AS 4024.1801—2006

Australian Standard™

Safety of machinery

Part 1801: Safety distances to prevent danger zones being reached by the upper limbs

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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
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Safety of machinery

Part 1801: Safety distances to prevent danger zones being reached by the upper limbs

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PREFACE

This Standard was prepared by the Standards Australia Committee SF-041, General Principles for the Guarding of Machinery, as a 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 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 of parts rather than the single part of AS 4024.1 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.

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FOREWORD

According to AS 4024.1201, machinery is considered safe if it is probable that the machinery can continue to be operated, adjusted, maintained, dismantled and disposed of under the conditions of its intended use without causing injury or damaging human health. Ways of achieving this include—

(a) risk reduction by design;

(b) safeguarding measures;

(c) information for use (signals, signs, instructions);

(e) safety measures taken by the users (safe working procedures, organizational means with respect to safety); and

(d) personal protective equipment.

Means and measures to achieve safety have to reflect the balance between—

(i) the benefit of reduced risk, and

(ii) the loss of other benefits needed to achieve this.

The balance should provide an adequate level of safety for the particular risk.

One method of eliminating or reducing risks caused by machinery is to make use of safety distances preventing danger zones from being reached by the upper limbs.

In specifying safety distances, a number of aspects have to be taken into consideration, such as—

(A) reach situations occurring when machinery is being used;

(B) reliable surveys of anthropometric data, taking into account ethnic groups likely to be found in the workplace concerned;

(C) biomechanical facts, such as compression and stretching of parts of the body and limits of joint rotation; and

(D) technical and practical aspects.

If these aspects were further developed, the current state of the art, reflected in this Standard, could be improved.

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STANDARDS AUSTRALIA

Australian Standard
Safety of machinery

Part 1801: Safety distances to prevent danger zones being reached by the upper limbs

1 SCOPE

This Standard establishes values for safety distances to prevent danger zones being reached by the upper limbs of persons of 3 years of age and above. The distances apply when adequate safety can be achieved by distances alone.

NOTE: These safety distances will not provide sufficient protection against certain hazards, for example radiation and emission of substances. For such hazards, additional or other measures need to be taken.

The safety distances protect those persons who try to reach danger zones without additional aid and under the conditions specified for the different reaching situations.

This Standard need not be applied to machinery which is covered by certain electrical standards in which specific testing procedures are laid down, for example using the test finger.

For certain applications there are justifiable reasons to deviate from these safety distances. Standards dealing with these applications indicate how an adequate level of safety can be achieved.

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 others working with or otherwise near machinery by providing safety distances to prevent entry to danger zone by the upper limbs.

3 REFERENCED DOCUMENTS

The following documents are referred to in this Standard.

AS	
4024	Safety of machinery
4024.1201	Part 1201: General principles—Basic terminology and methodology
4024.1301	Part 1301: Risk assessment—Principles for risk assessment

4 DEFINITIONS

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

4.1 Protective structure

Physical obstruction which restricts the movement of the body or part of it.

NOTE: For example, a guard or part of a machine.

4.2 Safety distance

Minimum distance a protective structure is to be placed from a danger zone.

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5 VALUES FOR SAFETY DISTANCES

5.1 General

5.1.1 *Assumptions*

The safety distances have been derived by making the following assumptions:

(a) The protective structures and any 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) That persons may force parts of the 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 need not necessarily be the floor (e.g. a working platform could be the reference plane).

(e) No aids such as chairs 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.

5.1.2 *Risk assessment*

Selection of the appropriate safety distances for reaching upwards (see Clause 5.2) or reaching over protective structures (see Clause 5.3) shall be dependent on a risk assessment (for risk assessment see AS 4024.1301. The risk assessment shall be based on the probability of occurrence of an injury and the foreseeable severity of that injury. An analysis of the technical and human elements on which the risk assessment is dependent is essential to achieve the appropriate selection from this Standard.

