INTERNATIONAL STANDARD

ISO 13997

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Protective clothing — Mechanical properties — Determination of resistance to cutting by sharp objects

Vêtements de protection — Propriétés mécaniques — Détermination de la résistance à la coupure par des objets tranchants

Reference number
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Contents

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Foreword

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

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

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 13997 was prepared by Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 13, *Protective clothing.*

Annexes A and B of this International Standard are for information only.

Introduction

Although textiles, composites, leather, rubbers and reinforced materials may resist cutting by sharp edges in different ways, a test method for evaluating the resistance to cut of materials in protective clothing needs to be applicable to all materials. The test described in this International Standard provides a method that allows calculations of the downwards (normal) force required to cause a blade drawn across the sample for a fixed distance to cut through the specimen.

The performance of protective clothing materials may be classified using the numerical values obtained from this test.

Protective clothing — Mechanical properties — Determination of resistance to cutting by sharp objects

1 Scope

This International Standard specifies a cut test method, and related calculations, for use on materials and assemblies designed for protective clothing. The test determines resistance to cutting by sharp edges, such as knives, sheet metal parts, swarf, glass, bladed tools and castings.

This test does not provide data on the resistance to penetration by pointed objects such as needles and thorns. The test described in this International Standard is not considered suitable for testing materials made from chain mail and metal plates. The text of this International Standard does not include provisions for the safeguard of the operator.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, this publication do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document 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 139:1973, *Textiles — Standard atmospheres for conditioning and testing.*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1
cut-through
event which has occurred when the blade edge first contacts the conducting material below the test specimen

3.2
cutting force
calculated force that would be required to be applied to a blade of standard sharpness to just cut through a material in a blade stroke of length 20 mm

3.3
cutting stroke length
distance the cutting edge travels before cut-through occurs

4 Requirements

This International Standard describes a method of test for materials and products. When it is cited as a test method in a materials or product standard, that standard shall contain the necessary information to permit the application of ISO 13997 to the particular product. The standard citing ISO 13997 shall include at least the following:

a) a normative reference to ISO 13997;

b) a description of the samples to be tested, their method of preparation, and pretreatment, if any, and the permitted size and orientation range of the specimens prepared for the samples;

c) details of the clamping and stretching method to be used with the specimens;

d) the number of tests to be performed;

e) details of any deviation from the method described in ISO 13997;

f) details of the format and content of the test report to be provided;

g) the performance requirements for the product and associated "level". The performance required shall be given as the minimum cutting force.

Information and guidance on using ISO 13997 in a product standard are given in annex A.

5 Sampling

5.1 Specimens shall be taken from regions of the sample product representative of the range of construction present in protective areas. Specimens shall be taken from positions representative of the variations in the quality of the material present.

5.2 Specimens from woven, knitted and other orientated materials shall be prepared so that test cuts are made at an angle of (45 ± 10)° to the machine direction of the material. Unoriented materials, or those in which the machine direction is uncertain, shall be tested in two directions at 45° to each other. Specimens from particular materials or products may be tested at other orientations specified by a standard citing ISO 13997.

5.3 Unless otherwise specified, specimen dimensions shall not be less than 25 mm × 100 mm, with the intended cut orientation at 90° to the long axis. The smallest specimen on which single cuts are made shall not be less than 25 mm × 25 mm.

5.4 Specimens shall be conditioned in accordance with ISO 139. Testing shall be carried out in the conditioning environment or within 5 min of withdrawing the specimens from the conditioning environment.

6 Test method

6.1 Principle

The cut resistance of a material is its ability to resist being cut through by a blade. This is measured in a machine in which a sharp blade is drawn across a specimen. The cuts are achieved in blade movements of 3 mm to 50 mm length when a range of forces are applied to the blade normal to the specimen surface. The cut resistance of a sample material is expressed as the cutting force that is required to be applied to a blade of standard sharpness to just cut through the material in a 20 mm blade stroke. The value of the cutting force may be used to classify materials.

Any apparatus can be used that can maintain a constant force between the cutting edge and the specimen, and can accurately measure the distance the blade travels to cut through the specimen. Annex B (informative) describes instrumentation that meets these requirements.

6.2 Test apparatus

The apparatus shall have the following components.

6.2.1 Rigid framework that supports the constituent parts when a force of up to 200 N is exerted between the cutting edge and the specimen.

