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Ergonomic design for the safety of machinery —

Part 2: Principles for determining the dimensions required for access openings

Conception ergonomique pour la sécurité des machines —

Partie 2: Principes de détermination des dimensions requises pour les orifices d'accès

Reference number
ISO 15534-2:2000(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 part of ISO 15534 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 15534-2 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 3, *Anthropometry and biomechanics*.

ISO 15534 consists of the following parts, under the general title *Ergonomic design for the safety of machinery* :

— *Part 1: Principles for determining the dimensions required for openings for whole-body access into machinery*

— *Part 2: Principles for determining the dimensions required for access openings*

— *Part 3: Anthropometric data*

Annex A forms a normative part ot this part of ISO 15534. Annexes B and C are for information only.

Introduction

This part of ISO 15534 is one of several ergonomics standards for the safety of machinery.

EN 614-1 ([2] in the Bibliography) describes the principles designers should adopt in order to take account of ergonomic factors. This part of ISO 15534 describes how these principles should be applied to the design of access openings.

This part of ISO 15534 is based on EN 547-2:1996 that was prepared as a harmonized standard conforming with the Machinery Directive and associated European Free Trade Association (EFTA) regulations.

Ergonomic design for the safety of machinery —

Part 2:
Principles for determining the dimensions required for access openings

1 Scope

This part of ISO 15534 specifies the dimensions of openings for access into machinery as defined in ISO/TR 12100-1. It provides the dimensions to which the values given in ISO 15534-3 are applicable. Values for additional space requirements are given in annex A. This part of ISO 15534 has been prepared primarily for non-mobile machinery; there may be additional specific requirements for mobile machinery.

Dimensions for access openings are based on the values for the 95th percentile, whereas reach distances are based on the values for the 5th percentile, in each case the least favourable body dimension of the expected user population being used as a basis. The same considerations apply to the location of access openings.

The anthropometric data given in ISO 15534-3 originate from static measurements of nude persons and do not take into account body movements, clothing, equipment, machinery-operating conditions or environmental conditions.

This part of ISO 15534 shows how to combine the anthropometric data with suitable allowances to take these factors into account.

Situations where people are to be prevented from reaching a hazard are dealt with in ISO 13852.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 15534. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 15534 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO/TR 12100-1:1992, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*. (EN 292-1:1991)

ISO 13852:1996, *Safety of machinery — Safety distances to prevent danger zones being reached by the upper limbs*. (EN 294:1992)

ISO 15534-3:2000, *Ergonomic design for the safety of machinery — Part 3: Anthropometric data*.

3 General requirements

Operations requiring reach through minimum-access openings are likely to be less efficient, less safe and less healthy than working with unrestricted access. Therefore, before installing access openings other options should be considered, e.g. possibility to open machinery, withdrawal of parts for repair. This is particularly important where the task demands frequent access.

When access openings cannot be avoided, the following criteria are of particular significance:

a) ease of access is influenced by

   — the demands of the task, e.g. posture, nature and speed of movement, lines of sight, application of force,

   — the location of the access opening relative to the position of the person, e.g. convenient height above floor, within easy reach, sufficient space outside to allow adoption of a comfortable posture, sufficient space inside to allow performance of the task,

   — frequency and duration of task,

   — whether tools are being carried, e.g. for maintenance or repair purposes,

   — length of access openings, e.g. through a relatively thin wall (wall of a vessel) or through a channel-type opening,

   — whether additional equipment, such as personal protective equipment (including protective clothing), or portable lighting, is being carried or worn,

   — the type of clothing, e.g. light or heavy clothing, bare hands or thick gloves, bare headed or wearing a helmet;

b) environmental conditions (e.g. darkness, heat, noise, moisture);

c) level of risk during the task.

Therefore, in addition to the anthropometric data in each case, allowances shall be provided for the respective opening dimensions and reach distances, taking into account the above criteria.

The applications on how to apply this part of ISO 15534 in practice are contained in annex A, concerning allowances, and in annex B, concerning the position of access openings.

Annex C gives information on the use of symbols for dimensions and anthropometric measurements.

4 Access openings

An access opening is an opening through which a person can lean forward, reach forward, or extend the upper body, (head, arm, hand, a finger or several fingers), leg or foot, to be able to carry out measures during work procedures, such as operating of control actuators, repair duties or monitoring of processes or displays. See Figures 1 to 12.

This part of ISO 15534 does not specify optimum dimensions, but minimum dimensions for the size of the opening and maximum dimensions for reach. Wherever possible, the basic dimensions for the openings should be increased, and the maximum dimensions for reach should be decreased.

