
Personal protective equipment — Test methods for footwear

*Équipement de protection individuelle — Méthodes d'essais pour les
chaussures*

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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 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 20344 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 161, *Foot and leg protectors*, 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).

This second edition cancels and replaces the first edition (ISO 20344:2004), which has been technically revised. It also incorporates the Technical Corrigendum ISO 20344:2004/Cor.1:2005 and the Amendment ISO 20344:2004/Amd.1:2007.

The main differences between this edition and the 2004 edition are:

- Annex A, inclusion of a new procedure for plasticine calibration;
- Annex C, inclusion of a new table for footwear sizing;
- 4.1, Table 1, clarification of the method for sampling;
- 5.1, clarification on testing of ergonomic features;
- 5.4 and 5.5, inclusion of a reference to EN 12568:2010;
- 5.8.3, different test methods for anti-penetration insoles;
- 5.15.2, inclusion of a new test method for water resistance;
- 6.4.2 and 6.5.2, inclusion of test methods (due to the withdrawal of ISO 2023);
- 6.11, replacement of the method for determination of chromium VI by a reference to ISO 17075;
- withdrawal of 5.11, "Determination of the electrical insulation".

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Personal protective equipment — Test methods for footwear

1 Scope

This International Standard specifies methods for testing footwear designed as personal protective equipment.

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 34-1:2010, *Rubber, vulcanised or thermoplastic — Determination of tear strength — Part 1: Trouser, angle and crescent test pieces*

ISO 868, *Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness) (ISO 868:2003)*

ISO 1817:2011, *Rubber, vulcanised — Determination of the effect of liquids*

ISO 3290-1, *Rolling bearings — Balls — Dimensions and tolerances*

ISO 3376, *Leather — Physical and mechanical tests — Determination of tensile strength and percentage extension*

ISO 3377-2, *Leather — Physical and mechanical tests — Determination of tear load — Part 2: Double edge tear*

ISO 4045, *Leather — Determination of pH*

ISO 4643:1992, *Moulded plastic footwear — Lined or unlined poly (vinyl chloride) boots for general industrial use — Specification*

ISO 4649:2010, *Rubber, vulcanized or thermoplastic — Determination of abrasion resistance using a rotating cylindrical drum device*

ISO 4674-1:2003, *Rubber- or plastics-coated fabrics — Determination of tear resistance — Part 1: Constant rate of tear methods*

ISO 5423:1992, *Moulded plastic footwear — Lined or unlined polyurethane boots for general industrial use — Specification*

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

ISO 17075, *Leather — Chemical analysis — Determination of chromium VI*

ISO 20345:2011, *Personal protective equipment — Safety footwear*

ISO 20347, *Personal protective equipment — Occupational footwear*

ISO 23529:2010, *Rubber — General procedures for preparing and conditioning test pieces for physical test methods*

EN 388:2003, *Protective gloves against mechanical risks*

EN 12568:2010, *Foot and leg protectors — Requirements and test methods for toecaps and penetration-resistant inserts*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 20345 and ISO 20347 apply.

4 Sampling and conditioning

4.1 Sampling

The minimum number of samples to be tested in order to check compliance with the requirements specified in ISO 20345, ISO 20347 and any specific job-related footwear standards (e.g. ISO 17249, *Safety footwear with resistance to chain saw cutting*), together with the minimum number of test pieces taken from each sample, shall be in accordance with Table 1.

Wherever possible and necessary to ensure the essential safety requirements, test pieces shall be taken from the whole footwear. This paragraph is applicable to all of Table 1.

NOTE 1 If it is not possible to obtain a large enough test piece from the footwear, then a sample of the material from which the component has been manufactured may be used instead. This should be noted in the test report.

NOTE 2 Footwear sizes are defined in Annex C.

Where samples are required from each of three sizes, these shall comprise the smallest, middle and largest size of the footwear under test [indicated as (SML) in Table 1].

4.2 Conditioning

All test pieces shall be conditioned in a standard atmosphere of $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \% \text{RH}$ for a minimum of 48 h before testing, unless otherwise stated in the test method.

The maximum time which shall elapse between removal from the conditioning atmosphere and the start of testing shall not be greater than 10 min, unless otherwise stated in the test method.

4.3 Prerequisites on the testing procedure

When several test pieces are tested, at least the worst results per size shall to be reported.

Footwear shall be tested as it is intended to be used, unless otherwise specified in the test method. For instance, if there is a removable insole, it shall be left in place to perform the tests.

The uncertainty of measurement for each test method described in this International Standard may be assessed. One of the two following approaches should be used:

- a statistical method, e.g. that given in ISO 5725-2;
- a mathematical method, e.g. that given in ENV 13005.

Table 1 — Minimum number of samples and test pieces

	Property under test (B = basic requirement, A = additional requirement)		Test only on the final footwear	Subclause reference	Type and number of samples	Type and number of test pieces per sample
Whole footwear	Specific ergonomic features	B	yes	5.1	1 pair of shoes in 3 sizes	1 pair of shoes
	Upper/outsole and sole interlayer bond strength	B	yes	5.2	1 shoe from each of 3 sizes (SML)	1 test piece taken from the shoe
	Internal toecap length	B	yes	5.3	1 pair of shoes from each of 3 sizes (SML)	1 pair of toecaps
	Impact resistance	B	yes	5.4	1 pair of shoes from each of 3 sizes (SML)	1 pair of shoes
	Compression resistance	B	yes	5.5	1 pair of shoes from each of 3 sizes (SML)	1 pair of shoes
	Behaviour of toecaps and inserts (thermal and chemical)	B	no	5.6	See Tables 3 and 4	
	Leakproofness	B	yes	5.7	2 shoes from different sizes	1 shoe
	Dimensional conformity and penetration resistance of inserts	A	yes	5.8	1 pair of shoes from each of 3 sizes (SML)	1 pair of shoes
	Flex resistance of penetration- resistant insert	A	no	5.9	1 pair of insert from each of 3 sizes (SML)	1 pair of inserts
	Electrical resistance	A	yes	5.10	1 pair of shoes from each of 3 sizes (SML)	1 pair of shoes
	Slip resistance	B	yes	5.11	1 shoe from each of 3 sizes (SML)	1 shoe
	Insulation against heat	A	yes	5.12	2 shoes from different sizes	1 shoe
	Insulation against cold	A	yes	5.13	2 shoes from different sizes	1 shoe
	Energy absorption of seat region	A	yes	5.14	1 pair of shoes from each of 3 sizes (SML)	1 pair of shoes
	Water resistance	A	yes	5.15	3 pairs of shoes (minimum 2 different sizes)	1 pair of shoes
	Impact resistance metatarsal protective device	A	yes	5.16	1 pair of shoes from each of 3 sizes (SML)	1 pair of shoes
	Ankle protection	A	yes	5.17	1 shoe from each of 3 sizes (SML)	2 test pieces

Table 1 (continued)

	Property under test (B = basic requirement, A = additional requirement)		Test only on the final footwear	Subclause reference	Type and number of samples	Type and number of test pieces per sample
Upper lining and tongue	Thickness	B	yes	6.1	1 shoe from each of 3 sizes (SML)	1 test piece
	Height of the upper	B	yes	6.2	1 shoe from each of 3 sizes (SML)	1 shoe
	Tear strength	B	yes	6.3	shoes from each of 3 sizes (SML)	3 test pieces per size
	Tensile properties	B	yes	6.4	shoes from each of 3 sizes (SML)	3 test pieces per size
	Flexing resistance	B	yes	6.5	1 shoe from each of 3 sizes (SML)	1 test piece
	Water vapour permeability	B	yes	6.6	1 shoe from each of 3 sizes (SML)	1 test piece
	Water vapour absorption	B	yes	6.7	1 shoe from each of 3 sizes (SML)	1 test piece
	pH value	B	no	6.9	Each leather	2 test pieces
	Hydrolysis	B	yes	6.10	1 shoe from each of 3 sizes (SML)	1 test piece
	Chromium VI content	B	no	6.11	Each leather	2 test pieces
	Abrasion resistance of lining	B	no	6.12	shoes or materials	6 test pieces, wet 6 test pieces, dry
	Water penetration and water absorption	A	no	6.13	shoes or materials	3 test pieces
	Cut resistance	A	no	6.14	1 pair of shoes from each of 3 sizes (SML) or material	2 test pieces
Insole and Insock	Thickness of insole	B	no	7.1	1 shoe from each of 3 sizes or material	1 test piece
	pH value	B	no	6.9	Each leather	2 test pieces
	Water absorption and desorption	B	no	7.2	1 shoe from each of 3 sizes or material	1 test piece
	Abrasion resistance of insole	B	no	7.3	1 shoe from each of 3 sizes or material	1 test piece
	Chromium VI content	B	no	6.11	Each leather	2 test pieces
	Abrasion resistance of insock	B	no	6.12	Shoes or materials	6 test pieces, wet 6 test pieces, dry

Table 1 (continued)

	Property under test (B = basic requirement, A = additional requirement)		Test only on the final footwear	Subclause reference	Type and number of samples	Type and number of test pieces per sample
Outsole	Thickness	B	yes	8.1	1 shoe from each of 3 sizes (SML)	1 test piece
	Tear strength	B	yes	8.2	1 shoe from each of 3 sizes (SML)	1 test piece
	Abrasion resistance	B	yes	8.3	1 shoe from each of 3 sizes (SML)	1 test piece
	Flexing resistance	B	yes	8.4	1 shoe from each of 3 sizes (SML)	1 test piece
	Hydrolysis	B	yes	8.5	1 shoe from each of 3 sizes (SML)	1 test piece
	Resistance to fuel oil	B	yes	8.6	1 shoe from each of 3 sizes (SML)	2 test pieces
	Resistance to hot contact	A	yes	8.7	1 shoe from each of 3 sizes (SML)	1 test piece

5 Test methods for whole footwear

5.1 Specific ergonomic features

The specific ergonomic features of the footwear shall be assessed by examining the footwear using wear trials on three wearers with appropriate foot sizes.

During the trials the wearers, wearing each pair of the correctly fitting footwear, simulate typical tasks likely to be undertaken in general use.

These tasks are:

- walking normally for 5 min at a speed between 4 and 5 km/h;
- climbing (17 ± 3) stairs and descending (17 ± 3) stairs in 1 min maximum;
- kneeling/crouching down (see Figure 1).

After having completed all tasks, each wearer shall fill in the questionnaire given in Table 2.

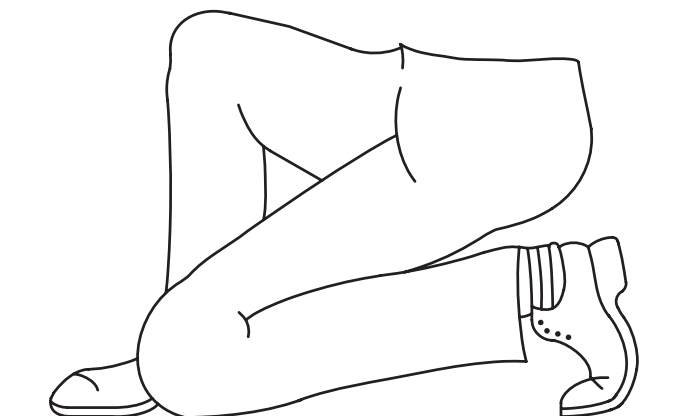


Figure 1 — Position to adopt during the kneel/crouch down test

Table 2 — Questionnaire for the assessment of ergonomic features

1	Is the inside surface of the footwear free from rough, sharp or hard areas that caused you irritation or injury (checked by hand)?	YES	NO
2	Is the footwear free of features that you consider make wearing the footwear hazardous?	YES	NO
3	Can the fastening be adequately adjusted (if necessary)?	YES	NO
4	Can the following activities be performed without problems?		
	4.1 Walking	YES	NO
	4.2 Climbing stairs	YES	NO
	4.3 Kneeling/crouching down	YES	NO

5.2 Determination of upper/outsole and sole interlayer bond strength

5.2.1 Principle

The force required to separate the upper from the outsole, or to separate adjacent layers of the outsole, or to cause tear failure of the upper or the sole is measured. The test is not applicable when the bond has been made by grindery (using e.g. nails or screws) or stitching.

NOTE In all cases the objective should be to test the bond strength nearest to the edge of the assembly.

5.2.2 Apparatus

5.2.2.1 Tensile machine, with a means of continuously recording load, with a jaw separation rate of (100 ± 20) mm/min and a force range of 0 N to 600 N. The machine shall be fitted with either pincers or flat jaws (depending on the construction of the test sample, see 5.2.4), $(27,5 \pm 2,5)$ mm wide, capable of firmly gripping the test pieces.

5.2.3 Preparation of test pieces

5.2.3.1 Sole/upper bond strength: construction type a

Take a test piece from either the inner or the outer joint region.

Make cuts at X-X and Y-Y at right angles to the edge of the sole, insole or outsole to produce a test piece about 25 mm wide. The length of the upper and sole shall be about 15 mm measured from the feather line (see Figure 3). Remove the insole.

NOTE See Figure 2.

5.2.3.2 Sole/upper bond strength: construction types b, c, d and e

Take a test piece from either the inner or outer joint region.

Cut the upper and sole at X-X and Y-Y to produce a test piece with a width of about 10 mm and a length of not less than 50 mm. Remove the insole.

Separate the upper from the sole for a length of about 10 mm by inserting a hot knife in the adhesive layer (see Figure 4).

It is considered that a construction is c or d when the distance from X-X to the upper face of the insole is at least 8 mm.

NOTE See Figure 2.

5.2.3.3 Interlayer bond strength: construction types f and g

Take a test piece from either the inner or the outer joint region.

Remove the upper by cutting along the feather line at X-X. Remove the insole if present. Cut a strip parallel to and including the sole edge at Y-Y to produce a test piece about 15 mm wide and at least 50 mm long. Separate the sole layers for a length of about 10 mm by inserting a hot knife into the adhesive layer (see Figure 4).

NOTE See Figure 2.

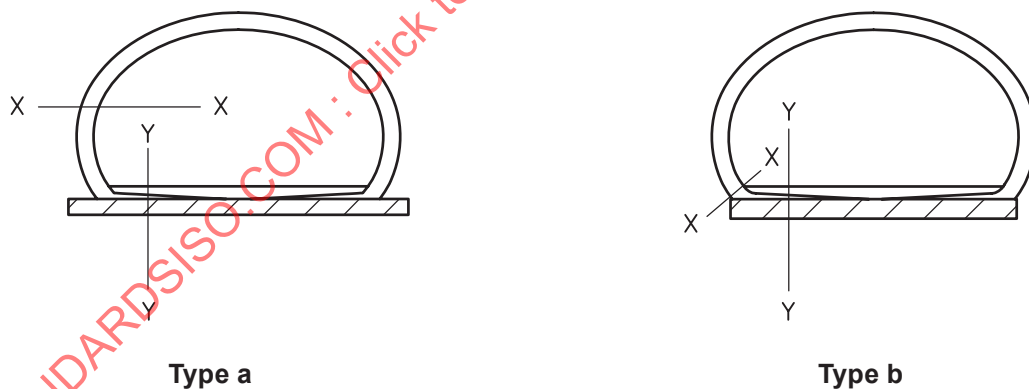
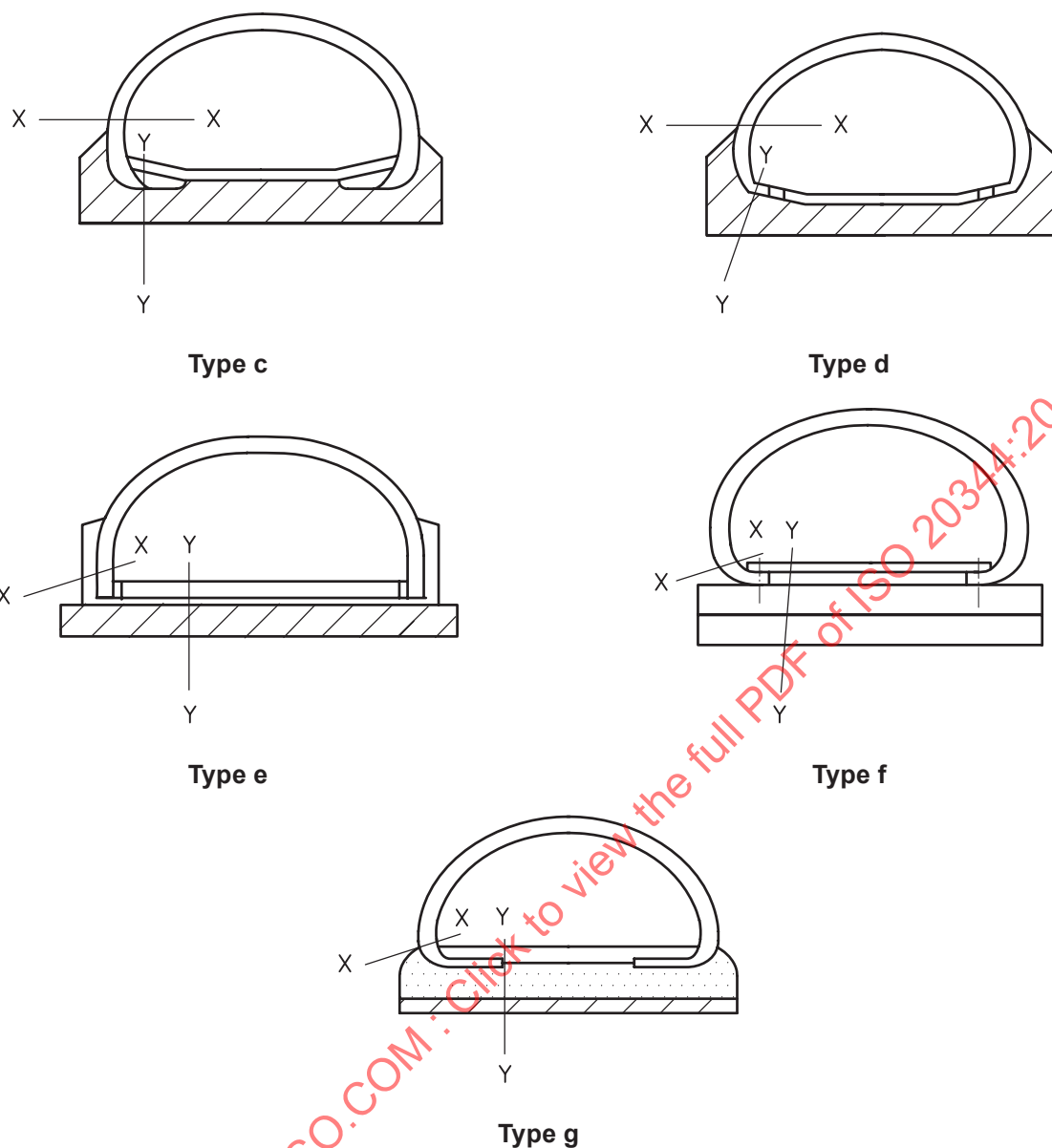


Figure 2 (continued)

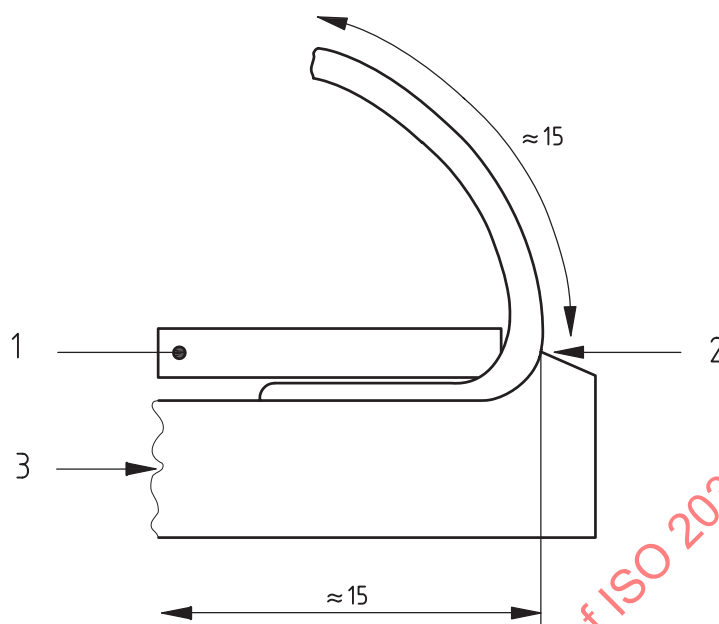


Key

- Type a conventional lasting, cemented or moulded outsole having an extended range
- Type b conventional lasting, close trimmed outsole
- Type c conventional lasting, direct injected or vulcanised outsole or cemented dishd outsole
- Type d Strobel stitched, cemented dishd outsole or direct injected or vulcanised outsole
- Type e conventional lasting or Strobel stitched with rubber mudguard and cemented outsole
- Type f machine sewn or welted where the outsole is bonded to the throughsole
- Type g multilayered sole, e.g. moulded-on sole, a moulded unit or a built unit

