INTERNATIONAL STANDARD

ISO 20349

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Personal protective equipment — Footwear protecting against thermal risks and molten metal splashes as found in foundries and welding — Requirements and test method

Équipement de protection individuelle — Chaussures de protection contre les risques thermiques et les projections de métal fondu comme rencontrés dans les fonderies et lors d'opérations de soudage — Exigences et méthode d'essai

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

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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 20349 was prepared by the European Committee for Standardization (CEN) Technical Committee ISO/TC 161, *Foot and leg protectors in equipment*, in collaboration with ISO Technical Committee ISO/TC 94 *Personal safety — Protective clothing and equipment*, Subcommittee SC 3, *Foot protection*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Personal protective equipment — Footwear protecting against thermal risks and molten metal splashes as found in foundries and welding — Requirements and test method

WARNING — This International Standard calls for the use of substances and/or procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

1 Scope

This International Standard specifies requirements and test methods for footwear protecting users against thermal risks and molten iron or aluminium metal splashes such as those encountered in foundries, welding and allied process.

Footwear complying with this International Standard also offers other protection as defined in ISO 20345.

NOTE Gaiters, over boot and clothing intended to provide protection to the feet and legs against molten metal are addressed by ISO 11611 and ISO 11612.

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 7000:2004, *Graphical symbols for use on equipment — Index and synopsis*

ISO 9185:2007, *Protective clothing — Assessment of resistance of materials to molten metal splash*

ISO 15025:2000, *Protective clothing — Protection against heat and flame — Method of test for limited flame spread*

ISO 17227:2002, *Leather — Physical and mechanical tests — Determination of dry heat resistance of leather*

ISO 20344:2004/Amd.1:2007, *Personal protective equipment — Test methods for footwear — Amendment 1*

ISO 20345:2004/Amd.1:2007, *Personal protective equipment — Safety footwear — Amendment 1*

EN 348, *Protective clothing — Test method: Determination of behaviour of materials on impact of small splashes of molten metal*

EN 702, *Protective clothing — Protection against heat and flame — Test method: Determination of the contact heat transmission through protective clothing or its materials*

3 Terms and definitions

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

3.1
large molten metal splash
large projections of molten metal such as found in foundries

3.2
small molten metal splash
small splashes of molten metal as produced during welding operations and allied processes

4 Requirements

Footwear shall be classified in accordance with Table 1.

Table 1 — Classification of footwear

Code designation	Classification
I	Footwear made from leather and other materials, excluding all-rubber or all-polymeric footwear
II	All-rubber (i.e. entirely vulcanized) or all-polymeric (i.e. entirely moulded) footwear

Footwear shall conform to the requirements specified in Table 2. Assessment and testing shall be carried out on three samples of the footwear, one of the smallest, one of the middle and one of the largest size of the manufactured size range.

Table 2 — Performance requirements

Requirements		Standard clause		Foundry footwear	Welding footwear	
		ISO 20345	ISO 20349	Class I	Class I	Class II
Design	Height of upper		5.1	X	X	X
	Seat region	5.2.2		X	X	X
Whole footwear	Sole performance:	5.3.1				
	Construction	5.3.1.1		X	X	
	Upper/outsole bond strength	5.3.1.2		X	X	
	Toe protection:	5.3.2				
	General	5.3.2.1		X	X	X
	Internal length	5.3.2.2		X	X	X
	Impact resistance	5.3.2.3		X	X	X
	Compression resistance	5.3.2.4		X	X	X
	Behaviour of toecaps	5.3.2.5		X	X	X
	Leak-proofness	5.3.3				X
	Specific ergonomic features		5.2	X		
		5.3.4			X	X
	Slip resistance	Amd.1:2007 Annex A				
	Slip resistance on tile floor ceramic with SLS ▲[a]					
	Slip resistance on steel floor with glycerol ▲[b]			X	X	X
	Slip resistance on ceramic tile floor with SLS and on steel floor with glycerol ▲[c]					

Table 2 (*continued*)

