भारतीय मानक ब्यूरो
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भारतीय मानक मसौदा

वस्त्रादि — एयरोस्पेस उद्देश्यों के लिए प्लास्टिक लैमिनेट्स के लिए बुने हुए ग्लास फाइबर कपड़े — विशिष्टि

भाग 3 पॉलीएस्टर रेज़िन सिस्टम के साथ उपयोग के लिए तैयार कपड़े

[*आई एस 5746* (भाग 3) *का तीसरा पुनरीक्षण*]

Draft *Indian Standard*

TEXTILES — WOVEN GLASS FIBRES FABRICS FOR PLASTIC LAMINATES FOR AEROSPACE PURPOSES — SPECIFICATION

PART 3 FINISHED FABRICS FOR USE WITH POLYESTER RESIN SYSTEMS

[*Third Revision of* IS 5746 (Part 3)]

ICS: 59.100.10

Textile Materials for Aeronautical and Related Products Sectional Committee, TXD 13

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FOREWORD

(*Formal clauses will be added later*)

Glass fiber fabrics are commonly used in composite materials, where they reinforce plastics to create laminates that are strong, lightweight, and suitable for demanding environments like aerospace.These laminates are often used in aircraft structures, interiors, and other aerospace applications due to their excellent strength-to-weight ratio, resistance to environmental factors, and durability

This standard was first published in 1970 and subsequently revised in 1983 and 1987. This revision has been made to incorporate the following changes:

a) Marking clause has been modified; and
b) References to standards have been updated.

This standard is published in three parts. The others part in the series are:

Part 1 Loom-state fabrics.
Part 2 Desized fabrics.

Part 1 of this standard covers loom-state woven glass fibre fabrics for plastic' laminates for aerospace purposes. Part 2 of this standard is intended to cover requirements for such desized fabrics.

In the preparation of this standard, considerable assistance has been derived from BS 3396 : Part 3 : 1970 'Woven glass fibre fabrics for plastic reinforcement: Part 3 Finished fabrics for use with polyester resin system', issued by the British Standards Institution.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, 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 value should be the same as that of the specified value in this standard.

1 SCOPE

This standard (Part 3) specifies requirements for woven glass fibre fabrics specified in Part 1 and Part 2 of this standard which have been desized and finished to make them suitable for use with polyester resin systems. Two grades of finish are provided as follows:

a) Grade S : Silane finish or finish of equivalent performance, and
b) Grade C *:* Chrome finish.

2 REFERENCES

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

3 DEFINITION

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

3.1 Finish — A chemical treatment applied to a desized glass fabric to enhance mechanical properties and resistance to water of the combination of glass fabric with synthetic resin.

4 MANUFACTURE

4.1 Yarn

The yarn used in the manufacture of fabric shall be of continuous filament type and low alkali glass containing not more than 1 percent alkali metal oxides expressed as Na_2O when tested as per IS 2303.

4.2 Fabric

The fabric shall be uniformly woven. The selvedges shall be well made, substantially straight and even, and shall have approximately the same tension as the rest of the fabric. The physical requirements of the fabric in the loom-state are given in Part 1 of this standard.

4.3 Desizing

The fabric should be desized prior to application of finish by a two-stage treatment involving aqueous wash followed by suitable heat treatment (*see* Note). The residual size content shall not exceed 0.1 percent when tested by ignition at 575 °C ± 25 °C.

NOTE — Glass fibre for weaving is to be coated with size or lubricant. The size prevents abrasion of yarns during weaving. However, the presence of sizing affects wetting of the fibre by resin and prevents effective bonding of glass and resin. Also, failure to remove the size results in laminates with high power factor and high water absorption which are undesirable properties for electrical insulation.

4.4 Finish

The finish imparted to the fabric shall be silane or chrome or other high-performance water-resistant finish *(see* Note) which is mutually agreed to between the manufacturer or supplier and the buyer and no change shall be made in the type of finish without the concurrence of the buyer.

