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**Protective clothing — Mechanical
properties — Test method for the
determination of the resistance to
puncture and dynamic tearing of
materials**

ICS 13.340.10

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Health, Labour and Welfare and the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal of establishing a Japanese Industrial Standard from Japan Safety Appliances Association (JSAA)/Japanese Standards Association (JSA), with a draft of Industrial Standard based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

This Standard has been made based on **ISO 13995:2000** *Protective clothing—Mechanical properties—Test method for the determination of the resistance to puncture and dynamic tearing of materials* for the purpose of making it easier to compare this Standard with International Standard; to prepare Japanese Industrial Standard conforming with International Standard; and to propose a draft of an International Standard which is based on Japanese Industrial Standard.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Ministers and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

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In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

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Contents

	Page
Introduction	1
1 Scope	1
2 Normative reference	1
3 Terms and definitions	1
4 Test apparatus and procedures	2
4.1 Principle of the puncture and dynamic tear test	2
4.2 Types of tear and their measurement	2
4.3 Performance levels	3
4.4 Test apparatus	3
4.5 Falling mass - blade holding block	3
4.6 The tearing blade	3
4.7 The test specimen mounting block and clamps	4
4.8 Preparing the apparatus	4
4.9 Preparation of test specimens	5
4.10 Mounting the test specimens	5
4.11 Carrying out a test	5
4.12 Classification of results	6
4.13 Test report	7
Annex A (informative) Information annex on the specification of puncture and dynamic tear tests on materials and clothing	8
Annex 1 (informative) Comparison table between JIS and corresponding International Standard	23

Protective clothing—Mechanical properties—Test method for the determination of the resistance to puncture and dynamic tearing of materials

Introduction This Japanese Industrial Standard has been prepared based on the first edition of ISO 13995 *Protective clothing—Mechanical properties—Test method for the determination of the resistance to puncture and dynamic tearing of materials* published in 2000 with some modifications of the technical contents.

The portions underlined with dots are the matters modified from the original International Standard. A list of modifications with the explanations is given in Annex 1 (informative).

1 Scope This Standard specifies a test method for the determination of the resistance to puncture and dynamic tearing of protective clothing materials which are used in situations where snagging and tearing could result in unacceptable damage to the clothing or danger to the wearer through loss of integrity of a barrier. It is intended that the performance levels determined will be of use in specifying materials for use in situations where the risk of harm is related to the size of puncture and tear that may occur in accidents.

NOTE : The International Standard corresponding to this Standard is as follows.

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and JIS are IDT (identical), MOD (modified), and NEQ (not equivalent) according to ISO/IEC Guide 21.

ISO 13995:2000 *Protective clothing—Mechanical properties—Test method for the determination of the resistance to puncture and dynamic tearing of materials* (MOD)

2 Normative reference The following standard contains provisions which, through reference in this text, constitute provisions of this Standard. The most recent edition of the standard (including amendments) indicated below shall be applied.

JIS L 1096 *Testing methods for woven fabrics*

3 Terms and definitions For the purposes of this Standard, the following terms and definitions apply:

3.1 test specimen mounting block a solid block of metal or plastic to which the test specimen is clamped for testing

3.2 tearing blade a blunt blade projecting from the falling mass which punctures and tears the test specimen

NOTE : The hard steel tearing blade has a ground wedge shaped end that has a radius of curvature so that it is not sharp, but will puncture test materials. The main body of the blade is 3 mm thick and the lower surface is half

round. This lower surface causes the blunt tear in the test specimen that is measured in the test. This blade performs the same function as the spike in ASTM D 2582-90, but it is more rigid so is capable of withstanding greater forces.

4 Test apparatus and procedures

4.1 Principle of the puncture and dynamic tear test A test specimen of fabric or leather is clamped securely to a solid block that is shaped so that the main part of the test specimen is vertical. The upper part of the block is machined to be a quadrant so that the test specimen lies back on it and presents a curved face upwards towards the tearing blade attached to a falling mass that is dropped onto the test specimen. The tearing blade is sharpened on its end so that it punctures the curved part of the test specimen. The rounded lower surface of the blade tears downwards into the vertical part of the test specimen until the energy in the falling mass is dissipated. The vertical face of the block has a slot machined into it so that the end of the blade is in the block and the middle part of the blade causes the tearing.