Requirements		Standard clause		Foundry footwear	Welding footwear	
		ISO 20345	ISO 20349	Class I	Class I	Class II
Whole footwear	Penetration resistance (P)	6.2.1		*	*	*
	Conductive footwear (C)	6.2.2.1		not allowed		
	Antistatic footwear (A)	6.2.2.2		*	*	*
	Electrically insulating footwear (I)	6.2.2.3		*	*	*
	Cold insulation of sole complex (CI)	6.2.3.2		*	*	*
	Energy absorption of seat region (E)	6.2.4		*	*	*
	Water resistance (WR)	6.2.5		*	*	
	Metatarsal protection (M)	6.2.6		*	*	*
	Ankle protection (AN)	6.2.7		*	*	*
	Resistance to effects of molten metal (Fe or Al)		5.3	X		
	Molten metal splashes (WG)		5.4	*	X	X
	Resistance of upper to contact heat transmission		5.5	X		
	Burning behaviour of upper material		5.6	X	X	X
	Heat insulation of sole complex (HI1 or HI3)		5.7	X	*	*
Upper (all parts)	Design		5.1	X	X	X
	General	5.4.1		X	X	X
	Thickness	5.4.2				X
	Tear strength	5.4.3		X	X	
	Tensile properties	5.4.4		X	X	X
	Flexing resistance	5.4.5				X
	Water vapour permeability and coefficient	5.4.6		X	X	
	pH value	5.4.7		X	X	
	Hydrolysis	5.4.8				X
	Chromium VI content	5.4.9		X	X	
	Water penetration and water absorption (WRU)	6.3.1		X	X	
	Cut resistance (CR)	6.3.3		*	*	*
	Surface shrinkage		5.8	X		
Insole/ insock		Table 3		X	X	O

Table 2 (*continued*)

Requirements		Standard clause		Foundry footwear	Welding footwear	
		ISO 20345	ISO 20349	Class I	Class I	Class II
Vamp lining	Tear strength	5.5.1		X	X	O
	Abrasion resistance	5.5.2		X	X	O
	Water vapour permeability and coefficient	5.5.3		X	X	O
	pH value	5.5.4		X	X	O
	Chromium VI content	5.5.5		X	X	O
Quarter lining	Tear strength	5.5.1		O	O	O
	Abrasion resistance	5.5.2		O	O	O
	Water vapour permeability and coefficient	5.5.3		O	O	O
	pH value	5.5.4		O	O	O
	Chromium VI content	5.5.5		O	O	O
Tongue	Tear strength	5.6.1		O	O	
	pH value	5.6.2		O	O	
	Chromium VI content	5.6.3		O	O	
Outsole	Thickness of non-cleated outsoles	5.8.1		X	X	X
	Cleated area	6.4.1		*	*	*
	Thickness of cleated outsoles	6.4.2		*	*	*
	Cleat height	6.4.3		*	*	*
	Tear strength	5.8.2		X	X	X
	Abrasion resistance	5.8.3		X	X	X
	Flexing resistance	5.8.4		X	X	X
	Hydrolysis	5.8.5		O	O	O
	Interlayer bond strength	5.8.6		O	O	O
	Resistance to fuel oil (FO)	5.8.7		X	X	X
	Resistance to hot contact (HRO)	6.4.4		*	*	*

The applicability of a requirement to a particular classification is indicated in this table by the following.

X The requirement shall be met. In some cases the requirement relates only to particular materials within the classification - e.g. pH value of leather components. This does not mean that other materials are precluded from use.

O If the component part exists, the requirement shall be met.

* Means that if the property is claimed, the requirement given in the appropriate clause shall be met.

The absence of X or O indicates that there is no requirement.

▲ Means that it is mandatory that one of the three slip resistance requirements shall be chosen.

[a] Marking symbol “SRA”.

[b] Marking symbol “SRB”.

[c] Marking symbol “SRC”.

5 Specific requirements

5.1 Footwear design

The requirements given in Table 3 shall be fulfilled.

Table 3 — Performance requirements for upper design

Requirements	Foundry footwear	Welding footwear
Height of upper (when tested in accordance with ISO 20345:2004, 5.2.1)	⩾design C	⩾design B
There shall be no features on the outer surface of the footwear that could trap molten metal.	X	X
All seams shall have an overlap of ⩾10 mm.	X	
With the exception of the seam around the counter, no seams shall be upward facing.	X	X
The vamp shall comprise a single piece.	X	X
All metal fittings (e.g. buckles or rivets) on the exterior surface of the footwear shall be covered or coated.	X	
The top of the boot shall be fitted with a feature to permit adjustment to give a close fit to the wearer's leg.	X	

5.2 Ergonomic performance and compatibility

When the footwear is assessed in accordance with Annex B, the following requirements shall be met.

a) It shall be possible for the top of the boot to be adjusted to give a snug fit against the leg.

b) The footwear shall remain in place during the activities listed in B.2.3.

c) The removal time shall be <5 s.

d) There shall be no “NO” answers.

