INTERNATIONAL STANDARD

ISO 13999-3

First edition
2002-07-01

Protective clothing — Gloves and arm guards protecting against cuts and stabs by hand knives —

Part 3: Impact cut test for fabric, leather and other materials

Vêtements de protection — Gants et protège-bras contre les coupures et les coups de couteaux à main —

Partie 3: Essai de coupure par impact pour étoffes, cuir et autres matériaux

Reference number
ISO 13999-3:2002(E)

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

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

Printed in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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 part of ISO 13999 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13999-3 was prepared by Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 13, *Protective clothing*. It is based on EN 1082-3:2000.

ISO 13999 consists of the following parts, under the general title *Protective clothing — Gloves and arm guards protecting against cuts and stabs by hand knives*:

— *Part 1: Chain-mail gloves and arm guards*

— *Part 2: Gloves and arm guards made of material other than chain-mail*

— *Part 3: Impact cut test for fabric, leather and other materials*

Annex A of this part of ISO 13999 is for information only.

Introduction

This test is based on the impact penetration test given in ISO 13998. It differs in that the blade-holding block and blade weigh 110 g rather than 1 000 g. The test specimen support is also changed to suit the testing of fabric, leather and other materials. The test is designed particularly to assess the stab resistance of materials for gloves and arm guards. The test is also suitable for assessing gloves exposed to severe abrasion and cutting threats such as motorcyclists' gloves, working gloves for handling concrete blocks or razor wire, or protective leggings and trousers for refuse collectors. Severe abrasion is a process involving multiple cuts and this test is a good indicator of abrasion resistance of the whole thickness of a material or sequence of materials.

It has been assumed in the drafting of this part of ISO 13999 that the execution of its provisions is entrusted to appropriately qualified and experienced people, for whose guidance it has been prepared. The apparatus described should only be used by competent persons and requires safeguards to prevent, as far as is reasonably practicable, injury to the operator and other persons.

Protective clothing — Gloves and arm guards protecting against cuts and stabs by hand knives —

Part 3:
Impact cut test for fabric, leather and other materials

1 Scope

This part of ISO 13999 specifies an impact cut test for use on fabric, leather and other materials used in protective clothing, gloves and arm guards.

Annex A of this part of ISO 13999 gives recommendations for the specification of impact cut tests on materials and products such as gloves and arm guards and gives the list of information which should be specified in the product standard in order to be able to apply this test.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 13999. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 13999 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 13999-1, *Protective clothing — Gloves and arm guards protecting against cuts and stabs by hand knives — Part 1: Chain-mail gloves and arm guards*

EN 388:1994, *Protective gloves against mechanical risks*

3 Terms and definitions

For the purposes of this part of ISO 13999, the terms and definitions given in ISO 13999-1 apply.

4 Principle

This test assesses the resistance of fabric, leather and other materials used in protective clothing, gloves and arm guards to cutting by a sharp, straight knife-edge. The test specimen is tested by impact of a standard knife blade held in a guided falling block. The length of the cut produced by the particular impact energy is proportional to the depth of penetration of the knife, which is easily measured.

5 Test apparatus

An example of the design of a test apparatus is shown in Figure 1. No specific design of the stand is required. Design details such as the means of allowing removal of the block and test blade after impact, and necessary safety guards are not shown.

5.1 Blade-holding block, as shown in Figure 2, for holding the test blade so that it protrudes by (55 ± 5) mm.

The position of the blade tip shall be offset by the distance l_4 which is (8 ± 1) mm from the centreline of the block which shall pass through the centre of gravity of the block. The centre of gravity of the block and blade shall be (100 ± 10) mm above the blade tip level. The mass of the block with test blade shall be (110 ± 5) g.

The block shall be held in its initial position by an electromagnet. The block shall have four sliders made of polytetrafluoroethylene or similar material which guide its drop down the guide rods. There shall be 0,5 mm to 1,5 mm clearance between the sliders and the guide rods. The heights from which the block is released shall be set so that the appropriate energy of impact is achieved.

5.2 Test blade, of which the edge shall be straight and sharp, made of cold-forged stainless steel (hardness > 45 HRC) and having the profile and dimensions as shown in Figure 3.

