भारतीय मानक

Indian Standard

IS 6192 : 2023

(*Amalgamating IS 6193 : 1971 and IS 11197 : 1985*)

वस्त्रादि — एकाक्षीय उन्मुख उच्च घनत्व पोलीइथाइलीन (एच डी पी ई)/ पोलीप्रोपाइलीन (पी पी) टेप — विशिष्टि

(तीसरा पुनरीक्षण)

Textiles — Monoaxially Oriented High Density Polyethylene (HDPE)/Polypropylene (PP) Tapes — Specification

(Third Revision)

ICS 59.080.01

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुर शाह ज़फर मार्ग, नई दिल्ली - 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI - 110002
www.bis.gov.in www.standardsbis.in

December 2023 **Price Group 8**

Textile Materials Made from Polyolefins (Excluding Cordage) Sectional Committee, TXD 23

FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Textile Materials Made from Polyolefins (Excluding Cordage) Sectional Committee had been approved by the Textiles Division Council.

This standard was first published in 1971 and subsequently revised in 1984 and 1994. It has been revised again on the basis of experience gained since its last revision and to amalgamate IS 6193 'Methods of tests for monoaxially oriented high density polyethylene tapes' and IS 11197 'Specification for monoaxially oriented polypropylene tapes' and also incorporate the following major changes:

a) The requirement for ash content and its test method has been specified;
b) All amendments have been incorporated;
c) Marking requirements have been modified to include the environment friendly recycling logo on the tape package; and
d) Sampling and criteria for conformity have been modified.

The monoaxially oriented flat tapes are manufactured using thin film extrusion technology in which wide width film is slit into narrow tapes which are subsequently stretched at elevated temperature. By doing so, the polymer molecules are oriented in a longitudinal direction resulting in considerably improved tensile strength in that direction combined with the reduction in linear density of tapes. Monoaxially oriented flat tapes are commonly used in the manufacture of woven fabrics.

In the last two decades, several technological developments have taken place in polymer materials and their performance, tape yarn manufacturing technology, tape yarn testing and analysis procedures and, the market requirements. This has called for the revision of the existing standards on the subject to make it in line with present requirements.

The composition of the Committee responsible for the formulation of this standard is given in Annex H.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final values, observed or calculated, expressing the results of tests, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off values should be the same as that of the specified values in this standard.

Indian Standard

TEXTILES — MONOAXIALLY ORIENTED HIGH DENSITY POLYETHYLENE (HDPE) AND POLYPROPYLENE (PP) TAPES — SPECIFICATION

(Third Revision)

1 SCOPE

This standard specifies requirements and test methods for monoaxially oriented high density polyethylene (HDPE) and polypropylene (PP) tapes suitable for weaving into fabric.

2 REFERENCES

The standards listed in Annex A contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards.

3 TERMS AND DEFINITIONS

For the purpose of this standard, the following definitions shall apply.

3.1 Accelerated Weathering Test — A type of short term, fast laboratory testing which is used to measure long term possibilities of material's durability under certain outdoor environmental conditions.

3.2 Breaking Strength — The maximum load (or force), supported by a specimen in a tensile test carried to rupture. It is usually expressed in Newton or kilogram (1 kgf = 9.81 N).

3.3 Elongation at Break — In a tensile test, the difference between the length of an elongated specimen at breaking load and its initial length, usually expressed as a percentage of the latter. It is measured in percentage. Higher elongation means higher ductility or higher plastic deformation.

NOTE — The result of elongation obtained in the test may have slight errors because of the possibility of tape slippage during testing.

3.4 High Density Polyethylene Tape — A flat tape made from high density polyethylene having a high ratio of width to thickness.

3.5 Linear Density — It is the measure of the amount of mass per unit length and is usually denoted by denier or tex.

3.6 Melt Flow Index (MFI) — This is a measure of the ease of flow of the melt of a thermoplastic polymer. It is defined as the weight of the polymer in grams flowing in 10 min through a capillary die of specific diameter and length by a pressure applied by a given weight at a given temperature. The applied pressure and the capillary die temperature vary with polymer type and are specified for various polymers.

3.7 Nominal Gauge Length — The length of a tape specimen under specified pre-tension, measured from nip to nip of the jaws of the holding clamps of the tensile tester in their starting position.

3.8 Polypropylene Tape — A flat tape made from polypropylene homopolymer, with a high width and thickness ratio.

3.9 Tape — A flat strip of thermoplastic polymer, extruded, stretched, monoaxially oriented, with high tensile strength and a high width and thickness ratio.