	Symbol	Explanation of measurement
4.1 Access opening for the upper body and arms		$A = a_1$ (P95[1)]) + x
	A	Opening diameter
	a_1	Elbow-to-elbow breadth
	x	Allowance

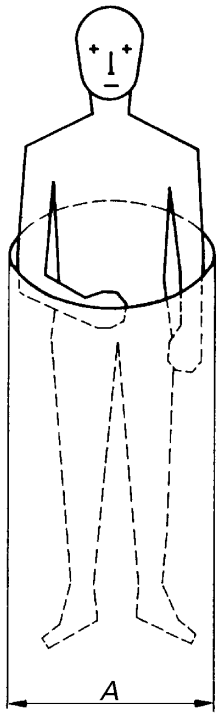
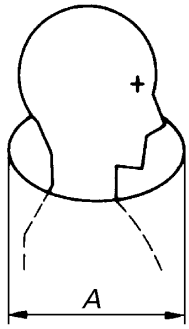
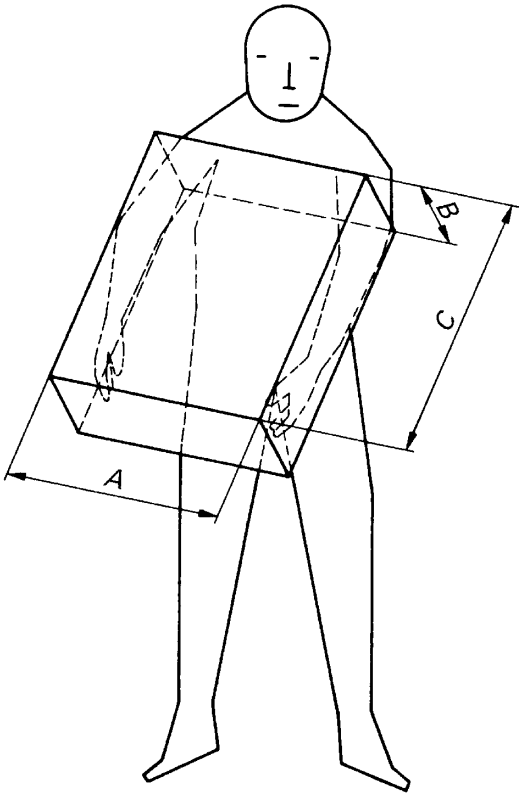


Figure 1

1) P95: 95th percentile of the expected user population.

	Symbol	Explanation of measurement
4.2 Access opening for the head as far as the shoulders for inspection tasks  **Figure 2**		This type of access should be avoided wherever possible $A = c_3$ (P95) + x A Opening diameter c_3 Head length from tip of nose x Allowance
4.3 Access opening for both arms (either forward or downward)  **Figure 3**		$A = a_1$ (P95) + x $B = d_1$ (P95) + y $C = t_1$ (P5) A Opening breadth B Opening width C Opening depth a_1 Elbow-to-elbow breadth d_1 Upper-arm diameter t_1 Operating-arm length x Breadth allowance y Width allowance