6.2.2 Force application system to move the specimen holder towards the blade, or the blade towards the specimen holder during operation of the machine such that the force between the cutting edge and the specimen is constant ± 5 %.

The force shall be variable between 1,0 N and 200 N. The force may be applied to the blade holder or to the specimen holder.

6.2.3 Specimen holder, with surface made of metal on which the specimen is mounted.

The specimen mounting area shall be curved with a radius of (38 ± 0,5) mm. The length of the mounting area shall be greater than 110 mm and the width across the curvature shall be greater than or equal to 32 mm. The mounting of the specimen holder shall provide for multiple cuts to be made on single specimens at minimum intervals of 10 mm.

6.2.4 Blades, made of stainless steel with a hardness greater than 45 HRC.

Blades shall be (1,0 ± 0,5) mm thick and ground to a bevel width of (2,5 ± 0,2) mm along a straight edge. This is an included angle of approximately 22° at the cutting edge. Blades shall have a cutting edge length greater than 65 mm and blades shall be more than 18 mm wide.[1)]

6.2.5 Blade holder, capable of holding the blade rigidly and with minimum distortion so that (12,0 ± 0,5) mm of the blade width is exposed.

The blade shall be held so that it is orientated across the curvature of the specimen holder with the plane of the blade at (90 ± 2)° to the long axis of the specimen holder.

6.2.6 Cutting-motion system to move the specimen holder and cutting edge relative to each other such that the cutting edge moves across the specimen at (90 ± 2)° to the long axis of the specimen holder at a velocity of (2,5 ± 0,5) mm/s.

A screw-thread drive system has been found satisfactory. The bearings in the system shall provide smooth movement with restricted lateral motion. The maximum transverse movement of the cutting edge when it is stationary and not in contact with a specimen shall be 0,5 mm when a force of (5 ± 0,5) N is applied alternately to the two sides of the blade at (90 ± 5)° to the long axis of the blade.

6.2.7 Cut-stroke length measurement system, to measure the length of the cutting edge that is drawn across the specimen to completely cut through it, accurate to 0,1 mm.

The distance to be measured is the blade movement from its initial stationary position in contact with the specimen to the point at which cut-through occurs and the first electrical contact between the blade and the specimen holder takes place.

6.3 Test procedure

6.3.1 Specimen mounting

Mount specimens with a piece of double-sided adhesive tape of width (50 ± 2) mm. Place a conductive material (e.g. aluminium, copper) of width (10 ± 2) mm and not thicker than 0,03 mm on top of the adhesive tape in its centre and connect it to the metal specimen holder to ensure good electrical contact. Lay specimens on the tape on the holder so that they are fixed without stretching.

Alternatively, specimens may be mounted on the holder with two longitudinal strips of double-sided adhesive tape. Place tape on the holder to leave a gap of (10 ± 2) mm in the centre where cutting-blade contact occurs.

Insulate electrically conductive specimens from the specimen holder by plastic film, such as low density polyethylene, not thicker than 0,03 mm. Stabilize multilayer materials before testing by sewing along their edges or by using intermediate layers of adhesive tape or by another appropriate technique. Loosely knitted materials may be mounted on filter paper on the specimen holder. The paper shall have an areic mass (grammage) of less than 65 g/m^2.

[1)] Blades of this description are available from American Safety Razor Co., Razor Blade Lane, Verona, VA 24482, USA, as blade No. 88-0121, Type GRU-GRU. This information is given for the convenience of users of this International Standard, 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.

6.3.2 Cutting-edge sharpness control

Blades shall be obtained in lots of not less than 200. Test every 20th blade by cutting a neoprene calibration material with a force of (5 ± 0,02) N (see 6.3.4).

A batch of blades is acceptable if the mean length of the cutting stroke is between 20 mm and 30 mm and the coefficient of variation of ten measurements is 10 % or less. Blades of an acceptable lot shall be stored with care until used, so that no damage occurs to their cutting edges.

The neoprene calibration material[2)] shall be (1,57 ± 0,05) mm thick and have a Shore A hardness of 50 ± 5. This material may be used to establish secondary calibration materials from local suppliers.