NOTES

1 The method of production of monoaxially oriented tapes consists of manufacturing a film by circular die tubular blown film process or by flat die cast film process. Slitting of film into narrow width tapes and uniaxial stretching of slit tapes in hot air oven at 130 °C to 170 °C at a stretch ratio of 1 : 5 to 1 : 8. The oriented tapes subsequently pass over hot rolls or through a heat-set stabilizing oven at 125 °C to 135 °C to attain a longitudinal shrinkage of 4 percent to 8 percent followed by cooling and winding of tapes over a package under uniform tension. The hot stretching process confers monoaxial molecular orientation, imparting high longitudinal strength to tapes.

2 Circular die tubular blown film process is occasionally used for manufacturing HDPE tapes, whereas, flat die cast film process is most commonly used for manufacturing of HDPE and PP tapes.

3 The temperatures used for extrusion, stretching and for heat-set stabilization are polymer dependent and vary for HDPE and PP tape production process.

3.10 Tape Denier — A unit of measure for the linear mass density of tape. Tape denier is the mass in grams per 9 000 metres of the tape. Tapes with high denier tend to be thick, strong, and durable.

NOTE — Tex is also one of the units of measure of tape linear density and is calculated by dividing tape denier value by 9.

3.11 Tape Shrinkage — A measure of the reduction in length of monoaxially oriented tape after it is

subjected to elevated temperatures, the heating medium may be hot air, hot oil or heat inducing light source. Tapes showing high shrinkage are considered dimensionally unstable and can cause deforming of the fabrics made out of these tapes.

3.12 Tape Tenacity — A measure of the tape breaking strength in gram divided by the linear density of tape, usually in denier. Tape tenacity is commonly denoted by unit, gram per denier or gpd.

3.13 Time-to-Break — The time interval, measured in suitable units during tensile testing, such as seconds, during which the tape specimen is under a (generally increasing) tension, that is, absorbing the energy supplied before the breaking strength is reached.

NOTE — Time-to-break does not include the time required to remove slack from the specimen. On machines supplied with an autographic recorder the time to break is indicated by the time elapsing after the pen registers the initial force sustained by the specimen until the pen registers the maximum force. The commonly accepted time to break the sample during tensile testing of tapes is 20 s ± 3 s.

4 MATERIAL AND MANUFACTURE

4.1 High Density Polyethylene Tapes

The tape shall be made from high density polyethylene having a density 0.940 g/ml to 0.965 g/ml at 27 °C (*see also* IS 7328) and melt flow index of 0.4 g/10 min to 1.5 g/10 min for blown film process and 0.8 g/10 min to 2.0 g/10 min for the cast film process when measured at 190 °C under a load of 2.16 kg when determined in accordance with IS 13360 (Part 4/Sec 1). The grade of polyethylene used for the manufacture of tapes shall be selected taking into consideration the film extrusion process used. Polyethylene used for the manufacturing of tapes shall conform to the requirements as specified in IS 10146, excluding overall migration.

4.2 Polypropylene Tapes

The tape shall be made from polypropylene homopolymer having a density 0.900 g/ml at 27 °C (*see also* IS 10951) and melt flow index of 1.5 g/ 10 min to 7.0 g/10 min for cast film process when measured at 230 °C under a load of 2.16 kg when determined in accordance with IS 13360 (Part 4/ Sec 1). The grade of polypropylene chosen shall be the one suitable for the manufacture of film by the cast film process. Polypropylene used for the manufacturing of tapes shall conform to the requirements as specified in IS 10910, excluding overall migration.

4.3 Additives and Masterbatches

As agreed between buyer and seller, functional additives like antioxidants, UV stabilizers, antistatic agents, anti-rodent agents, pigments, carbon black, fillers (calcium carbonate) and reinforcement agents may be added to HDPE or PP raw materials for improved tape properties.

5 REQUIREMENTS

5.1 The high density polyethylene and polypropylene tapes shall conform to the requirements as specified in **5.1.1** to **5.1.8**.

5.1.1 The finished tape width shall be as agreed to between the buyer and the seller. The finished width, however, shall be more than 2 mm but not exceeding 5 mm and shall be subjected to a tolerance of ± 5 percent on agreed or declared width, when tested as per method given in Annex B.

5.1.2 The thickness of the tape shall correspond to the linear density and width. The tape thickness shall be subjected to a tolerance of ± 10 percent on agreed or declared thickness, when tested as per method given in Annex B.

5.1.3 The linear density of tape shall be as agreed to between the buyer and the seller. The linear density of the tape shall be minimum 380 denier (42.22 tex) when tested as per method given in Annex C. The denier of tape shall be subjected to the tolerances ± 10 percent on individual value, and ± 5 percent on average value.

5.1.4 The average tenacity shall be minimum 36 g/tex (4 g/denier) for high density polyethylene tapes and 45 g/tex (5 g/denier) for polypropylene tapes when tested as per method given in Annex D. The average tenacity shall not be less than the value specified and none of the individual value shall not be less than 10 percent of the specified tenacity value.