Example 1:

Where there is a low risk from a friction or abrasion hazard, the values given in Table 1 apply (see Clause 5.3.2.1). A risk is considered to be low when the severity of injury or damage to health is found to be slight, that is, normally reversible.

Example 2:

Where there is a high risk from an entanglement hazard, the values given in Table 2 apply (see Clause 5.3.2.2). A risk is considered to be high when the severity of injury or damage to health is found to be serious, that is, normally irreversible or death.

5.2 Reaching upwards (see Figure 1)

5.2.1 *Low risk*

If there is a low risk from the danger zone, then the height of the danger zone *h* shall be 2500 mm or more.

5.2.2 *High risk*

If there is a high risk (see Clause 5.1.2) from the danger zone, then—

(a) either the height of the danger zone *h* shall be 2700 mm or more; or

(b) other safety measures shall be used.

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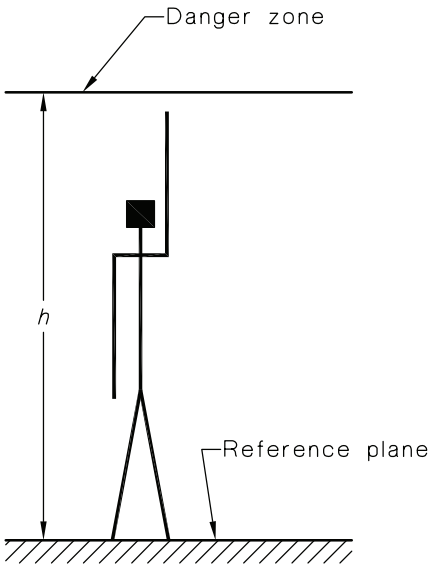


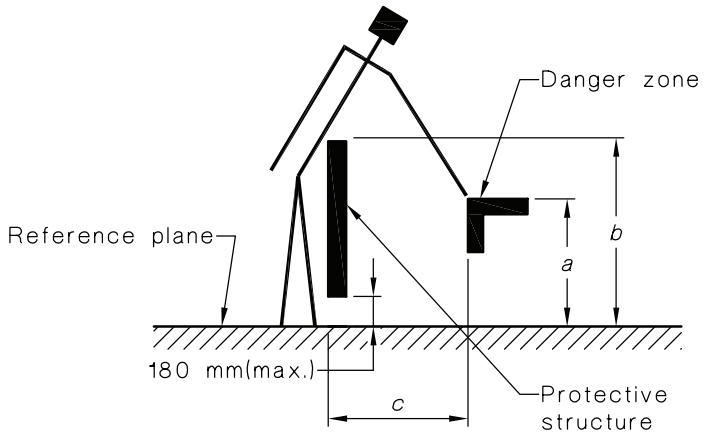
FIGURE 1 REACHING UPWARDS

5.3 Reaching over protective structures

5.3.1 *General*

There is a relationship between the height of a protective structure, the height of a danger zone and the horizontal distance to the danger zone from the protective structure.

This relationship is shown in Figure 2, and used in Table 1 and Table 2 to determine the appropriate safety distances.



LEGEND
a = height of danger zone
b = height of protective structure
c = horizontal distance to danger zone

FIGURE 2 REACHING OVER PROTECTIVE STRUCTURES

5.3.2 *Values*

5.3.2.1 *Low risk*

If there is a low risk (see Clause 5.1.2) from a danger zone, the values given in Table 1 shall be used as minimum values.

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There shall be no interpolation of the values given in Table 1 (see Clause 5.3.3). Consequently, when the known values of *a*, *b* or *c* are between two values in Table 1, values to be used are those which provide the higher level of safety.