NOTE — Finish applied to glass cloth provides some lubrication to the fibres and improves the bond between glass and subsequently applied resin. Details of some of the finishes are as under:

a) Chrome Finish – Methacrylate chromic chlorides for polyester resins. When glass fabric is treated with this compound, the chromium attaches itself through the absorbed moisture layer to the silica of glass and leaves the methacrylate group to take part in the curing of the laminating resin.

b) Silane Finish

i) Pretreatment of glass fabric with vinyl triethoxy silane will give a laminate of higher retention of strength after water immersion. Vinyl triethoxy silane forms a chemical bond with the glass, leaves vinyl group available to take part in copolymerization of the unsaturated polyester and monomer.

ii) Gamma — Methacryloxy propyltrimethoxy silane, commonly known **as** methacrylate silane finish or acrylic silane finish may be used. This finish gives glass fibre/polyester resin laminates higher physical properties particularly flexural strength and the resistance of laminate to moisture.

5 REQUIREMENTS

In addition to the requirements specified in Part 1 of this standard except the breaking strength, the finished fabric shall satisfy the following requirements.

5.1 Breaking Strength

When tested in accordance with Annex B, the breaking strength of the finished fabric in the warp and weft directions shall be not less than 40 percent of the minimum average breaking strength specified in Part 1 of this standard for the same fabric in the loom-state condition.

5.2 Compatibility

5.2.1 The finished fabric when made into a laminate by the method described in Annex C shall readily wet out with resin conforming to Type 3 of IS 6746.

5.2.2 For fabrics listed in Table 1, the laminates when tested according to the method laid down in Annex C, the laminates shall meet the requirement of cross breaking strength in dry condition specified in that table. Minimum cross-breaking strength in wet condition shall be 85 percent and 75 percent of cross-breaking strength in dry condition for fabrics with Grade *S* and Grade *C*, respectively.

5.2.3 Other fabrics shall be accepted as satisfactory for laminating in accordance with the procedure given in **5.2.3.1.**

5.2.3.1 A sample of one of the fabrics listed in Table 1 shall be included in the finishing batch. The laminate thus obtained shall be tested according to the method described in Annex C, and the cross-breaking strength thus determined shall meet the requirements specified for that fabric in Table 1

Table 1 Cross-Breaking Strength of Laminates Using Grades S and C Finishes and Drape Stiffness of Finished Fabric

(*Clauses* 5.2.2, 5.2.3.1 and 5.4)

Sl No.	Designation of Fabric	Minimum Cross Breaking Strength of Dry Laminates, *Min*		Drape Stiffness of Finished Fabric, *Max*
		Warp	Weft	
		(mN/m^2)	(mN/m^2)	(mg cm)
(1)	(2)	(3)	(4)	(5)
i)	P 2/11	385	360	250
ii)	P 4/11	380	315	425
iii)	P 5/34	345	350	625
iv)	P 6/22	345	340	650
v)	P 6/34	345	340	700
vi)	P 8/34	275	400	875
vii)	P 41/68	345	315	750
viii)	T 3/22	380	360	1 100
ix)	T 3/34	380	360	350
x)	S 2/22	415	415	1 020
xi)	S 2/34	415	415	1 020
xii)	S 11/22/11	615	90	975
xiii)	P 38/34	320	320	375

5.3 Conductivity of Aqueous Extract

The conductivity of aqueous extract of the finished fabric shall be not more than 12·5 µS/m when tested in accordance with IS 4420.

5.4 Drapability and Flexibility

The finished fabric shall have sufficient drapability and flexibility such that it withstands normal handling and shall not offer any difficulty in the laminating process of components with intricate contour. The drape stiffness of finished fabric shall not exceed values indicated in Table 1 when assessed as specified in Annex D.

5.5 Freedom from Defects and Impurities

The fabric shall be uniform in quality and substantially free from defects. Holes, smashes, grease or oil spots or other contamination, torn selvedges, excessive ends out, missing picks and such

other defects which are detrimental to the use of the fabrics shall be classified as major defects. It shall be reasonably free from creases and wrinkles and shall not be brittle or fused.

5.6 Colour

The colour of the fabric shall be uniform and be characteristic of natural glass fabric which has been cleaned and finished.

5.7 Storage

To ensure quality stability of glass fabric during storage, necessary care shall be taken during storage. The glass fabric shall be stored in dry, if possible, air-conditioned room in original unopened, packing. Direct sunlight shall be avoided. The rolls shall be stored horizontally avoiding external pressure to the glass fabric.