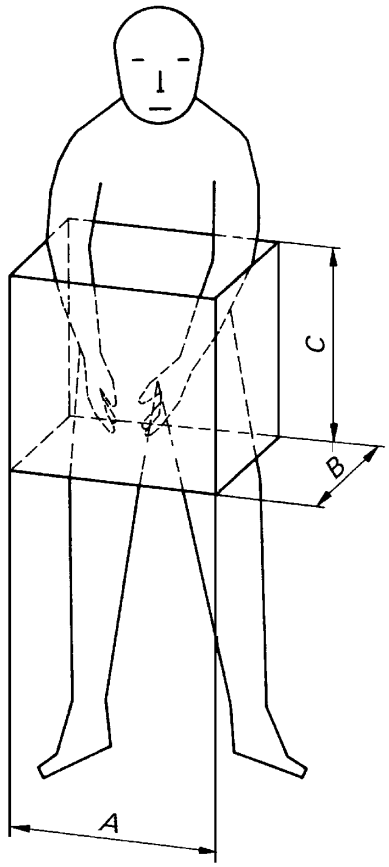
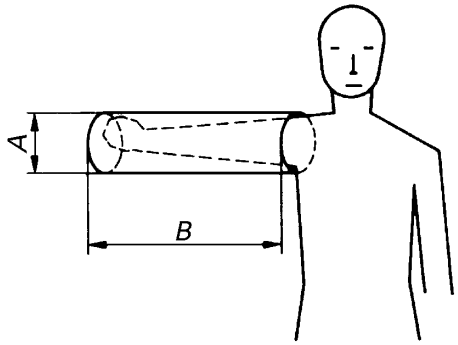
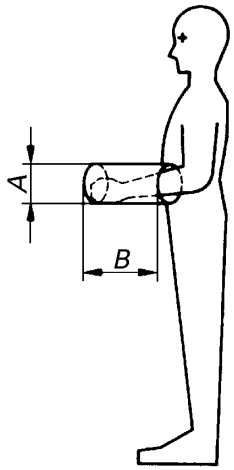
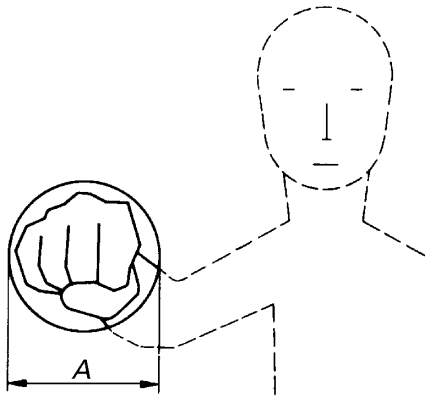
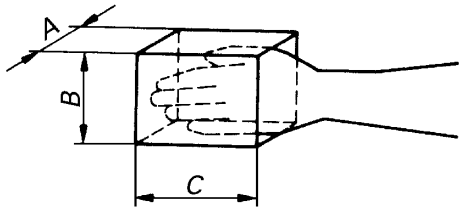
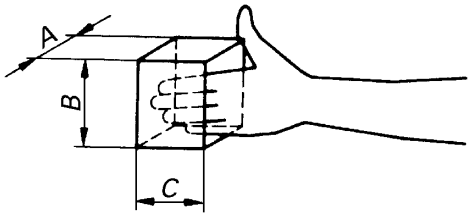
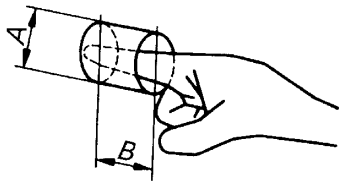
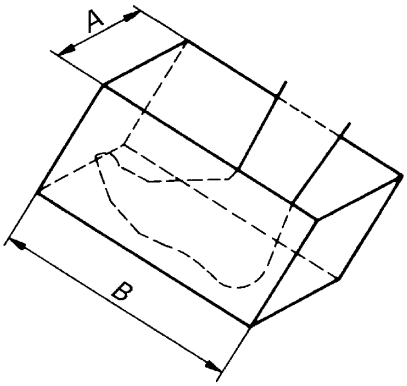
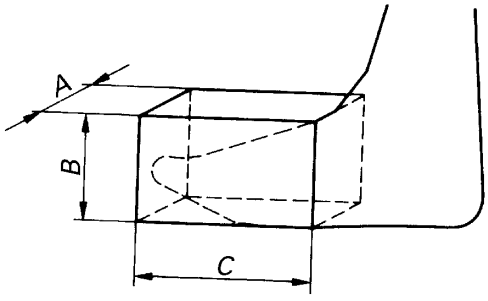
	Symbol	Explanation of measurement
4.4 Access opening for both lower arms up to the elbow (either forward or downward)		$A = 2d_2$ (P95) + x $B = d_2$ (P95) + y $C = t_2$ (P5)
	A	Opening breadth
	B	Opening width
	C	Opening depth
	d_2	Lower-arm diameter
	t_2	Forearm reach
	x	Breadth allowance
	y	Width allowance

Figure 4

	Symbol	Explanation of measurement
4.5 Opening for access to the side for one arm up to shoulder joint  **Figure 5**		$A = d_1$ (P95) + x $B = t_3$ (P5)
	A	Opening diameter
	B	Opening depth
	d_1	Upper-arm diameter
	t_3	Arm reach to the side
	x	Allowance
4.6 Access opening for one lower arm up to the elbow  **Figure 6**		$A = a_3$ (P95) + x $B = t_2$ (P5)
	A	Opening diameter
	B	Opening depth
	a_3	Hand breadth at thumb
	t_2	Forearm reach
	x	Allowance
4.7 Access opening for fist  **Figure 7**		$A = d_3$ (P95) + x
	A	Opening diameter
	d_3	Fist diameter
	x	Allowance

	Symbol	Explanation of measurement
4.8 Access opening for flat hand to wrist, including thumb  **Figure 8**		$A = b_4$ (P95) + x $B = a_3$ (P95) + y $C = t_4$ (P5)
	A	Opening width
	B	Opening height
	C	Opening depth
	a_3	Hand breadth with thumb
	b_4	Hand depth at thumb
	t_4	Hand length
	x	Width allowance
	y	Height allowance
4.9 Access opening for flat hand (four fingers) to base of thumb  **Figure 9**		$A = b_3$ (P95) + x $B = a_4$ (P95) + y $C = t_5$ (P5)
	A	Opening width
	B	Opening height
	C	Opening depth
	a_4	Hand breadth at metacarpals
	b_3	Hand depth at palm
	t_5	Hand length to thumb
	x	Width allowance
	y	Height allowance