Choosing an end point or pass/fail value of 40 mm ensures that the main property measured is the dynamic tear resistance of the punctured material. The tear length is the vertical dimension of the hole made by the blade. It may be appropriate to specify a lower tear length for assessing materials to be used where tearing of products would expose the wearers to hazards (see Annex A).

4.2 Types of tear and their measurement The following types of tear are commonly caused:

- a) A vertical slit tear in which the blade breaks horizontal fibres in the test specimen;
- b) A “V” tear which has two legs diverging from the puncture point. In woven fabrics the legs may proceed at 90° to the warp and weft fibres giving an angle between the legs of 90°. In leather, composite materials and unsupported plastics the angle between the legs is often about 30°;
- c) A horizontal tear in which a tear propagates horizontally from the puncture point along a line of weakness. This is found sometimes in one orientation of testing of coated knitted fabrics. When test specimens of such material are cut at 90° to the orientation giving this type of tear, the result is usually a very long vertical slit tear;
- d) Complex tears combining various properties of the above tears. Some warp knits give V tears with one vertical and one 45° leg, or one vertical and one horizontal leg.

For all types of tear the tear length is the vertical dimension of the hole made by the blade. The hole is measured with the blade in situ if the hole is long enough. This ensures the dynamic rolling up of the material in V tears is consistently treated. Similarly the stretching effect of the mass of the block on the test specimen will be consistent for each falling mass. If the tear is shorter than the vertical height of the blade, the blade is lifted out and the hole measured while the test specimen is still clamped. In materials with unusual responses and a particular weakness in one orientation, test samples should be prepared that permit the “worst case” tear to be produced and measured.

The final falling mass position is not a reliable indicator of tear length in all materials as very elastic fabrics stretch during the test, and the upper edge of the hole will be drawn downwards. The hole length would be over estimated by comparing the position of the falling mass when it first contacts the test specimen and its final position. The falling mass resting in the tear will increase its measured length in compliant materials and this should be considered when citing this Standard.

4.3 Performance levels The performance level reached by a material is determined as described below. It is based on the mean value of the tear lengths in all orientations of test, if these are similar, or on the mean value of the tear lengths at the worst orientation if this value is more than 50 % greater than the value from the orientation giving the smallest tear length.

4.4 Test apparatus The test apparatus shall consist of a rigid heavy base on which a test specimen mounting block and a falling mass guidance system are mounted (see Annex A figure 1). The guidance system shall consist of two vertical polished steel rods at least 15 mm in diameter. The steel rods shall be sufficiently long to accommodate a drop height of 750 mm between the base of the tearing blade and the puncture point on the test specimen. A dropping mechanism shall be provided such as an electromagnet to hold the falling mass in its initial position. Its height shall be adjustable so that the energy losses due to friction may be allowed for and the appropriate energy of impact achieved. A means of measuring the impact velocity of the falling mass and blade shall be provided.

4.5 Falling mass - blade holding block The proportions and dimensions of the falling mass blade holding block are shown in Annex A figure 2. Four blocks should be provided that with the tearing blade fitted have the following masses:

- No 1 (250 ± 10) g
- No 2 (500 ± 10) g
- No 3 (1 000 ± 20) g
- No 4 (2 000 ± 40) g

The blade holding block may be constructed of any convenient rigid material. Higher mass blocks may be provided by adding weights to lighter ones provided the block remains within the dimensions given in Annex A figure 2.

The blocks shall be provided with low friction guides. Plastic tubes running through the block, or slides of at least 20 mm length in the top and bottom of the block, may be used. The clearance on the guidance rods shall be (1 ± 0.5) mm. Systems using linear bearings or wheels have been found to absorb significant amounts of energy during the tearing action because of the moment between the block and the guidance rods. A system of plastic tubes and a light oil on the guidance rods has been found to give consistent results.