After machine grinding, the blade edge should be made smooth and sharp by hand finishing on an oilstone. Blades may be re-sharpened after use. When fabrics and leathers are tested re-sharpening is not required after every test. However, before every penetration, test the blade to ensure that it is both straight and sharp. Sharpen the test blade if the results for the calibration material reveal the need for the blade to be re-sharpened.

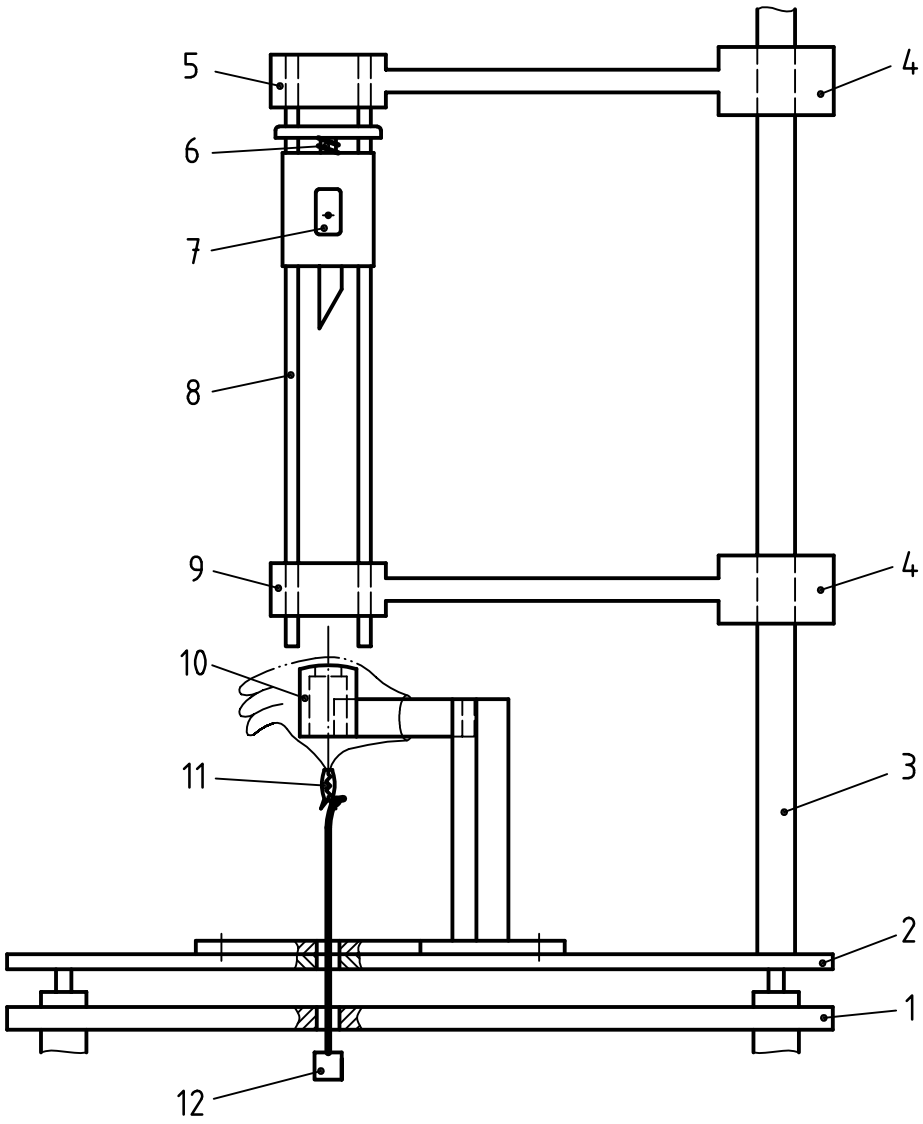
5.3 Test specimen support, as shown in Figure 4.

The material test specimen or glove is supported on a horizontal arm which ends in a circular anvil with a hole in which the knife enters during the test (see Figure 5). It has been found convenient to make the support from mild steel.