	Symbol	Explanation of measurement
4.10 Access opening for index finger, restricted by the other fingers  **Figure 10**		$A = a_5$ (P95) + x $B = t_6$ (P5)
	A	Opening diameter
	B	Opening depth
	a_5	Index finger breadth, proximal
	t_6	Index finger length
	x	Allowance
4.11 Access opening for one foot to ankle bone  **Figure 11**		$A = a_6$ (P95) + x $B = c_2$ (P95) + y
	A	Opening width
	B	Opening length
	a_6	Foot breadth
	c_2	Foot length
	x	Width allowance
	y	Length allowance
4.12 Access opening for forefoot-operated control actuators  **Figure 12**		$A = a_6$ (P95) + x $B = h_8$ (P95) + y $c \leqslant 0{,}74 \times c_2$ (P5)
	A	Opening width
	B	Opening height
	C	Opening length (depth)
	h_8	Ankle height
	a_6	Foot breadth
	c_2	Foot length
	x	Width allowance
	y	Height allowance

Annex A
(normative)

Application of the measurements in practice

A.1 Introduction

The purpose of this annex is to explain how to apply the anthropometric measurements given in this part of ISO 15534 according to ergonomic and safety and health principles.

This part of ISO 15534 describes minimum dimensions for access openings based on anthropometric measurements, i.e. static measurements of nude persons.

The opening dimensions, including allowances, in this part of ISO 15534 do not always take into consideration, for example:

— aspects of health and safety arising from contact with the access opening itself;

— whether the body positions and movements that must be used in the access opening mean any risk to the user's safety and health, e.g. in relation to how often or how long the person has to use the access opening;

— whether the person has to adopt a certain body position in order to meet the force demands of the task without becoming overloaded;

— the space required for transportation of equipment and tools through the access opening;

— the space required for using equipment and tools in the access opening in a proper ergonomic way, e.g. cleaning, repair and maintenance work;

— personal protective equipment the user might wear when reaching through the access opening;

— the speed reduction caused by a space that is too narrow;

— whether the task puts special visual demands on the user;

— any mental load factor, e.g. whether the task must be completed within a specific period of time;

— the space requirements, for entrance to and exit from the access opening.

The design of an access opening that takes ergonomic principles into proper consideration usually leads to more efficient work, which is also of economic benefit. For example, in most cases the operation time increases as the size of the opening decreases or if the opening is given an unsuitable position. Information on suitable positions for access openings is contained in annex B.

A.2 Principles for determining additional space

For each of the openings in this part of ISO 15534, a number of allowances are described in clause A.3 for conditions that need to be taken into consideration when determining the practical size of a specific access opening. Where they are applicable, these conditions determine allowances which shall be added to the anthropometric measurements in order to ensure safety and health while using the access openings. These allowances are not simply additive; some of the conditions overlap. When designing a specific access opening, consideration shall be given to each condition given in clause A.3. A decision has to be made as to which ones are applicable and which ones are the most critical and then an integration of the factors shall be made by an expert, ending with a definite figure on the total allowance required in each direction.

A.3 Additional space requirements for access openings

A.3.1 Access opening for the upper body and arms (see 4.1)

The following allowances shall be added, where appropriate, to the anthropometric measurements given in ISO 15534-3.

Allowance x for

— clearance for entering the access opening ..... 50 mm

— working clothes ..... 20 mm

— heavy winter clothing or personal protective clothing ..... 100 mm

— clothes that will be damaged by contact with the access opening walls ..... 100 mm

— personal protective equipment (excluding breathing apparatus) ..... 100 mm

A.3.2 Access opening for the head as far as the shoulders for inspection tasks (see 4.2)

The following allowance shall be added, where appropriate, to the anthropometric measurements given in ISO 15534-3.

Allowance x for

— clearance for head movement ..... 50 mm

— personal protective equipment (helmet, hearing protectors, safety goggles, respirators) ..... 100 mm

— to avoid touching the access opening, e.g. because of chemicals, dirt, grease ..... 100 mm

A.3.3 Access opening for both arms (see 4.3)

The following allowances shall be added, where appropriate, to the anthropometric measurements given in ISO 15534-3.

Breadth allowance x and width allowance y for

— basic allowance for movement ..... 20 mm

— working clothes ..... 20 mm

— heavy winter clothing or personal protective clothing ..... 100 mm

— clothes that will be damaged by contact with the access-opening walls ..... 100 mm

A.3.4 Access opening for both lower arms up to the elbow (see 4.4)

The following allowances shall be added, where appropriate, to the anthropometric measurements given in ISO 15534-3.