5.1.5 The average value of the elongation at break of tape shall not be less than 15 percent but shall not exceed 25 percent and none of the values shall fall outside the range specified when tested as per the method specified in Annex D.

5.1.6 If agreed to between the buyer and seller, the tapes may be manufactured from UV stabilized HDPE and PP resins. The UV stabilized tapes shall have at least 50 percent retention of the original breaking strength when tested after the same has been exposed to UV radiation and accelerated weathering in accordance with the test method given in Annex E. The average tape tenacity before and after UV radiation exposure shall be determined as per the test procedure given in Annex D.

5.1.7 The average heat shrinkage of HDPE tapes at 60 °C shall not exceed 5 percent and at 100 °C shall

not exceed 8 percent. On the other hand, the heat shrinkage of PP tapes at 100 °C shall not exceed 5 percent and at 125 °C shall not exceed 8 percent. For heat shrinkage testing, the tapes shall be subjected to the specified temperatures for a period of 10 min in hot air circulating oven in accordance with the test method given in Annex F.

5.1.8 The tapes when tested for ash content in accordance with the test procedure given in Annex G, shall not be more than 6 percent for non-UV stabilized tapes and 2.2 percent for UV stabilized tapes.

6 MARKING, PACKING AND STORAGE

6.1 Marking

Each tape package shall be tagged with a label/sticker containing the following information:

a) Manufacturer's name and identification mark;
b) Polymer type (HDPE/PP)
c) Lot number;
d) Tape denier/Tape width in mm;
e) Net mass (when packed);
f) Recycling logo (*see* Note 1);
g) *Swachh* Bharat logo (*see* Note 2); and
h) Any other information as required by the law in force.

NOTES

1 Each tape package shall be marked with a recycling logo as shown below. While marking the symbol, the respective basic raw material name corresponding to polymer identification number shall be indicated below the symbol in accordance with IS 14534.

2 Each tape package shall also be marked with a Swachh Bharat logo, clearly visible on the label, either compatible with the art work of the buyer or in black colour.

6.2 Packing

Unless otherwise agreed to between the buyer and the seller, each tape package shall be suitably packed in a film pouch and about 100 of such tape packages shall further be packed into a larger secondary package and secured from soiling and damage during storage and transportation.

6.3 BIS Certification Marking

The tape packages conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the tape packages may be marked with the Standard Mark.

6.4 Storage

The tape packages shall be stored in cool and dry place, covered warehouse at temperature below 50 °C and shall be protected from direct sunlight, smoke, fumes, open flame and radiation.

7 ATMOSPHERIC CONDITIONS FOR SAMPLE CONDITIONING AND TESTING

Prior to the test, specimens shall be conditioned to moisture equilibrium from dry side in standard atmosphere of (65 ± 2) percent relative humidity and 27 °C ± 2 °C temperature as laid down in IS 6359.

NOTE — Prior to the test, the test specimens preferably be conditioned in the atmosphere as specified in **7**, for at least 24 h.

8 SAMPLING AND CRITERIA FOR CONFORMITY

8.1 All tape packages of the same polymer material, tape width, tape denier, colour and produced under similar conditions of production and delivered to a buyer shall be grouped together to constitute a lot.

8.2 Unless otherwise agreed to between the buyer and the seller, the number of tape packages to be selected from a lot shall be in accordance with the sampling data given in Table 1. These packages shall be selected at random and to ensure the randomness of selection, IS 4905 may be followed.

8.3 Conformity of lot to the requirements of standard shall be determined based on the tests carried out on samples selected from it.

8.4 The number of samples to be selected depends on the size of the lot and the number of tape packages to be sampled, shall be in accordance with col (2) and col (3) of Table 1. At least 10 test specimens are to be taken from randomly sampled tape packages for testing tape width, tape thickness, tape denier, tape tenacity, elongation at break, tenacity of UV stabilized tape for strength retention, tape shrinkage and ash content analysis.

8.5 Criteria for Conformity

The lot shall be considered in conformity with the requirements of the relevant specification if the specimens drawn from all the packages satisfy the relevant requirements as specified in **5.1.1** to **5.1.8**.