The circular metal anvil shall be (50 ± 3) mm in diameter and have a vertical height of approximately 60 mm. The top surface shall be machined to be domed with a radius of curvature of (200 ± 5) mm. The anvil shall have a slot cut in its centre. The slot shall be (3,5 ± 0,05) mm wide and (23 ± 0,2) mm long. The ends shall be semi-circular. The slot shall be vertical and pass through the anvil. The anvil may be machined out from below so that the centre of the anvil is not less than 7 mm thick.

The anvil shall be attached to a horizontal arm such that the axis of the arm is at (45 ± 5)° to the long axis of the slot. The arm shall be attached to the anvil so that its top surface is (30 ± 2) mm below the centre of the top of the anvil. The arm shall be (15 ± 2) mm wide and (35 ± 5) mm deep. The arm shall be attached to a rigid support such that there is at least 180 mm clearance below it and the arm has an unobstructed length of at least 150 mm.

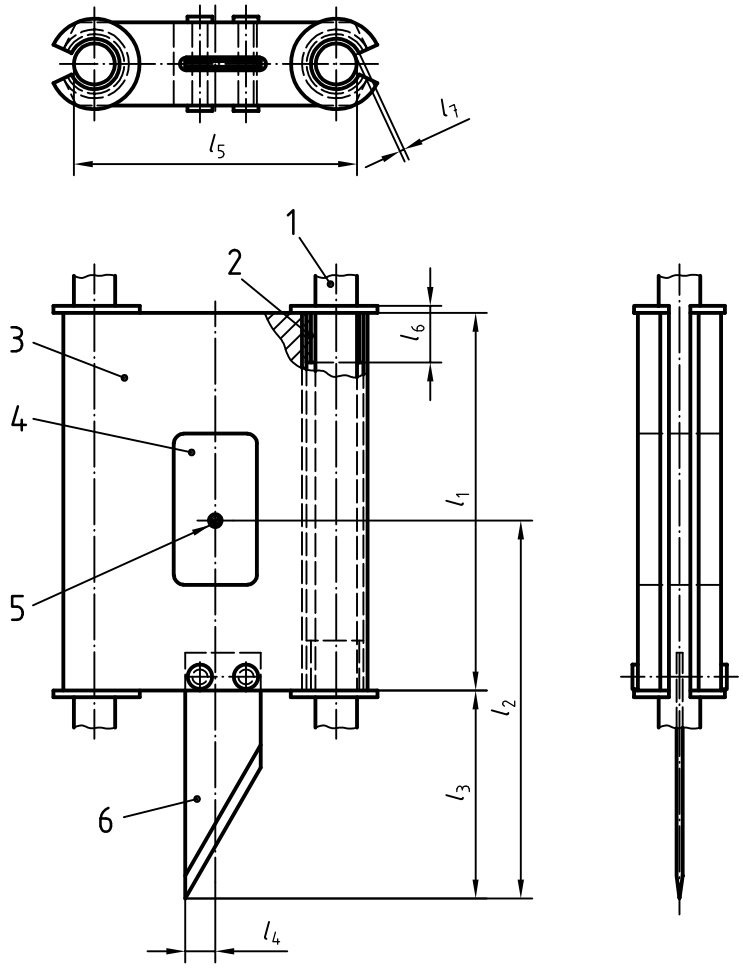
The test specimen support shall be firmly attached to the base plate of the apparatus which shall be provided with a hole at least 50 mm wide directly under the anvil so that a weight piece suspended on a string can be clipped to the lower side of the test specimen on the support.



Key

1 Table
2 Base plate
3 Support
4 Bracket
5 Fixing block for the upper end of the guide rods
6 Electromagnetic release mechanism
7 Falling block and test blade
8 Guide rods
9 Fixing block for the lower end of the guide rods (the falling block passes through it)
10 Test specimen support
11 Clip
12 Weight piece