5.3 Resistance to the effects of molten metal

Testing shall be carried out in accordance with Annex A and the results shall be as follows.

a) There shall be no penetration of molten metal to inner surface within 10 s of start of pouring.

b) After-flame time shall be ⩽ 5 s after cessation of pouring.

c) No melting or ignition of inner surface.

d) No metal shall stick to the surface of the footwear.

5.4 Small molten metal splash test

Testing shall be carried out in accordance with the procedure described in EN 348.

The whole upper assembly shall be tested, 4 samples shall be taken and these shall be from different items of footwear.

The number of droplets required to produce a temperature rise of 40 °C shall be at least 25.

5.5 Resistance of upper to contact heat transmission

Testing shall be carried out in accordance with the procedure described in EN 702 with a contact temperature of 500 °C.

The threshold time shall be $\geqslant$6 s and there shall be no melting of the inner surface.

5.6 Burning behaviour of upper material

Testing shall be carried out in accordance with Annex C.

After-flame time shall be $\leqslant$2 s and the afterglow time shall be $\leqslant$5 s. The upper shall not form holes and the inner surface of the lining shall not melt.

5.7 Heat insulation of sole complex

The footwear shall meet one of the requirements detailed below. Testing shall be carried out in accordance with the procedure described in 5.12 of ISO 20344:2004 with the following modifications:

a) Sand bath temperature 150 °C, exposure time of 30 min.

   The temperature inside the footwear shall be $\leqslant$42 °C; Marking code HI-1.

b) Sand bath temperature of 250 °C, exposure time of 40 min.

   The temperature inside the footwear shall be $\leqslant$42 °C; Marking code HI-3.

5.8 Surface shrinkage of leather

Testing shall be carried out in accordance with ISO 17227:2002, 7.6. The test temperature should be 180 °C $\pm$ 5 °C and the testing time 5 min $\pm$ 10 s.

The area dimensional change shall not be more than 10 %.

6 Marking

Each item of footwear shall be clearly and permanently marked with at least the following information:

a) the name or trademark of the manufacturer;

b) a product code that uniquely identifies the footwear;

c) the size of the footwear;

d) the number and date of this International Standard (i.e. ISO 20349:2010); note that d) and e) should be adjacent to each other, as specified in ISO 20345:2004;

e) all the marking codes given in ISO 20345:2004 may be applied when the relevant tests have been passed and in conformance with those found in Table 2, as applicable, the following marking shall be used:

   — Al indicates the footwear complies with 5.3, using aluminium as test metal,

   — Fe indicates the footwear complies with 5.3, using iron as test metal,

   — WG indicates that the footwear complies with the requirements defined for welding footwear;

f) the symbol ISO 7000-2417 shown in Figure 1 indicating the protection against heat and flame;

g) an instruction to refer to the instructions for use provided with the item, such as the symbol indicating that the user should see the information supplied by the manufacturer (a letter “i” in an open book; see symbol ISO 7000-1641, see Figure 2).

Figure 1 — Symbol ISO 7000-2417 to indicate clothing for protection against heat and flame

Figure 2 — Symbol ISO 7000-1641 information pictogram

7 Information to be supplied by the manufacturer

The footwear shall be supplied with the information specified in ISO 20345:2004, Clause 8, and the following information and instructions, in at least the official language of the country of destination:

a) the information specified in Clause 6 of this International Standard, as applicable;

b) the following instructions:

   1) “The compatibility of this footwear with other items of PPE (trousers or gaiters) shall be checked to avoid the occurrence of any risk during use.”

   2) “Do not use these boots if they are contaminated with flammable materials such as oil.”

   3) “Always carefully inspect the boots before use for signs of damage, see below for guidance. Never use damaged footwear.”

c) the following damage assessment guidelines:

   1) boots should be discarded if any of the following are discovered:

      i) beginning of a pronounced and deep cracking affecting half the upper material thickness [see Figure 3a)];

      ii) the upper shows areas with deformations, burns, fusion or bubbles, or split seams in the leg [see Figure 3b)];

      iii) the outsole shows cracks higher than 10 mm long and 5 mm wide (deep) [see Figure 3c)];

      iv) upper/outsole separation of more than 15 mm long and 5 mm wide (deep) [see Figure 3d)];

      v) cleat height in the flexing area lower than 1,5 mm [see Figure 3e)];

      vi) original in-sock (if any) showing pronounced deformation and crushing.