6.3.3 Setting up the apparatus

a) Level the machine.

b) Mount a specimen on the holder.

c) Fit a new blade and bring the blade holder and specimen holder to their starting positions for a cutting stroke. Set the displacement measuring system to zero.

d) Adjust the machine so that when the blade is in contact with the specimen the force between them is less than 0,01 N.

6.3.4 Conducting a test sequence

a) Apply a selected force progressively between the specimen and the blade.

b) Start the cutting stroke within 5 s.

c) Make trial cut tests to establish a force resulting in a cutting stroke length between 5 mm and 50 mm. Record this force and the cutting stroke length.

d) Repeat the test with different forces until at least 15 readings have been obtained with cutting stroke lengths distributed between 5 mm and 50 mm. Five readings should be obtained in each of the following cutting stroke length ranges:

   5 mm to 15 mm; 15 mm to 30 mm; 30 mm to 50 mm

   Obtain each reading with an unused length of cutting edge. Make each cut at least 10 mm from any other cut and from the end of the specimen.

e) Repeat the test to obtain five readings with the force calculated according to 6.3.5 c) from the readings obtained in 6.3.4 d); if necessary, obtain a further five readings [see 6.3.5 e)].

6.3.5 Calculations

a) Calculate the blade sharpness correction factor C as follows:

$$C = \frac{K}{l}$$

where

C is the correction factor;

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2) Stocks of this neoprene are available for purchase from IRSST (Institut de Recherche en Santé et en Sécurité du Travail du Quebec, 505 boulevard de Maisonneuve Ouest, Montreal, Quebec, Canada H3A 3C2) with certificate of conformity. This information is given for the convenience of users of this International Standard, and does not constitute an endorsement by ISO of this product.

l is the cutting stroke length, in millimetres, on neoprene at 5,0 N;

K = 20.

b) Normalize each cutting stroke length recorded in 6.3.4 d) by multiplication by the blade sharpness correction factor; recorded stroke length XC = normalized cutting stroke length.

c) Plot the normalized cutting stroke lengths against the applied forces. Obtain the best-fit curve, either using a computer program or graphically.

d) Determine the force that would be required to cut through the material in a 20 mm cutting stroke from the curve obtained in c).

e) Use the force calculated in d) to obtain at least five further readings according to 6.3.4 e). If the mean cutting stroke length from these readings is between 18,0 mm and 22,0 mm, include these results in a recalculation of the cutting force in d). If the mean of the results is outside the limit of 18,0 mm to 22,0 mm, obtain a further five readings and use all readings to calculate the cutting force.

f) Report the cutting force to the nearest 0,1 N.

7 Test report

The test report shall contain at least the following information:

a) the test specimen source, identification, name or code;

b) the performance level(s) of testing required;

c) any additional test or test conditions requested;

d) test conditions;

e) values of all individual cut tests (force, distance and orientation);

f) the blade sharpness correction factor;

g) the normalized cutting stroke lengths;

h) the curve plotted through the initial fifteen or more cut tests;

i) the cutting force determined from the curve;

j) the results from the further five or ten cut tests;

k) the curve replotted through all the data points;

l) the cutting force derived from all the data points;

m) any deviations from the method specified in this International Standard;

n) date(s) of test and signatures.

Annex A
(informative)

Specification of a cut test

A.1 Introduction

The method specified in this International Standard may be used to test a wide variety of materials used in personal protective equipment. The test assesses the resistance of a specimen to cutting by a sharp blade drawn across it with a constant force between the blade and the specimen. The test results are expressed as the force on the knife blade that would be required to cut through the specimen in a 20 mm cutting stroke. A larger force required indicates a higher resistance to cutting.

Table A.1 gives some typical results.

Table A.1 — Typical test results

Material	Areic mass g/m^2	Cutting force N	Typical application
Cotton	545	5,9	Work gloves
Latex	469	1,0	Surgical gloves
p-Aramid	688	11	Industrial gloves
Leather	754	2,3	Work gloves
Reinforced HMWPE [1)]	581	20,8	Food-handling gloves
Reinforced HMWPE [1)]	853	31,9	Food-handling gloves
Vinyl	590	3,5	Protective clothing (liquids)
p-Aramid	1900	38,7	Multilayer protective apron

1) HMWPE: High molecular weight polyethylene.

A.2 Use of this International Standard

When ISO 13997 is cited, a number of parameters shall be specified, as listed under clause 4.