Figure 1 — Example of an impact cut penetration testing apparatus

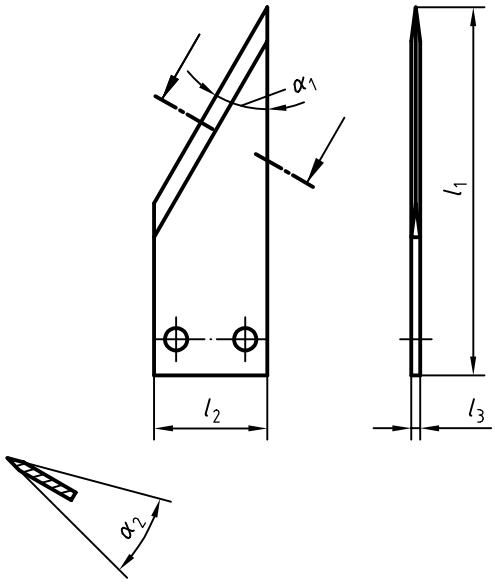


Key

1	Guide rods	l_1	= (100 ± 1) mm
2	Plastic slider	l_2	= (100 ± 10) mm
3	Block	l_3	= (55 ± 5) mm
4	Cut out space to achieve correct mass distribution	l_4	= (8 ± 1) mm
5	Centre of gravity for block and test blade	l_5	= (75 ± 1) mm
6	Test blade	l_6	= (15 ± 1) mm
		l_7	Clearance, 0,5 mm < l_7 < 1,5 mm

The mass of the block and test blade are equal to (110 ± 5) g

Figure 2 — Blade-holding block



Key

α_1 Angle of the sharp edge to the back of the blade, $\alpha_1 = (30 \pm 1)°$

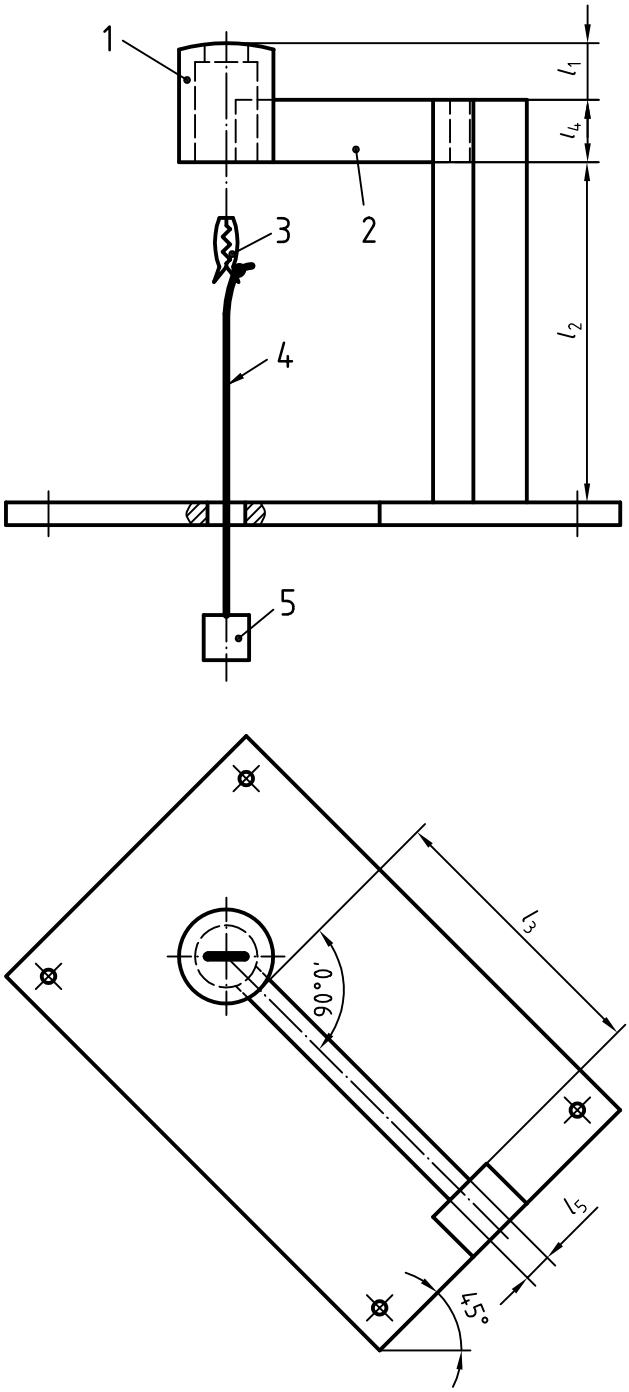
α_2 The included angle of the sharp edge, $\alpha_2 = (30 \pm 3)°$