Figure 2 — Types of construction showing position for preparation of the test piece for bond strength

Dimensions in millimetres



Key

- 1 insole (removed)
- 2 feather line
- 3 outsole

Figure 3 — Cross section of test piece

Dimensions in millimetres

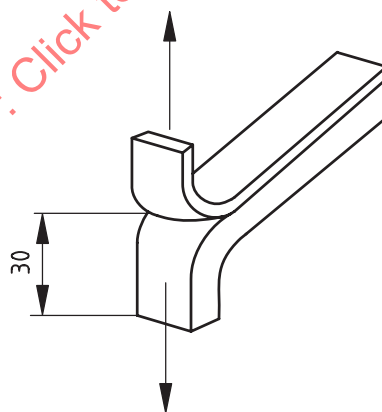
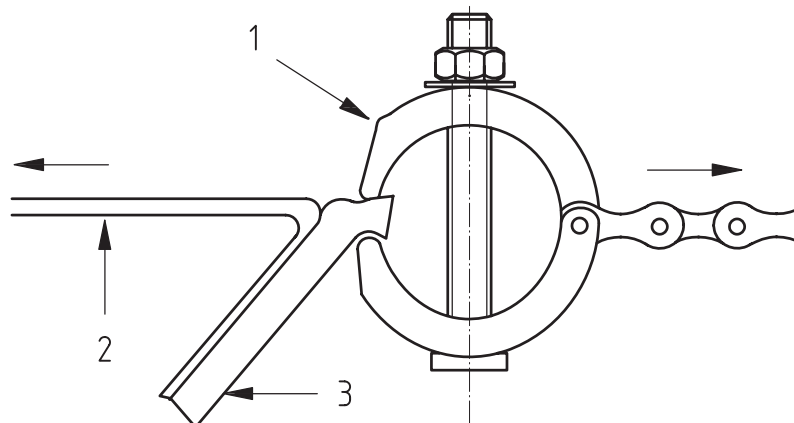


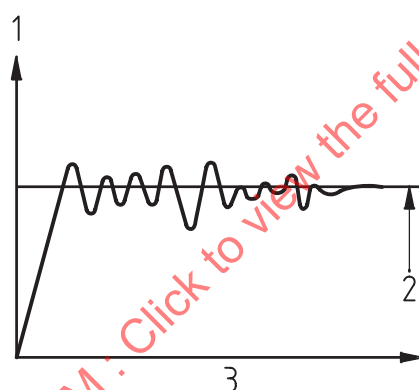
Figure 4 — Prepared test piece



Key

- 1 pincer jaw for sole edge
- 2 upper
- 3 sole

Figure 5 — Pincer jaw showing position of test piece



Key

- 1 peeling force, expressed in newtons
- 2 average
- 3 deformation

Figure 6 — Example of load/deformation graph

5.2.4 Measurement of bond strength

Before carrying out the test, measure the width of the test piece to the nearest mm at several points using a calibrated steel rule and calculate the average value to the nearest mm. Then measure the bond strength on a minimum length of 30 mm in one of the following ways.

- For sole/upper bond strength (construction type a): clamp the test piece into the jaws of the tensile machine, using a pincer jaw to grip the short edge of the sole (see Figure 5), and record the load/deformation graph (see Figure 6) at a jaw separation speed of (100 ± 20) mm/min.
- For sole/upper bond strength (construction types b, c, d and e) and sole interlayer bond strength (construction types f and g): clamp the separated ends of the test piece in the flat jaws and record the load/deformation graph (see Figure 6) at a jaw separation speed of (100 ± 20) mm/min.

5.2.5 Calculation and expression of results

Determine, from the load/deformation graph, the average peeling load in newtons and divide by the average width (calculated in 5.2.4) to give the bond strength in N/mm.

5.3 Determination of internal toecap length

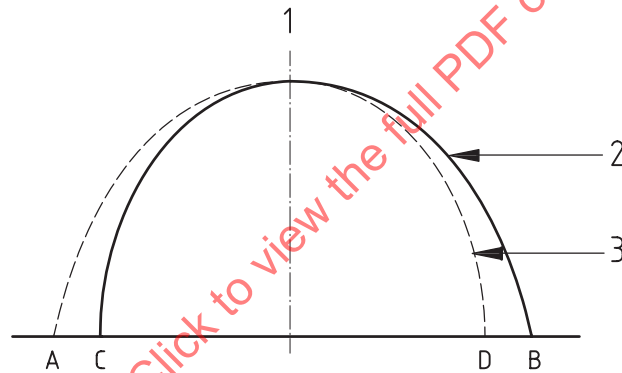
5.3.1 Preparation of test piece

Carefully extract the toecaps from an untested pair of footwear and remove all foreign materials adhering to them, or take a new pair of identical toecaps.

NOTE Preconditioning of the test piece is unnecessary.

5.3.2 Determination of the test axis

Position the left toecap with its rear edge in line with a base line and draw its outline. Repeat the exercise with the right toecap of the pair. Position the outlines in such a manner that the outlines at both the toe end of the toecaps and the base lines coincide (see Figure 7).



Key

- 1 test axis
- 2 right cap
- 3 left cap

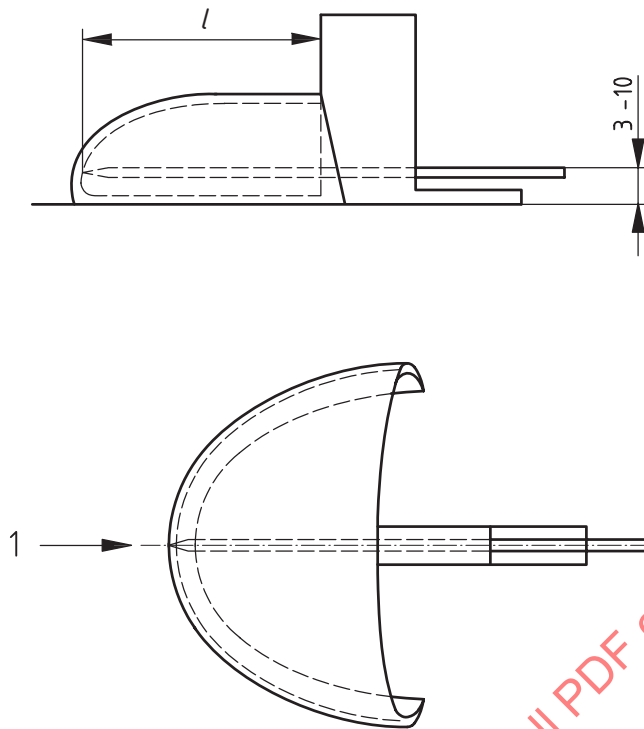
Figure 7 — Determination of the test axis

Mark the four points A, B, C and D where the outlines of the left and right toecaps intersect on the base line. Erect the perpendicular from the base line at the midpoint of A-B or C-D. This constitutes the test axis of the toecap.

5.3.3 Test procedure

Place the toecap, open side down, on a flat surface. Using an appropriate gauge, measure the internal length, l , along the test axis from the toe to the back edge at a distance between 3 mm and 10 mm above and parallel to the surface upon which the toecap rests (see Figure 8). l is the maximum length which can be measured.

Dimensions in millimetres

**Key**

- 1 test axis
 l internal length

Figure 8 — Measurement of internal toecap length

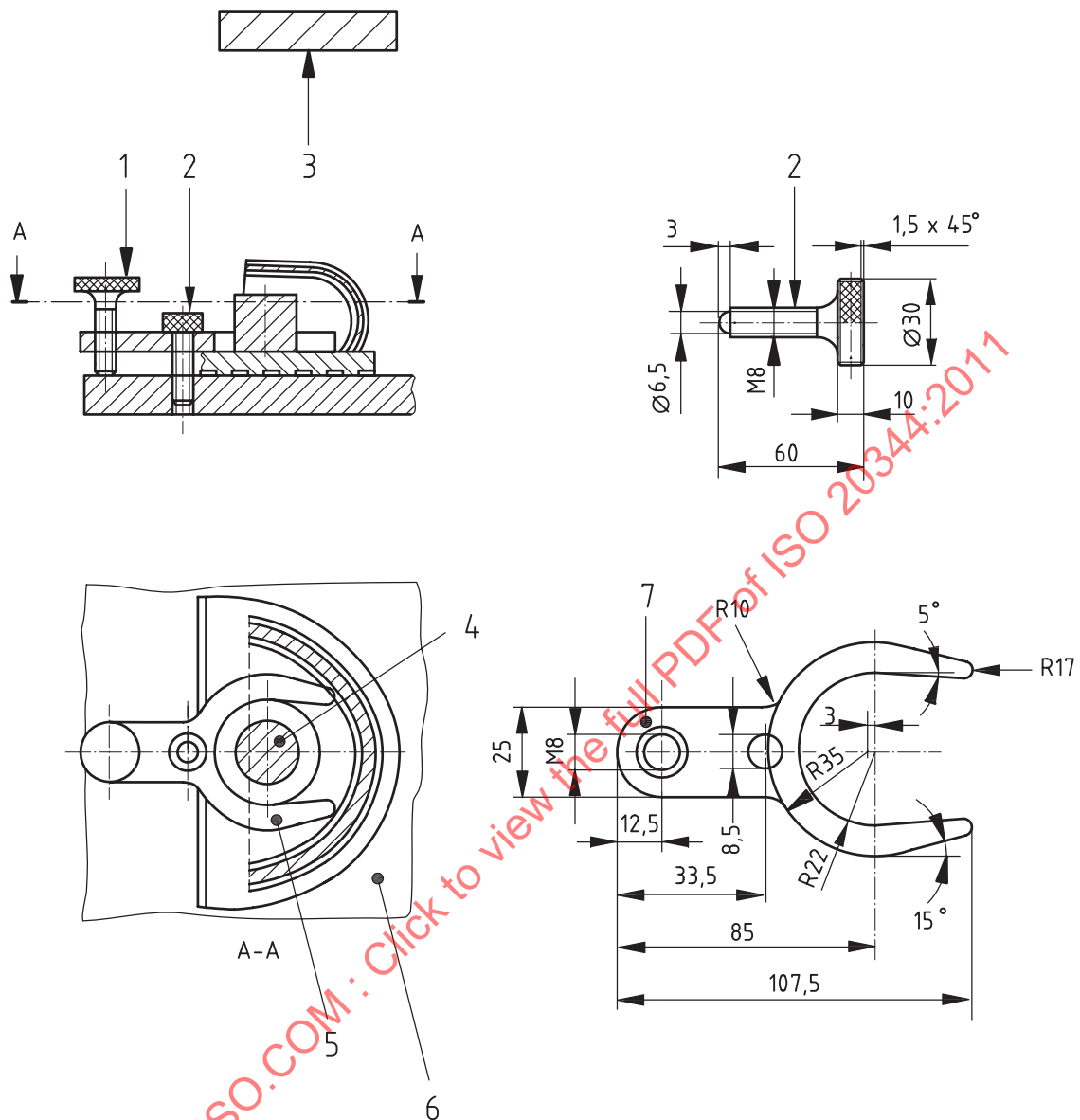
5.4 Determination of impact resistance

5.4.1 Apparatus

5.4.1.1 Impact apparatus, as described in EN 12568:2010, 5.2.2.1.1.

5.4.1.2 Clamping device, consisting of a smooth steel plate at least 19 mm thick and 150 mm × 150 mm, of minimum hardness 60 HRC, with a screw clamp for clamping the forepart of the insole/insock of the toe-end of the footwear under test to the plate in a way which will not restrict lateral expansion of the toecap during the impact test (see Figure 9).

Dimensions in millimetres

**Key**

- 1 adjusting screw
- 2 clamping screw
- 3 striker
- 4 modelling clay cylinder
- 5 stabilizing fork
- 6 base plate
- 7 thickness = 10 mm

NOTE The dimensions given in this figure are illustrative only. Smaller stabilizing forks of the same proportions may be used for smaller toecaps.

Figure 9 — Example of footwear clamp

The stabilizing fork, which is to be introduced into the front part of the footwear, shall be adjusted by means of the adjusting screw to rest on the insole, parallel to the base plate. The clamping screw (M8 thread) shall be tightened by applying a torque of $(3 \pm 1) \text{ N}\cdot\text{m}$.

5.4.1.3 Cylinders, of modelling clay of diameter (25 ± 2) mm and of height (20 ± 2) mm for footwear up to and including size 40 (French) and of height (25 ± 2) mm for footwear above size 40. The flat ends of the cylinder shall be covered with aluminium foil to prevent them sticking to either the test piece or the test equipment.

The modelling clay shall fulfil the requirement given in Annex A.

5.4.1.4 Dial gauge, with a hemispherical foot of $(3,0 \pm 0,2)$ mm radius and a hemispherical anvil of (15 ± 2) mm radius exerting a force not greater than 250 mN.

5.4.2 Procedure

5.4.2.1 Determination of the test axis (see Figure 10)

Locate the testing axis by placing the footwear on a horizontal surface and against a vertical plane so that it touches the edge of the sole at points A and B on the inner side of the footwear. Construct two further vertical planes at right angles to the first vertical plane so that they meet the sole at points X and Y, the toe point and heel point respectively. Draw a line through X and Y. This constitutes the test axis for the forepart of the footwear.

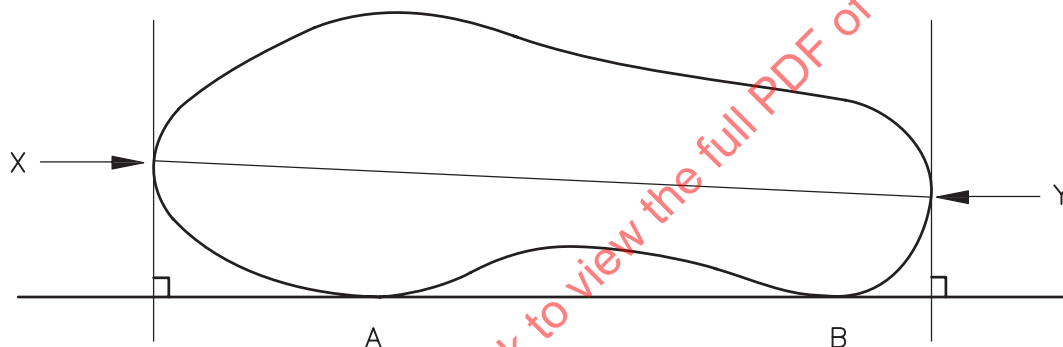


Figure 10 — Test axis for footwear

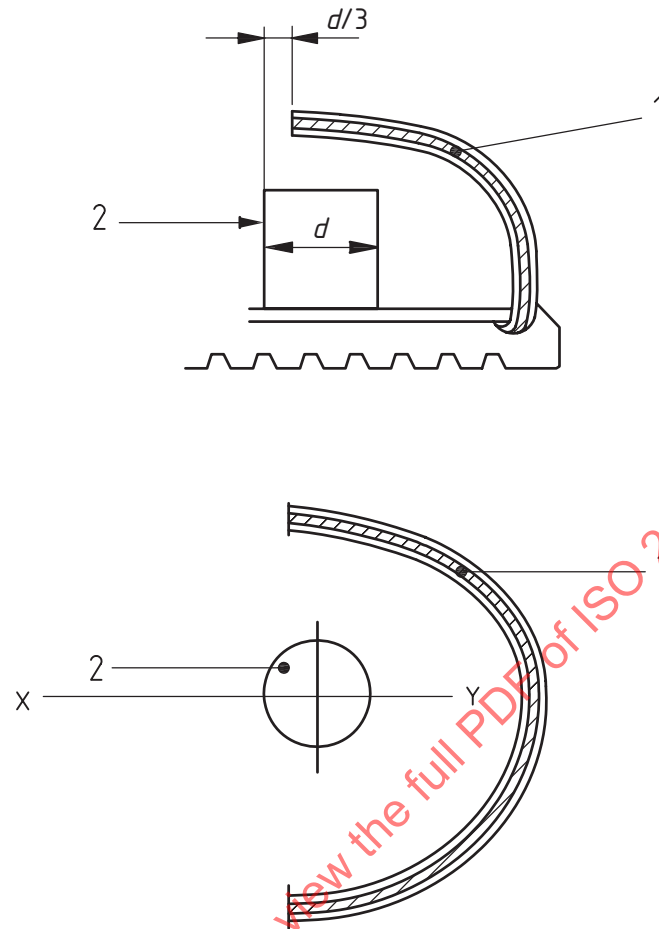
5.4.2.2 Preparation of the test piece

Prepare the forepart of the footwear by cutting off the toe end 30 mm behind the rear edge of the toecap. Then remove the complete upper assembly flush with the rear edge of the toecap. Do not remove the upper and lining in the toecap area. If the footwear has been supplied with a removable insock, carry out the test with it in place.

NOTE Preconditioning of the test piece is unnecessary.

5.4.2.3 Test procedure

Position a cylinder (5.4.1.3) on one of its ends inside the test piece as shown in Figure 11.

**Key**

1 toecap

2 modelling clay cylinder

Text axis XY

Figure 11 — Position of cylinder for the impact or compression test of footwear

Position the test piece in the impact apparatus (5.4.1.1) so that when the striker hits it, the striker shall project over the back and the front of the toecap. Adjust the clamping device (5.4.1.2).

Allow the striker to drop on to the test axis from the appropriate height to give an impact energy of (200 ± 4) J for safety footwear.

With the measuring device (5.4.1.4), measure the lowest height to which the cylinder has been compressed to the nearest 0,5 mm. This value is the clearance at the moment of impact.

5.5 Determination of compression resistance

5.5.1 Apparatus

5.5.1.1 Compression testing machine, as described in EN 12568:2010, 5.1.3.1.1.

5.5.1.2 Cylinders, as described in 5.4.1.3.

5.5.1.3 Dial gauge, as described in 5.4.1.4.

5.5.1.4 Clamping device, as described in 5.4.1.2.

5.5.2 Procedure

5.5.2.1 Determination of the test axis

Determine the test axis as described in 5.4.2.1.

5.5.2.2 Preparation of the test piece

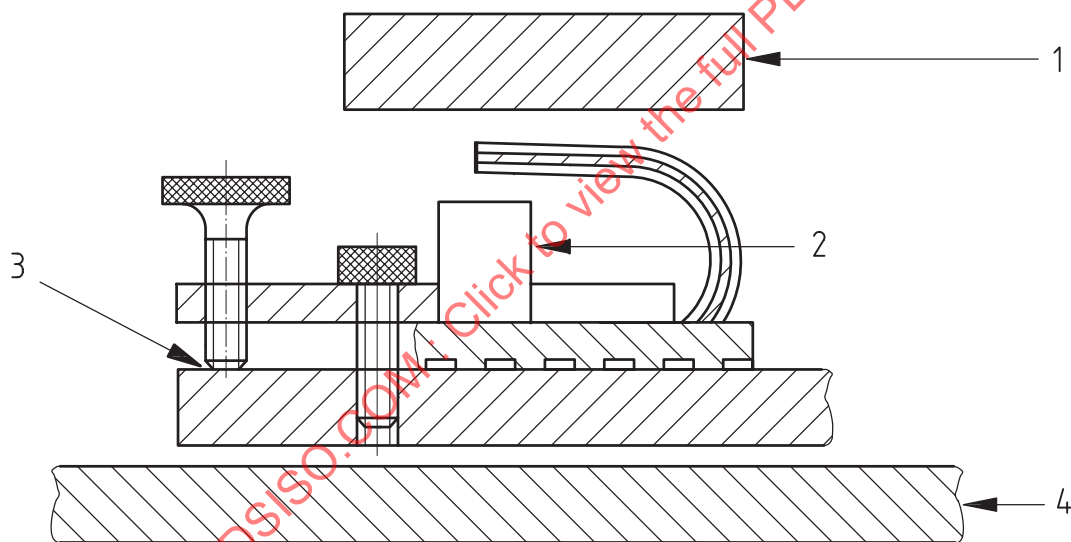
Prepare the test piece as described in 5.4.2.2.