Table 1 Sample Size and Criteria for Conformity

(*Clauses* 8.2, 8.4 *and* C-3)

Sl No.	No. of Tape Packages in a Lot	No. of Tape Packages to be Sampled
(1)	(2)	(3)
i)	Up to 150	5
ii)	151 to 500	8
iii)	501 to 3 000	13
iv)	3 001 and above	20

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ANNEX A

(*Clause* 2)

LIST OF REFERRED STANDARDS

IS No.	*Title*
IS 4905 : 2015/ ISO 24153 : 2009	Random sampling and randomization procedures (*first revision*)
IS 6359 : 2023	Methods for conditioning of textiles (*first revision*)
IS 7328 : 2020	Specification for polyethylene material for moulding and extrusion (*second revision*)
IS 10146 : 1982	Specification polyethylene for its safe use in contact with foodstuffs, pharmaceuticals and drinking water
IS 10910 : 1984	Specification for polypropylene and its copolymers for its safe use in contact with foodstuffs, pharmaceuticals and drinking water
IS 10951 : 2020	Specification for polypropylene (PP) materials for moulding and extrusion (*second revision*)
IS 13360 (Part 4/ Sec 1) : 2000	Plastics — Methods of testing: Part 4 Rheological properties, Section 1 Determination of the melt mass flow rate (MFR) and the melt volume flow rate (MVR) of thermoplastics (*first revision*)
IS 14534 : 2023	Plastics — Recovery and recycling of plastics waste — Guidelines (*second revision*)

ANNEX B

(*Clauses* 5.1.1 *and* 5.1.2)

METHOD OF TEST FOR MEASUREMENT OF TAPE WIDTH AND TAPE THICKNESS

B-1 PRINCIPLE

Physical measurement of tape specimen to quantify the size, such as width, thickness or length using suitable measuring devices with high accuracy levels.

B-2 TAPE WIDTH

B-2.1 Apparatus

The width of the tape shall be determined by measuring with a steel rule having 0.1 mm divisions.

B-2.2 Test Procedure and Results

The width shall be measured to the nearest 0.1 mm. The average of 10 readings shall be taken over a length of not less than 2 m and reported as the average width of the tape. A tolerance of ± 5 percent on the average value shall be permissible.

B-3 TAPE THICKNESS

B-3.1 Apparatus

The thickness of tape shall be determined by means of suitably calibrated spring-loaded dial micrometre. The thickness shall be measured to an accuracy of 2 micrometre. The pressure applied by the contact foot of the dial micrometre shall be not less than 140 kN/m^2 (1.428 kgf/cm^2).

B-3.2 Test Procedure

Dry and clean the surface of the anvil and spindle head, and of the specimen. Place the specimen on the anvil and lower the spindle head on to it slowly. The total load applied by the spindle shall be 110 g. Ten readings shall be taken over a length of not less than 2 m at regular intervals and between 15 s and 2 min after the load is applied and the average value to be reported as the thickness of the tape.

B-4 TEST RESULTS

Take average of the measurements of all the specimens of a sample to obtain the average thickness value. This method can produce measurements with a maximum error of + 0.002 5 mm. A tolerance of ± 10 percent on the average value shall be permissible.

ANNEX C

(*Clauses* 5.1.3, D-4.1 *and* F-3.2)

METHOD OF TEST FOR MEASUREMENT OF LINEAR DENSITY (DENIER) OF TAPE

C-1 PRINCIPLE

The linear density is determined from the mass of a specified length of tape and expressed in denier or tex. The specimen is first conditioned free from tension for predetermined time duration and then the length is measured under standard pretension. The specimen is then weighed, and the mass is used in calculating the linear density (denier) of the specimen.

C-2 APPARATUS

C-2.1 Digital Balance with Pan — Digital balance with sample holding pan, capable of weighing test specimen to an accuracy of 1 mg.

C-2.2 Length Measuring Scale — A metallic ruler or a suitable length measuring instrument graduated in millimetres, and capable of measuring dimensions up to 10 m with an accuracy of 1 mm.

C-3 PREPARATION OF TEST SPECIMENS

Select at least five tape packages as given in Table 1 and before initiating tape specimen sampling, discard the initial few metres of tape from the sample package. From each tape package, draw enough length of tape specimen and keep on a flat horizontal table with markings at both ends, having specified dimension between the two marks, preferably 9 m for denier and 10 m for tex measurement. Render the tape yarn flat on a table and free from any twist or wrinkles and apply fixed pretension of 0.5 cN/tex ± 0.1 cN/tex. Measure and cut the tape specimen between the two marks. Measure at least 10 tape specimens.

C-4 TEST PROCEDURE

For determination of mass of the test specimen (M), take at least 9 m and 10 m length of tape specimen (L) for Denier and Tex measurement, respectively. Measure the specimen length to an accuracy of 1 mm and correspondingly weigh each test specimen correctly to 1 mg.

C-5 CALCULATIONS

Calculate the linear density for each test specimen by one of the following formulae:

a) $$\text{Denier} = \frac{100 \times 90 \times M}{L}$$

b) $$\text{Tex} = \frac{100 \times 10 \times M}{L}$$

where

M = Mass of the test specimen in grams; and

L = length of test specimen in metre.

C-6 TEST RESULTS

Calculate denier for at least 5 samples and obtain the average denier value. This method allows denier measurements with a maximum error of + 0.5 percent. A tolerance of ± 5 percent on the average value shall be permissible.