l_1 Length of the blade, $l_1 \geqslant 65$ mm

l_2 Width of the blade, $l_2 = (20 \pm 0{,}5)$ mm

l_3 Thickness of the blade, $l_3 = (1{,}5 \pm 0{,}05)$ mm

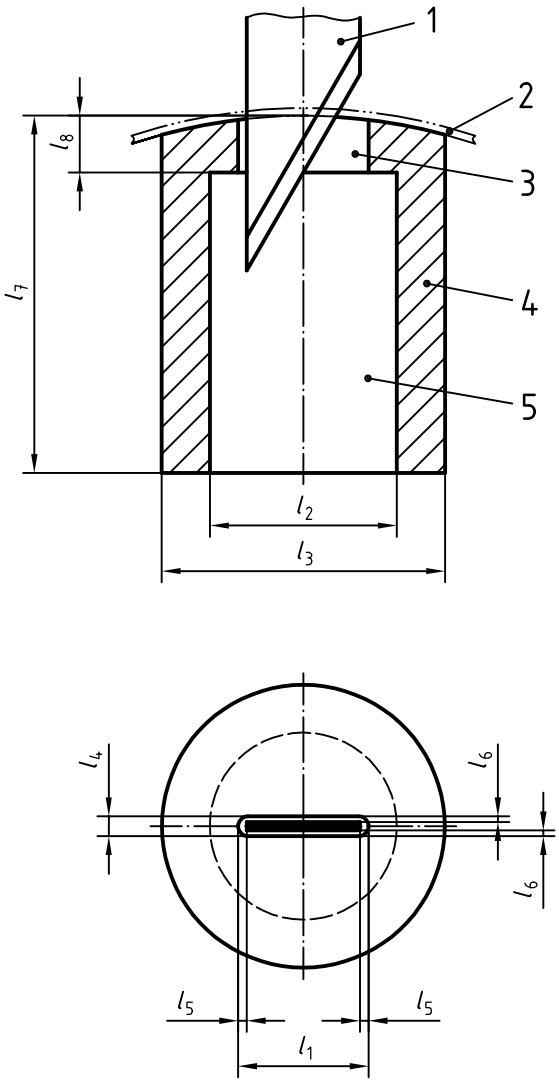
Figure 3 — Test blade



Key

1	Anvil	l_1	Height of anvil top above support arm, $l_1 = (30 \pm 2)$ mm
2	Support arm	l_2	Clearance below anvil, $l_2 > 180$ mm
3	Clamp	l_3	Length of support arm, $l_3 > 150$ mm
4	String	l_4	Depth of support arm, $l_4 = (35 \pm 5)$ mm
5	Weight piece	l_5	Width of support arm, $l_5 = (15 \pm 2)$ mm

Figure 4 — Test specimen support



Key

1	Test blade	l_1	Knife slot length, l_1 = (23 ± 0,2) mm
2	Test specimen material	l_2	Width of machined out base of anvil, l_2 = (33 ± 3) mm
3	Anvil	l_3	Width of anvil, l_3 = (50 ± 3) mm
4	Knife slot	l_4	Knife slot width, l_4 = (3,5 ± 0,05) mm
5	Lower slide of anvil machined out	l_5	Clearance of full blade width at end of the knife slot, l_5 = (1,5 ± 0,2) mm
		l_6	Clearance either side of knife blade in knife slot, l_6 = (1 ± 0,2) mm
		l_7	Height of anvil, l_7 = approximately 60 mm
		l_8	Minimum thickness of top anvil, l_8 = 7 mm

Figure 5 — Dimension of knife hole in support block

6 Sampling

6.1 Preparation of test specimens

The location, shape and dimensions of the test specimens to be cut from the product to be sampled shall be as specified in the appropriate national or International Standard for the product (hereafter referred to as the product standard). Pre-treat and prepare the number of test specimens as specified in the product standard.

Join the edges of flat materials to form a tube by possibly sewing, stapling or welding the test specimen edges. The tube should be at least 100 mm in length, but not so long that its length impedes positioning of the test specimen as required in 7.2. The tube shall have a circular diameter of (100 ± 20) mm. Prepare knitted materials so that the area to be tested is representative of the use of the material in the product. Stabilize the test specimen, if necessary, by a line of stretchable over-lock stitches around its edge to prevent the knitted structure from breaking down.