TABLE 1

SAFETY DISTANCES USED WHERE A LOW RISK EXISTS

millimetres

Height of danger zone, (*a*) (see Note 2)	Height of protective structure, (*b*) (see Note 1)								
	1000	1200	1400	1600	1800	2000	2200	2400	2500
	Horizontal distance to danger zone, (*c*)								
2500	—	—	—	—	—	—	—	—	—
2400	100	100	100	100	100	100	100	100	—
2200	600	600	500	500	400	350	250	—	—
2000	1100	900	700	600	500	350	—	—	—
1800	1100	1000	900	900	600	—	—	—	—
1600	1300	1000	900	900	500	—	—	—	—
1400	1300	1000	900	800	100	—	—	—	—
1200	1400	1000	900	500	—	—	—	—	—
1000	1400	1000	900	300	—	—	—	—	—
800	1300	900	600	—	—	—	—	—	—
600	1200	500	—	—	—	—	—	—	—
400	1200	300	—	—	—	—	—	—	—
200	1100	200	—	—	—	—	—	—	—
0	1100	200	—	—	—	—	—	—	—

NOTES:

1 Protective structures less than 1000 mm in height are not included because they do not sufficiently restrict movement of the body, or toppling over the structure.

2 For danger zones above 2500 mm, refer to Clause 5.2.

5.3.2.2 *High risk*

If there is a high risk (see Clause 5.1.2) from a danger zone, then—

(a) the values given in Table 2 shall be used; or

(b) other safety measures shall be used.

There shall be no interpolation of the values given in Table 2, (see Clause 5.3.3). Consequently, when the known values of *a*, *b* or *c* are between the two values in Table 2, the values to be used are those which provide the higher level of safety.

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TABLE 2

SAFETY DISTANCES USED WHERE A HIGH RISK EXISTS

millimetres

Height of danger zone, (*a*) (see Note 3)	Height of protective structure, (*b*) (see Note 1)									
	1000	1200	1400	1600 (see Note 2)	1800	2000	2200	2400	2500	2700
	Horizontal distance to danger zone, (*c*)									
2700	—		—	—	—	—	—	—	—	—
2600	900	800	700	600	600	500	400	300	100	—
2400	1100	1000	900	800	700	600	400	300	100	—
2200	1300	1200	1000	900	800	600	400	300	—	—
2000	1400	1300	1100	900	800	600	400	—	—	—
1800	1500	1400	1000	900	800	800	—	—	—	—
1600	1500	1400	1000	900	800	500	—	—	—	—
1400	1500	1400	1100	900	800	—	—	—	—	—
1200	1500	1400	1100	900	700	—	—	—	—	—
1000	1500	1400	1000	800	—	—	—	—	—	—
800	1500	1300	900	600	—	—	—	—	—	—
600	1400	1300	800	—	—	—	—	—	—	—
400	1400	1200	400	—	—	—	—	—	—	—
200	1200	900	—	—	—	—	—	—	—	—
0	1100	500	—	—	—	—	—	—	—	—

NOTES:

1 Protective structures less than 1000 mm in height are not included because they do not sufficiently restrict movement of the body, or toppling over the structure.

2 Protective structures lower than 1600 mm should not be used without additional safety measures.

3 For danger zones above 2700 mm, refer to Clause 5.2.

5.3.3 *Use of tables 1 and 2 with intermediate values*

There will be occasions when values other than those given in Tables 1 and 2 have to be used. In this event, there shall be no interpolation of the values given, and the next higher value shall be used.

The following examples illustrate the concept. For the purpose of the examples, values in Table 1 are used.

Example 1:

To determine the height *b* of the protective structure with known values for *a* and *c*. The height *a* of the danger zone is 1500 mm and its horizontal distance *c* from the proposed protective structure is 700 mm.

Using Table 1, the height *b* of the protective structure is at least be 1800 mm.

Example 2:

To determine the horizontal distance *c* of the danger zone with known values for *a* and *b*. The height *b* of the protective structure is 1300 mm and the height *a* of the danger zone is 2300 mm.

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Using Table 1, the horizontal distance *c* of the protective structure from the danger zone 600 mm.

Example 3:

To determine the height *a* of the danger zone with known values for *b* and *c*.