Breadth allowance x and width allowance y for

— basic allowance for movement ..... 120 mm

If any of the conditions mentioned for the allowances in A.3.3 are present, the corresponding allowances from A.3.3 shall be used.

A.3.5 Opening for access to the side for one arm up to shoulder joint (see 4.5)

The following allowances shall be added, where appropriate, to the anthropometric measurements given in ISO 15534-3.

Allowance x:

If any of the conditions mentioned for the allowances in A.3.3 are present, the corresponding allowances from A.3.3 shall be used.

A.3.6 Access opening for one lower arm up to the elbow (see 4.6)

The following allowances shall be added, where appropriate, to the anthropometric measurements given in ISO 15534-3.

Allowance x:

If any of the conditions mentioned for the allowances in A.3.3 are present, the corresponding allowances from A.3.3 shall be used.

A.3.7 Access opening for fist (see 4.7)

The following allowances shall be added, where appropriate, to the anthropometric measurements given in ISO 15534-3.

Allowance x for

— basic allowance for movement ..... 10 mm

— use of hand-protective equipment ..... 20 mm

A.3.8 Access opening for flat hand to wrist, including thumb (see 4.8)

The following allowances shall be added, where appropriate, to the anthropometric measurements given in ISO 15534-3.

Width allowance x and height allowance y:

If any of the conditions mentioned for the allowances in A.3.7 are present, the corresponding allowances from A.3.7 shall be used.

A.3.9 Access opening for flat hand to (four fingers) to base of thumb (see 4.9)

The following allowances shall be added, where appropriate, to the anthropometric measurements given in ISO 15534-3.

Width allowance x and height allowance y:

If any of the conditions mentioned for the allowances in A.3.7 are present, the corresponding allowances from A.3.7 shall be used.

A.3.10 Access opening for index finger, restricted by the other fingers (see 4.10)

The following allowances shall be added, where appropriate, to the anthropometric measurements given in ISO 15534-3.

Allowance x:

If any of the conditions mentioned for the allowances in A.3.7 are present, the corresponding allowances from A.3.7 shall be used.

A.3.11 Access opening for one foot to ankle bone (see 4.11)

The following allowances shall be added, where appropriate, to the anthropometric measurements given in ISO 15534-3.

Width allowance x and length allowance y for

— basic allowance for movement ..... 10 mm

— footwear ..... 30 mm

A.3.12 Access opening for forefoot-operated controls (see 4.12)

The following allowances shall be added, where appropriate, to the anthropometric measurements given in ISO 15534-3.

Width allowance x and length allowance y for

— basic allowance for movement ..... 10 mm

— footwear ..... 40 mm

Annex B
(informative)

Position of access openings

B.1 Introduction

This annex gives information on the position of access openings to facilitate access for the intended user population.

B.2 Provision for adjustability

In some cases, access can only be ensured by provision of a supporting surface that can be changed in height to accommodate people of differing anthropometric dimensions. In certain figures in clause B.3, the symbol shown in Figure B.1 is used to indicate that changes in height of the supporting surface (e.g. platforms, steps) are required. The height of the symbol represents the difference in stature between the 5th percentile (small person) and the 95th percentile (tall person), and therefore covers the range of positions of the supporting surface to be provided.

For allowances for footwear, clothing, etc. see annex A.

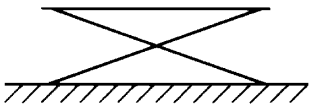


Figure B.1

B.3 Conditions to be met with in location of access openings

B.3.1 Dimensions

In figures B.2 to B.16, all dimensions are in millimetres.

B.3.2 Access opening for the upper body and arms (see 4.1)

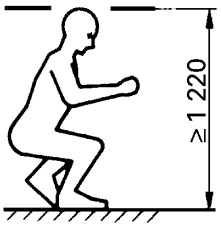


Figure B.2

Sufficient space should be allowed underneath the access opening. For access openings of the minimum size given in 4.1, this should accommodate a tall person crouching. Increase in the size of the access opening will allow the space underneath it to be reduced but it should not be less than that given in 4.5 of ISO 15534-1.

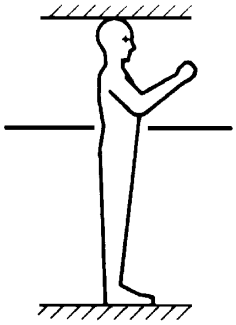


Figure B.3

Sufficient space to accommodate a tall person standing upright should be calculated according to clause 4.1 of ISO 15534-1.

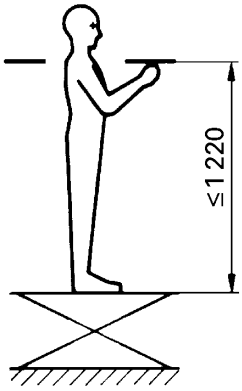


Figure B.4

For monitoring tasks, the height of the access opening above the supporting surface should be less than or equal to the shoulder height of a small person standing upright.