Test specimens that are gloves or arm guards may be suitable to be tested in their entirety. Cut very stiff products and stabilize their cut edges so that they can be positioned as required in 7.2.

If washing and dry cleaning pre-treatments are to be conducted, then intact products, or large material specimens, should be pre-treated before test specimens are prepared.

6.2 Mounting a test specimen

Slide the test specimen onto the anvil and arm so that the area to be tested lies over the anvil. Clip a weight piece of (1 000 ± 50) g to the pendant side of the test specimen so as to pull on it with a force of 10 N. Smooth out the test specimen over the anvil using the procedure specified in the product standard. By twisting the test specimen on the anvil, cuts can be made parallel to the longitudinal axis of the test specimen, transversely across the test specimen and at any angle between these orientations.

7 Procedure

7.1 Setting up the apparatus

Ensure the guide rods are vertical (± 2 mm over 1 m), and the blade-holding block runs freely on the guide rods from the electromagnetic catch to the test specimen support. The guide rods should end no more than 10 mm above the top of the anvil. Wipe the guide rods with light oil and rub them clean before use. Ensure that the test specimen support is horizontal (± 10 mm over 1 m).

Set up an instrument to measure the velocity of the falling block over at least 5 mm within the last 100 mm of the fall distance before the knife tip strikes the test specimen. Carry out test drops of the block fitted with the knife. Measure the velocity to an accuracy of ± 0,05 $m \cdot s^{-1}$. Weigh, to the nearest ± 0,5 g, the mass of the block and knife. Calculate the energy of impact the knife tip would make upon the test specimen. Adjust the height of the electromagnet so that the mean impact energy of ten test drops is within 5 % of the impact energy specified in the product standard.

NOTE The normal impact energy used for this test is 0,65 J and is obtained by a drop from a height of 600 mm.

7.2 Test

The requirements for the performance level and the protective area to which the product is to be tested shall be as specified in the product standard.

Set up a test specimen on the support in the test apparatus with the electromagnetic catch at the appropriate height. Line up the test specimen so that the knife blade is parallel to the axis of the test specimen as specified in the product standard.

Release the block fitted with the knife. Mark the knife blade with a pen level to the top of the test specimen. Measure the distance, to the nearest 0,5 mm, from this mark to the blade tip. Subtract the material thickness and record the result as the penetration of the knife through the test specimen. Wipe the blade and repeat the test at least 10 mm from any previous impact. Rotate the specimen approximately 45° and perform two more tests. Repeat this sequence so that altogether the test specimen is tested by making impact cuts along its longitudinal axis, across the test specimen and at 45° to these directions. Calculate the mean impact cut penetration depth for the six tests. Calculate the relative impact cut penetration depth for the material with reference to cotton canvas (see 7.3).

7.3 Use of the reference material

Variations in knife sharpness and performance of different test apparatus are compensated by use of a reference material. Use cotton canvas as specified in EN 388 as the reference material. Prepare reference specimens in the form of tubes in the same manner as the test specimens, i.e. by stapling or sewing the fabric edges together. The tubes shall be at least 100 mm in length and have a circular diameter of (100 ± 20) mm. Use two layers of fabric with the warp fibres running in the same direction. Make six impact cuts on the reference specimen, i.e. two along the weft, two along the warp and two at 45° to these cuts. Calculate the mean impact cut penetration depth of the knife through the reference specimen. The reference impact cut penetration depth for an impact energy of 0,65 J is 14 mm.

For convenience, a locally available cotton fabric may be used as a reference material after each batch has been calibrated against the reference canvas specified in EN 388.

When fabrics of normal fibres and leathers are tested, the knife sharpness should be calibrated at least every 50 cuts. If fabrics containing metal or ceramic fibres are tested, the knife sharpness should be checked more frequently. Some materials blunt the knife in a single impact and blades should be re-sharpened after each cut.