A.2.1 Sampling and specimens

Samples of woven, knitted, non-woven and coated products should be taken at points diagonally across the roll. With materials of even construction quality, the cutting force should be determined on specimens taken from four samples across the roll. The mean value of the four determinations should be reported.

Materials of an inhomogeneous nature, such as animal hide, should be sampled at specific points in a consistent manner, which should be defined. A number of hides sampled at the same point may give more informative data than one hide sampled at several points.

Samples of products such as gloves should be taken from a number of pairs of gloves at specific points to represent the different constructions and the variation between items. The sample numbers and sampling sites should be defined.

To obtain consistent results, the orientation and size of specimens cut from samples should be exactly specified.

Any pretreatment, such as washing and drying, should be specified and normally should be performed on complete products rather than on cut samples or specimens.

A.2.2 Mounting of specimens

Test results show less variation if mounting procedures are specified in detail and always carried out in the same way. Normally, specimens freshly cut from samples should be laid out onto the adhesive tape on the specimen holder and pressed into place. No stretch should be applied. However, if the technique is inappropriate for a particular product, an alternative technique should be specified and described in detail.

A.2.3 Number of tests to be performed

A series of cut tests to give one cutting-force value involves at least fifteen cuts. These should be on similar specimens from the same sample. It will be necessary, for assessing different materials or products, to determine the number of samples that need to be tested to provide a sufficiently accurate mean value for the cutting force. Normally this will be not less than three samples. The necessary orientations for testing particular materials should be taken into account.

A.2.4 Deviations from the test method

It is desirable to test some products wet with water, oil or grease, or other conditions, and at non-standard temperatures because of the nature of the situations in which the products are used. Such special test conditions should be specified in detail.

Some materials or products may yield specimens of non-standard shape. Techniques for handling these should be specified in detail.

A.2.5 Test report

The details to be provided in test reports on materials or products should be specified. These could include sampling information, test conditions, normalized cutting stroke lengths as well as the calculated cutting force, and other information. Test reports should also contain detailed information to identify the materials or products tested, including the structure, thickness and areic mass.

A.2.6 Performance requirements

Any standard citing this International Standard shall provide values for the minimum cutting force to be withstood by samples meeting the requirements of that standard. These values should normally be the minimum mean cutting forces for particular performance levels. Products and materials should be classified to provide different levels of protection. It is recommended that a factor of twice the cutting force of one performance should be set for the one next above it.

A.2.7 Risk assessment

In setting the performance requirements for products in a standard, a risk assessment should be carried out. This should include consideration of the nature of the hazards, including the sharpness of the threat and the range of forces that will be exerted between the sharp object and the person to be protected, the frequency of exposure, the nature of injury that might be sustained with inadequate protection, and the negative ergonomic effects of protective equipment. The performance and/or cost of current protective equipment should not determine the value of the performance levels set. It is reasonable to set performance levels that will only be reached after further product development, provided lower levels are also set.

In carrying out a risk assessment of the situation in which cut-resistant materials might be used, and in setting performance levels, it should be understood that the test described in this International Standard is a laboratory test designed for the specific purposes stated in this Standard. The test may not provide data appropriate for assessing some products for use under certain conditions or against certain threats.

Annex B
(informative)

Instrumentation meeting the requirements of this International Standard

Accurate determination of the cut resistance of materials by calculation of the cutting force, as defined in this International Standard, requires an instrument having the following characteristics:

— ability to apply a constant known force between the blade and the sample throughout the cutting stroke;

— ability to apply this force normal to the blade edge at all times;