The height *b* of the protective structure is 1700 mm and the horizontal distance *c* from the danger zone is 550 mm.

Using Table 1, the height *a* of the danger zone not be between 120 mm and 2200 mm.

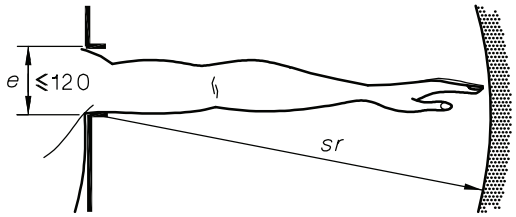
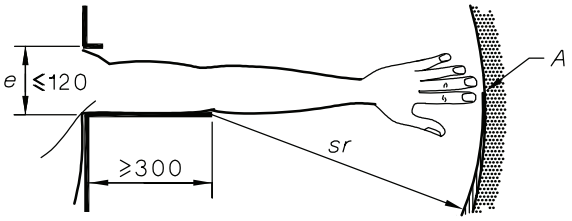
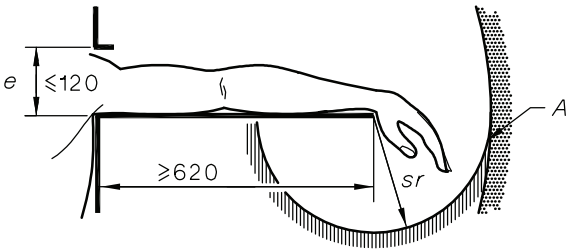
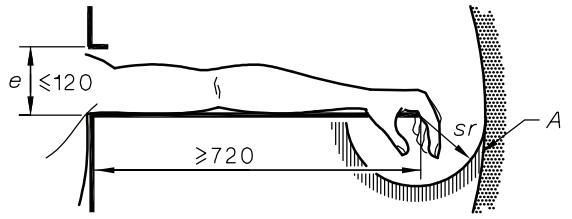
5.4 Reaching round

Table 3 shows fundamental movements for persons of 14 years of age and over (see also Clause 6).

TABLE 3

REACHING AROUND OPENINGS

millimetres

Limitation of movement	Safety distance, (*sr*)	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	

LEGEND:

A = range of the movement of the arm.

e = either the diameter of a round opening, the side of square opening or the width of a slot opening.

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5.5 Reaching through openings

5.5.1 *Regular openings for persons of 14 years of age and above*

Table 4 gives safety distances *sr* for regular openings for persons of 14 years of age and above.

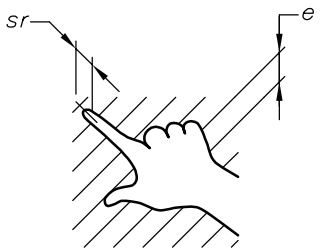
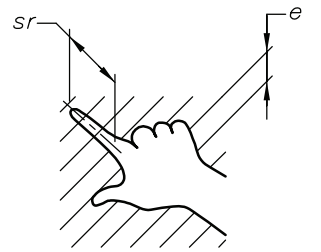
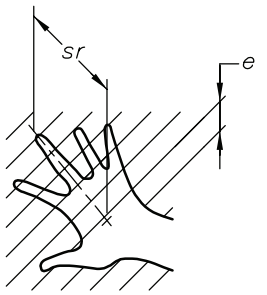
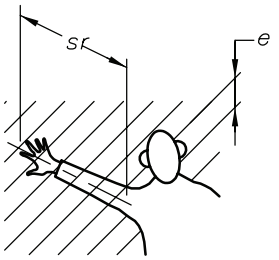
The dimensions of openings *e* correspond to the side of a square opening, the diameter of narrowest dimension of a slot opening.

For openings >120 mm, safety distances in accordance with Clause 5.3 shall be used.