8 Calculation

Calculate the relative impact cut penetration depth, h_{rel}, of a test specimen with respect to the reference specimen:

$$h_{\text{rel}} = \frac{14}{h_{\text{rf}}} \times h_{\text{s}} \tag{1}$$

where

14 is the reference impact cut penetration depth, expressed in millimetres (see 7.3);

h_{rf} is the mean impact cut penetration depth, expressed in millimetres, of the reference material;

h_{s} mean impact cut penetration depth, expressed in millimetres, of the test specimen.

9 Estimation of measurement uncertainty

For each of the required sequences of measurements performed, determine the corresponding estimate of the uncertainty of the final result. This uncertainty, U_{m}, shall be expressed in the test report in the form of $U_{\text{m}} = \pm x$. The uncertainty shall be used in determining whether a pass performance, as specified in the product standard, is achieved. The final result, h_{fin}, is expressed as follows:

$h_{\text{fin}} = h_{\text{rel}} + x$ (upper limit value) or $h_{\text{fin}} = h_{\text{rel}} - x$ (lower limit value) (2)

For example, if an upper limit value is specified not to be exceeded in the product standard and the higher h_{fin} (= $h_{\text{rel}} + x$) exceeds this value, the product shall be considered to have failed the test.

10 Test report

The test report shall include the following information:

a) a reference to this part of ISO 13999, i.e. ISO 13999-3;

b) a reference to the product standard for which the product is tested;

c) a description of the test specimens (location in the product, shape and dimensions), their method of preparation and pre-treatment, if any, and the permitted size range of test specimens;

d) the details of the clamping and stretching method used with the test specimens;

e) the energy(ies) of impacts used in the test;

f) the performance level (s) and the protective areas tested;

g) the orientations of blade impacts relative to a specified axis of the test specimens;

h) the number of tests performed and their location;

i) the details of any deviations from this method;

j) the results of the test (i.e. the values of impact cut penetration depths h_{rel}, h_{rf}, h_s), the measurement uncertainty U_m and the final result h_{fin};

k) whether or not the product has passed or failed this test.

NOTE Information and guidance for use of this part of ISO 13999 in a product specification are given for information in annex A.

Annex A
(informative)

Recommendations for the specification of impact cut tests on materials and products such as gloves and arm guards

A.1 General considerations

The test method specified in this part of ISO 13999 may be used to test a wide variety of materials used in clothing, gloves and arm guards. The test method provides information about the resistance of the product to stabbing cuts, slashing cuts, shearing cuts and impact cuts by acute-edged objects that are not necessarily sharp. Abrasion by coarse sharp abraders such as road surfaces, concrete building blocks, or rough metal castings, is the superimposition of numerous small cuts. The results from this test give a good prediction of the resistance of products to these types of harsh abrasion. However, this test does not provide information about the resistance of the product to penetration by thorns or needles.

The following information should be specified in the product standard in order to be able to apply this test:

a) a description of the samples to be tested, their method of preparation and pre-treatment, if any, and the permitted size range of samples;

b) details of the clamping and stretching method to be used with the samples;

c) the energy(s) of impacts to be used in the test;

d) the orientations of blade impacts relative to a specified axis of the samples;

e) the number of tests to be performed, and where they are to be located;

f) the performance requirements for the product, and associated “levels”; the performance required for the product to pass, i.e. the limit value(s) for h_{fin};

g) the location, dimensions and shape of the protective area of the product that is to meet the requirements.

A.2 Product testing considerations

A.2.1 Impact energy

The impact energy and therefore drop height should be chosen such that a product that just reaches a pass level has a mean knife penetration depth of around 10 mm. Poor products or weak orientations of better products can then show penetrations that are measurable and are up to three times this value. The uncertainty in measurements of small penetrations of very good products will not be a significant problem.

It has been found that stab-resistant gloves are best tested at 0,65 J impact energy. Highly cut-resistant chain-mail gloves and energy absorbing composite construction gloves are better tested using 2,45 J impacts which can be provided by using the 1 000 g blade-holding block specified in ISO 13998. Because of the uncertain effects of the velocity of impact, it is recommended that block and knife masses are controlled to give either 110 g or 1 000 g combinations, and that intermediate masses are not used.

A.2.2 Test specimen support

The test specimen support in this part of ISO 13999 is designed to apply a consistent test condition that replicates how gloves are supported over relatively hard bone-containing parts of the body like the hands, and how cut-resistant pads are worn on the knees.

