental permanent deformation under the following loads applied by means of a 125 mm diameter disc:

a) if a person can touch the guard — 250 N applied at possible points of contact;

b) if a person can fall or lean against the guard — 500 N applied at possible points of contact;

c) if the guard also serves as a step or platform of the access system — 2 000 N applied at any location on the surface (see ISO 2867).

4.5 Rotating shafts that constitute a hazard shall be guarded either by barrier or distance guarding or by warning.

5 Barrier guards

5.1 The safety distance from a hazardous component to a barrier guard is measured from the nearest location a person can occupy in proximity to the component. See Clause 10.

5.2 Barrier guards that cause restricted operator visibility during operation, such as side guarding on skid steer loaders, shall have opening dimensions not greater than 40 mm by 80 mm or an equivalent opening area.

6 Fenders

6.1 Fenders shall be provided on machines without a cab if there is risk of injury to the operator from inadvertent contact with moving wheels or tracks. The manufacturer shall be able to substantiate the choice of distances for determining the minimization of risk.

6.2 Fenders shall be provided if there is risk of injury to the operator or of damage to critical information displays from material being thrown from the wheels or tracks. The area of protection shall include the operator’s space envelope as defined in ISO 3411.

6.3 If fenders are fitted, the determination of the covering length and width in accordance with 6.1 and 6.2 shall also take into consideration factors such as the required operator visibility of the wheels or tracks, the longitudinal and transverse position of the operator’s space envelope relative to the wheels or tracks, the circumferential speed of the wheels or tracks, and the required area of protection.

6.4 Fenders that are a part of the access system shall be in accordance with ISO 2867.

7 Fan guards

7.1 An enclosed engine compartment shall satisfy fan guarding requirements when the manufacturer's recommended routine maintenance is performed with the engine off. A safety warning sign (see ISO 9244) shall be provided, and included in the operator's manual.

7.2 If the engine cooling fan can be reached by a person standing on the ground or on a platform, guarding shall be provided to protect against inadvertent contact with the fan. The distance from the guard to the fan and the guard opening size shall be in accordance with Table 1.

Table 1 — Distances and opening sizes

Distance from guard to fan mm	Max. opening width mm
$\leqslant$ 90	12
91 to 140	16
141 to 165	19
166 to 190	22
191 to 320	32

8 Thermal guards

8.1 Thermal guarding shall be provided to prevent contact with metallic surfaces (painted or coated) that reach temperatures $>$ 75 °C under normal operating conditions and which are within hand reach from the operating position (see ISO 6682).

8.2 Thermal guarding or other means shall be considered for preventing contact with hot surfaces in the path of access systems and when accessing routine maintenance points according to manufacturer's recommendations.

9 Hose guards

9.1 Hoses containing fluid at pressures exceeding 5 000 kPa or temperatures above 60 °C which are located within 1,0 m of the operator in the normal operating position and whose direct spray in case of failure can reach the operator shall be guarded.

9.2 Hose guards, including flexible hose coverings, shall be sufficiently sturdy to stop, disperse or divert the fluid stream, in case of hose failure, from direct contact with the operator.

NOTE Cab doors or windows able to be opened during machine operations do not satisfy this requirement.

10 Distance guarding

10.1 Basic assumptions

The safety distances given in Table 2 have been derived based on the following assumptions.

a) The protective structures and openings in them retain their shape and position.

b) Safety distances are measured from the surface restricting the body or the relevant part of the body.

c) A person could force parts of his or her body over protective structures or through openings in an attempt to reach the danger zone.

d) The reference plane is a level at which persons would normally stand, but it need not necessarily be the floor. For example, a working platform could be the reference plane.

e) No aids, such as stools or ladders, are used to change the reference plane.

f) No aids, such as rods or tools, are used to extend the natural reach of the upper limbs.

10.2 Requirements

A hazardous component shall be beyond safety distances if not independently guarded. Openings shall not exceed the size appropriate to the distance of the guard from the component.

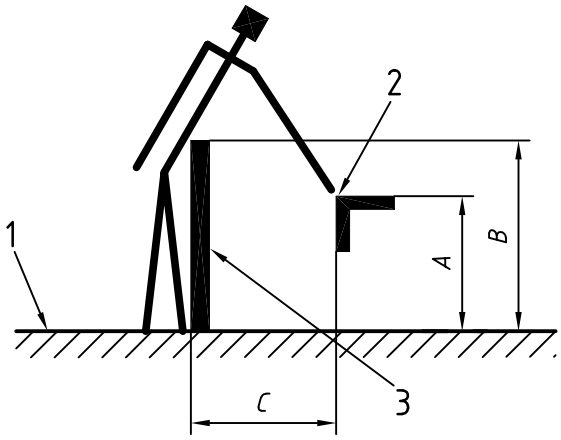
10.3 Reaching upwards

The safety distance for upward reach shall be 2,5 m above the reference plane for persons standing upright.