NOTE Preconditioning of the test piece is unnecessary.

5.5.3 Test procedure

Position a cylinder (5.5.1.2) on one of its ends inside the test piece as shown in Figure 11. Place the test piece in the clamping device (5.5.1.4) and adjust.

Position the clamping device and test piece between the plates of the compression machine (5.5.1.1) and compress the test piece until the load of $(15 \pm 0,1)$ kN for safety footwear (see Figure 12) has been reached.



Key

- 1 upper plate
- 2 modelling clay cylinder
- 3 clamping device
- 4 lower plate

Figure 12 — Apparatus for compression resistance

Reduce the load, remove the cylinder and, with the measuring device (5.5.1.3), measure the lowest height to which the cylinder has been compressed to the nearest 0,5 mm. This value is the compression clearance.

5.6 Behaviour of toecaps and inserts (thermal and chemical)

5.6.1 Test method for metallic toecaps and metallic inserts in class II footwear

5.6.1.1 Preparation of the test piece

See Tables 3 and 4.

NOTE Preconditioning of the test piece is unnecessary.

5.6.1.2 Test solution

Use a mass fraction of 1 % aqueous solution of sodium chloride.

5.6.1.3 Procedure

Pour sufficient test solution into a test piece to fill it up in order to be sure that the toecap/insert is under the level of the solution. Cover the top of the footwear with e.g. a polyethylene cover, to minimise evaporation.

Leave for 7 days and then discard the test solution.

Remove the toecap/insert from the footwear and examine for any evidence of corrosion. When present, measure the longest distance across each area of corrosion and note the number of such areas.

5.6.2 Behaviour of toecaps (thermal and chemical)

Toecaps shall be tested in accordance with Table 3.

Table 3 — Minimum number of samples and test pieces and test methods for toecaps

Footwear	Type and number of sample	Type and number of test pieces per sample	Test only on the final footwear	Test method
Class I metal toecap	1 toecap in 2 sizes	1 toecap	No, only new toecaps can be tested	EN 12568:2010, 5.3
Class II metal toecap	1 shoe in 2 sizes	1 shoe	Yes	ISO 20344:2011, 5.6.1
Class I and II non-metal toecap	5 pairs of toecaps	1 pair of toecap for each of the 5 treatments	No, only new toecaps can be tested	EN 12568:2010, 5.4

5.6.3 Behaviour of inserts (thermal and chemical)

Inserts shall be tested in accordance with Table 4.

Table 4 — Minimum number of samples and test pieces and test methods for inserts

Footwear	Type and number of sample	Type and number of test pieces per sample	Test only on the final footwear	Test method
Class I metal insert	1 insert in 2 sizes	2 test pieces	No, only new inserts can be tested	EN 12568:2010, 7.3
Class II metal insert	1 shoe in 2 sizes	1 shoe	Yes	EN ISO 20344:2011, 5.6.1
Class I and II non-metal insert	1 insert for each of the 5 treatments	1 insert for each of the 5 treatments (2 penetration tests on each test piece)	No, only new inserts can be tested	EN 12568:2010, 7.4

5.7 Determination of leakproofness

5.7.1 Apparatus

5.7.1.1 Waterbath.

5.7.1.2 Supply of compressed air.

5.7.2 Preparation of the test piece

Take the entire item of footwear as the test piece.

5.7.3 Procedure

Carry out the test at a temperature of $(23 \pm 2) ^\circ\text{C}$.

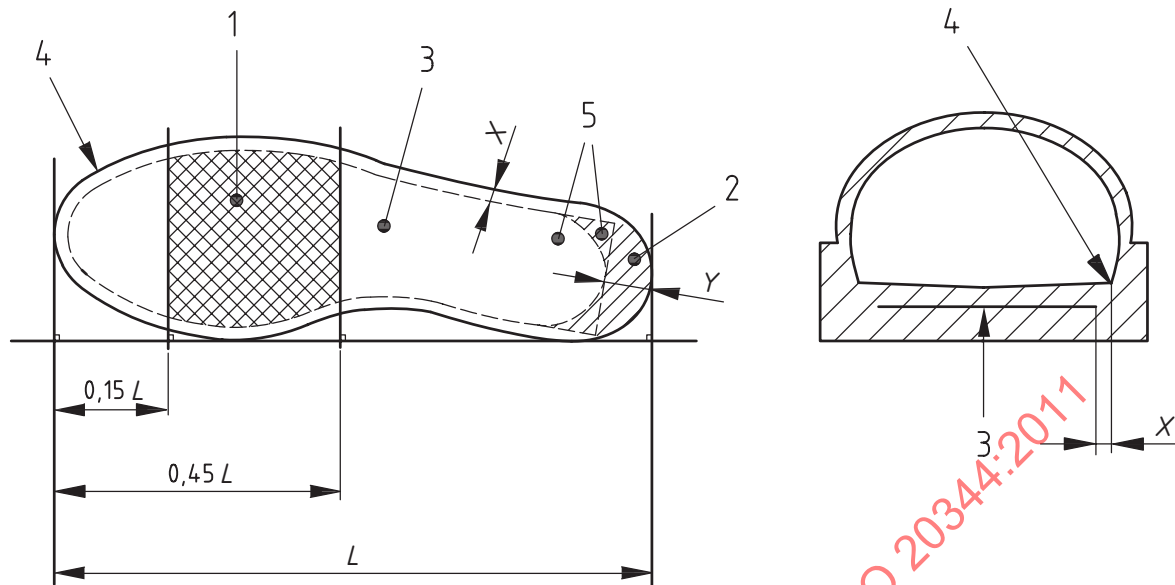
Seal the top edge of the test piece, e.g. with a rubber collar through which compressed air may be fed via appropriate connections. Immerse the test piece in a waterbath up to the edge and apply a constant internal pressure of (30 ± 5) kPa for 30 s. Observe the test piece throughout the test and determine whether there is a continued formation of air bubbles, indicating leakage of air.

5.8 Determination of the dimensional conformity of inserts and the penetration resistance of the sole

5.8.1 Dimensional conformity of inserts

Measure L , the length of the inside of the bottom of the footwear. Draw as in Figure 13 the shaded areas 1 and 2.

Section the footwear and measure the distances X and Y (see Figure 13) being the distances between the edge of the insert and the line left by the feather edge of the last, to the nearest 0,5 mm.

**Key**

- 1 shaded area 1
- 2 shaded area 2
- 3 insert
- 4 line left by feather edge of the last
- 5 alternative shapes of insert
- L length of the inside of the bottom of the footwear

Figure 13 — Determination of dimensions for the insert

5.8.2 Determination of the penetration resistance of footwear using a metallic anti-penetration insert

5.8.2.1 Apparatus

5.8.2.1.1 Test equipment. capable of measuring a compressive force up to at least 2 000 N, fitted with a pressure plate, in which a test nail (5.8.2.1.2) is fixed, and a parallel plate with a circular opening of diameter 25 mm. The axes of this opening and the test nail shall be coincident (see Figure 14).

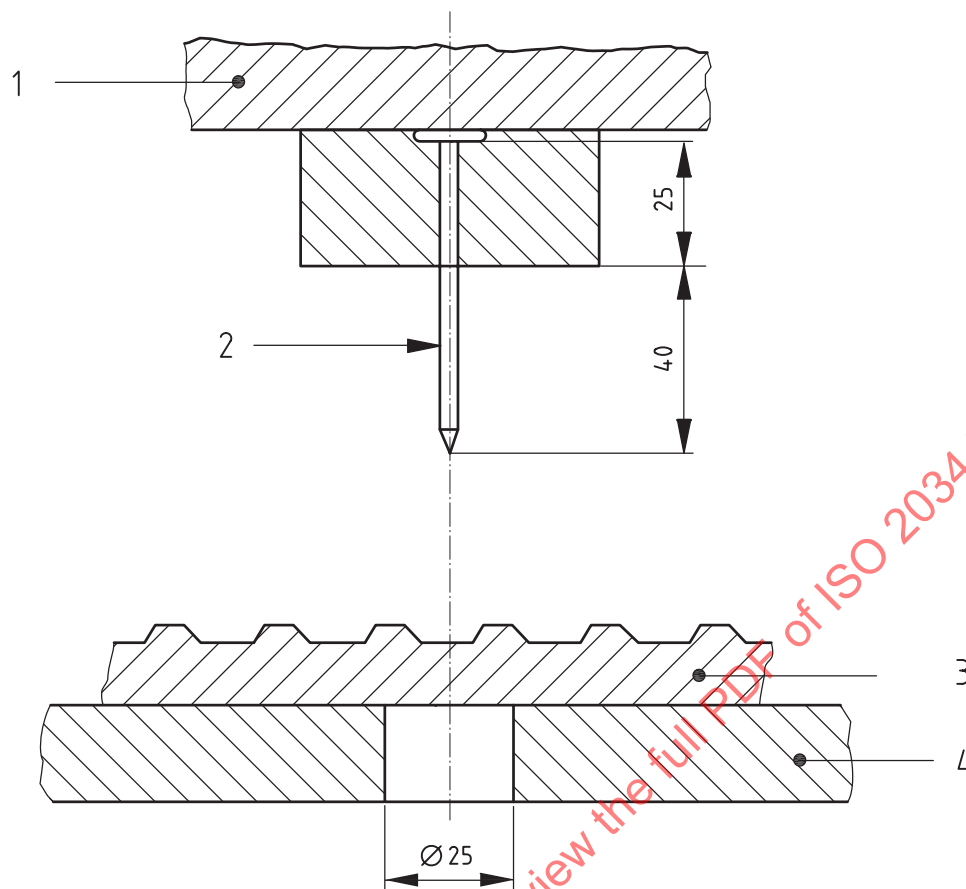
5.8.2.1.2 Test nail, as described in EN 12568:2010, 7.2.1.1.2.

5.8.2.2 Preparation of the test piece

Remove the upper from the bottom of the footwear and use the bottom as the test piece.

For absorbent soling material (e.g. leather) carry out the tests after the sole unit has been immersed in deionised water at $(23 \pm 2) ^\circ\text{C}$ for (16 ± 1) h.

NOTE Preconditioning of non-absorbent test pieces is unnecessary.

**Key**

- 1 pressure plate
- 2 nail
- 3 sole unit of the test piece
- 4 plate

Figure 14 — Apparatus for penetration resistance test of a metallic insert (example)

5.8.2.3 Test procedure

Place the test piece on the plate in such a way that the steel nail can penetrate it through the bottom. Press the nail against the sole unit at a speed of (10 ± 3) mm/min until the point has penetrated completely and measure the maximum force.

Carry out the test at four different points on the sole unit (at least one in the heel region) with a minimum distance of 30 mm between any two penetration points and a minimum distance of 10 mm from the edge of the insole. For cleated soles, carry out the test between cleats. Two of the four measurements shall be made at a distance of 10 mm to 15 mm from the line represented by the feather edge of the last.

Report the minimum value of the individual measurements as the test result.

5.8.3 Determination of the penetration resistance of footwear using a non-metallic anti-penetration insert

5.8.3.1 General

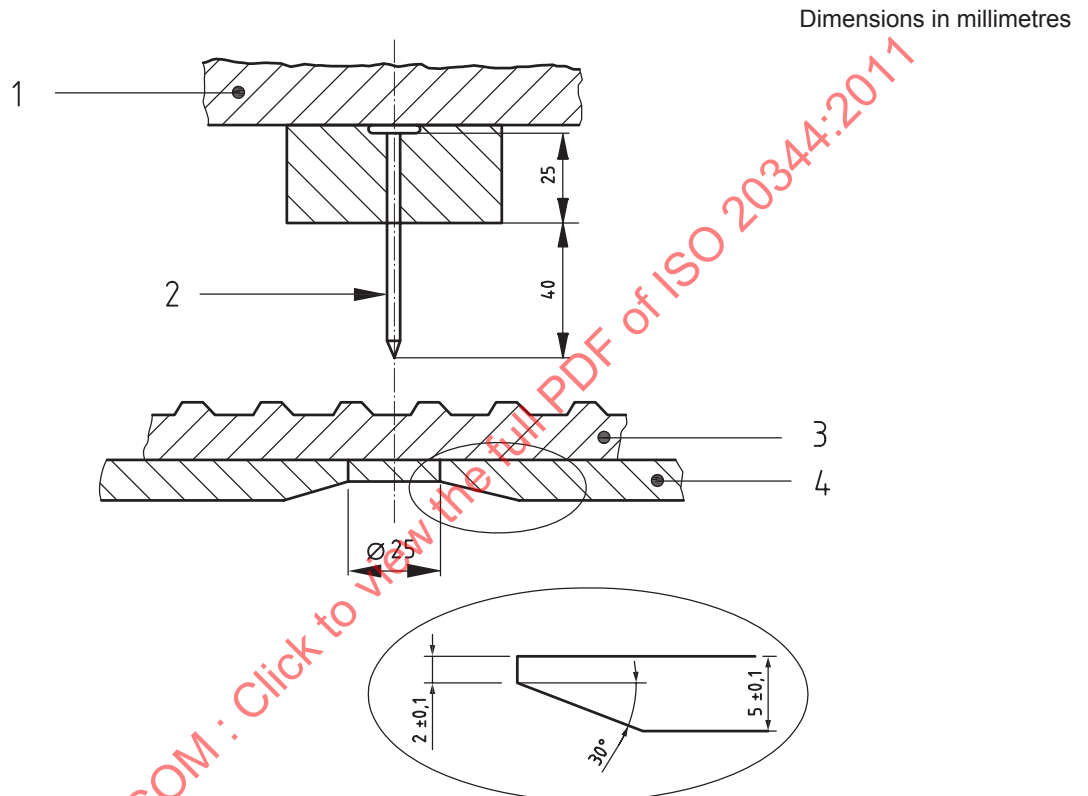
If the non-metallic anti-penetration insert is not used as an insole (e.g. in a Strobel construction) the test shall be conducted in accordance with 5.8.2.

If the non-metallic anti-penetration insert is used as an insole, the following test shall be conducted.

5.8.3.2 Apparatus

5.8.3.2.1 Test equipment, capable of measuring a compressive force up to at least 2 000 N, fitted with a pressure plate, in which a test nail (5.8.2.1.2) is fixed, and a parallel plate with a circular opening of diameter 25 mm. The axes of this opening and the test nail shall be coincident (see Figure 15).

5.8.3.2.2 Test nail, as described in EN 12568:2010, 7.2.1.1.2.



Key

- 1 pressure plate of the test piece
- 2 nail (length sufficient to fully cross the test piece)
- 3 sole unit
- 4 plate

Figure 15 — Apparatus for penetration resistance test of a non-metallic insert

5.8.3.3 Preparation of the test piece

Remove the upper from the bottom of the footwear and use the bottom as the test piece. The non-metallic anti-penetration insert shall be visible.

If the non-metallic anti-penetration insert incorporates stitches associated with antistatic properties, one of the penetrations at least shall be performed in this area.

For absorbent soling material (e.g. leather) carry out the tests after the sole unit has been immersed in deionised water at $(23 \pm 2) ^\circ\text{C}$ for (16 ± 1) h.

NOTE Preconditioning of non-absorbent test pieces is unnecessary.

5.8.3.4 Test procedure

Place the test piece on the plate in such a way that the steel nail can penetrate it through the bottom. Press the nail against the sole unit.

Run the testing machine at a speed of (10 ± 3) mm/min up to the required force of 1 100 N (see 6.2.1), then stop the machine and carry out either the visual inspection within 10 s at an angle of $(90 \pm 15)^\circ$ to the nail axis or an electrical or cinematographic detection.

Carry out the test at four different points on the sole unit (at least one in the heel region) with a minimum distance of 30 mm between any two penetration points and a minimum distance of 10 mm from the edge of the insole. For cleated soles, carry out the test between cleats. Two of the four measurements shall be made at a distance of 10 mm to 15 mm from the line represented by the feather edge of the last.

Report the test results (pass or fail).

5.9 Determination of the flex resistance of penetration-resistant inserts

Determine the flex resistance of penetration-resistant inserts in accordance with the method described in EN 12568:2010, 7.2.2.

5.10 Determination of electrical resistance

5.10.1 Principle

The electrical resistance of conductive footwear is measured after conditioning in a dry atmosphere [5.10.3.3 a)]. The electrical resistance of antistatic footwear is measured after conditioning in a dry atmosphere and afterwards conditioning in a wet atmosphere [5.10.3.3 a) and b)]. If there are enough samples, the two conditionings can be conducted in parallel.

5.10.2 Apparatus

5.10.2.1 Testing instrument, capable of measuring electrical resistance to an accuracy of $\pm 2,5$ % while applying a voltage of (100 ± 2) V DC.

5.10.2.2 Internal electrode, comprising stainless steel balls of 5 mm diameter and of total mass $(4 \pm 0,1)$ kg. The steel balls shall conform to the requirements of ISO 3290-1. The balls are connected to the testing instrument using a copper cable. A good contact shall be obtained by using a square end of at least 2 cm². Steps should be taken to prevent or remove oxidation of the steel balls and the copper plate since oxidation could affect their conductivity.

5.10.2.3 External electrode, comprising a copper contact plate cleaned with ethanol before use.

5.10.2.4 Conductive lacquer, having a resistance of less than $1 \times 10^3 \Omega$.

5.10.2.5 Device for measuring the conductive resistance of the lacquer, consisting of three conductive metal probes, each $(3 \pm 0,2)$ mm radius, attached to an electrical insulating base plate. Two of the probes are (45 ± 2) mm apart and connected by a metal strap. The third probe is set at a distance of (180 ± 5) mm from the centre line joining the other two and is electrically insulated from them.

5.10.3 Preparation for conditioning of the test piece

5.10.3.1 Preparation

If the footwear has been supplied with a removable insock, carry out the test with it in place. Clean the surface of the sole of the footwear with ethanol to eliminate all traces of mould silicone, wash with distilled water and

allow drying at $(23 \pm 2) ^\circ\text{C}$. The surface shall not be buffed or abraded or cleaned with organic materials which attack or swell the sole.

5.10.3.2 Specific preparation for conditioning under wet conditions

For test pieces (only for anti-static footwear) which are tested following conditioning under wet conditions (see 5.10.3.3), apply a conductive lacquer (5.10.2.4) to the sole over an area 200 mm by 50 mm, including the heel and the fore part. Allow to dry and then check that the resistance of the lacquer is less than $1 \times 10^3 \Omega$.

Fill the footwear with clean steel balls (5.10.2.2) and place on the metal probes of the device (5.10.2.5) such that the front area of the outsole is supported by the two probes spaced 45 mm apart and the heel area is supported by the third probe. Using the testing instrument (5.10.2.1), measure the resistance between the front probes and the third probe.

5.10.3.3 Conditioning

Condition the prepared test piece in one of the following atmospheres, according to the type of footwear being tested:

- a) dry conditions — $(20 \pm 2) ^\circ\text{C}$ and $(30 \pm 5) \% \text{ RH}$ (for 7 days);
- b) wet conditions — $(20 \pm 2) ^\circ\text{C}$ and $(85 \pm 5) \% \text{ RH}$ (for 7 days).

The test shall be performed within 5 min of the removal of the test piece from the conditioning atmosphere if the test is not carried out in that atmosphere.

5.10.4 Procedure

Fill the test piece with clean steel balls to a total mass of 4 kg using a piece of insulating material to extend the height of the upper if necessary. Place the filled test piece on the copper plate, apply a test voltage of $(100 \pm 2) \text{ V DC}$ between the copper plate and the steel balls for 1 min and calculate the resistance.

The energy dissipation in the sole shall not be greater than 3 W.

Wherever necessary, reduce the voltage in order to respect the 3 W limit and record the voltage value in the test report.

5.11 Determination of footwear slip resistance

5.11.1 Test parameters

The coefficient of friction of the footwear is determined in accordance with ISO 13287 under the test conditions given in Table 5, ensuring that the 7° heel mode contact angle is set up with the shoemaking last holding the footwear lowered onto the 7° setting wedge under its own weight.

Table 5 — Test conditions for slip resistance

Conditions	Floor	Lubricant
A (forward heel slip)	Ceramic tile(s)	NaLS
B (forward flat slip)		
C (forward heel slip)	Steel	Glycerine
D (forward flat slip)		

5.11.2 Calibration procedure of ceramic tiles

5.11.2.1 General

Before performing a test on a ceramic tile, the tile shall be calibrated in accordance with the following procedure. Only ceramic tiles giving test results in the range 0,18 to 0,22 shall be accepted for testing footwear. Tiles giving results outside this range shall be rejected.