ANNEX D

(*Clauses* 5.1.4, 5.1.5, 5.1.6 *and* E-4.1)

METHOD OF TEST FOR MEASUREMENT OF BREAKING STRENGTH, ELONGATION AT BREAK AND TENACITY

D-1 PRINCIPLE

D-1.1 Conditioned tape specimen is gripped between the two clamps of the tensile testing machine and a continual increasing load is axially applied by moving one of the clamps until the specimen breaks. Values of elongation corresponding to a predetermined load, maximum breaking strength and elongation at break of the test specimen are noted. Tenacity is determined by dividing the breaking strength in grams by the linear density in denier, whereas, the elongation at break (percent) is determined by dividing the elongation by the initial gauge length.

D-2 APPARATUS

D-2.1 Tensile Testing Equipment — A tensile testing machine is provided with two crossheads; one is adjusted for the length of the specimen and the other is driven to apply tension to the test specimen till it breaks. The crosshead driving mechanisms used are Constant Rate of Traverse (CRT), Constant Rate of Loading (CRL) and, Constant Rate of Extension (CRE). However, the most commonly used driving mechanism is the CRT.

D-2.2 Clamps

a) Two clamps with the following provisions to grip the tape specimens:

   1) Each clamp of the machine shall consist of two metallic jaws and each jaw face shall be in line both with respect to its mate in the same clamp and to the corresponding jaws of the other clamp; and

   2) Each clamp of the machine shall be of curved type in which the tape is gripped between the plain-faced jaws and this makes a half turn around a cylindrical extension of one of the jaws before passing on to the other similar clamp. The cylindrical friction surface shall be between 10 mm to 20 mm in diameter. Each clamp shall be provided with a mechanical or pneumatic device so constructed that through its means a specimen can be secured firmly between the jaws of the clamps so that it does not slip during the test. Also, the edge of the surface of each jaw shall be such test it would not cut or damage the specimen during testing;

      NOTE — The faces of the jaws are generally, flat, engraved or corrugated. To avoid the chances of slippage or damage to the specimen, packing materials like paper, felt, leather, plastic or rubber sheet may be used.

   A schematic diagram of the above type of clamp is shown in Fig. 1. The length of specimen between points A and A_1 is the test length or the gauge length.

b) Means for adjusting the distance between the clamps such that the tape specimens can be tested at 200 mm nominal gauge length;

   NOTE — For undrawn tapes having very high potential of extension during test, it is recommended to test the tape specimens at 50 mm nominal gauge length.

c) Means for driving by power, one of the pair of clamps at a specified constant-rate-of-traverse (CRT) so that the test specimen breaks in 20 s ± 3 s (average time to break). Test shall be carried out at the rate of traverse of 300 mm/min ± 15 mm/min; and

d) A scale or dial or autographic recording chart graduated to give load in newtons (kilograms) and elongation in millimetres. The load cell of the testing shall be selected such that all the observed values would lie between 20 percent and 80 percent of the full-scale load. The permissible error in the machine at any point in this range shall not exceed ± 1 percent.

D-2.3 Other Requirements

a) Means for applying pre-tension of (0.05 ± 0.01) g/denier to the specimen when clamped (tension device may be a dead weight, a spring or an air-actuated mechanism);

b) An analogue or digital scale and dial or autographic chart recorder graduated to give load and elongation at predetermined load and at break; and

c) A pair of scissors or a sharp blade, measuring scale, stopwatch, etc.