TABLE 4

REACHING THROUGH OPENINGS FOR >14 YEAR OLD

millimetres

Part of body	Illustration	Opening	Safety distance (*sr*)		
			Slot	Square	Round
Finger tip		$e \leq 4$	≥ 2	≥ 2	≥ 2
		$4 < e \leq 6$	≥ 10	≥ 5	≥ 5
Finger up to knuckle joint or hand		$6 < e \leq 8$	≥ 20	≥ 15	≥ 5
		$8 < e \leq 10$	≥ 80	≥ 25	≥ 20
		$10 < e \leq 12$	≥ 100	≥ 80	≥ 80
		$12 < e \leq 20$	≥ 120	≥ 120	≥ 120
		$20 < e \leq 30$	≥ 850 (see note)	≥ 120	≥ 120
Arm up to junction with shoulder		$30 < e \leq 40$	≥ 850	≥ 200	≥ 120
		$40 < e \leq 120$	≥ 850	≥ 850	≥ 850

NOTE: If the length of the slot opening is less than or equal to 65 mm, the thumb will act as a stop and the safety distance can be reduced to 200 mm.

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5.5.2 *Regular openings for persons of 3 years of age and above*

Table 5 considers the smaller dimensions of the thickness of the upper limbs and the behaviour of persons of 3 years of age up to 14 years of age. Persons above 14 years of age are also protected by using this table.

The dimensions of openings *e* correspond to the side of a square opening, the diameter of a round opening and the narrowest dimension of a slot opening.

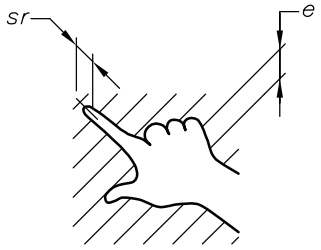
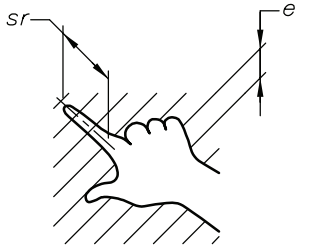
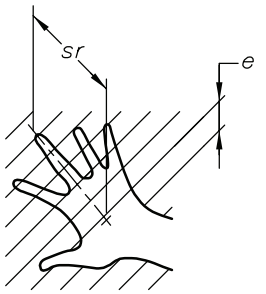
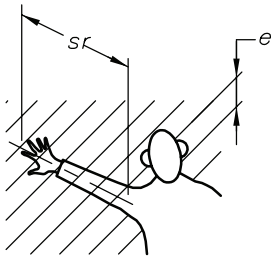
For openings > 100 mm, safety distances in accordance with Clause 5.3 shall be used.

NOTE: Measures for children's protection against strangulation are not the subject of this Standard.

TABLE 5

REACHING THROUGH OPENINGS FOR >3 YEAR OLD

millimetres

Part of body	Illustration	Opening (*e*)	Safety distance (*sr*)		
			Slot	Square	Round
Finger tip		$e \leq 4$	≥ 2	≥ 2	≥ 2
		$4 < e \leq 6$	≥ 20	≥ 10	≥ 10
Finger up to knuckle joint or hand		$6 < e \leq 8$	≥ 40	≥ 30	≥ 20
		$8 < e \leq 10$	≥ 80	≥ 60	≥ 60
		$10 < e \leq 12$	≥ 100	≥ 80	≥ 80
		$12 < e \leq 20$	≥ 900 (see note)	≥ 120	≥ 120
Arm up to junction with shoulder		$20 < e \leq 30$	≥ 900	≥ 550	≥ 120
		$30 < e \leq 100$	≥ 900	≥ 900	≥ 900

NOTE: If the length of the slot opening is ≤ 40 mm, the thumb will act as a stop and the safety distance can be reduced to 120 mm.

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5.5.3 *Irregular openings*

In the case of irregular openings, the following steps shall be carried out:

(a) Determine—

(i) the diameter of the smallest round opening;

(ii) the side of the smallest square opening; and

(iii) the width of the narrowest slot opening;

into which the irregular opening can be completely inserted (see Figure 3).