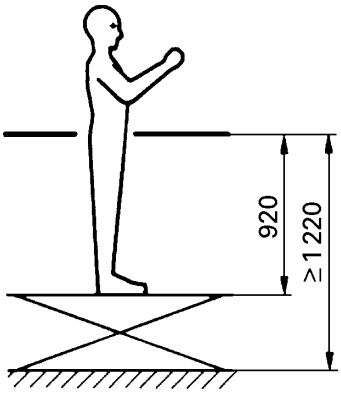
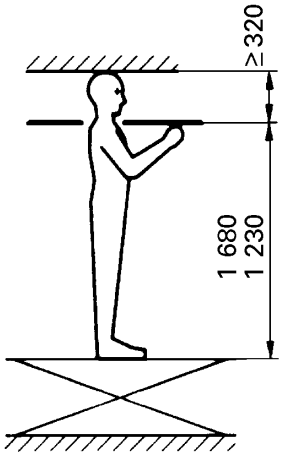


Figure B.5

If the task to be undertaken through the opening requires the use of the arms, the opening should be below the elbow of the person carrying out the task when standing upright. It will not be possible to meet the space requirements given above by provision of a single fixed supporting surface.

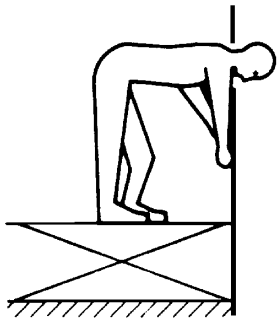
The items to be handled should be within reach of a small person.

B.3.3 Access opening for the head as far as the shoulders for inspection tasks (see 4.2)



Sufficient space should be allowed on the inside of the access opening to accommodate the head as far as the shoulders.

Figure B.6



When this type of access opening is situated in a vertical surface, it will only be possible for persons to look forward, downward and sideways. In this case, provision for a carefully positioned supporting surface and hand-holds is essential, and the work should be only of short duration.

Entry into an access opening for the head only may cause distress. For this reason, where frequent access would be necessary, it is recommended that other means be provided for carrying out the tasks, e.g. video monitoring.

Figure B.7

B.3.4 Access opening for both arms (either forward or downward) (see 4.3)

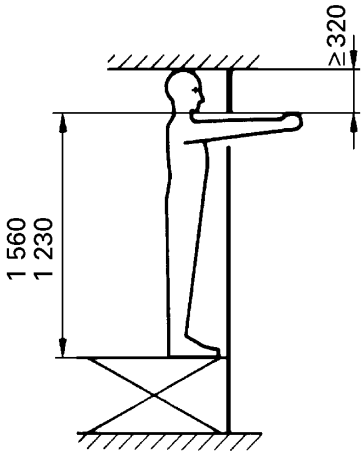


Figure B.8

For access openings in vertical surfaces, the dimensions in this part of ISO 15534 apply only to access openings located at shoulder height with the body in an upright posture.

This posture can only be maintained if the height of the supporting surface can be adjusted, e.g. by providing platforms, steps, etc.

Where such changes in the supporting surface are not possible, the dimensions of the access openings should be increased or the reach distance should be reduced.

The required field of vision should be maintained, e.g. by providing windows.

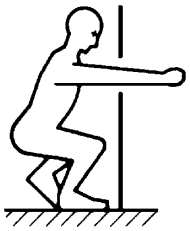


Figure B.9

Where access openings in vertical surfaces are to be used from a crouching posture, and where increased space for the operator's knees is not provided, the effective operating-arm length will be reduced by 30 %. Since maintaining this position necessitates a stressful posture, such uses should only be required infrequently and for a short duration.

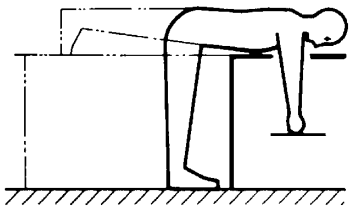


Figure B.10

Where access openings are in a horizontal surface for downward entry, space should be allowed for outside the openings for the operator's body. This posture causes stress unless the body is supported.

If the distance from the opening to the farthest point to be reached is greater than the operating-arm length t_1, the dimensions of the opening should be increased to allow entry of the upper body.