NOTE It is convenient to manually check the inside of the footwear from time to time in order to detect any deterioration of the lining or sharp borders of the toe protection which could cause wounds [see Figure 3 f)].

Dimensions in millimetres

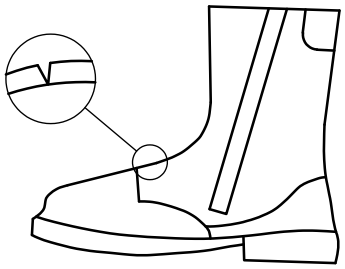


Figure 3 a)

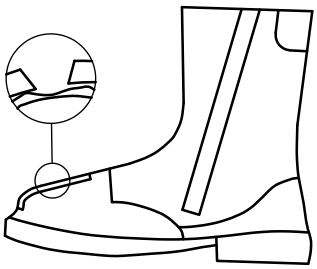


Figure 3 b)

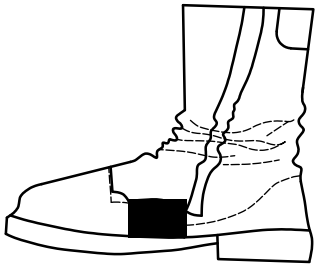


Figure 3 c)

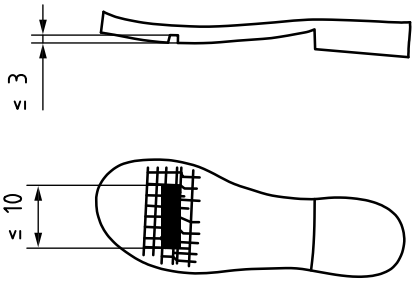


Figure 3 d)

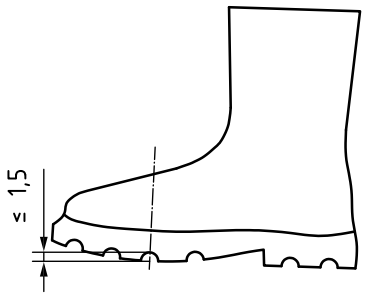


Figure 3 e)

Figure 3 f)

Figure 3 — Damage assessment guidelines

Annex A
(normative)

Test method for the resistance of footwear to the effects of large quantities of molten metal

WARNING — Suitable protective clothing should be worn when carrying out this test, particularly when removing a test sample from the leg form as there could be flaming due to lodgement of molten metal on the test sample. Removal of the test sample from the leg form is normally sufficient to dislodge any adhering metal.

A.1 Principle

A quantity of molten metal is poured under controlled conditions onto a test sample fitted to a leg form and observations are made during and after pouring. Iron or aluminium can be selected.

A.2 Materials

A.2.1 Molten iron, with a pouring temperature (1 400 ± 50) °C (for the composition of the metal, see ISO 9185:2007, Table A.1).

A.2.2 Molten aluminium, with a pouring temperature (780 ± 50) °C (for the composition of the metal, see ISO 9185:2007, Table A.1).

A.3 Apparatus (see Figure A.1)

A.3.1 Leg form, to hold the test sample (see Figure A.2).

A.3.2 Chute, constructed from refractory brick hollowed out to form a channel.

A.3.3 Ladle, of sufficient capacity to hold 500 cm^3 of molten metal with a mark indicating (360 ± 50) cm^3 filling level.

A.3.4 Cradle, to support the ladle (A.3.3) over the chute (A.3.2) and enable it to be tipped to pour out the molten metal.