(b) Select the corresponding three safety distances according to either Table 4 or Table 5.

(c) The shortest safety distance of the three values selected in Item b) may be used.

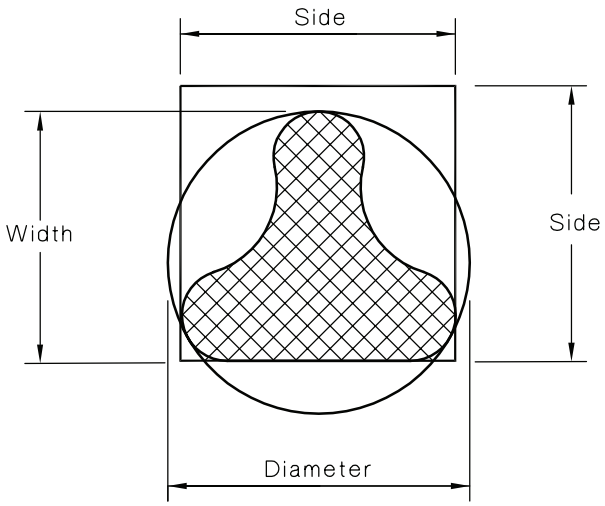

FIGURE 3 REACHING THROUGH IRREGULAR OPENINGS

6 EFFECT OF ADDITIONAL PROTECTIVE STRUCTURES ON SAFETY DISTANCES

In Tables 1, 2, 3 (first illustration), 4 and 5, the protective structures referred to are located in one plane. It should be borne in mind that additional protective structures or surfaces which function as such can reduce the free movement of the arm, the hand or the fingers and can increase the zone where danger points can be admissible.

Examples of how this may be achieved are shown in Tables 3 and 6.

Protective structures and surfaces upon which the arm can rest may be inclined at any angle.

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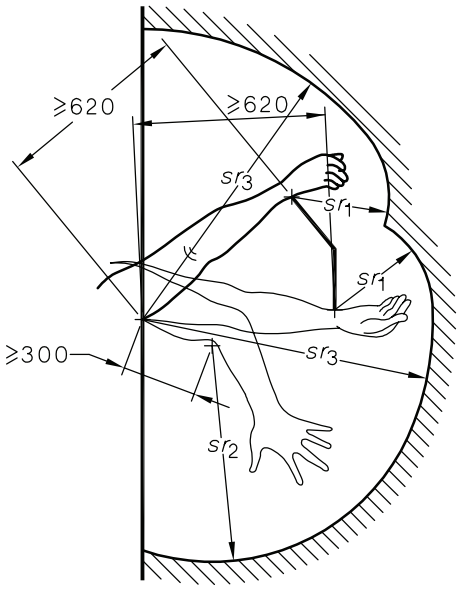
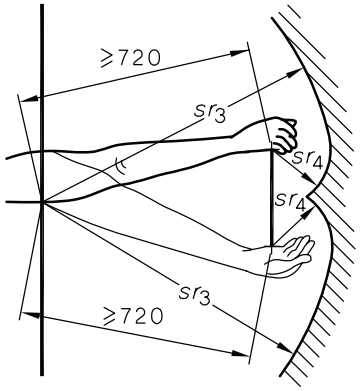
TABLE 6

USE OF ADDITIONAL PROTECTIVE SURFACES TO REDUCE SAFETY DISTANCES

millimetres

Limitation of movement	Safety distance, (*sr*)	Illustration
Limitation of movement at shoulder and armpit: two separate protective structures one permits movements from the wrist the other permits movement from the elbow	$sr_1 \geq 230$ $sr_2 \geq 550$ $sr_3 \geq 850$	
Limitation of movement at shoulder and armpit: one separate protective structure which permits movement from the fingers up to the knuckle joint	$sr_3 \geq 850$ $sr_4 \geq 130$	

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