B.3.5 Access opening for both lower arms up to the elbow (either forward or downward) (see 4.4)

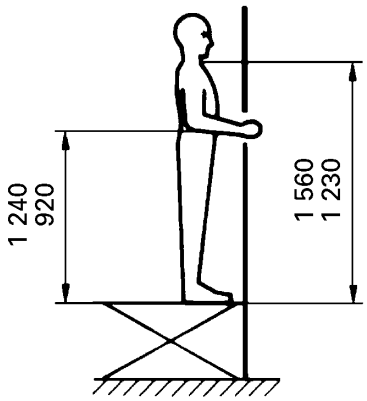


Figure B.11

For access openings in vertical surfaces, the dimensions in this part of ISO 15534 apply only to access openings located between shoulder and elbow height with the body in an upright posture.

This posture can only be maintained if the height of the supporting surface can be changed, for example, by providing seats, platforms, steps, etc.

Where such changes to the supporting surface are not possible, the dimensions of the access openings should be increased and/or the reach distance should be reduced.

The required field of vision should be maintained, e.g. by providing windows.

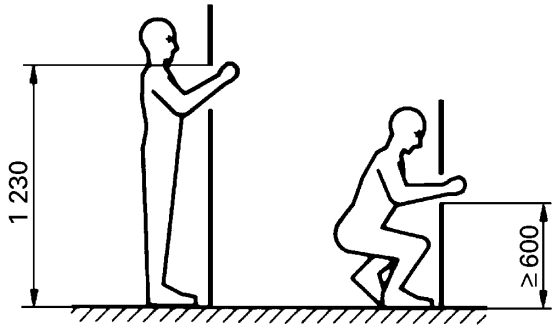


Figure B.12

Only where access is infrequent and of short duration, the access opening may be located between the shoulder height of a small person standing upright, and the elbow height of a tall person crouching.

B.3.6 Opening for access to the side for one arm up to the shoulder joint (see 4.5)

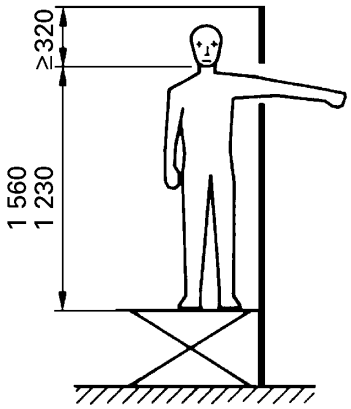


Figure B.13

For access openings in vertical surfaces, the dimensions in this part of ISO 15534 apply to access openings located at shoulder height with the body in an upright posture.

This posture can only be maintained if the height of the supporting surface can be changed, for example, by providing platforms, steps, etc.

Where such changes are not possible, the dimension A should be increased and/or the reach-distance dimension B should be decreased.

The required field of vision should be maintained, e.g. by providing windows.

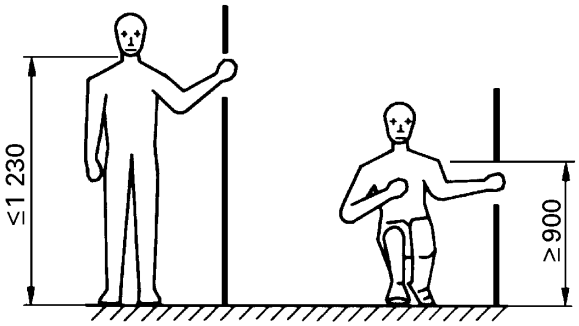


Figure B.14

Only where access is infrequent and of short duration, the access opening can be located between the shoulder height of a small person standing upright, and the shoulder height of a tall person crouching.

B.3.7 Access opening for one lower arm up to the elbow (see 4.6)

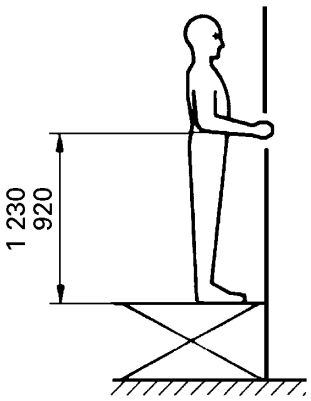


Figure B.15

For access openings in vertical surfaces, the dimensions in this part of ISO 15534 apply to access openings located between shoulder height and elbow height with the body in an upright posture.

This posture can only be maintained if the height of the supporting surface can be changed, for example, by providing platforms, steps, etc.

Where such changes are not possible, the dimension A should be increased and/or the reach distance dimension B should be decreased.

The required field of vision should be maintained, e.g. by providing windows.

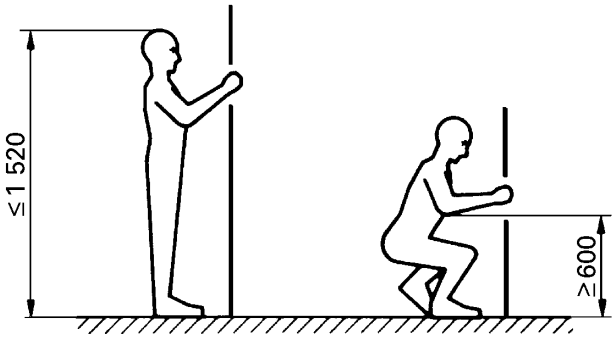


Figure B.16

Only where access is infrequent and of short duration, the access opening can be located between the body height of a small person standing upright, and the elbow height of a tall person crouching.