5.11.2.2 Materials and apparatus

5.11.2.2.1 Material Slider 96¹⁾ of calibrated hardness (96 ± 2) IRHD measured value at (23 ± 2) °C and resilience of (24 ± 2) % at 23 °C. Required test piece size: ($25,4 \pm 0,1$) mm wide, at least 50 mm long and greater than 5 mm thick and with vertical walls and square edges.

Storage of Slider 96 rubber: the storage temperature should be below 25 °C and preferably below 15 °C. Moist conditions should be avoided, and conditions should be such that condensation does not occur. Protect from light, particularly direct sunlight and strong artificial light. Protect from circulating air by wrapping it in paper or polyethylene (but not plasticized PVC film such as cling film) or storing in an air tight container. It is recommended that Slider 96 sliders are discarded 12 months after issue.

5.11.2.2.2 Means of cutting: Slider 96. The slider (5.11.2.2.1) is supplied pre-moulded in a suitable size and form. However, if larger sheets of Slider 96 rubber are obtained, then a means is required of cutting a rectangular test piece such that it has vertical walls, square edges, is ($25,4 \pm 1,0$) mm wide and at least 50 mm long. A means of trimming test pieces parallel to the 25,4 mm edge while retaining a vertical wall and square edge can also be required (see 5.11.2.3, Notes 1 and 2).

NOTE Cutting by some methods, such as shoemaking press knives, can produce concave shapes.

5.11.2.2.3 A rigid, rectangular backing plate, with dimensions at least as wide as the test piece cut with the device and at least 50 mm long.

5.11.2.2.4 Means of securely attaching a test piece of Slider 96 rubber (5.11.2.2.1) to the backing plate (5.11.2.2.3). Suitable adhesives include: epoxy resins, cyanoacrylate or solvent-based contact adhesive. The face to be bonded should be lightly abraded with abrasive paper (5.11.2.2.6) then cleaned by blowing with clean air or by wiping with a suitable solvent such as methanol and allowing to dry in air before bonding.

NOTE Double-sided tape may be suitable at the low level of coefficient of friction expected when testing on ceramic tile with detergent solution.

5.11.2.2.5 Means of attaching the test piece backing plate (5.11.2.2.3) to the test apparatus at the required contact angle.

NOTE A rectangular metal box of dimensions 180 mm × 90 mm × 90 mm can be used to replace the shoemaking last described in ISO 13287 and the backing plate (5.11.2.2.3) attached to it.

5.11.2.2.6 400 grit silicon carbide abrasive paper, mounted on a flat, rigid surface.

5.11.2.2.7 Dry, absorbent paper towel.

5.11.2.2.8 Ceramic tile as specified in ISO 13287.

5.11.2.2.9 Test machine as specified in ISO 13287.

1) Slider 96 material (formerly known as Four S rubber) is available from RAPRA Technology Ltd., Shrewsbury, Shropshire, UK, <http://www.rapra.net/>. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

5.11.2.3 Preparation of the test slider and ceramic tile

5.11.2.3.1 If necessary, cut to size a test piece of Slider 96 rubber (5.11.2.2.1) using the device (5.11.2.2.2). Clean using distilled water, then dry in air. Do not use the Slider 96 test piece that is used for calibration purposes for any other purpose or with any other lubricant.

5.11.2.3.2 Attach the test piece of rubber (5.11.2.2.1) to the backing plate (5.11.2.3.3) using adhesive (5.11.2.2.4).

5.11.2.3.3 Holding the test piece by the backing plate (5.11.2.2.3) and applying a light, evenly distributed pressure, abrade the surface of the rubber against the abrasive paper (5.11.2.2.6) until a visually even level of abrasion is achieved and the surface is parallel with the backing plate. For this procedure alternately use a backward and forward linear movement in a direction parallel to the long side of the test piece, and a side to side movement in a perpendicular direction to the final direction of abrasion parallel to the long side.

5.11.2.3.4 Remove any debris from the test slider surface by lightly brushing with a dry paper towel (5.11.2.2.7).

5.11.2.3.5 Clean the ceramic tile (5.11.2.2.8) in accordance with ISO 13287.

The condition of the Slider 96 test slider should be restored at intervals as repeated use will cause edges to become rounded or a concave chamfer might develop across the tested edge. Either use the abrasion method described above to restore the slider to the correct condition and/or cut away the affected end section of material, ensuring that at least 50 mm length remains and the new cut edge is vertical and flat.

NOTE 1 Both ends of the slider may be used, provided that the end used is in the correct condition.

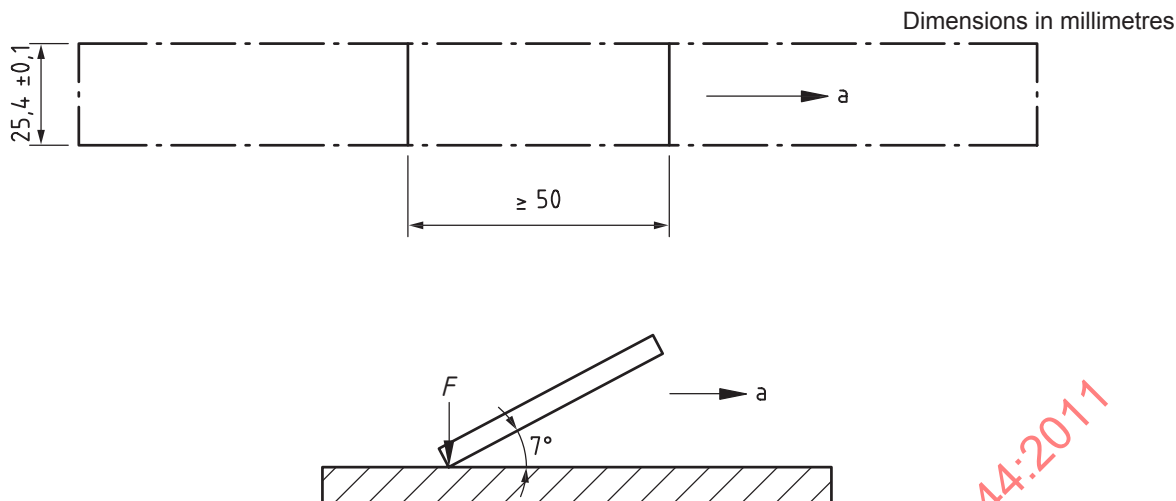
NOTE 2 When the thickness of the slider has been reduced to 5 mm by repeated use, it is advisable to replace it.

5.11.2.4 Calibration test procedure

5.11.2.4.1 Condition the ceramic floor tile and the test slider (5.11.2.3) for at least 3 h at the test atmosphere.

5.11.2.4.2 Attach the test slider (5.11.2.3) to the test machine so that the 25,4 mm edge is perpendicular to the direction of sliding movement and the line of action of the vertical force passes through the Slider 96 rubber/floor contact area.

5.11.2.4.3 Set the face of the test slider at a contact angle of $(7 \pm 0,5)^\circ$ to the surface of the ceramic tile (see Figure 16).



Key

F normal force

a Sliding direction.

Figure 16 — Orientation and contact angle of the Slider 96 test slider

5.11.2.4.4 Mount the tile and lubricate with detergent solution in accordance with ISO 13287.

5.11.2.4.5 Apply the test conditions specified in ISO 13287 for the forward heel slip mode, applying a 500 N normal force.

5.11.2.4.6 Carry out the test procedure defined in ISO 13287 and determine the coefficient of friction of the tile in a single test run.

5.11.2.4.7 If the coefficient of friction is outside the specified range (0,18 to 0,22), reject the tile.

5.11.2.4.8 If the coefficient of friction is within the specified range, accept the tile and record the values obtained.

5.11.2.4.9 Clean (5.11.2.3.1) and dry the Slider 96 before returning to storage.

5.12 Determination of insulation against heat

5.12.1 Apparatus

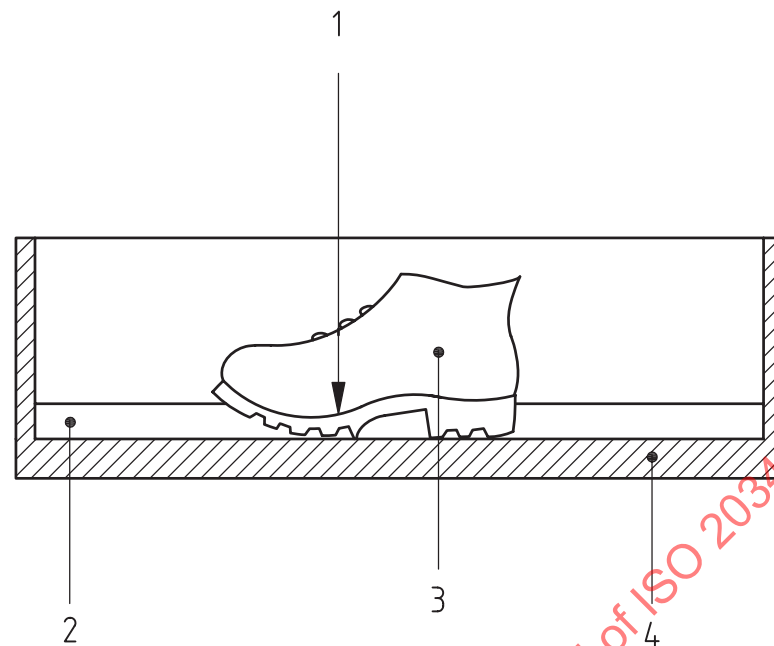
5.12.1.1 Sandbath, the size of the bath holding the sand shall be $(40 \pm 2) \text{ cm} \times (40 \pm 2) \text{ cm}$ with a height of at least 5 cm (see Figure 17).

The volume of sand shall be $(5\,000 \pm 250) \text{ cm}^3$, with a granular size of 0,3 mm to 1,0 mm.

The temperature of the plate shall be measured where the footwear will contact the plate (forepart and heel) and shall be regulated according to the test temperature. Two parameters are defined in the requirements of the product standards:

- the temperature of the plate, T_{hp} ;
- the contact time.

The power of the heating system should be at least $(2\,500 \pm 250) \text{ W}$.



Key

- 1 point for measuring temperature
- 2 sandbath (height of sand approximately 30 mm)
- 3 footwear filled with stainless steel balls
- 4 hotplate

Figure 17 — Heat insulation test apparatus

5.12.1.2 Thermal transfer medium, comprising stainless steel balls with 5 mm diameter and a total mass of $(4\,000 \pm 40)$ g.

The stainless steel balls shall conform to the requirements of ISO 3290-1.

5.12.1.3 Temperature probe with an accuracy of $\pm 0,5$ °C, soldered to a copper disc $(2 \pm 0,1)$ mm thick and (15 ± 1) mm diameter.

5.12.1.4 Temperature measuring device, with a compensator, suitable for use with the temperature probe.

5.12.2 Preparation of the test piece

Use the complete item of footwear as the test piece. Fix the temperature probe to the insole or insock, if present.

The temperature inside the footwear shall be measured in the forepart in an area directly above the area where the sole contacts the hot plate. Place the steel balls inside the footwear. If the upper is not high enough to support the balls, increase its height with a collar.

5.12.3 Test procedure

Condition the prepared test piece until the temperature of the insole is constant at (23 ± 2) °C and test under ambient conditions of (23 ± 2) °C.

Preheat the sandbath for 2 h minimum, and adjust the temperature of the hot plate to T_{hp} ; maintain this temperature during the test. Record the initial temperature, T_i . Place the test piece on it. Move the footwear forward and backward in order to get the best possible contact between the footwear and the hot plate.

Replace the sand around the footwear at the correct height. Then ensure that the surface of the sand is homogenously flat.

Use the temperature measuring device connected to the temperature probe to measure the temperature on the insole as a function of time. Record the final temperature, T_f , after an appropriate time given in the requirement of the product standard. Temperatures are measured to the nearest 0,5 °C.

Continue the test until the appropriate times given in the requirement of the product standard have been reached. Remove the sample and the steel balls for inspection and note signs of serious damage that affects the functionality of the footwear, applying Annex B. In case of doubt about the right functionality of the footwear, carry out an abrasion resistance of the outsole in accordance with 8.3.

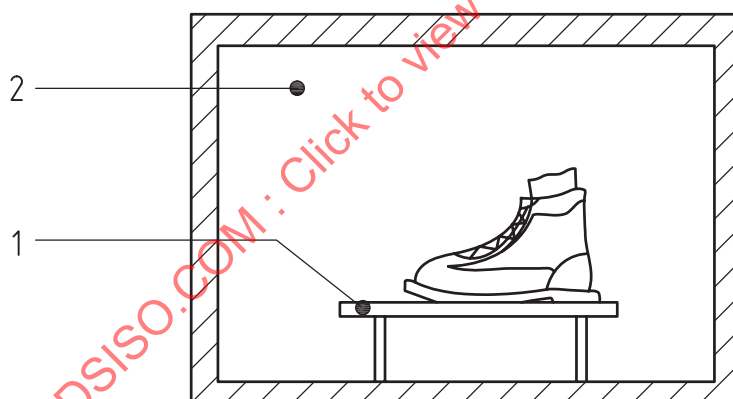
The results are:

- the increase of temperature, $T_f - T_i$, after a defined time;
- a final temperature, T_f , after a defined time;
- the report of damage that can seriously affect the functionality of the footwear (e.g. beginning of separation of upper and sole) applying Annex B.

5.13 Determination of insulation against cold

5.13.1 Apparatus

5.13.1.1 Insulated cold box, the internal air temperature of which can be regulated to $(-17 \pm 2) ^\circ\text{C}$ (see Figure 18).



Key

- 1 copper plate (5.15.1.5)
- 2 cold box

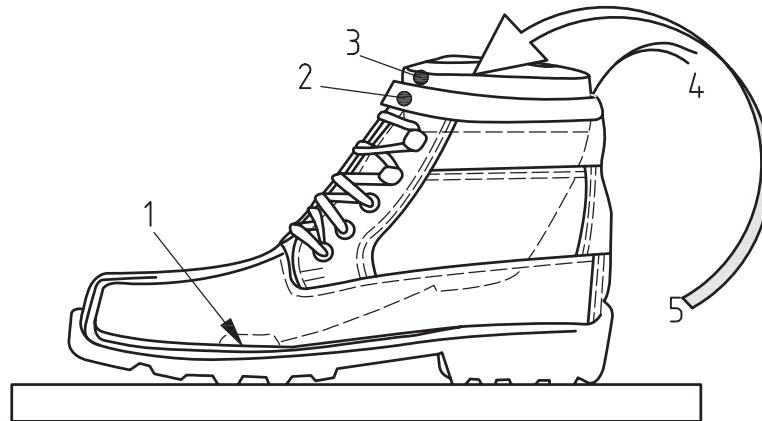
Figure 18 — Cold insulation test apparatus

5.13.1.2 Thermal transfer medium, as described in 5.12.1.2.

5.13.1.3 Temperature probe, as described in 5.12.1.3.

5.13.1.4 Temperature measuring device, as described in 5.12.1.4.

5.13.1.5 Copper plate, of length (350 ± 5) mm, width (150 ± 1) mm and thickness $(5 \pm 0,1)$ mm, positioned as illustrated in Figure 19.

**Key**

- 1 point to measure temperature
- 2 tape
- 3 closing plug
- 4 wires to thermocouple
- 5 steel ball filling (not shown here)

Figure 19 — Preparation of the test piece for cold insulation test

5.13.2 Preparation of the test piece

Use the complete item of footwear as the test piece. Fix the temperature probe to the insole or insock, if present, in order to measure the temperature in the forepart of the footwear directly above the area where the sole contacts the support platen. Place the steel balls inside the footwear.

If the upper is not high enough to support the balls, increase its height with a collar of closed-cell elastomeric foam (EVA, PE, PU, etc.) of minimum substance 8 mm, which needs to be cut out carefully in order to avoid any gap of more than 3 mm in width. This auxiliary material may be fixed or stuck to the inner side of the collar, taking care that overlapping is limited to max. 20 mm at the lowest point of the upper edge of the collar.

The upper top opening is then carefully closed with a suitable plug, made up from semi-rigid polymer foam of not less than 25 mm thickness, which may be composed by more than one layers. The plug is fixed to the collar or its prolongation by adhesive tape or other suitable means.

5.13.3 Test procedure

Condition the prepared test piece for at least 3 h, until its temperature is constant at $(23 \pm 2) ^\circ\text{C}$. Adjust the temperature of the cold box to $(-17 \pm 2) ^\circ\text{C}$ and maintain this temperature during the test. Place the test piece on the support platen inside the cold box. Use the temperature measuring device connected to the temperature probe to measure the temperature on the insole/insock right after placing the test piece in the cold box and after 30 more minutes.

Rounded to the nearest $0,5 ^\circ\text{C}$, report the temperature decrease measured during the 30 min. period of cooling.

5.14 Determination of energy absorption of the seat region

5.14.1 Apparatus

5.14.1.1 Test equipment, capable of measuring compressive force up to 6 000 N, with a means of recording loading/deformation characteristics.

5.14.1.2 Test punch, the back part of a standardised last made in polyethylene²⁾. The last shall be sectioned on a plane vertical to the feather edge and at 90° to the axis of the back part (see Figure 20). The dimension of the punch in relation to footwear shall be in accordance with Table 6.

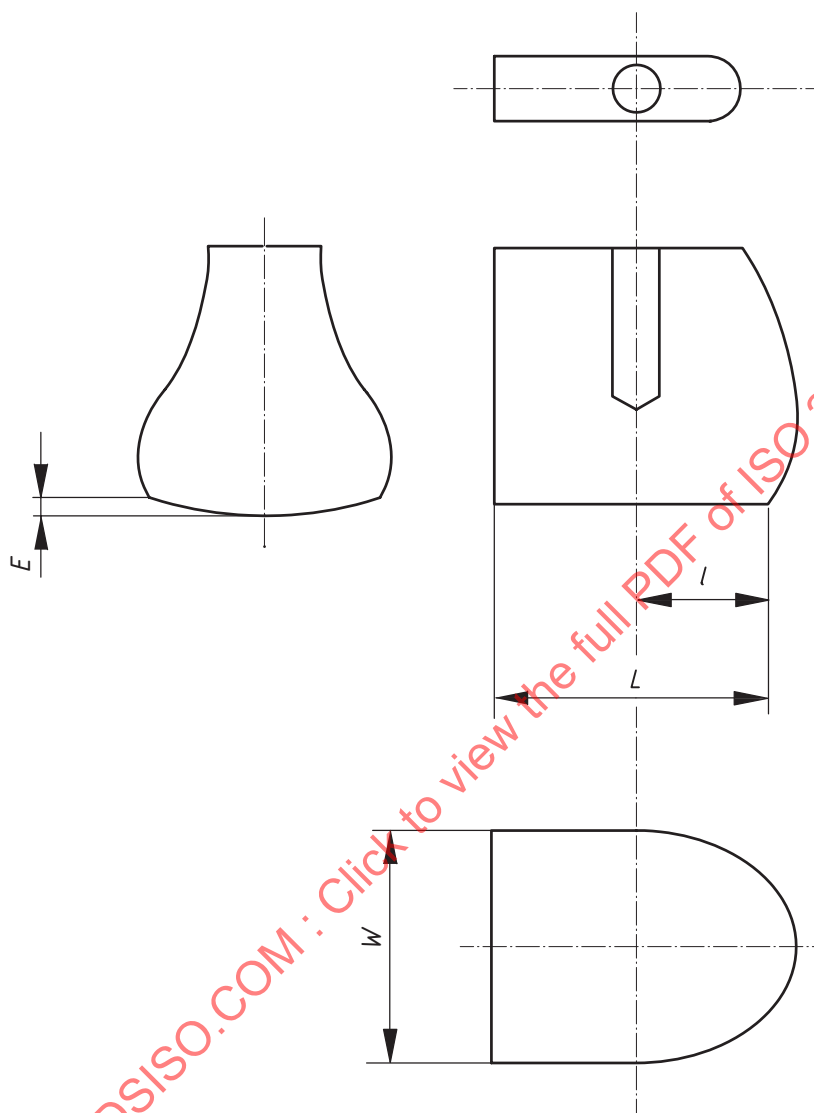


Figure 20 — Test punch for energy absorption test

2) Suitable punches may be obtained from CTC, Lyon, France, <http://www.ctc.fr>. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product. Equivalent products may be used if they can be shown to lead to the same results.