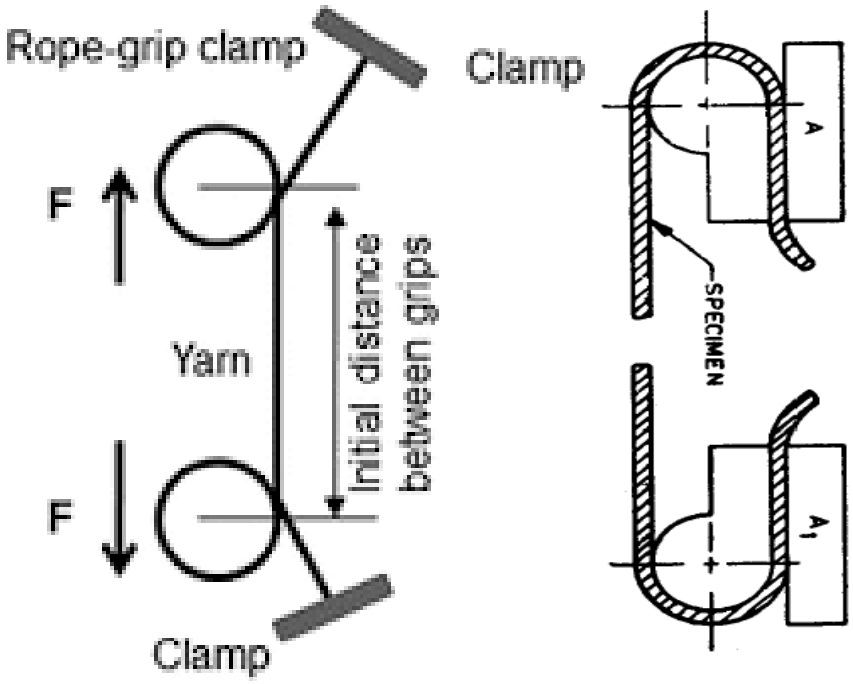

FIG. 1 SCHEMATIC DIAGRAM OF GRIPPING CLAMPS

D-3 TEST PROCEDURE

D-3.1 Test on Conditioned Specimens for Tenacity and Elongation

D-3.1.1 Set the clamps of the testing machine so that the distance between the clamps is 200 mm ± 2 mm or as agreed to between the buyer and the seller. Take the tape from the conditioned sample and discard a first few metres of tape. Fix one end of the specimen in jaw of top clamp and apply the required pre-tension from the free end and secure the other end in jaw of bottom clamp.

D-3.1.2 Operate the tensile testing machine and continue the test to rupture and record the breaking load and elongation at break from the load elongation curve of the autographic chart recorder provided.

NOTES

1 For determining breaking strength of tapes having elongation at break greater than 75 percent, the nominal gauge lengths may be reduced to 100 mm. For testing undrawn tapes, the nominal gauge lengths may be reduced to 50 mm.

2 Even if a test value is isolated because of a break near the jaw, the value shall be noted but not considered in calculations. If such breaks exceed 10 percent of the number of test specimens analysed, suitable corrective action should be taken on jaws and clamps of the machine.

D-3.1.3 Open both the clamps and remove the broken specimen. Test another test specimen in a similar manner as in **D-3.1.1** and **D-3.1.2** discarding at random several metres of tape between two successive tests. Perform minimum 10 tests or as agreed to between the buyer and the seller.

D-3.2 Repeat the procedures laid down in **D-3.1.1** to **D-3.1.3** for all the specimens to be tested.

D-4 CALCULATIONS

Determine the tape tenacity in grams per denier (gpd) and elongation at break in percentage for each test specimen.

D-4.1 Tenacity

Calculate the tape tenacity as per the formulae given below and compute the average tape tenacity from all the observed values.

$$\text{Tenacity, gpd} = \frac{\text{Average breaking strength in newton}}{\text{Average linear density in denier}} \times 100$$

NOTE — The linear density of tape shall be determined from the same package in accordance with Annex C of this standard.

D-4.2 Elongation at break

Calculate the elongation at break as per the formulae given below and compute the average elongation at break from all the observed values.

$$\text{Elongation at break, percent} = \frac{\text{gauge length at break} - \text{initial gauge length}}{\text{Initial gauge length}} \times 100$$

D-5 TEST RESULTS

Calculate the average tape tenacity and elongation at break for at least 10 samples. The minimum tape tenacity (gpd) and the elongation at break shall confirm to the requirements given in **5.1.4** and **5.1.5**.

NOTE — If required, the test results for tape tenacity may be provided in tex based measuring units. The typical unit conversion chart is provided below (g = gram, den = denier, dtex = decitex, and cN = centi Newton):

Sl No.	*Unit*	*g/den*	*g/tex*	*g/dtex*	*cN/tex*
(1)	(2)	(3)	(4)	(5)	(6)
i)	g/den	1	(g/tex)/9	(g/dtex) × 10/9	(cN/tex) × 0.113
ii)	g/tex	(g/den) × 9	1	(g/dtex) x 10	(cN/tex) × 1.02
iii)	g/dtex	(g/den) × 0.9	(g/tex)/10	1	(cN/tex) × 0.102
iv)	cN/tex	(g/den) / 0.113	(g/tex)/1.02	(g/dtex)/0.102	1

ANNEX E

(*Clause* 5.1.6)

UV RESISTANCE TEST

E-1 PRINCIPLE

UV light resistance of HDPE/PP monoaxially oriented tapes is analysed using accelerated weathering test. UV exposure testing uses fluorescent UV light, rain, dew and in special case wind to simulate long term outdoor exposure to natural sunlight. This test measures the effect of ultraviolet light on the mechanical properties of a product.

To determine the effects of UV radiation and weathering on HDPE/PP tape samples, the tapes are exposed to UV radiation under accelerated weathering test as given in **E-3** and **E-4**. The UV exposed tapes are then tested for tape tenacity and the extent of tape tenacity retained vis a vis unexposed tape sample is determined.

E-2 APPARATUS

UV accelerated weathering tester is an instrument that reproduces outdoor environmental effects like sunlight, rain and dew with alternating cycles of fluorescent UV light exposure and moisture at controlled, elevated temperatures.