B.3.8 Access opening for fist (see 4.7)

The access opening should be within easy reach of the operator with the body in an upright posture.

For infrequent and short-duration use, it will not normally be necessary for the operator to maintain an upright posture and the access opening may be placed farther away as long as it remains within reach.

For further information see B.3.7.

B.3.9 Access opening for flat hand to wrist, including thumb (see 4.8)

See B.3.8.

B.3.10 Access opening for flat hand (four fingers) to base of thumb (see 4.9)

See B.3.8.

B.3.11 Access opening for index finger, restricted by the other fingers (see 4.10)

See B.3.8.

B.3.12 Access opening for one foot to ankle bone (see 4.11)

The access opening should be on the same level as the supporting surface of the feet. Otherwise, additional body support should be provided.

B.3.13 Access opening for forefoot-operated control actuators (see 4.12)

See B.3.12.

Annex C
(informative)

Symbols for dimensions and anthropometric body measurements

The purpose of this annex is to explain the use of symbols for dimensions and anthropometric body measurements in this part of ISO 15534.

The size of passages, access openings and other physical dimensions is calculated by a formula determined for each dimension considering the relevant anthropometric measurement and one or more allowances.

The physical dimensions are shown in Figures 1 to 12 and are denoted by the capital letters A, B and C. The letters are used in order in each figure. The meaning need not be the same from figure to figure. Indices (subscripts) are used when needed.

The terms height, breadth, width and depth are used to help to differentiate between the opening dimensions. It should be noted that these terms may not be strictly appropriate in certain geometrical orientations of an opening.

Allowances and body measurements are not indicated in Figures 1 to 12.

Anthropometric measurements are denoted by lower-case letters with indices. For allowances, the lower-case letters x and y are used.

The letters denoting the anthropometric body measurements have the following general meaning:

- h height of whole body or part of body
- a breadth of trunk including arms and shoulders, etc., breadth of body part
- b depth of body or body part; in one case used for forward reach
- c length of body part or segment
- d diameter of body part having an approximately circular cross-section
- t functional reach or extension of body part

The indices (subscripts) are used in order with no particular meaning attached, with the following exception. When a measure is taken in both the standing and sitting posture, the index for the measurement in the standing posture is a one-digit number, the index for the corresponding measurement in the sitting posture is 10 higher.

When a specific percentile of the body measurement is referred to, this is denoted by the actual percent figure preceeded by the letter “P” within brackets after the index.

The anthropometric measurements are defined in the ISO 7250:1996. The corresponding European Standard is EN ISO 7250:1997. Values for the measurements are given in ISO 15534-3.

The symbols for the anthropometric measurements used in this part of ISO 15534 are listed in Table C.1. The index numbers are not consecutive since not all the defined anthropometric measurements are used in this part of ISO 15534.

Table C.1 — Symbols and definitions of anthropometric measurements in this part of ISO 15534

Symbol	Explanation	Definition see ISO 7250:1996 [a], subclause	Use See this part of ISO 15534, subclause
h_8	Ankle height	—	4.12
a_1	Elbow-to-elbow breadth	4.2.10	4.1, 4.3
a_3	Hand breadth with thumb	—	4.6, 4.8
a_4	Hand breadth at metacarpals	4.3.3	4.9
a_5	Index finger breadth, proximal	4.3.5	4.10
a_6	Foot breadth	4.3.8	4.11, 4.12
b_3	Hand depth at palm	—	4.9
b_4	Hand depth at thumb	—	4.8
c_2	Foot length	4.3.7	4.11, 4.12
c_3	Head length from tip of nose	—	4.2
d_1	Upper-arm diameter	—	4.3, 4.5
d_2	Lower-arm diameter	—	4.4
d_3	Fist diameter	—	4.7
t_1	Operating-arm length	—	4.3
t_2	Forearm reach	—	4.4, 4.6
t_3	Arm reach to the side	—	4.5
t_4	Hand length	4.3.1	4.8
t_5	Hand length to thumb	—	4.9
t_6	Index finger length	4.3.4	4.10

[a] The number in EN ISO 7250 is the same.

Bibliography

[1] ISO 7250:1996, *Basic human body measurements for technological design*. (EN ISO 7250:1997)

[2] EN 614-1:1995, *Safety of machinery — Ergonomic design principles — Part 1: Terminology and general principles*.

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