Table 6 — Dimensions of the test punch depending on sizes

Sizes (see Annex C)		Dimensions			
UK	French	$L \pm 2$ mm	$l \pm 2$ mm	$W \pm 2$ mm	$E \pm 1$ mm
Up to 3 1/2	Up to 36	65 mm	32,5 mm	52,25 mm	2 mm
4 to 5	37 and 38	67,5 mm	33,7 mm	57 mm	2 mm
5 1/2 to 6 1/2	39 and 40	70,5 mm	35 mm	58,75 mm	2 mm
7 to 8	41 and 42	72,5 mm	36,2 mm	60,5 mm	3 mm
8 1/2 to 10	43 and 44	75,5 mm	37,7 mm	62,25 mm	3 mm
10 1/2 and above	45 and above	77,5 mm	38,5 mm	64 mm	3 mm

5.14.2 Procedure

Place the test piece with the heel on a steel base and press the test punch against the bottom unit from the inside at the centre of the heel area at a test rate of (10 ± 3) mm/min until a force of 5 000 N is obtained.

Plot the load/compression curve for each test and determine the energy absorption, E , in joules, rounded to the nearest 1 J, using the equation:

$$E = \int_{50 \text{ N}}^{5000 \text{ N}} F ds \quad (1)$$

where

F is the applied compressive force, in N;

s is the distance, in m.

5.15 Determination of resistance to water for whole footwear

5.15.1 Trough test

5.15.1.1 Principle

A pair of footwear is worn while a defined number of paces is walked over a surface flooded with water to a defined depth. The extent of water penetration is determined by examination.

5.15.1.2 Testers

Choose the tester(s) so that the footwear fits the tester.

5.15.1.3 Apparatus

5.15.1.3.1 Horizontal watertight trough, having the following essential features (see also Figure 21):

- a moveable platform near each end, high enough and large enough to enable the tester to step up and turn around above the water level;
- sufficient length to allow the tester to take 10 normal paces in the water between the platforms;
- a width of approximately 0,6 m;
- a plug to enable the water to be drained away.

NOTE It is preferable for the trough to have a piped water supply so that it can readily be filled to the required depth.

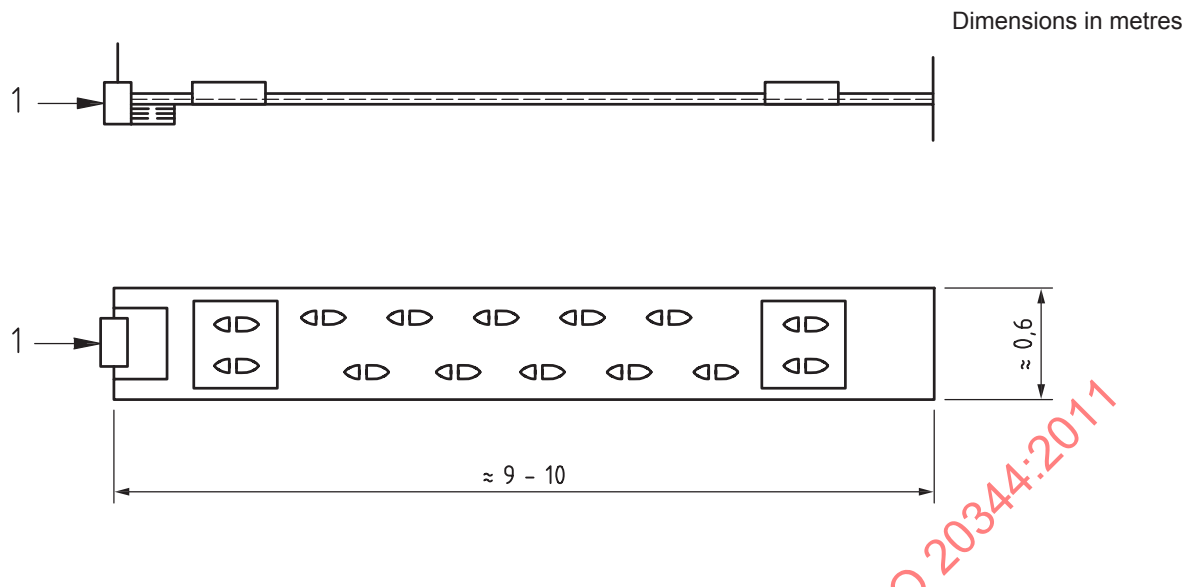


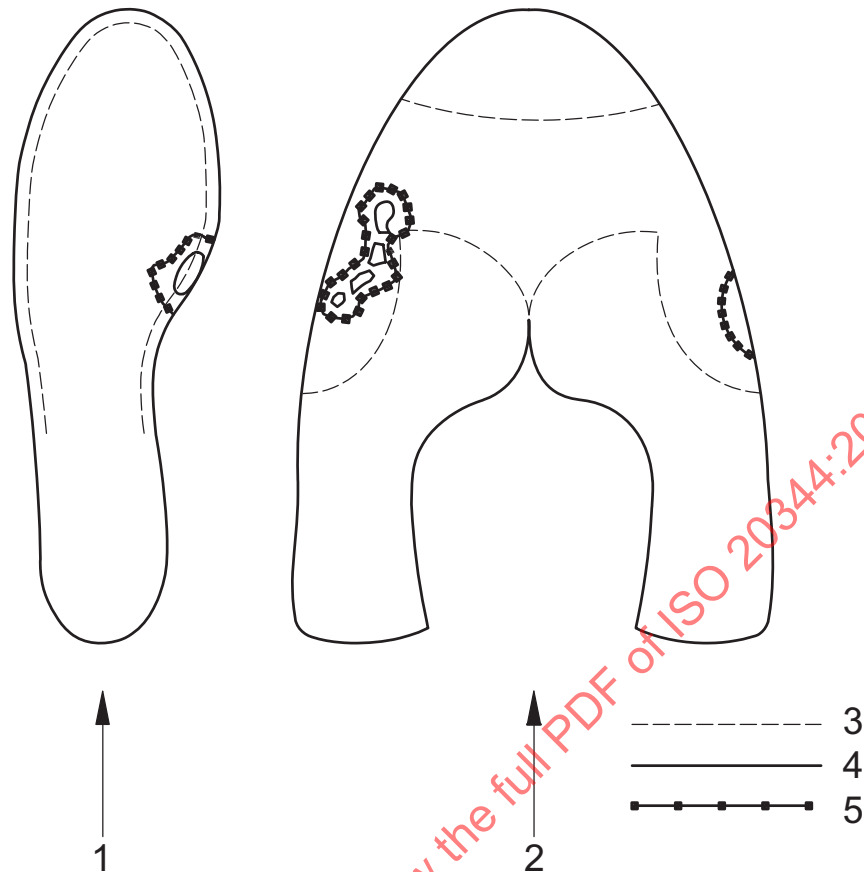
Figure 21 — Trough

5.15.1.4 Procedure

With the empty trough, position the turning platforms so that the tester takes 11 paces walking from one to the other with a normal length stride (i.e. so that each foot is placed on the floor of the trough five times). Fill the trough up to a depth of (30 ± 3) mm with water.

Ensure that the footwear is thoroughly dry. Put on the dry footwear over normal hose using a legging or guard to cover the top line, and step on to one of the platforms. Walk 100 trough lengths in the water using the platforms whenever turning. Take great care to make sure that no water is splashed over the top line of the footwear. To avoid splashing, walk at a slower pace than normal, if necessary, but preferably not slower than one pace per second.

After 100 trough lengths, step out of the trough, remove the footwear carefully, and examine the inside both visually and by touch for signs of water penetration. If any penetration has occurred, record its position and extent on diagrams (Figure 22 shows a suitable form of diagram) for each boot or shoe. Repeat the test with the other two pairs of footwear.

**Key**

- 1 insole
- 2 upper
- 3 seams in upper and insole
- 4 first areas of penetration
- 5 extended areas of penetration

Figure 22 — Suitable form of diagram for a shoe, with an example of recorded penetration added

5.15.2 Dynamic footwear water penetration test

5.15.2.1 Principle

This test method is intended to provide a means of evaluating the degree of water resistance of footwear. The method is applicable to all types of shoes and boots.

The footwear is secured in a flexing machine with water at a defined level above the featherline. The footwear is flexed at a constant rate and inspected at intervals for water penetration.

5.15.2.2 Apparatus and materials

5.15.2.2.1 Dynamic footwear flexing machine, having at each testing station:

- a system for flexing the footwear through an angle of $(22 \pm 5)^\circ$ at a rate of (60 ± 6) flexes per min;
- a flexible foot-form which is fitted inside the footwear to control the way the footwear flexes (this foot-form may be provided with water sensors);

— a clamping mechanism capable of holding the heel of the footwear firmly while it is being flexed.

NOTE A screening test using the test method described in 8.4.1 can be used. Footwear bending less than 22° from the horizontal is not subjected to the test in 5.15.2.4.

5.15.2.2.2 Water-holding tank large enough to contain the footwear and flexing mechanism.

5.15.2.2.3 Means of recording the number of flexes carried out.

5.15.2.2.4 Balance having a weighing range large enough for the footwear under test and reading to the nearest 0,1 g.

5.15.2.2.5 Absorbent paper.

5.15.2.2.6 Polythene bags or sheet.

5.15.2.3 Preparation of test pieces

5.15.2.3.1 Use a pair of shoes as the test piece(s).

5.15.2.3.2 Store the test piece(s) in a standard controlled environment of $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \% \text{ RH}$ for at least 48 h. It is preferred, although not necessary, to carry out the test in this atmosphere.

5.15.2.3.3 If the mass of water absorbed by the footwear during the test is necessary, then weigh each test piece before testing. In this case, the test shall be conducted in the controlled environment.

5.15.2.4 Procedure

5.15.2.4.1 The footwear should be mounted on the flexing machine so that the flexing point corresponds to the ball joint position of a wearer's foot. Determine the flexing point by drawing a line down the length of the insole of the test piece from the centre of the heel towards the centre of the toecap.

5.15.2.4.2 Measure along the line the appropriate distance from the heel in Table 7 to the nearest millimetre and mark this point. This corresponds to the typical position of the ball joint of the wearer's foot.

Table 7 — Average distance from the heel end of the insole to the ball joint position of the foot

Sizes (see Annex C)		Heel/ball length on insole mm
UK	French	
1	33	143
2	34 1/2	149
3	35 1/2	155
4	37	160
5	38	166
6	39 1/2	172
7	40 1/2	178
8	42	184
9	43	189
10	44 1/2	195
11	45 1/2	201
12	47	207

5.15.2.4.3 Draw a line across the width of the insole passing through this marked point and at 90° to the line drawn as described in 5.15.2.4.1. This is regarded as the flexing line of the footwear.

5.15.2.4.4 Secure the test piece onto the flexing system so that the flexing point is as close as possible to the line drawn as described in 5.15.2.4.3.

5.15.2.4.5 Ensure that all the fastenings (e.g. laces, straps, zips and touch-&-close fasteners) are engaged, suitably adjusted, tightened and fully secure and that the ends of the laces, if present, will not hang in the water during testing.

5.15.2.4.6 If there is any opening at the top of the footwear which would allow water to splash inside, seal this with a polythene bag or sheet.

5.15.2.4.7 Add water to the tank so that the water level is at the recommended depth for the type of footwear being assessed. This should be 20 mm above the featherline.

5.15.2.4.8 Operate the machine so that the footwear is flexed at a rate of 60 ± 6 flexes per min, for a duration of 80 min.

5.15.2.4.9 Remove the test piece from the machine and inspect it for water penetration. If no obvious water penetration has occurred, use absorbent paper or other suitable means to determine if and where water penetration has occurred. If dampness is observed, estimate and record the wet area, in cm².

NOTE Water penetration can also be detected by sensors.

5.15.2.5 Test report

Include in the test report:

- reference to this test method;
- a description of the footwear tested;
- the corresponding water penetration area as recorded in 5.15.2.4.9;
- any deviations from the standard test method.

5.16 Determination of impact resistance of a metatarsal protective device

5.16.1 Apparatus

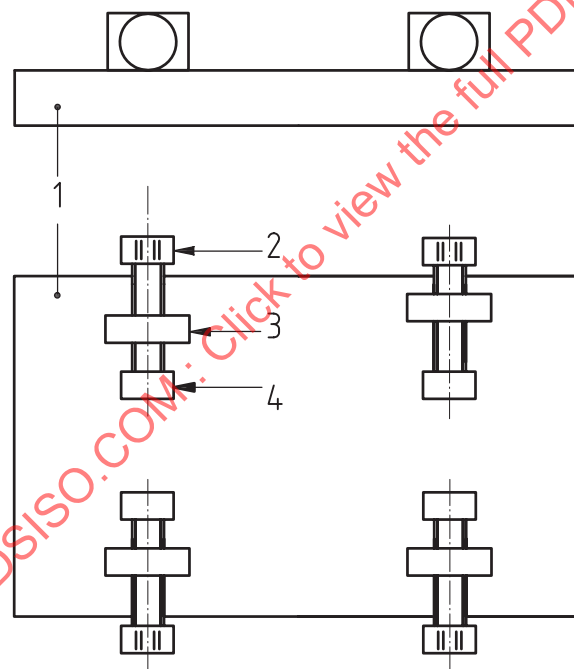
5.16.1.1 Impact apparatus, incorporating a steel striker of mass $(20 \pm 0,2)$ kg adapted to fall freely on vertical guides through a predetermined height to give required impact energy calculated as potential energy.

The striker shall consist of a wedge at least 60 mm long, the faces of which subtend at an angle $(90 \pm 1)^\circ$ and a minimum hardness of 60 HRC. The apex where the faces meet shall be rounded to a $(3 \pm 0,1)$ mm radius. During the test the apex shall be parallel within $\pm 17'$ to the surface of the clamping device (see EN 12568:2010, Figure 4).

The base of the apparatus shall have a mass of at least 600 kg. A metal block of dimensions at least 400 mm $\times$ 400 mm $\times$ 40 mm deep shall be bolted to it.

The apparatus shall be free standing on a flat and level floor, which is sufficiently massive and rigid to support the test equipment.

5.16.1.2 Clamping device, consisting of a smooth steel plate at least 19 mm thick of a minimum hardness 60 HRC, with a device for clamping the heel and joint region of the shoe (see Figure 23).



Key

- 1 base plate
- 2 screw
- 3 threaded lug
- 4 clamping plate

Figure 23 — Clamping device

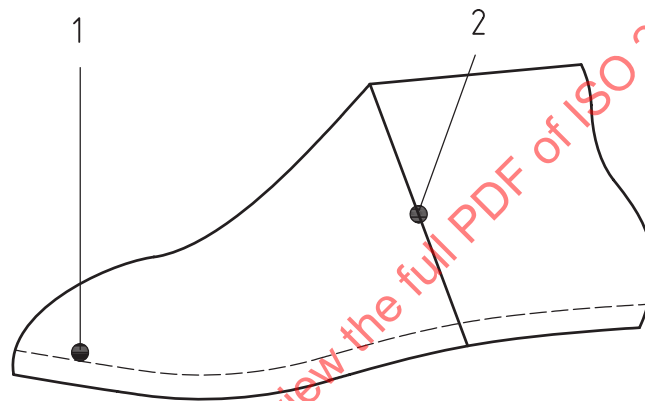
5.16.1.3 Dial gauge, with hemispherical foot of $(3,0 \pm 0,2)$ mm radius capable of exerting a force not greater than 250 mN.

5.16.1.4 Wax test form

5.16.1.4.1 This represents the inside of the footwear and is used to measure the deformation of the metatarsal region during impact. This form shall be made by one of the methods described in 5.16.1.4.2 and 5.16.1.4.3.

5.16.1.4.2 Production of the wax form using the making last (preferred method) involves a two stage operation, the first of which is to form a mould of the last used to make the footwear. The second consists of producing a wax test form of this mould.

Stage 1: Using a last one size smaller than the test footwear, fill in any 'V' cut in the last and any holes and form a shell using a vacuum former and a thermoplastic material (e.g. 0,4 mm thick unplasticized PVC sheets) over the upper surface. When cool, trim off surplus material below the feather edge of the last and remove. Similarly, form a shell over the bottom surface and trim at between 5 mm and 10 mm above the feather edge to form a flange on the edge. Join the two shells, using a tape, such that the upper shell fits inside the flange formed on the bottom shell and tape the join. Cut the joined shell to produce front and heel end moulds (see Figure 24).



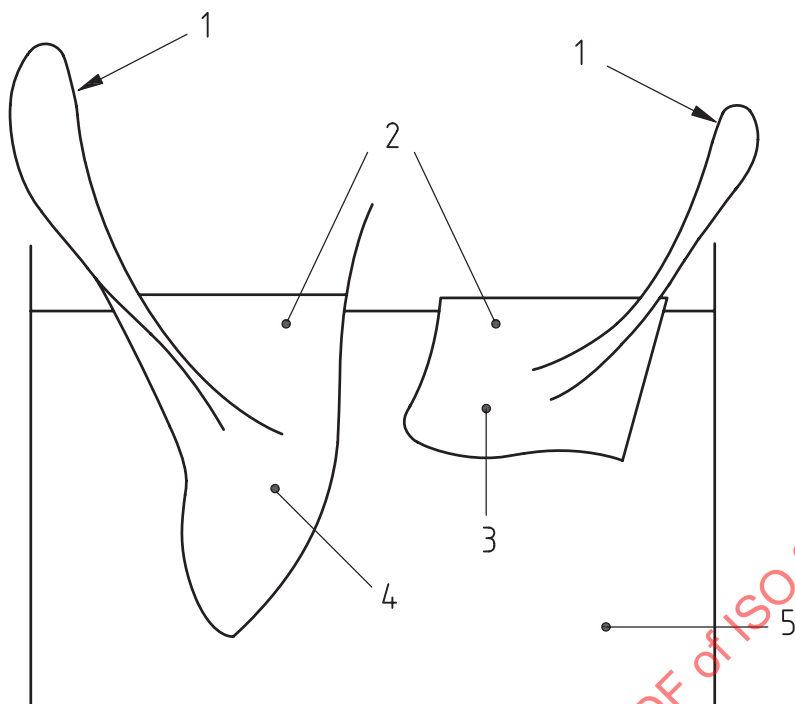
Key

- 1 flange overlapping top shell
- 2 cut

Figure 24 — Shells joined together showing separation cut

Stage 2: Stand up the two moulds in a container such that the top surfaces are horizontal, and support with sand (see Figure 25). Prepare the wax for the test last from a mixture of paraffin wax (with a melting point of 50 °C to 53 °C) and beeswax in a ratio 5:1. Combine the paraffin wax and the beeswax in a suitable mixing vessel, place in an oven and heat to approximately 85 °C. Remove the vessel from the oven and stir until the mixture cools to approximately 60 °C and pour into the two moulds. Insert a loop of thin tape into the molten wax to facilitate later removal from the test footwear, ensuring that the tape does not penetrate to the outer surface of the front mould (see Figure 25). Allow to cool. Remove the wax forms from the moulds.

NOTE With care, the moulds can be used to produce a number of wax forms.



Key

- 1 tape to help in removal from test piece
- 2 moulds filled to top with wax
- 3 heel end mould
- 4 toe end mould
- 5 container filled with sand

Figure 25 — Moulds supported in sand and filled with wax

5.16.1.4.3 Production of wax forms using footwear involves a three stage operation, the first of which is to produce a plaster of Paris cast of the inside of the footwear, followed by the production of moulds and casts as described in 5.16.1.4.1. It requires one extra item of footwear, which will be destroyed during the production of the plaster of Paris mould.

Stage 1: Coat with petroleum jelly or releasing agent the inside of an item of footwear the same size as that to be tested. Secure the fastening system and fill to the top of the opening with a mixture of plaster of Paris and water. Leave until set and then remove by cutting away the footwear. After removal, place in an oven at about 80 °C to dry.

Stage 2: Continue as for stage 1 in 5.16.1.4.1 using the plaster of Paris cast in the place of making last.

Continue as for stage 2 in 5.16.1.4.1.

5.16.2 Preparation of the test piece

Use the complete item of footwear as the test piece. If removable insoles are present, remove these before the test.