This instrument essentially has the following accessories and systems:

a) Fluorescent UV lamps to simulate short-wave ultraviolet part of sunlight;

b) Water spaying and humidity control system during the condensation cycle;

c) Temperature setting, temperature cycle repeatability and monitoring system; and

d) Pre-set timer functions incorporated for accuracy and time cycle repeatability.

E-3 TEST CONDITIONS

The test shall be carried out with fluorescent UV-lamp Type B (313 nm or its equivalent). The test duration shall be 192 h (about eight days) in continuous mode.

The test cycle shall be 8 h at 60 °C ± 3 °C with UV-radiation alternating with 4 h at 50 °C ± 3 °C with condensation. Irradiance level throughout the test shall be maintained at $0.63 \begin{matrix} +0.04 \\ -0.00 \end{matrix}$ W/m^2.

E-4 TEST PROCEDURE

E-4.1 Determine the average initial tape tenacity (before UV exposure) as per the test method specified in Annex D.

The sample holder for tapes shall ensure unobstructed exposure to UV light and other weathering conditions. The exposed tape sample size shall be appropriate in length suitable for tensile testing.

E-4.2 Expose the specimen alternately to ultraviolet light and condensation in respective test cycle in continuous mode for total 192 h.

E-4.3 The type of fluorescent UV lamp, the timing of the UV and condensation exposure and the temperature of UV exposure and condensation shall be as specified in **E-3**.

E-5 TEST RESULTS

E-5.1 Determine the average tape tenacity separately after UV exposure as mentioned in **D-4.3**.

E-5.2 Determine the percent retention of original tape tenacity as follows:

Retention of original tape tenacity, percent =

$$\frac{b}{a} \times 100$$

where

a = Average tape tenacity before UV exposure as obtained in **E-4.1**; and

b = Average tape tenacity after UV exposure as obtained in **E-5.1**.

NOTES

1 The UV source is an array of fluorescent lamps (with lamp emission concentrated in the UV range).

2 Condensation is produced by exposing the test surface to a heated, saturated mixture of air and water vapour, while the reverse side of test specimen is exposed to the cooling influence of ambient room air.

ANNEX F

(*Clause* 5.1.7)

METHOD OF TEST FOR MEASUREMENT OF HEAT SHRINKAGE

F-1 PRINCIPLE

F-1.1 Physical measurement of dimensional changes in the length of monoaxially oriented tape specimen before and after exposure to elevated temperatures. The shrinkage is determined by the ratio of the contraction in length of the tape sample after test and the initial sample length before the test.

F-1.2 Shrinkage is an important quality control parameter to ensure the dimensional stability of monoaxially oriented tapes and the products made thereof.

F-2 APPARATUS

F-2.1 Hot Air Circulating Oven — A hot air circulating oven made of heat insulating walls and having enough size to hold at least twenty specimens, freely hanging from the top without touching the bottom. The oven shall have suitable temperature control and monitoring device, capable of maintaining air temperature in the range of 50 °C to 150 °C with an accuracy of ± 1 °C. The oven shall also be equipped with a forced air circulation and monitoring system.

F-2.2 Specimen Mounting Frame — The specimen mounting frame shall be such that test specimens of at least 150 mm in length can be vertically mounted on it with one of its ends is fixed to the top clamp and the other end hanging downwards and attached with dead weight for applying pre-tension. The dead weights shall have suitable grip or fastening arrangement to attach to the tape. The oven height shall be such that the weights are supported only by the tape, that is, the weights shall not be allowed to rest on the bottom of the oven (*see* Fig. 2).

F-3 TEST PROCEDURE

F-3.1 Test specimens

Ten test specimens each about 150 mm long are required.

F-3.2 The linear density of tape is first determined according to Annex C. Dead weights are prepared, each having a mass in grams equal to 0.05 times the linear density value in denier. Top end of each specimen is tied to the specimen mounting frame and the bottom end of the specimen is attached with dead weight. Two marks are made on each tape such that:

a) The distance between the marks shall be 100 mm ± 0.5 mm;

b) The distance from the top mark to the specimen holder shall be minimum 10 mm; and

c) The distance from the bottom mark to the point of attachment of the weight shall be minimum 10 mm (*see* Fig. 2).

F-3.3 Specimens shall be exposed to the following specified temperatures for 10 min;

For HDPE tapes — at (60 ± 2) °C and at (100 ± 2) °C

For PP tapes — at (100 ± 2) °C and at (125 ± 2) °C

On completion of the test period for 10 min, the oven temperature is brought down to room temperature. The specimens are then removed from the mounting frame and the distance between the two marks is re-measured to an accuracy of 1 mm.

F-3.4 Take at least 10 readings for each sample.