4.6 The tearing blade The position and overall dimensions of the tearing blade in relation to the holding block are shown in Annex A figure 2. The blade shall be made of steel. It shall preferably have a hardness of 58 HRC (Rockwell hardness scale C). It shall

be rigidly attached to the holding block. Its lower edge shall be horizontal, and shall have a radius of (1.5 ± 0.1) mm, and level with the lower edge of the blade holding block (see Annex A figure 2). The blade height shall be (10 ± 0.1) mm for the end 10 mm. The top surface shall be flat and parallel to the lower surface. The vertical end of the blade shall be ground to an angle of $(60 \pm 3)^\circ$ and radiused at (0.2 ± 0.1) mm.

4.7 The test specimen mounting block and clamps The test specimen mounting block shall be made of metal or a hard plastic. The clamps shall be made of steel and the bolts and fixings shall be hardened steel. The block and clamps are designed to accept material samples 110 mm wide and 180 mm to 200 mm long. The test specimens are clamped across the top and down the sides. The test specimen mounting block shall be provided with a means of fixing it firmly to the base of the apparatus. The fixing system shall allow the block to be positioned accurately with respect to the tearing blade. The blade shall enter the slot in the block by (10 ± 0.5) mm and shall be central in the slot ± 0.5 mm.

4.7.1 Dimensions of the test specimen mounting block The test specimen mounting block is shown in Annex A figure 3. It shall be (250 ± 10) mm high, at least 200 mm wide, and at least 100 mm front to back. The top of the front face shall be machined to be a quadrant of (100 ± 1) mm radius. A slot (8 ± 0.5) mm wide and (15 ± 1) mm deep shall be machined in the centre of the front face.

4.7.2 The test specimen clamping system The clamping system is shown in Annex A figure 4. Five steel clamps shall be provided that can be drawn onto the test specimen mounting block by 14 bolts as shown in the figure. The clamps shall have five parallel ridges with angles of $(60 \pm 3)^\circ$ and a pitch (separation) of (3 ± 0.05) mm. These ridges shall be machined to stand out from the inner clamp faces. The ridges shall fit into matching grooves machined into the front face of the test specimen mounting block. The positions of these grooves are shown in Annex A figure 3. The surface of the test specimen mounting block beneath the upper transverse clamp may be machined flat to accept a flat clamp more easily (see Annex A figure 4). Set screws shall be provided to permit adjustment of the clamps for materials of different thickness. The remaining normative dimensions of the clamping system are given in the legend to Annex A, figure 4.

4.8 Preparing the apparatus The test specimen mounting block shall be bolted to the base in the appropriate position (4.7). An appropriate blade holding block shall be put on the guidance system and its free running checked. Test drops shall be made and the velocity of the block measured at the point the end of the tearing blade begins to enter the slot on the test specimen mounting block. The dropping height shall be adjusted so that the mean velocity in five consecutive drops is such that the block and blade have a kinetic energy within the required range, below, taking into account the exact mass of the block.

For the 250 g block the energy range shall be 1.6 J to 1.8 J.

For the 500 g block the energy range shall be 3.3 J to 3.5 J.

For the 1 000 g block the energy range shall be 6.6 J to 7.0 J.

For the 2 000 g block the energy range shall be 13.4 J to 14.0 J.

4.9 Preparation of test specimens Whenever possible test specimens for the assessment of materials shall be cut from rolls of material, whole skins or half hides. The long axis of the roll (machine direction), or the head to tail axis of a skin shall be established. Equal numbers of test specimens orientated along the long axis, across the long axis and at 45° to the long axis shall be cut (110 ± 5) mm wide and (200 ± 20) mm long. The long axis shall be marked in each specimen. If washing or dry cleaning pre-treatments are specified in **JIS L 1096**, intact products, or large material specimens shall be pre-treated before test specimens are cut from them.

If finished PPE (personal protective equipment) products are the source of the test specimens, the construction materials should be examined to determine an identifiable axis. If this is impossible an axis related to the product construction shall be chosen and recorded. Test specimens should be taken from a number of PPE items, as required by the product standard.