5.16.3 Procedure

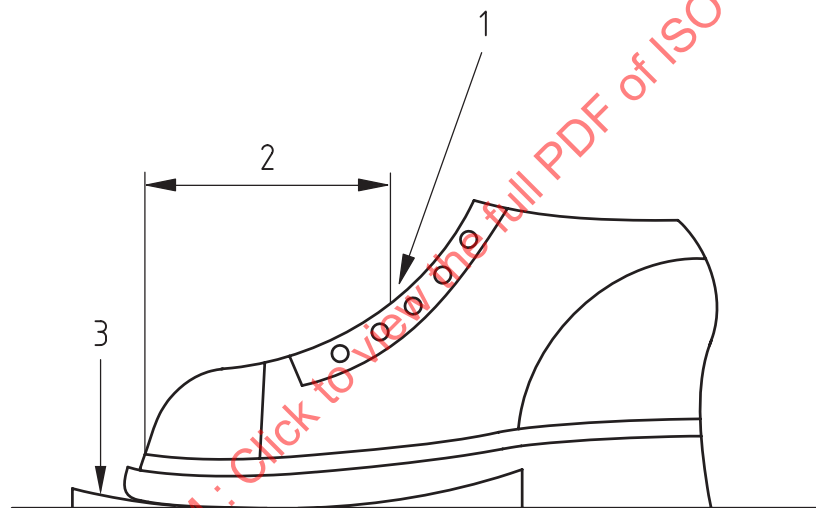
Insert the wax forms into the test piece and close the fastening system. The test axis as defined in 5.3.2 should be marked onto the wax test form by marking through the footwear. Clamp the test piece onto the base plate (5.16.1.1) using the clamping device (5.16.1.2) and position it such that, at the moment of impact, the striker

shall be at 90° to the axis of the test piece, as described in 5.4.2.1. The striker shall hit the test piece once, at a distance from the toe as specified in Table 8 (see Figure 26).

Table 8 — Distances of impact

Size of footwear		Distance of impact from toe ^a
UK	French	
Up to 3 1/2	36 and below	90
4 to 5	37 and 38	95
5 1/2 to 6 1/2	39 and 40	100
7 to 8	41 and 42	105
8 1/2 to 10	43 and 44	110
10 1/2 and above	45 and above	115

^a This distance is measured along the test axis from the toe end.



Key

- 1 point of impact
- 2 dimension from Table 8
- 3 wedge

Figure 26 — Point of impact

Place a wedge under the forepart of the test piece to prevent deformation of the footwear during impact.

Allow the striker to drop onto the test piece from an appropriate height (measured vertically from the impact point) to give an impact energy of (100 ± 2) J.

5.16.4 Test results

After testing, carefully remove the wax form from the footwear and position it on a flat support such that it maintains the same horizontal orientation it had within the test piece.

Using the dial gauge (5.16.1.3), measure the vertical height above the flat surface on the axis as determined in 5.4.2.1 at the maximum point of deformation.

Measure the thickness of the removable insock in the region of the strike using the dial gauge (5.16.1.3). Subtract this value from the clearance value achieved.

5.17 Determination of the shock absorption capacity of ankle protection materials incorporated into the upper

5.17.1 Principle

A test piece taken from the ankle protective area of the upper is subjected to an impact test and the transmitted force measured.

5.17.2 Apparatus

5.17.2.1 Impact apparatus, consisting of a guided mass of $(5\,000 \pm 10)$ g which strikes a test anvil in a vertical drop. The centre of gravity of the falling weight shall be vertically above the centre of the anvil during the whole operation.

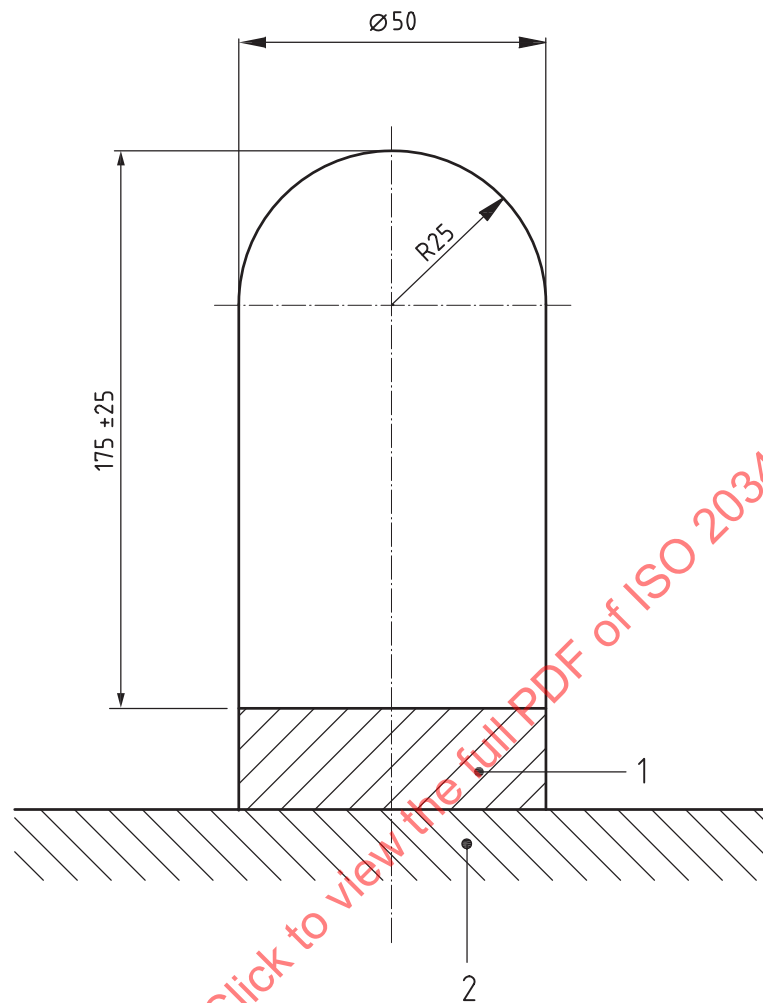
The drop height shall be approximately 0,2 m, in order to ensure a kinetic energy of 10 J.

5.17.2.2 Striker. The drop striker face shall be made from polished steel with dimensions of 80 mm × 40 mm, all edges being rounded with a radius of (5 ± 1) mm.

5.17.2.3 Anvil, made of polished steel with an overall height of (175 ± 25) mm, consisting of a cylinder with the radius 25 mm which in its upper part is rounded to a hemispherical shape also with 25 mm radius (see Figure 27). The anvil shall be attached, in a vertical position and through a piezo-electric load cell or gauge cell, to a solid mass of at least 600 kg. The cell shall be properly preloaded and calibrated.

5.17.2.4 Force measurement instrumentation. The anvil shall be mounted so that during impact testing the whole force between the anvil and the compact base of the apparatus passes through the piezoelectric quartz force transducer in line with its sensitive axis. The force transducer shall have a calibrated range of not less than 120 kN and a lower threshold of less than 0,1 kN. The output of the force transducer shall be processed by a charge amplifier and the peak force shall be recorded by suitable instrumentation.

Dimensions in millimetres

**Key**

- 1 force transducer
- 2 solid base

Figure 27 — Anvil and base

5.17.2.5 Templates, prepared from a suitable flexible material (e.g. fabric, fleece, paper), capable of maintaining its shape and dimensions during use.

The templates shall be circular and of the dimensions stated in Table 9. Their centre point shall be indicated by suitable marking or by cutting a small hole.

5.17.3 Sampling

At least two samples (inside and outside) shall be taken from each of three pairs of footwear (small, medium and large sizes) to enable at least six impact tests to be performed, three on inner ankle protection and three on outer ankle protection.

5.17.4 Preparation of the test pieces

The selected footwear sample is fitted to the foot of an individual for whom it is the correct size. While this tester stands freely in an upright position, a second tester marks onto the footwear upper the position of the ankle, referring to the most prominent part of the ankle bone. A template of suitable size (see Table 9) is then fitted onto the ankle protector by matching its centre to the centre marked on the upper.

The test area is defined by drawing around the template onto the upper, and the test piece containing all material layers is completed by cutting it in a way which assures an added margin of at least 1,0 cm around the marked template shape.

NOTE It is not mandatory that the extra margin surrounds the test piece completely on all sides. The margin is beneficial because, if necessary, it can be used to attach the material layers to each other, which is useful when the tester intends to perform the impact test close to the border of the impact area.

The four ankle protectors of a pair of footwear need not necessarily be of a unified shape, but they shall match at least the circular sizes indicated in Table 9.

Table 9 — Minimum size of ankle protectors

Size of footwear		Minimum diameter mm
UK	French	
6 1/2 and below	40 and below	56
7 to 9	41 to 43	60
9 1/2 and above	44 and above	64

5.17.5 Conditioning

Samples and test pieces shall be conditioned for at least 24 h at $(23 \pm 2) ^\circ\text{C}$ and $50 \% \text{ RH} \pm 5 \% \text{ RH}$ before testing.

5.17.6 Procedure

The test piece is positioned outer surface upwards on the anvil in such a way that a part of the test area covers the centre point of the anvil. The test piece may be fixed in the selected position by covering with a suitably thin net or fabric with a centre hole of 20 mm to 25 mm diameter to avoid influencing the result. This auxiliary device should be pulled down, by means of elastic straps, with an overall force of 5 N to 10 N, which can easily be controlled by the force measuring system itself.

The drop striker is then released. The transmitted force, as well as damage or breakage of the test piece, is recorded.

The test piece shall be tested once only at each point.

5.17.7 Test report

The mean force and the highest obtained single value are reported. In case of different inside/outside construction, the results shall be stated separately for the ankle protectors from the inside and outside of the footwear's uppers. Any damage to the test pieces shall be recorded.

6 Test methods for upper, lining and tongue

6.1 Determination of thickness of upper

Determine the thickness in accordance with Method A in ISO 23529:2010, 7.1, using a thickness gauge with a flat presser foot of $(10 \pm 0,1)$ mm diameter and a load of $(1 \pm 0,1)$ N. The thickness of the upper shall include any associated textile layer.

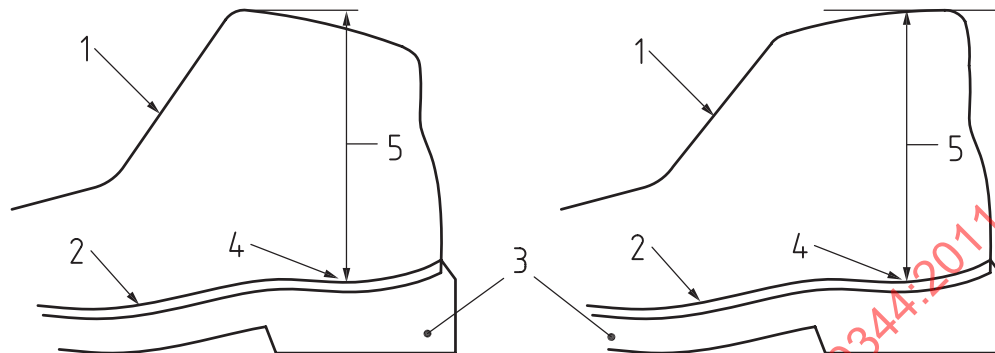
6.2 Measurement of the height of the upper

6.2.1 Preparation of the test piece

Use one complete item of footwear as the test piece.

6.2.2 Measurement

The height (in mm) of the upper is the vertical distance between the lowest point on the insole/insock, i.e. between the heel breast and the back of the heel (see Figure 28) and the highest point on the upper.



Key

- 1 upper
- 2 insole/insocks
- 3 outsole
- 4 lowest point of the insole within the heel region
- 5 height of the upper

Figure 28 — Measurement of the height of the upper

6.3 Determination of tear strength of the upper, lining and/or tongue

Determine the tear strength in accordance with one of the following methods (whichever is appropriate):

- ISO 3377-2 for leather;
- ISO 4674-1:2003, method B, for coated fabric and textile.

For coated fabric and textile, use a test piece as large as possible. The width shall be between 25 mm and 50 mm and the length between 50 mm and 200 mm, with a cut 20 mm long placed centrally and parallel with the longer sides to form a trouser shaped test piece. Carry out the test at a constant rate of transverse of 100 mm/min. For knitted and non-woven materials, use the largest possible test piece obtainable from the footwear.

6.4 Determination of the tensile properties of the upper material

6.4.1 General

Determine the tensile properties of the upper material in accordance with the appropriate method given in Table 10.

Table 10 — Tensile properties

Type of material	Test method	Tensile property
Leather split	ISO 3376 ^a	Tensile strength
Rubber ^b	See 6.4.2	Breaking force
Polymeric ^c	ISO 4643	Modulus at 100 % elongation Elongation at break
^a Using the test piece $l = 90$ mm, $b_1 = 25$ mm. ^b The test pieces shall include any associated textile layer if present. ^c Remove the textile layer before testing.		

6.4.2 Determination of the breaking force of a rubber boot upper

6.4.2.1 Apparatus

6.4.2.1.1 Tensile-testing machine, with a constant rate of traverse and with means for indicating or preferably recording the maximum load applied to the test piece at rupture. The central points of the two jaws of the machine shall be in the line of pull, the front edges shall be perpendicular to the line of pull and their clamping faces shall be in the same plane. The jaws shall be capable of holding the test piece without allowing it to slip, they shall be so designed that they do not cut or otherwise weaken the test piece and they shall be wider than the prepared test piece. The rate of traverse of the pulling jaw shall be $100 \text{ mm/min} \pm 10 \text{ mm/min}$.

6.4.2.2 Test pieces

Cut test pieces from the boot upper above the vamp so that they are 25 mm wide and of a convenient length to allow a distance of 75 mm between the jaws of the tensile-testing machine.

Cut three test pieces (two in one direction and one across). Where the height of the product does not permit a test piece to be cut to give a free length of 75 mm between the jaws, use a free length of 25 mm.

6.4.2.3 Procedure

Place each of the test pieces in the tensile-testing machine in turn and measure the force required to break each test piece.

6.4.2.4 Expression of results

Express the breaking force of the boot upper in both the length and breadth directions as the mean value, in newtons, of the breaking force recorded for each of the three test pieces. Record the dimensions of the test piece used.

6.5 Determination of upper flexing resistance

6.5.1 General

Determine the upper flexing resistance in accordance with whichever of the following methods is appropriate:

- see 6.5.2 for rubber (the test piece should include any associated textile layer);
- ISO 4643:1992, Annex B, for polymers (test carried out at -5°C).

6.5.2 Determination of resistance to flexing of a rubber upper

6.5.2.1 Apparatus

6.5.2.1.1 Micrometer dial gauge, accurate to within 0,1 mm.

6.5.2.1.2 Flexing machine, the essential features of which shall be as follows.

The machine shall have an adjustable stationary part with grips 25 mm in width for holding one end of the test piece in a fixed position, and a similar reciprocating part for holding the other end of the test piece.

The reciprocating part shall be mounted so that its motion is in the direction of, and in the same plane as, the centreline between the grips, and its travel adjusted so that the reciprocating part approaches the stationary grip to a distance of $13 \text{ mm} \pm 1 \text{ mm}$ and recedes to a distance of $57 \text{ mm} \pm 1 \text{ mm}$.

The cam which actuates the reciprocating part shall be driven by a constant-speed motor to give 340 flexes/min to 400 flexes/min, and with sufficient power to flex at least six and preferably twelve test pieces at one time.

The test pieces shall be arranged in two equal groups so that one group is being flexed while the other is being straightened, thus reducing the vibration in the machine. The grips shall hold the test pieces firmly and shall enable individual adjustments to be made to each test piece.

The test equipment shall be kept away from any ozone source.

6.5.2.2 Test pieces

Cut one test piece from the thinnest portion of the boot upper containing the fewest layers of fabric. The test piece shall have the dimensions shown in Figure 29.

Dimensions in millimetres

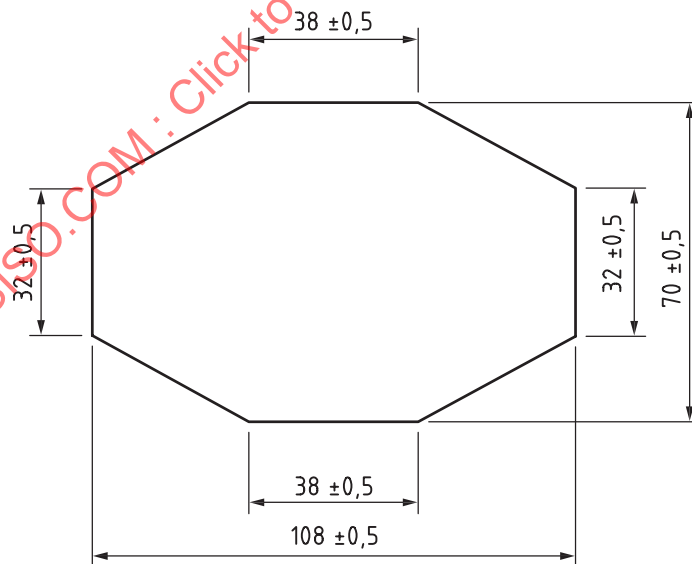


Figure 29 — Test piece for flexing test

Ensure that the test pieces are cut cleanly from the sample material.

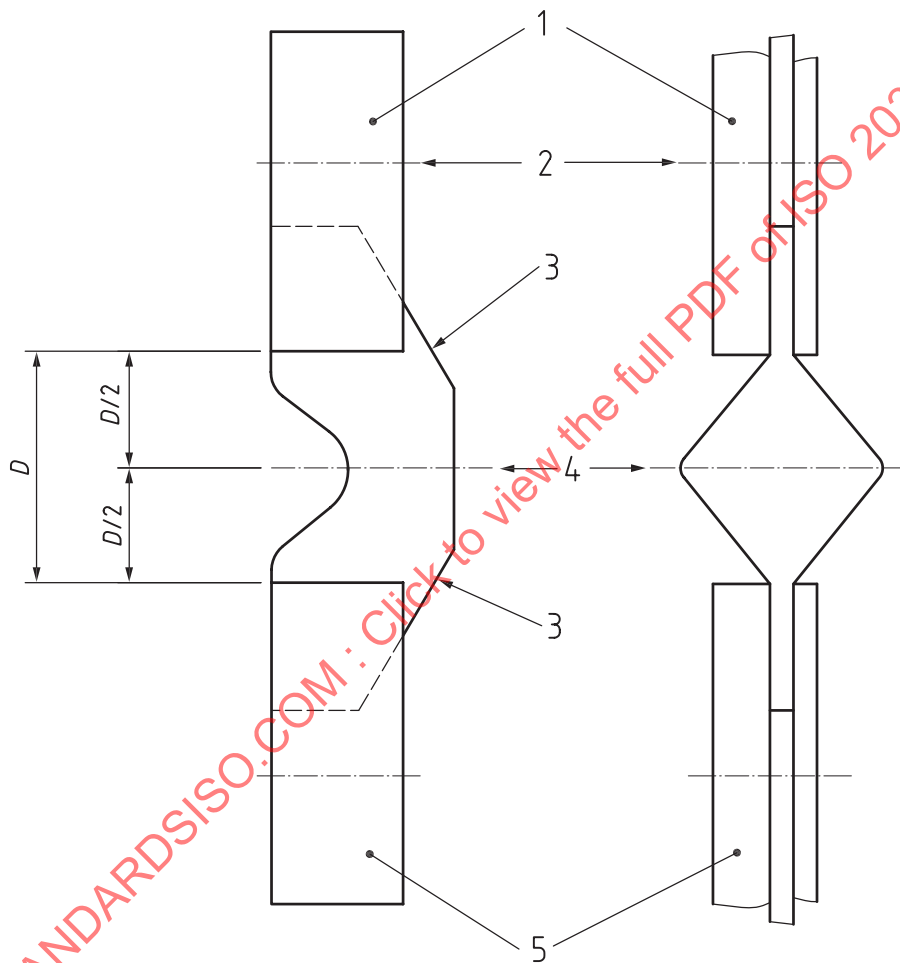
Measure the thickness of the test pieces with a micrometer dial gauge at each corner and in the centre and take the median of the five readings as the thickness of the individual test piece to the nearest 0,1 mm.