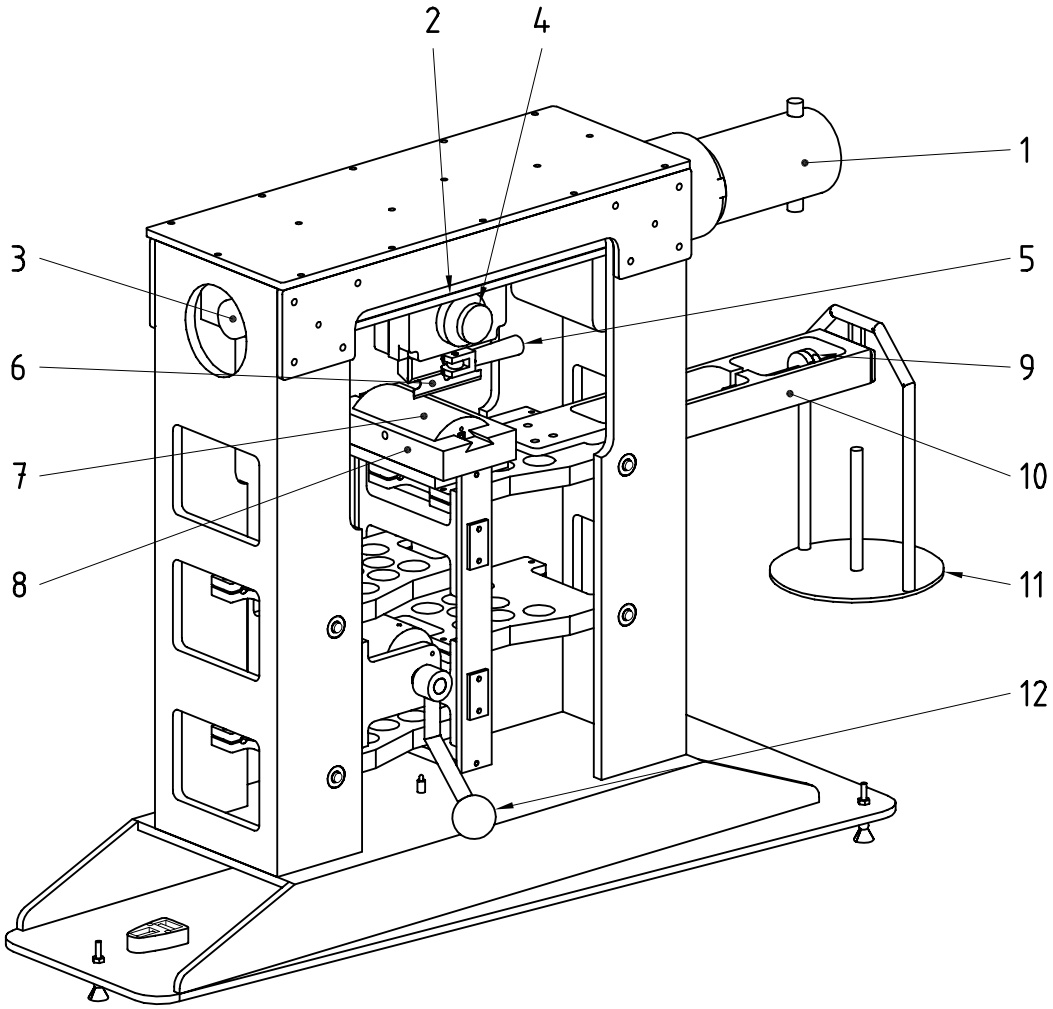
— adequate sensitivity and accuracy in measurement devices;

— ability for all characteristics to remain verifiably within the specifications laid down in clause 6 of this International Standard during test sequence.

Although a number of instruments to measure the cutting force by means of applications of the “load vs. distance” concept have been built, and have been used to provide published data that appears to correctly rank the cut resistance of materials, only the type of apparatus [3)] shown in Figure B.1 is known to also meet all the requirements of ISO 13997.

In the apparatus illustrated in Figure B.1, the force is applied between the blade and the specimen holder through a leverage system that transfers the effect of a mass mounted on the platen through a scale beam assembly. The use of a Watt straight-line mechanism provides a constant application of the force, while the blade traverses the specimen perpendicularly until cut-through occurs. Measurements made with this apparatus are not influenced by the thickness of the material being cut or by the direction of the knife motion.

3) An apparatus known as the TDM-100 Tonodynamometer embodying these principles is available from RGI Industrial Products, Inc., 755 Pierre Caisse, St-Jean-sur Richelieu, Quebec, Canada J3B 7Y5. This information is given for the convenience of user of this International Standard 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.



Key

1 Motor and drive system	7 Specimen holder
2 Blade support guidance system	8 Specimen holder mount
3 Position transducer	9 Balance weights
4 Blade support	10 Beam
5 Blade clamp	11 Platen for weights
6 Blade	12 Safety lock

Figure B.1 — TDM-100 test instrument

ICS 13.340.10

Price based on 9 pages

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