A.2.3 Test specimen tension

This part of ISO 13999 specifies one 1 000 g weight piece to provide tension to the test specimen. If the tension in a particular test specimen type is not appropriate, the mass of the weight piece may be altered. Care needs to be taken as this will alter the test results. It is not recommended.

A.2.4 Test number

This part of ISO 13999 provides for six impacts in three orientations. Products with very heterogeneous constructions may require more numerous impacts at more orientations. It may be necessary to consider "worst-case" testing, but this is not recommended as it is difficult to standardize for worst-case determination in different test houses. If small specimens such as finger materials from gloves are to be tested, they should be cut off the gloves and sewn into suitable fabric test tubes to fit over the anvil. The compliance of the tube fabric should be close to that of the specimen.

A.2.5 Performance levels

These should be determined by experimentation. Points to consider are the level of protection required to prevent injury, the performance of new and used examples of products shown by experience to give both good and poor protection, and whether the performance required of the product is a threshold level or a point on a continuous scale. It is recommended that accident data and test results from accident-damaged products be taken into consideration. The interpretation of performance levels with respect to hazard levels should be included in the product standard.

This data is provided by manufacturers in the information they supply with the material as required by ISO 13688 and EN 420.

Fabric and leather gloves are normally significantly less stab-resistant than the chain-mail products specified in ISO 13999-1. A risk assessment at the point of use, should determine which type of product should be used. This risk assessment should be strongly recommended in the product specification.

A.2.6 Conditioning of test specimens

If the results of the test are dependent on the pre-conditioning of the test specimens, these conditions should be specified. The standard atmosphere of (20 ± 2) °C and a relative humidity of (65 ± 5) % is recommended. Other temperatures may be appropriate for specific types of products for use under specific conditions.

A.2.7 Test conditions

If the results of the test are significantly altered by conditions to which the product is commonly exposed when the user is at risk, testing under these specific conditions should be considered. Such conditions might include:

a) the product with a wet surface or wetted throughout with water;

b) the product coated in oil;

c) the product heated or cooled to replicate common exposure conditions;

d) the product after a specific number of cleaning cycles;

e) the product after specific ageing processes.

Each new test condition introduced to a product specification adds to the cost of the product so it needs to be shown that testing under a single standard condition fails to identify particular products that have unacceptable losses of performance under particular conditions before such conditions are specified as requirements.

A.3 Examples of test results

Examples of test results are given in Tables A.1 and A.2 for different kinds of protective gloves.

Table A.1 — Test results obtained with a 110 g block and knife, at an impact of 0,65 J on gloves

No. test specimen	Gloves providing slash protection only	Penetration depth h_{rel} mm
1	Ceramic and polyethylene plain knit	24,3
2	Steel, aramid and polyethylene plain knit	16,0
3	Terry loop knit aramid	23,8
Gloves providing limited stab protection		
4	Glove similar to test specimen 1 inside a PVC work glove	6,9
5	Glove with thin metal plates	3,6
Gloves providing significant stab protection		
6	Chain mail	4,8[a]

[a] No ring cut.

Table A.2 — Test results obtained with a 1 000 g block and knife, at an impact of 1,47 J on gloves

No. test specimen	Gloves providing limited stab protection	Penetration depth h_{rel} mm
4	Glove similar to test specimen 1 inside a PVC work glove	Total (> 30)
5	Glove with thin metal plates	24,0
Gloves providing significant stab protection		
6	Chain mail	5,0 [a]
6	Chain mail 2,45 J (tested in accordance with ISO 13999-1)	5,0 [a]

[a] No ring cut.

Bibliography

[1] ISO 13688, *Protective clothing — General requirements*

[2] ISO 13998, *Protective clothing — Aprons, trousers and vests protecting against cuts and stabs by hand knives*

[3] EN 420:1994, *General requirements for gloves*

[4] EN 1082-3:2000, *Protective clothing — Gloves and arm guards protecting against cuts and stabs by hand knives — Part 3: Impact cut test for fabric, leather and other materials*

ICS 13.340.40; 13.340.99

Price based on 14 pages