6.5.2.3 Fitting the test pieces in place

Fold the test piece symmetrically about its major axis so that the rubber surface is outwards. In the folded condition, insert one tapered end into the stationary grip so that the central axis of the test piece is midway between the stationary and reciprocating grips when these are at their greatest separation. Both folded tapered ends shall be aligned with the edges of their respective grips. For convenience, the tapered ends of the test piece may be marked at the gripping points in order to align the test piece correctly in the grips. Tighten the grip, insert the other end of the test piece into the reciprocating grip and tighten.

It is essential that the test piece is not under tension.

Figure 30 shows the arrangement of the apparatus and test piece during the flexing cycle.



Key

- 1 stationary grip
- 2 centre of guide pins (approximately 6 mm diameter)
- 3 tapered ends of test piece
- 4 central axis of test piece
- 5 reciprocating grip

Figure 30 — Arrangement of apparatus and test piece during the flexing cycle

6.5.2.4 Procedure

Carry out the required number of flex cycles. Record the number of completed flex cycles by using a trip counter operated by one of the reciprocating grips. A complete to-and-fro movement of the reciprocating grip shall be counted as one flex cycle. The ambient temperature during testing shall be $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$.

Remove the test piece and examine for pinholes and cracking.

6.5.2.5 Expression of results

Record the number of flex cycles completed, the thickness of the test piece and whether any pinholes or cracks were visible with the unaided eye, for each test piece tested.

6.6 Determination of water vapour permeability (WVP)

6.6.1 Principle

The test piece is fixed over the opening of a jar, which contains a quantity of solid desiccant. This unit is placed in a strong current of air in a conditioned atmosphere.

The air inside the container is constantly agitated by the desiccant, which is kept in movement by the rotation of the jar.

The jar is weighed in order to determine the mass of the moisture that has passed through the test piece and has been absorbed by the desiccant.

6.6.2 Apparatus

6.6.2.1 Jars or bottles, fitted with a screw top with a circular opening whose diameter is equal to the diameter of the neck of the jar (approximately 30 mm) (see Figure 31).

Dimension in millimetres

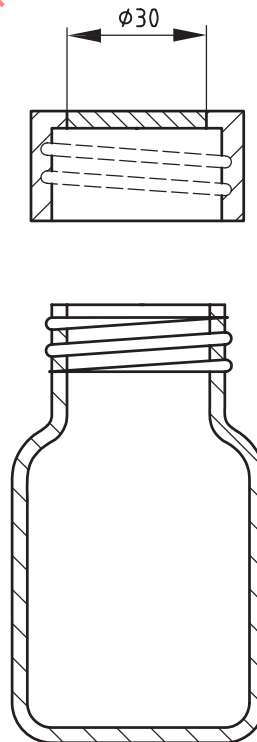


Figure 31 — Jar to be used in WVP test

Dimension in millimetres

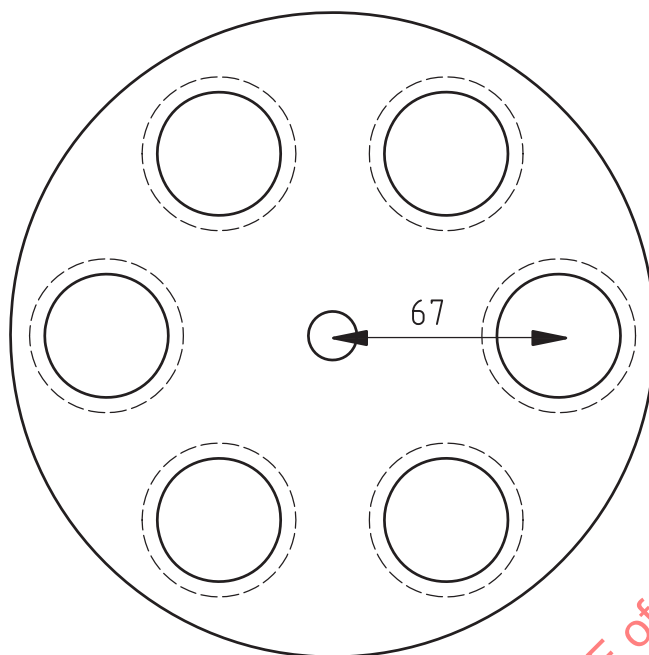


Figure 32 — Holders for jars used in WVP test

6.6.2.2 Holder, in the form of a disc which is rotated at (75 ± 5) r/min by an electric motor. The jars are placed on this disc with their axes parallel to the axle of the disc and at a distance of 67 mm from it (see Figure 32).

6.6.2.3 Fan, mounted in front of the mouths of the jars and consisting of three flat blades in planes that are inclined at 120° to one another. The planes of the blades shall pass through the prolongation of the axle of the disc. The blades shall have dimensions of approximately 90 mm by 75 mm, and the 90 mm long side of each blade nearest to the mouths of the jars passes them at a distance of not greater than 15 mm (see Figure 33). The fan shall rotate at $(1\,400 \pm 100)$ r/min. The apparatus shall be used in a conditioning atmosphere of $(23 \pm 2)^\circ\text{C}$, $(50 \pm 5)\%$ RH.

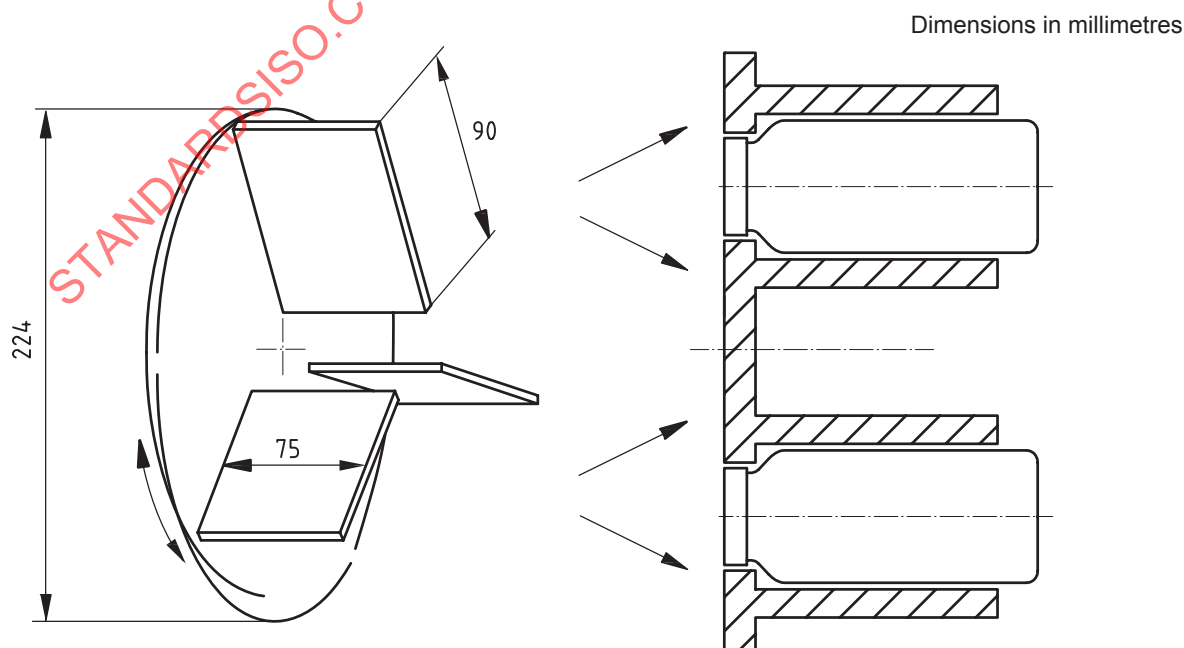


Figure 33 — Schematic diagram of apparatus to be used in water vapour permeability test

6.6.2.4 Silica gel desiccant, freshly regenerated by at least 16 h in a ventilated oven at $(125 \pm 5) ^\circ\text{C}$ then cooled to ambient temperature in a hermetically sealed vessel. The granular size of the crystals shall be between 2 mm to 5 mm.

NOTE Silica gel beads are preferred to granules as they generate less dust.

The silica gel should be sieved before regeneration in order to eliminate small particles and dust. At regeneration, the specified temperature $130 ^\circ\text{C}$ should not be exceeded due to the risk of reducing the absorptive capacity of the gel. The ventilation of the oven by use of a fan is not necessary but the oven should not be sealed; it should allow continuous exchange of the air inside the oven with that outside. The gel should not be used while it is warmer than the test piece and, since it cools slowly in a closed vessel, a long cooling time is needed.

6.6.2.5 Balance, capable of weighing to the nearest 0,001 g.

6.6.2.6 Stopwatch.

6.6.2.7 Instrument, capable of measuring to the nearest 0,1 mm the internal diameter of the neck of the jars.

6.6.2.8 Pre-flexing apparatus, comprising the following features.

- An upper clamp, consisting of a pair of flat plates. One plate has the shape of a trapezium (see Figure 34, ABCD) but with a sharp corner at D, rounded to a radius of 2 mm. It shall have a ledge, EF, on which the folded test sample rests. The other plate shall have the shape EGHCF. The two plates shall be screwed together, so as to hold one end of the sample between them as shown in Figure 34. The screw, K, which draws the plates together shall also act as a stop, to prevent the ends of the sample from being thrust too far towards the back of the clamp. Between the plates near the edge, AB, shall be a stop to prevent them from coming together near AB, and so ensuring that they clamp the sample firmly near F. The upper clamp shall be reciprocated by a motor about a horizontal axis.

Dimensions in millimetres

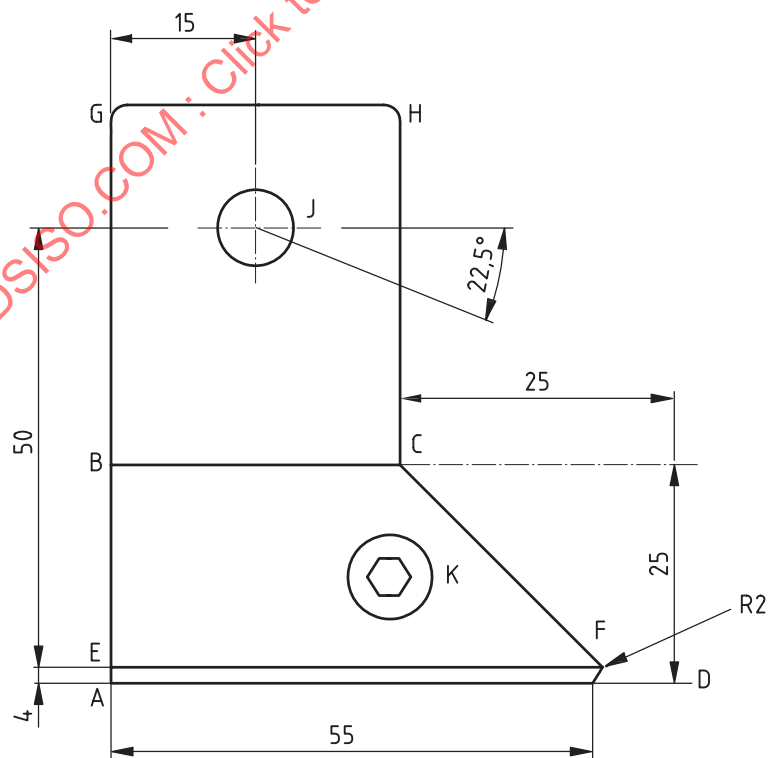
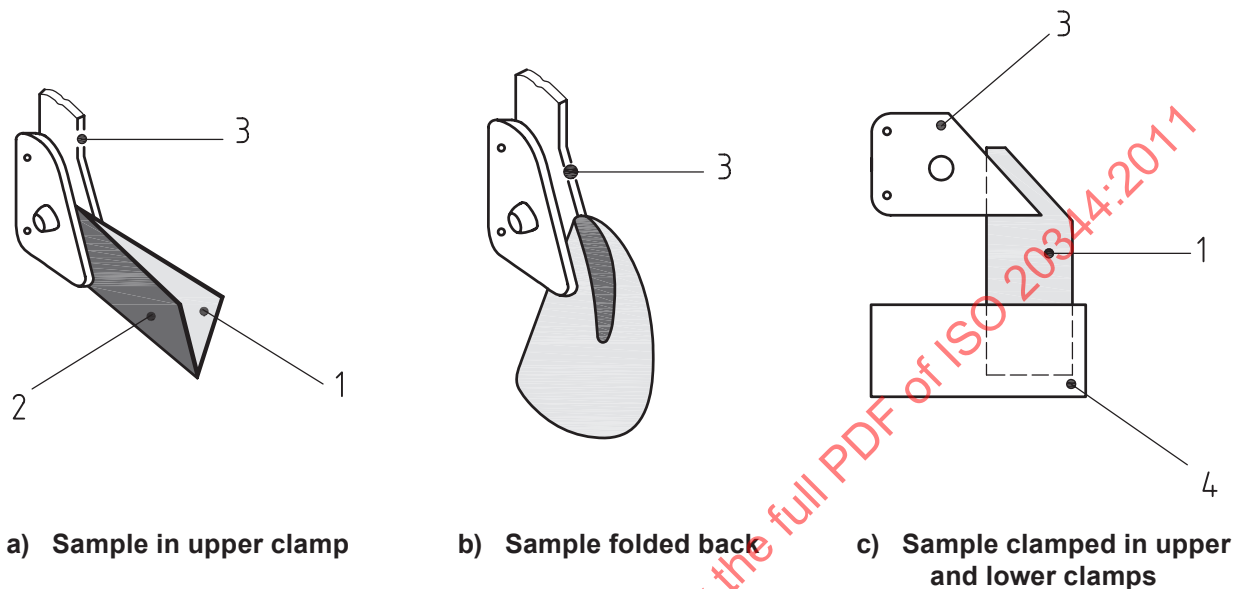


Figure 34 — Upper clamp

In the position shown in Figure 34 the ledge EF is horizontal, and the end F is its highest point. The clamp descends through an angle of $22,5^\circ$ and returns (100 ± 5) times/min. The number of cycles is recorded by a counter.

- A lower clamp, fixed and lying in the same vertical plane as the upper clamp. It shall consist of a pair of plates, which can be screwed together to hold the other end of the sample between them. If the upper clamp has been turned to the position where the ledge EF is horizontal (see Figure 34) the upper edges of the plates of the lower clamp shall be 25 mm below the ledge of EF.



Key

- 1 outer side
- 2 inner side
- 3 upper clamp (see Figure 34)
- 4 lower clamp

Figure 35 — Insertion of the test sample in the clamps

6.6.3 Preparation of the test piece

6.6.3.1 Preflexing

Cut a test sample of dimensions 70 mm × 45 mm.

Turn the motor until the ledge EF is horizontal. Fold the test sample in two, with the grain side inwards, and clamp it to the upper clamp as shown in Figure 35 a), with one end of the sample against the stop and the folded edge against the ledge.

Draw the free corners of the sample outwards and downwards as shown in Figure 35 b) so that the surface which is turned inwards in the clamp is turned outwards below it. Draw the sample down, bringing together its two corners which have not been clamped. Clamp it in the lower clamp [as shown in Figure 35 c)] with the part of the fold between the clamps vertical, using no more force than is needed to make the sample just taut.

Switch on the machine and carry out 20 000 flexing cycles.

Switch off the machine and remove the test sample from the clamps.

6.6.3.2 Cutting the test piece

Cut a circular test piece of 34 mm diameter from the preflexed sample centrally about the point at which the flexing creases meet.

6.6.4 Test procedure

Measure the internal diameter of the neck of a jar (to the nearest 0,1 mm) in two directions perpendicular to each other and calculate the average diameter in mm.

Add regenerated silica gel to the jar until it is approximately half full. Fix the test piece over the neck of the jar by means of the screw top with the side facing the foot pointing outwards.

If it is necessary to seal the junction between the test piece and the neck of the jar, warm the bottle and apply a thin layer of wax to the flat end surface of the neck.

If the opening of the jar has been coated with wax, warm to around $(50 \pm 5) ^\circ\text{C}$ before introducing the silica gel and fixing the test piece.

Place the jar in the holder of the apparatus and switch on the machine, noting the time.

After it has run for 1 h, stop the machine and weigh the jar, m_1 .

Place the jar in the apparatus and switch on the machine, noting the time.

After ≥ 7 h and ≤ 16 h stop the machine and reweigh the jar, m_2 , noting once again the time.

6.6.5 Calculation and expression of results

Calculate the water vapour permeability using the equation:

$$W_3 = \frac{m}{At} = \frac{m}{\pi r^2 t} \quad (2)$$

where

W_3 is the water vapour permeability, in $\text{mg}/(\text{cm}^2 \cdot \text{h})$;

m is $m_2 - m_1$, in mg;

m_1 is the initial mass of the jar with test piece and silica gel, in mg;

m_2 is the final mass of the jar with test piece and silica gel, in mg;

A is πr^2 = the test surface area, in cm^2 ;

r is the radius of the test surface, in cm;

t is the time between the first and second weighing, in h.

6.7 Determination of water vapour absorption (WVA)

6.7.1 Principle

An impermeable material and the test piece are clamped over the opening of a metal container, which holds 50 ml of water, for the duration of the test.

Water absorption of the test piece is determined by the difference in its mass before and after the test.

6.7.2 Apparatus

6.7.2.1 Circular metal container (volume 100 cm³) and an upper ring, between which the impermeable material and the test piece are clamped (see Figure 36). The container and the ring shall have an internal diameter of 3,5 cm which corresponds to a test area of approximately 10 cm². The upper ring shall be clamped to the apparatus with three hinged bolts equipped with wing nuts, or by any other appropriate means.

6.7.2.2 Balance, capable of weighing to the nearest 0,001 g.

6.7.2.3 Stopwatch.

6.7.3 Preparation of test piece

Cut a test piece 4,3 cm in diameter.

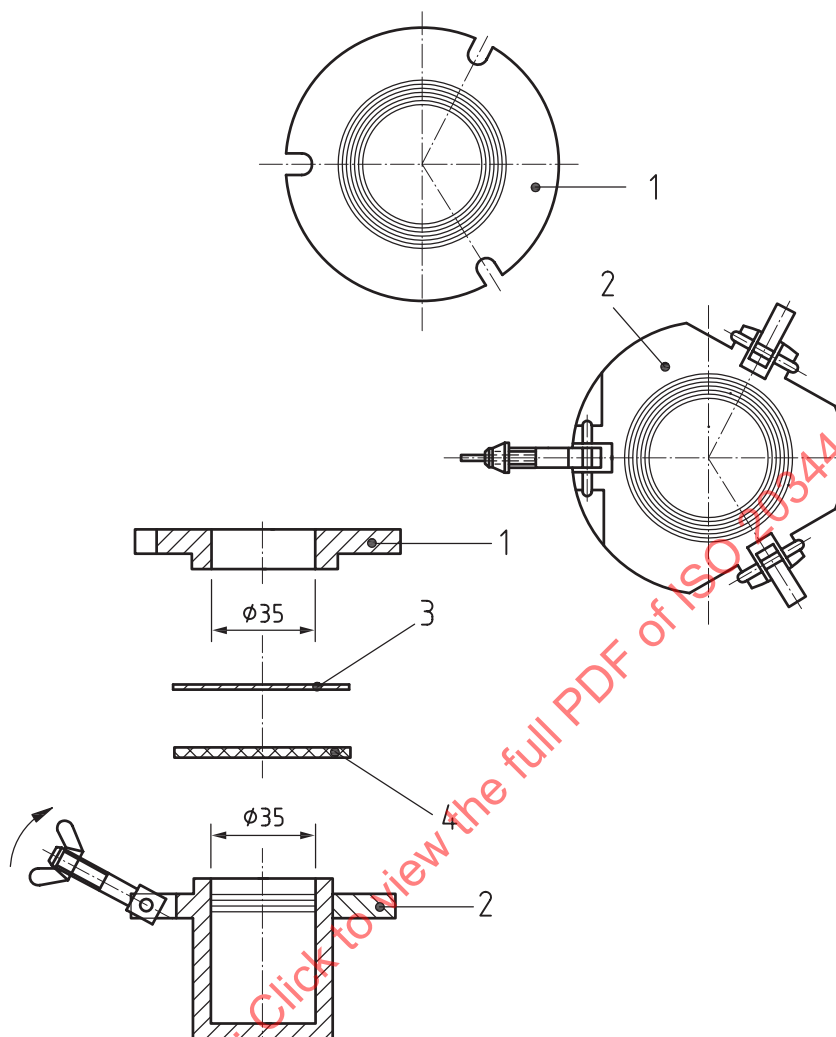
6.7.4 Test procedure

Carry out the test in a conditioning atmosphere of $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \% \text{ RH}$. Weigh the conditioned test piece and record its mass, m_1 .