The test specimens shall be conditioned at $(20 \pm 2)^\circ \text{C}$ and a relative humidity of $(65 \pm 5) \%$, for at least 24 h before testing. Testing shall be carried out in the conditioning environment or within 5 min of withdrawing the specimens from the conditioning environment.

4.10 Mounting the test specimens The clamps of the specimen mounting block shall be loosened off and pushed clear of the block. A specimen is fed under the clamps. The horizontal clamp is held up as the specimen is pushed under it. When the specimen is equally under all the clamps the bolts shall be done up in the order shown in Annex A figure 5, except that the order is not normally critical after bolt 8. Light pressure with the finger tips flat on the specimen should be used while doing up bolts 1, 2, 3, 4, 7, and 8, in the directions of the arrows in the figure. Firmer pressure should be used while doing up bolts 5 and 6 to ensure even flattening of the specimen.

The specimen should not be stretched during the mounting, but after the clamps are all tightened it should be flat and taut. To ensure even clamping the set screws of the vertical straight and curved clamps should be adjusted to just touch the face of the block when the clamps are firm before the final tightening. The set screws in the horizontal clamping bar should be set to ensure the nuts on the studs pull the clamp evenly onto the test specimen and the ridges engage in the grooves equally. In all cases the thicker the test specimen the longer the protrusion of the set screws should be.

4.11 Carrying out a test The blade holding block shall be released by the electro-magnet from the height determined in 4.8, onto a test specimen mounted as described in 4.10. The length of tear shall be measured with callipers accurate to 0.1 mm. For all tears longer than 15 mm, the distance between the top of the tearing blade and the top of the tear is measured while the block and blade are at rest supported by the test specimen. A value of 10 mm is added to the measured value to give the tear length. For tears shorter than 15 mm the blade holding block shall be raised, and the blade disengaged from the test specimen. The whole tear length shall then be measured with the callipers while the test specimen is still clamped in the machine.

The test specimen shall be removed from the clamps and examined. The clamps should have left even marks on the specimen. There should be no evidence of any slippage and no fibres should have pulled partly or completely out of the clamps.

NOTE : If the specimen shows evidence of slippage, the result should normally be rejected. That will be except in the cases of some very strong fabrics such as plain weave continuous aramid fabrics which show holes or tears of only 10 mm to 20 mm with the 2 000 g block. These fabrics have a low compliance so high yarn tensions occur on impact in the test. The slipping fibres are difficult to clamp. Results of 10 mm to 20 mm are well within the highest performance level so the results can be accepted despite some yarn slippage. Slippage should be noted in the test report.

At least two test specimens cut in each orientation shall be tested. The mean tear length in tests in each orientation shall be calculated. If the largest value is more than 1.5 times the smallest value, further test specimens cut in the same orientation as those giving the largest value shall be tested. All the results in this orientation shall be combined to give an overall result. If the largest value is not more than 1.5 times the smallest value, the six results shall be averaged to give the overall result.

NOTE : Normally tears remain within the area of the specimen and do not reach the edge. Materials that tear to the edge in one test orientation usually give long tears in at least one other orientation, and do not meet the requirements for the performance level being assessed. If necessary additional test specimens should be prepared for testing in particular orientations if it is considered a weakness in the material has not been fully evaluated.

4.12 Classification of results The overall result obtained in 4.11 shall be used to classify the materials tested to different performance levels. To meet the requirement for a particular performance level, the test material shall have a mean tear length less than the length specified in the standard citing this Standard under the particular conditions. Performance levels should be expressed as in table 1.

Table 1 Performance levels

Mass of blade holding block and blade g	Energy of impact J	Mean tear length specified in the citing standard mm	Performance level
250	1.7	> XX	FAIL
250	1.7	< XX	1
500	3.4	< XX	2
1 000	6.8	< XX	3
2 000	13.6	< XX	4

For each of the required sequences of measurements performed in accordance with this Standard a corresponding estimate of the uncertainty of the final result shall be determined. This uncertainty (U_m) shall be given in the test report in the form $U_m = \pm X$. It shall be used in determining whether a “Pass” performance has been achieved. For example if the final result plus U_m is above the pass level when the requirement is that a certain value shall not be exceeded, the sample shall be considered to have failed.