10.4 Reaching over barriers

10.4.1 Principles for determining the distance from a guard to a hazardous component are shown in Figure 1. Safety distances shall be as given in Table 2. When the height of the danger zone, the height of the barrier guard or the horizontal distance to the danger zone falls between two values in Table 2, the value providing the greater distance shall be used.

10.4.2 The minimum height of a reach-over barrier guard shall be 1 m.



Key

A height of danger zone
B height of barrier guard
C horizontal distance to danger zone
1 reference plane
2 danger zone
3 barrier guard

NOTE Drawing adapted from Figure 2 of ISO 13852:1996.

Figure 1 — Principles for determining distance from guard to hazard

Table 2 — Downward and sideward safety distances

Dimensions in millimetres

Height of danger zone	Height of barrier guard [a]								
	1 000	1 200	1 400	1 600	1 800	2 000	2 200	2 400	2 500
	Horizontal distance to danger zone								
2 500	—	—	—	—	—	—	—	—	—
2 400	100	100	100	100	100	100	100	100	—
2 200	600	600	500	500	400	350	250	—	—
2 000	1 100	900	700	600	500	350	—	—	—
1 800	1 100	1 000	900	900	600	—	—	—	—
1 600	1 300	1 000	900	900	500	—	—	—	—
1 400	1 300	1 000	900	800	100	—	—	—	—
1 200	1 400	1 000	900	500	—	—	—	—	—
1 000	1 400	1 000	900	300	—	—	—	—	—
800	1 300	900	600	—	—	—	—	—	—
600	1 200	500	—	—	—	—	—	—	—
400	1 200	300	—	—	—	—	—	—	—
200	1 100	200	—	—	—	—	—	—	—
0	1 100	200	—	—	—	—	—	—	—

NOTE Adapted from Table 1 of ISO 13852:1996[1].

[a] Barrier guards less than 1 000 mm in height are not included because they do not sufficiently restrict movement of the body.

10.5 Reaching around or below barriers

10.5.1 The extent to which a person can reach around a barrier, taking into account the aperture and the distance from other obstructions, is given in Table 3. For openings greater than 120 mm, safety distances in accordance with Table 2 shall be used.

10.5.2 The safety distance dimensions for finger, hand and arm reach according to Tables 3 and 4 are to be used when considering reaching below a barrier.

10.6 Reaching through openings

10.6.1 Fan guards

See Clause 7.

10.6.2 Slot, square, or round openings

See Table 4 for reach-through safety distances. The dimension e of openings corresponds to the side of a square opening, the diameter of a round opening and the narrowest dimension of a slot opening. For openings greater than 120 mm, safety distances in accordance with Table 2 shall be used.

10.6.3 Irregular openings

For safety distances with irregular openings, determine

a) the diameter of the smallest round opening,

b) the side of the smallest square opening, and

c) the width of the narrowest slot opening into which the irregular opening can be completely inserted (see Figure 2).

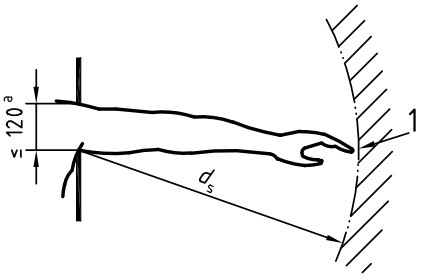
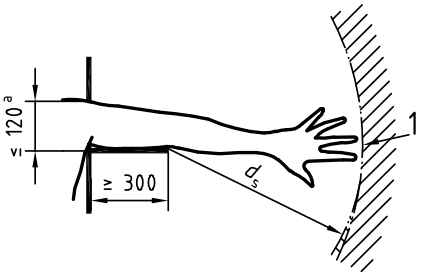
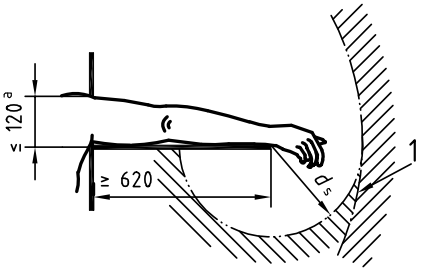
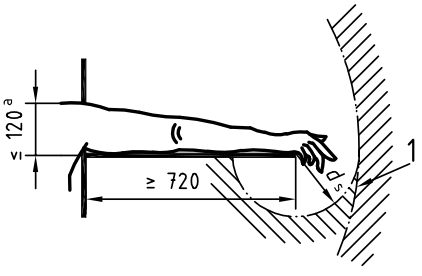
Select the corresponding three safety distances in accordance with Tables 3 or 4. The shortest safety distance of the three values selected is to be used.

10.7 Crushing

Safety distances (minimum gaps) for avoiding crushing of parts of the human body shall be in accordance with Table 5.