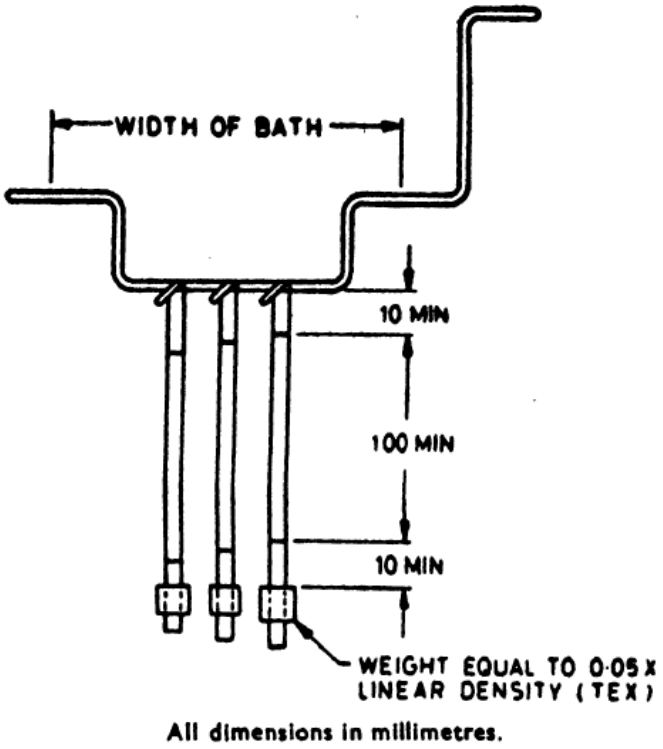

FIG. 2 SPECIMEN MOUNTING FRAME

F-4 TEST RESULTS

Express the shrinkage as a percentage shrinkage at the temperature at which the test was carried out. Calculate the heat shrinkage percentage from the initial and the final lengths of test specimen.

$$\text{Heat shrinkage, percent} = \frac{a-b}{a} \times 100$$

where

a = Initial length of the specimen; and

b = Final length of the specimen after heat treatment.

ANNEX G

(*Clause* 5.1.8)

DETERMINATION OF ASH CONTENT

G-1 PRINCIPLE

The procedure is used to find the inorganic residue in the HDPE/PP tape sample by ashing it in a muffle furnace. A weighed amount of tape sample is heated to 590 °C. The polymer sample (organic portion) is burnt at 590 °C until the constant mass of inorganic matter is obtained. The residue (inorganic matter) is reported in terms of percentage ash content in a given sample.

G-2 APPARATUS

G-2.1 Weighing Balance — accurate to 0.001 g

G-2.2 Silica Crucibles — sufficient volume to accommodate 3 g of sample in such a way that the level of the sample after filling the crucible does not cross half the height of the crucible.

G-2.3 Bunsen burner

G-2.4 Silica triangle and tripod

G-2.5 Muffle Furnace — capable of being controlled thermostatically at 590 °C ± 10 °C

G-2.6 Desiccator — containing an effective drying agent (for example silica gel) that does not react chemically with ash components

G-2.7 Gloves and crucible holder

G-3 TEST PROCEDURE

G-3.1 Clean the crucible and heat it at 590 °C ± 10 °C for 10 min to 15 min and cool it in a desiccator.

G-3.2 Weigh the empty crucible to nearest 0.001 g.

G-3.3 Weigh 3 g of tape sample in the crucible (nearest to 0.001 g).

G-3.4 Heat the crucible directly on burner so that the sample burns slowly, and loss of ash is avoided. Continue burning until no more smoke is evolved.

G-3.5 Transfer the crucible in the muffle furnace, which is already maintained at approx. 590 °C and keep inside for about 2 h.

G-3.6 Remove the crucible from the furnace and cool it to room temperature in a desiccator and weigh it and record the weight to an accuracy of 0.001 g.

G-3.7 Keep the crucible in the muffle furnace for another 30 min, cool in a desiccator and weigh again. Repeat the procedure until the constant mass is obtained.

G-4 TEST REPORTING

$$\text{Ash content, percent} = \frac{\text{Weight of ash}}{\text{Weight of tape sample}} \times 100$$

ANNEX H

(*Foreword*)

COMMITTEE COMPOSITION

Textile Materials Made from Polyolefins (Excluding Cordage) Sectional Committee, TXD 23

Organization	*Representative(s)*
Indian Institute of Packaging (IIP), Mumbai	DR TANWEER ALAM (***Chairperson***)
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This Indian Standard has been developed from Doc No.: TXD 23 (21629).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
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Regional Offices:		*Telephones*
Central	: 601/A, Konnectus Tower -1, 6th Floor, DMRC Building, Bhavbhuti Marg, New Delhi 110002	2323 7617
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Published by BIS, New Delhi