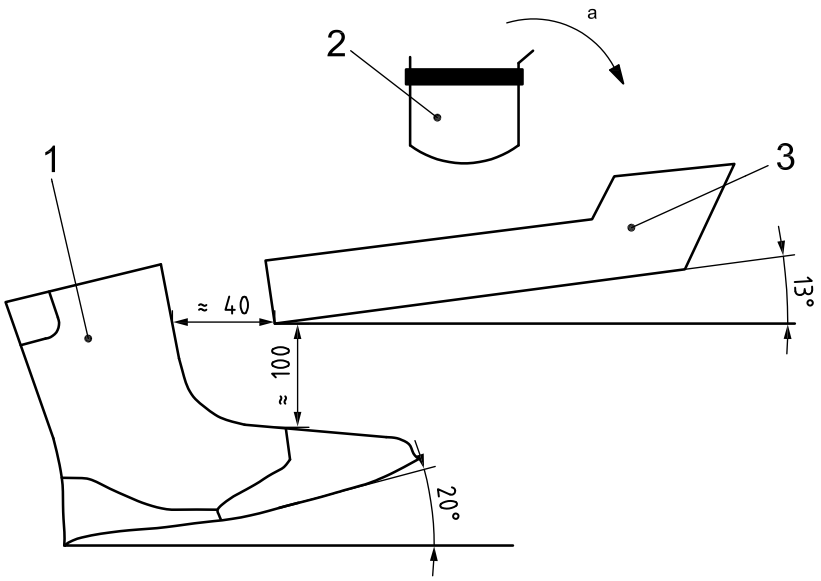
NOTE The machine specified in ISO 9185:2007 is an example of a laboratory device that could be used to heat the metals.

A.4 Test samples

The test samples shall consist of complete footwear (one of each of the 3 sizes, see Clause 4).

Footwear shall be prepared for fitting to the leg form (A.3.1) by removing the sole at the feather edge and cutting longitudinally down the back.

Dimensions in millimetres



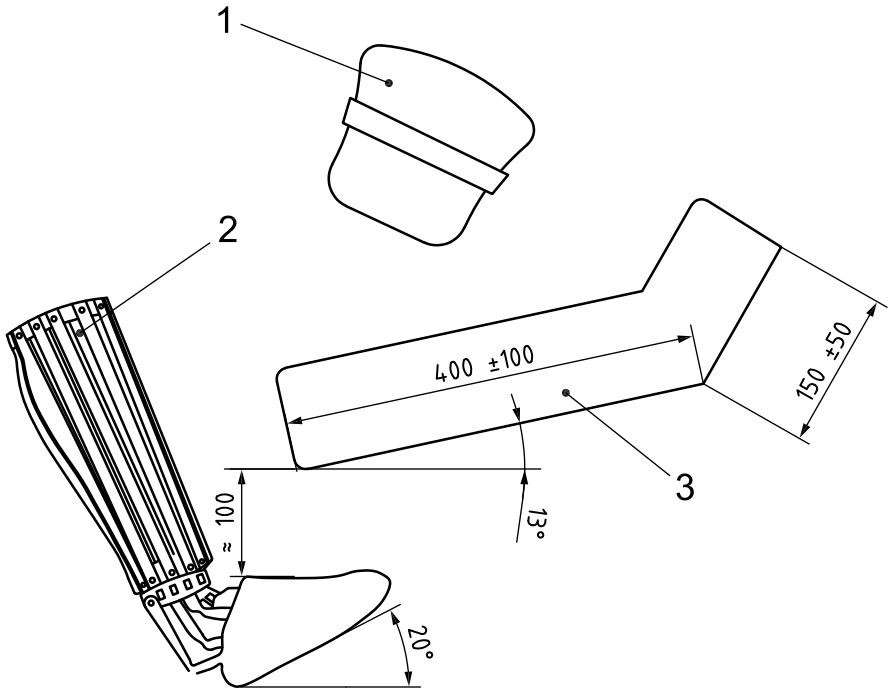
Key

a Direction of pour.

1 sample boot
2 ladle
3 chute

Figure A.1 — Example of test configuration

Dimensions in millimetres



Key

1 crucible 2 leg form 3 chute

Figure A.2 — Example leg form

A.5 Marking of test samples

A test point shall be marked on the footwear at the centre of the front at the joint between the foot section and leg section (i.e. defined as the point on the instep at which a straight edge placed at 45^{o} to the vertical would be normal to the surface of the footwear). On each test sample, a vertical line shall be drawn through the test point.

A.6 Procedure

Place the test sample on the leg form which is held at an angle of 20° to the vertical. Position the lower end of the chute (A.3.2), inclined at about 13° to the horizontal, approximately 100 mm above the test point on the test sample and approximately 40 mm away from the vertical line through the test point.

Place the pre-heated ladle (A.3.3) containing $(360 \pm 50)\ cm^3$ of molten metal (A.2.1 or A.2.2) in the cradle (A.3.4) over the chute and tip it so that the metal falls at a steady rate, impinging on the test sample just above the test point. Complete the pouring of the metal within (4 ± 1) s.