Place 50 ml of water into the container and place the test piece over the container with the side facing the foot downwards. Place the impermeable disc and the upper ring over the test piece and screw down firmly. Ensure that no water laps against the bottom of the test piece.

Remove the test piece after 8 h and weigh immediately, recording its mass, m_2 .

Dimensions in millimetres

**Key**

- 1 top
- 2 bottom
- 3 seal
- 4 test piece

NOTE The means of clamping the top to the bottom is illustrative only.

Figure 36 — Apparatus for determination of WVA

6.7.5 Calculation and expression of results

Calculate the water vapour absorption using the equation:

$$W_1 = \frac{m_2 - m_1}{a} \quad (3)$$

where

W_1 is the water vapour absorption, in mg/cm²;

m_1 is the initial mass of the test piece, in mg;

m_2 is the final mass of the test piece, in mg;

a is the test surface area, in cm².

Round the result to the nearest 0,1 mg/cm².

6.8 Determination of water vapour coefficient

Calculate the water vapour coefficient using the equation:

$$W_2 = 8W_3 + W_1 \quad (4)$$

where

W_2 is the water vapour coefficient, in mg/cm²;

W_3 is the water vapour permeability, in mg/(cm²·h);

W_1 is the water vapour absorption, in mg/cm².

Round the result to the nearest 0,1 mg/cm².

6.9 Determination of pH value

Determine the pH value of leather (upper, lining, tongue, insole or insock) in accordance with ISO 4045.

6.10 Determination of resistance to hydrolysis of upper

Determine the upper hydrolysis in accordance with Annex B of ISO 5423:1992, after preparing and conditioning in accordance with Annex E of ISO 5423:1992. The test pieces shall include any associated textile layer.

6.11 Determination of chromium VI content

Determine the chromium VI content of leather (upper, lining, tongue, insole or insock) in accordance with ISO 17075.

If the footwear incorporates different types of leather, whether in contact with the skin or not, each leather type shall be tested separately.

6.12 Determination of abrasion resistance of lining and insock

6.12.1 Principle

Circular test pieces are abraded on a reference abradant, under a specified pressure, with a cyclic planar motion in the form of a Lissajous figure (the result of two simple harmonic motions at right angles to each other). The resistance to abrasion is assessed by subjecting the test piece to a defined number of cycles at which point it shall not exhibit any holes.

6.12.2 Apparatus

6.12.2.1 Abrasion machine, fulfilling the following requirements.

- Rotational speed of each of the outer pegs: $(47,5 \pm 5)$ r/min.
- Drive ratio of outer pegs to inner pegs: 32 : 30.
- Dimensions of the Lissajous figure: (60 ± 1) mm.
- Symmetry of Lissajous figure: curves shall be parallel and evenly spaced.
- Face diameter of test piece holder insert: $(28,65 \pm 0,25)$ mm.
- Combined mass of test piece holder, spindle and weight: (795 ± 7) g.
- Parallelism of plate and abrading tables: $\pm 0,05$ mm.
- Circumferential parallelism: $\pm 0,05$ mm.
- Diameter of abrading base: (125 ± 5) mm.

The test piece holders and abrading tables shall be plane and parallel over their entire surfaces. The drive from the motor to the machine shall be connected to a counter and switch so that the revolutions of the outer pegs are induced. The machine shall be stopped after a predetermined number of cycles has been measured by the counter.

6.12.2.2 Reference abrasant ³⁾ consisting of a crossbred worsted spun, plain woven fabric, conforming to Table 11.

The reference abrasant shall be mounted on the abrading tables over a piece of felt. The felt shall be non-woven felt of mass per unit area (750 ± 50) g/m² and $(3 \pm 0,5)$ mm thick.

NOTE The felt need not be renewed until damaged or soiled on both sides or until approximately 100 h of testing have been completed.

Table 11 — Reference abrasant

	Warp	Weft
Yarn linear density	R63 tex/2	R74 tex/2
Threads per cm	17	12
Singles twist, turns per metre	540 ± 20 'Z'	500 ± 20 'Z'
Two-fold twist, turns per metre	450 ± 20 'S'	350 ± 20 'S'
Fibre diameter, μm	$27,5 \pm 2,0$	$29,0 \pm 2,0$
Mass per unit area of fabric, minimum g/m ²	195	
Oil content, %	$0,9 \pm 0,2$	

6.12.2.3 Backing for test pieces, having a mass per unit area less than 500 g/m², consisting of polyether urethane foam (3 ± 1) mm thick, of density (30 ± 1) kg/m³ and indentation hardness $(5,8 \pm 0,8)$ kPa, cut to the same size as the test piece. Backings shall be renewed with every test.

6.12.2.4 Fabric punch or press cutter, to produce a test piece to fit the holder, having a diameter of 38 mm.

3) A suitable reference abrasant, felt and polyether urethane foam, may be obtained from SATRA Technology Centre, Northamptonshire, United Kingdom, <http://www.satratr.co.uk>. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

6.12.2.5 Weight, of mass $(2,5 \pm 0,5)$ kg and diameter (120 ± 10) mm.

6.12.2.6 Balance, capable of weighing to the nearest 0,001 g.

6.12.3 Atmosphere for testing

The testing atmosphere shall be (23 ± 2) °C and (50 ± 5) % RH.

6.12.4 Preparation of test pieces and materials

Using the fabric punch (6.12.2.4), cut four circular test pieces from the lining, two for the dry test and two for the wet test. Expose the test pieces and materials to the standard atmosphere test for at least 24 h.

6.12.5 Procedure

6.12.5.1 General

Check that the top plate and abrading tables are parallel. Insert a diameter gauge through the spindle bearing and move the top plate by turning the drive shaft by hand. The needle movement of the dial gauge shall be within $\pm 0,05$ mm over the whole surface of the abrading table. If machines are being used in which the test piece holders are connected to the weights by spindles, assemble each empty test piece holder and place each one in position on the appropriate abrading table and insert the spindles. Use a feeler gauge to check for any gap between the face of the holder insert and the table. The gap shall not be greater than 0,05 mm. Rock the spindle from side to side and recheck with the feeler gauge. To avoid damaging abrading tables and metallic inserts, do not run the machine with metallic inserts in contact with the uncovered abrading tables.

6.12.5.2 Mounting the test pieces

Remove the outer ring of a test piece holder together with the accompanying metallic insert. Insert the test piece centrally into the outer ring so that the face to be abraded shows through the hole.

For test pieces of fabric which have a mass per unit area of less than 500 g/m^2 , insert a disc of polyether urethane foam (6.12.2.3) which has the same diameter as the test piece. Use a new backing for each test. Place the metallic insert carefully into the outer ring with its raised surface next to the test piece. Complete the assembly of the test piece holder by screwing on the back plate while pressing the face of the test piece firmly against a hard surface to prevent wrinkling. Check that no wrinkling has occurred. Repeat for remaining test pieces.

6.12.5.3 Preparation of abradant and backer for wet test

Thoroughly wet the fabric abradant and felt backer by one of the following methods:

- a) soak overnight;
- b) agitate thoroughly in water;
- c) wet with a high pressure water jet.

Allow excessive water to drain and mount them in accordance with 6.12.5.4.

Rewet the abradant fabric and felt every 6 400 cycles by gradually pouring on up to 30 ml of water and lightly rubbing it with the fingertips. Place the weight (6.12.2.5) on the fabric and leave for a few seconds to squeeze out excess water.

6.12.5.4 Mounting abradant

Mount a new piece of reference abradant (6.12.2.2) on each table with a piece of felt of the same dimensions beneath the reference abradant. Flatten the reference abradant by placing the weight (6.12.2.5) on its surface,

and then position and tighten up the retaining frame evenly. Make sure that the reference abrasant is held in place firmly and that there are no tucks or ridges.

6.12.5.5 Mounting test piece holders

Mount the test pieces in the machine.

Every time a holder is taken from the machine to check a test piece, re-tighten the holder before it is replaced on the machine.

If during the test pilling occurs, it shall not be cut off.

6.12.6 Method of assessment

Continue the test until either a hole forms in the test piece or the intended number of cycles have been performed (25 600 or 51 200 cycles for the dry sample and 12 800 or 25 600 cycles for the wet test). If the fabric has a hole, it is only necessary to take account of holes in the base fabric. A hole should only be considered as a hole when it extends through the full thickness of the layer constituting the wear surface. This is assessed by the naked eye.

6.13 Determination of water penetration and water absorption for upper

6.13.1 Principle

The material is partially immersed in water and flexed on a machine in a manner simulating conditions of wear. Measurements are taken of:

- a) the percentage gain in mass of the test piece due to water absorption 60 min from the start of the test;
- b) the mass of water which has passed through the test piece after 60 min of test.

6.13.2 Equipment

6.13.2.1 Test apparatus, comprising the following items.

6.13.2.1.1 Two cylinders, 30 mm diameter, made of inert rigid material, mounted with their axis horizontal and co-axial. One cylinder shall be fixed and the other shall be movable along the direction of its axis.

6.13.2.1.2 Electric motor, which drives the movable cylinder backwards and forwards along its axis with crank motion at 50 cycles/min. When the movable cylinder is at the greatest distance from the fixed one, the adjacent flat faces of the two cylinders shall be 40 mm apart.

6.13.2.1.3 Tank, containing distilled water, in which the trough-shaped test piece can be partly immersed.

6.13.2.1.4 Metallic plate, carried by a spring, resting on the roll of absorbent cloth, applying a load of 1 N to 2 N.

6.13.2.1.5 Ring shaped clamps, to clamp the longer edges of the test piece round the adjacent ends of the cylinders so that it forms a trough whose ends are closed by the cylinders.

6.13.2.2 Absorbent cloth, used to absorb water transmitted to the interior of the trough formed by the test piece. The absorbency of the material may not be optimum when new. It shall therefore be washed before the first use.

NOTE A suitable cloth consists of a rectangle of cotton towelling-type textile of approximately 120 mm × 40 mm with a mass of approximately 300 g/m².

6.13.2.3 Balance, capable of weighing to the nearest 0,001 g.

6.13.2.4 Clock, with an accuracy of within 1 min.

6.13.3 Preparation of test piece

Cut from the upper a rectangle of 75 mm × 60 mm. For leather and coated materials, the wear surface shall be buffed by rubbing with a grade 180 emery paper, placing a rigid plate and 10 N load on top of it and moving it 100 mm 10 times.

The absorbent cloth shall also be conditioned, as the test piece, prior to use.

In order to avoid leakage of water at the clamps, especially with thin or lightweight materials, apply a layer of adhesive along the edges (covering about 1 to 2 mm of the adjacent faces) to ensure a proper seal.

6.13.4 Procedure

Adjust the apparatus to give a 7,5 % compression of the test piece.

Weigh the test piece to the nearest 0,001 g and record the mass, m_1 .

Fix the test piece in the apparatus, with the outer surface of the upper in contact with the water, as follows.

With the two cylinders at their maximum distance apart, wrap the test piece round their adjacent ends so that it forms a trough whose upper edges, formed by the shorter side of the test piece, are horizontal and at the same level. Keep the test piece between the cylinders under slight tension to remove folds, and with approximately the same length (about 10 mm) overlapping on each cylinder, clamp it using ring clamps. Position the inner edges of the two ring clamps as close as possible in the planes of the adjacent ends of the cylinders, so that the length of the trough is the same as the free length of the test piece between the clamps.

Weigh the absorbent cloth (6.13.2.3), recording its mass, P_1 . Roll it up to form a cylinder of 40 mm length and immediately place it in the trough formed by the test piece. Place the plate (6.13.2.1.4) so that it rests on the cloth.

Raise the level of water in the tank until water lies about 10 mm below the top of the cylinders.

Start the motor. Stop the motor after 60 min.

Remove the metal plate.

Remove the absorbent cloth and mop up any surplus water within the trough. Reweigh the cloth. This mass is P_2 .

Remove the test piece from the cylinders, blot to remove adhering water and reweigh. This mass is m_2 .

6.13.5 Calculation and expression of results

Calculate the water penetration using the equation:

$$W_p = P_2 - P_1 \quad (5)$$

where

W_p is water penetration, in g;

P_1 is the initial mass of the absorbent cloth, in g;

P_2 is the final mass of the absorbent cloth, in g.

Calculate the water absorption using the equation:

$$W_A = \frac{m_2 - m_1}{m_1} \times 100 \quad (6)$$

where

W_A is the water absorption, as a percentage by mass;

m_1 is the initial mass of the test piece, in g;

m_2 is the final mass of the test piece, in g.

6.14 Determination of resistance of upper to cutting

6.14.1 Preparation of the test piece

Take three samples (see Table 1), then cut two test pieces from the protective area of each sample. The dimensions of the test pieces are 100 mm × 80 mm.

Carry out one test on each test piece within the protective area (see ISO 20345:2011, 6.2.8.2).

NOTE The width of the test piece taken from the protective area can be smaller than the one requested. In this case several test pieces can be taken in order to complete the five cuts for each test.

6.14.2 Procedure

Test in accordance with the method described in EN 388:2003, 6.2.2.

7 Test methods for insole and insock

7.1 Determination of insole thickness

Cut through the sole in the region of the cleat and measure the thickness of the insole using a graduated eyepiece with 0,1 mm scale graduations.

7.2 Determination of water absorption and desorption of insole and insock

7.2.1 Principle

A test piece is positioned on a wet base plate and is submitted to repeat flexing under a given pressure (in the same manner as the insole of a shoe during walking).

The water absorption at the end of test and the water desorption following the tests are determined.

7.2.2 Apparatus

The apparatus comprises the following items (see Figure 37).

7.2.2.1 Brass roller (A), of diameter (120 + 1) mm and width (50 + 1) mm, which is placed over the test piece (B).

7.2.2.2 Platform (C), with roughened upper surface and with sufficient perforations to allow the surface to be kept wet by a flow of water through the platform. The upper surface of the platform (C) is covered by a strip of cotton gauze consisting of 50 % of cotton and 50 % of polyamide of mass per unit area (60,5 ± 2) g/m².

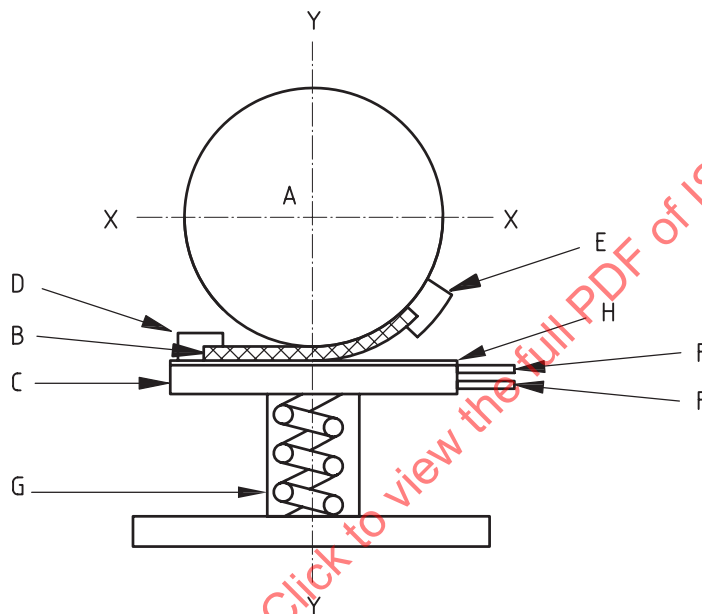
7.2.2.3 Clamp (D), to hold one short side of the test piece (B) in a horizontal position on the platform (C).

7.2.2.4 Clamp (E), to attach the other short side of the test piece to the roller with the attached side being parallel to the axis of the roller. The clamp is held by a weak spring to maintain the sample under slight tension.

7.2.2.5 Water supply (F), through the platform (C) and a means of draining away excess water.

7.2.2.6 Means, of moving the axis of the roller, with a to-and-fro motion along the X-X axis, with an amplitude of (50 ± 2) mm about a point directly over the midpoint of the test piece at frequency of (20 ± 1) cycles per min. The movement of the axis causes the roller to move backwards and forwards along the test piece, raising one end and bending it to conform to the shape of the roller.

7.2.2.7 Means (G), of pressing the platform, test piece and roller together with a force of (80 ± 5) N.



Key

- A brass roller
- B test piece
- C platform
- D clamp on the platform
- E clamp on the brass roller
- F water supply
- G means of pressing the platform
- H cotton gauze

Figure 37 — Schematic diagram of test apparatus (example)

7.2.2.8 Press knife, to cut test pieces of dimensions (110 ± 11) mm $\times$ (40 ± 1) mm.

7.2.2.9 Balance, capable of measuring to within 0,001 g.

7.2.2.10 Clock, with an accuracy of within 1 s.

7.2.2.11 Silicone grease, or suitable adhesive.

7.2.3 Sampling and conditioning

In the case of footwear, the test piece should be taken from the forepart of the insole, in the longitudinal direction. For sheet materials, the test pieces are taken in the two principal directions, one at 90° to the other.

Test pieces shall be strips of (110 ± 11) mm $\times$ (40 ± 1) mm. If the test piece is too thick for the clamps, reduce the thickness in the clamping area, removing the face which is not in contact with the foot.

Apply a little silicone grease or a suitable adhesive over the edges of the test piece in order to prevent the ingress of water through the sides.

7.2.4 Procedure

Weigh the test piece to the nearest 0,001 g (m_O).

Place the cotton gauze on the platform (C).

Apply the test piece in the apparatus with the surface which would be in contact with the foot in contact with platform (C) covered with the cotton gauze. Attach the narrow ends to the platform and roller and apply a force of (80 ± 5) N.

Open the valve to enable the flow of water and adjust this to $(7,5 \pm 2,5)$ ml/min over the platform.

Switch on the machine and note the time.

Run the test for 1 h and stop the water supply 1 min before stopping the machine.

Remove the test piece and weigh it to the nearest 0,001 g, recording its mass, m_F .

Recondition the test piece by leaving it on a flat waterproof surface in a controlled environment (see Clause 4) for a period of 24 h, then reweigh the test piece to the nearest 0,001 g, m_R .

7.2.5 Expression of results

7.2.5.1 Water absorption

Calculate the water absorption using the following equation:

$$W_A = \frac{m_F - m_O}{A} \quad (7)$$

where

W_A is the water absorption, expressed in mg/cm²;

m_O is the initial mass of the test piece, in mg;

m_F is the final mass of the test piece, in mg;

A is the area of the test piece in cm².

Express the water absorption to the nearest 1 mg/cm².

7.2.5.2 Water desorption

Calculate the water desorption using the following equation:

$$W_D = \frac{m_F - m_R}{m_F - m_O} \times 100 \quad (8)$$

where

W_D is the water desorption, as a percentage of the mass of water absorbed;

m_O is the initial mass of the test piece, in g;

m_F is the final mass of the test piece in g;

m_R is the mass of the reconditioned test piece in g.

Report the water desorption to the nearest 1 %.

7.2.6 Test report

Include in the test report:

- the results for water absorption and water desorption expressed in accordance with 7.2.5.1 and 7.2.5.2;
- nature and full identification of the sample;
- description of sampling procedure, where relevant;
- reference to the method of test.

7.3 Determination of abrasion resistance of insole

7.3.1 Principle

The test piece is rubbed with pieces of wet, white wool felt, covered with the abradant fabric, under a given pressure, with a number of to-and-fro motion cycles. The test is carried out on conditioned insole material, and abrasion damage is assessed visually (with naked eye).

7.3.2 Apparatus

7.3.2.1 Test equipment, incorporating the following features:

- carriage, with a horizontal, completely planar metal platform, a holder for fastening the material leaving 80 mm freely exposed and a device which allows the test piece to be maintained under a slight tension in the direction of the rubbing;
- finger, of mass 500 g, removable but able to be fixed firmly, with a base of 15 mm × 15 mm, a device for attaching pieces of wool felt pads (7.3.2.2) to the base, an additional mass of 500 g and a means of guiding the finger when fully loaded (total mass 1 kg) flat on the test piece;
- means for driving the carriage to and fro, with an amplitude of 35 mm and a frequency of (40 ± 2) cycles/min.

NOTE The following items are convenient, but not essential parts of the equipment:

- means to move the finger at right angles to the direction of rubbing, so that two or three tracks can be used for rubbing on one test piece;
- means for pre-selecting a given number of cycles.