Table 3 — Extent of reach safety distance

Dimensions in millimetres

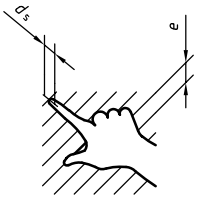
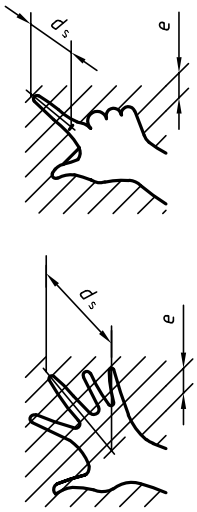
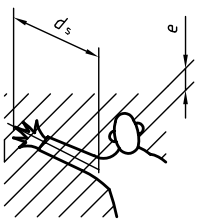
Limitation of movement	Safety distance, d_s	Illustration
Limitation of movement only at shoulder and armpit	⩾ 850	
Arm supported up to elbow	⩾ 550	
Arm supported up to wrist	⩾ 230	
Arm and hand supported up to knuckle joint	⩾ 130	 **Key** 1 range of movement of arm

NOTE Adapted from Table 3 of ISO 13852:1996.

a This is either the diameter of a round opening, the side of a square opening or the width of a slot opening.

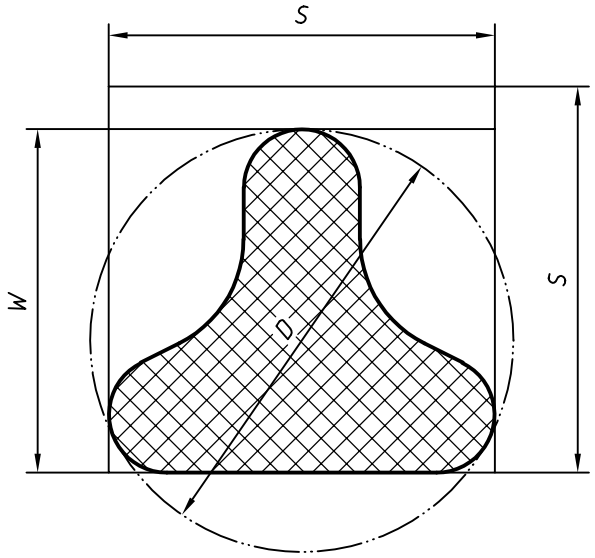
Table 4 — Reach-through safety distances

Dimensions in millimetres

Part of body	Illustration	Opening, e	Safety distance, d_s		
			Slot	Square	Round
Finger tip		$e \leqslant 4$	$\geqslant 2$	$\geqslant 2$	$\geqslant 2$
		$4 < e \leqslant 6$	$\geqslant 10$	$\geqslant 5$	$\geqslant 5$
Finger up to knuckle joint or Hand		$6 < e \leqslant 8$	$\geqslant 20$	$\geqslant 15$	$\geqslant 5$
		$8 < e \leqslant 10$	$\geqslant 80$	$\geqslant 25$	$\geqslant 20$
		$10 < e \leqslant 12$	$\geqslant 100$	$\geqslant 80$	$\geqslant 80$
		$12 < e \leqslant 20$	$\geqslant 120$	$\geqslant 120$	$\geqslant 120$
		$20 < e \leqslant 30$	$\geqslant 850$[a]	$\geqslant 120$	$\geqslant 120$
Arm up to junction with shoulder		$30 < e \leqslant 40$	$\geqslant 850$	$\geqslant 200$	$\geqslant 120$
		$40 < e \leqslant 120$	$\geqslant 850$	$\geqslant 850$	$\geqslant 850$

NOTE Adapted from Table 4 of ISO 13854:1996.

[a] If the length of the slot opening is $\leqslant 65$ mm, the thumb will act as a stop and the safety distance may be reduced to 200 mm.



Key

S side
W width
D diameter

Figure 2 — Irregular openings

Table 5 — Crushing minimum gap

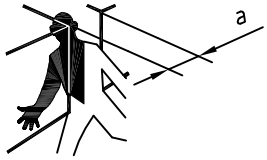
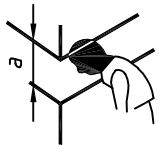
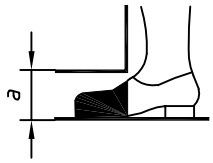
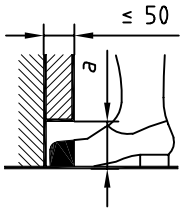
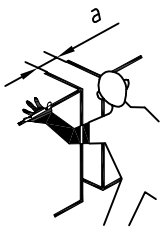
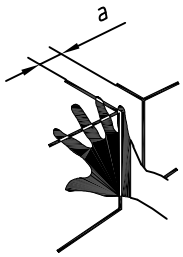
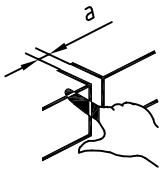
Part of body	Minimum gap, a mm	Illustration
Body	500	
Head (least-favourable position)	300	
Leg	180	
Foot	120	

Table 5 (*continued*)

Toes	50	
Arm	120	
Hand, wrist or fist	100	
Finger	25	
NOTE Adapted from Table 1 of ISO 13854:1996[2].		

Bibliography

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

[2] ISO 13854:1996, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

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