Immediately upon completion of pouring, carefully remove the test sample from the leg form. The examination of the footwear shall take place (6 ± 1) s after completion of pouring. Examine the test sample, then measure and record the following:

a) after-flame time measured from the cessation of pouring;

b) any penetration of metal to the inner surface of the test sample within 10 s of the start of pouring;

c) any signs of melting or ignition of the inner surface of the test sample;

d) any metal stuck to the surface of the footwear.

If required, repeat the test on a new test sample using the other metal (A.2.1 or A.2.2).

A.7 Test report

The following information shall be recorded in the test report:

a) the metal used for the test; the composition of the iron and/or aluminium used in test shall be given;

b) any penetration of metal to the inner surface of the test sample within 10 s of the start of pouring;

c) whether flaming continued for longer than 5 s after pouring had ceased;

d) whether the inner surface of the test sample showed signs of melting or ignition.

Annex B
(normative)

Assessment of ergonomic performance and compatibility of footwear

B.1 Test subjects

Test subjects shall be selected whose feet require footwear between half a size below and half a size above the size marked on the footwear to be assessed (see B.2).

The test subjects selected do not need to be experienced foundry workers but shall be capable of performing the activities listed in B.2.3 while wearing their own footwear.

Each type and size of footwear submitted for testing shall be assessed by one test subject. At least 3 different sizes shall be tested.

B.2 Procedure

B.2.1 Pre-donning assessment

Before donning the footwear the test subject shall examine them and respond to the following question.

1	Is the inner surface of the footwear free from rough, sharp or hard areas or features that might cause excessive irritation or injury to the wearer? This assessment shall be made by hand.	YES	NO

If the answer to Question 1 is “NO”, the assessment shall be stopped at this point and the footwear under test shall be deemed to have failed the assessment.

B.2.2 Donning

The test subject shall don the footwear and respond to the following questions.

NOTE Once the footwear has been put on, it is permissible for the test subject to “wear in” the footwear for a short time to overcome any initial fitting problems before proceeding with the rest of the assessment.

2	Is it easy to operate the fasteners and/or adjusters?	YES	NO
3	When fitted, is the footwear correctly positioned and is it possible to adjust the length of the top of the boot to fit comfortably against the leg?	YES	NO

B.2.3 Mobility

The test subject shall carry out the activities listed and respond to the following question.

4	Can the following activities be carried out without difficulty and does the footwear remain in place during each activity?		
	a) Walking rapidly at 4,5 km/h for 5 min.	YES	NO
	b) Climbing (17 ±3) s and descending (17 ±3) s stairs for 1 min.	YES	NO
	c) Bending over.	YES	NO
	d) Crouching and picking up a small object from the floor.	YES	NO
5	Is the footwear free from excessive tightness around the feet?	YES	NO

B.2.4 Doffing

The test subject shall remove the footwear as quickly as possible, while being timed, and shall respond to the following question.

NOTE Several attempts at removal are permitted to ensure the test subject is fully familiar with the particular fastening system.

6	Can you easily remove both boots within 5 s? This assessment is carried out with the naked hand.	YES	NO

B.3 Test report

The following information shall be recorded in the test report:

a) the details of the item or items being assessed;

b) the test subject's responses to all the questions listed in B.2.

Annex C
(normative)

Method for determination of burning behaviour of footwear upper

Testing shall be carried out in accordance with ISO 15025:2000, procedure A, with the following modifications.

a) Two test pieces of 80 mm by 80 mm shall be used. One test piece shall be taken from the upper of each boot in a pair.

b) Each test piece shall be positioned horizontally with the surface forming the outer surface of the footwear, facing downwards to constitute the test surface.

c) A vertical flame of height 40 mm shall be used.

d) The burner shall be arranged so that the flame strikes the test piece in the centre.

e) The flame shall be applied to the test piece for 15 s.

Bibliography

[1] ISO 11611, *Protective clothing for use in welding and allied processes*

[2] ISO 11612, *Protective clothing — Clothing to protect against heat and flame*

[3] ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

[4] ISO 13287, *Personal protective equipment — Footwear — Test method for slip resistance*

[5] EN 407, *Protective gloves against thermal risks (heat and/or fire)*

[6] EN 15090, *Footwear for firefighters*

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