5.7.1 Unless the contrary is stated by the manufacturer, it may be presumed that the storage life of the finished fabric is one year when stored at a temperature not exceeding 27 °C and an ambient relative humidity not exceeding 65 percent.

6 PACKAGING

The finished fabrics shall be packed in rolls weighing not more than 100 kg. No roll shall contain more than 3 pieces and no piece shall be less than 15 meters in length. The fabric shall be rolled evenly on tubes of sufficient length and strength to produce firm packages so as to prevent collapsing or telescoping during transit, storage or handling. Both ends of the roll shall be suitably protected to prevent damage to the edges of the cloth and the whole shall be packed in moisture-proof containers.

7 MARKING

7.1 Each roll of fabric shall be marked with the following:

a) Designation of the fabric;
b) Type of finish;
c) Date of manufacture; and
d) Manufacturer’s name, trade-mark or initials.

7.2 BIS Certification Marking

The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 2016 and Rules and Regulations made thereunder. The details of the conditions under which

the licence for use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

8 SAMPLING

A sample not less than 3 meters long and full width of the fabric shall be taken for each lot of 1 000 meters or fractions thereof from the fabric of one type submitted for acceptance at one time.

9 CRITERIA FOR CONFORMITY

The sample selected in accordance with **8** shall be tested for all the requirements given in **5**. There shall be no failure in respect of any of the requirements if the lot is to be accepted.

ANNEX A

(*Clause* 2)

LIST OF REFERRED STANDARDS

IS No	*Title*
IS 1969 (Part 1) : 2018	Textiles — Tensile Properties of Fabrics Part 1 Determination of Maximum force and Elongation at Maximum Force Using the Strip Method (*fourth revision*)
IS 2303 (Part 1/Sec 1) : 2021	Grading Glass for Alkalinity Part 1 Hydrolytic Resistance of Glass Grains Section 1 Determination and Classification of Hydrolytic Resistance at 98 °C (*third revision*)
IS 4420 : 2022	Methods for determination of conductivity of aqueous and organic extracts of textile materials (*first revision*)
IS 6746 : 1994	Unsaturated polyester resin systems — Specification (*first revision*)

ANNEX B

(*Clause* 5.1)

DETERMINATION OF BREAKING STRENGTH

B-1 SELECTION OF TEST SPECIMEN

B-1.1 Six specimens not less than 30 cm long and 6.5 cm wide shall be cut from the test sample in the direction of warp and six in the direction of weft. No two specimens cut in the same direction shall contain the same longitudinal threads.

B-2 CONDITIONING OF TEST SPECIMENS

B-2.1 Prior to testing, the specimens shall be conditioned for not less than 6 hours, in an atmosphere with relative humidity of 65 percent ± 2 percent and a temperature of 27 °C ± 2 °C and tested under the same conditions.

B-3 PREPARATION OF TEST SPECIMENS

B-3.1 Method 1 — The specimens shall be laid on stiff kraft paper and the ends of the specimens impregnated, coated and attached to papers with polymethyl methacrylate cement (*see* Note), leaving 20 cm length of the specimens untreated at the middle. After the cement has dried, the threads are removed from the sides of the specimen by careful cutting and fraying so as to reduce the width to 5 cm in the untreated portion. When the specimen has been fixed in the jaws of the machine, the paper is cut across at the middle. The 20 cm centre area of the test specimen shall not be distorted or contaminated during the application of the cement. The cement shall thoroughly impregnate the fabric at the points of application so that when dry, the test specimens are securely cemented to the kraft paper at these points. Each specimen shall be fixed in the jaws of testing machine so that the unsupported length is not less than 20 cm. The load is steadily applied at such rate that a load equal to the specified minimum breaking load is reached in approximately one minute.

NOTE — The cement can be prepared by dissolving methyl methacrylate moulding powder in methyl ethyl ketone to produce a liquid solution having the consistency of paint.

B-3.2 Method 2 — Lay the specimen, already frayed to 50 mm width, on a flat surface with each end between two sheets of polyvinyl butyral and leave 200 mm uncovered at the middle of the specimen. Cover the sheets of polyvinyl butyral with medium weight paper and apply an electric iron to soften the polyvinyl butyral and cause it to penetrate and adhere to the glass fibre.

B-4. PROCEDURE

B-4.1 Carry out the test according to grab method as prescribed in IS 1969.

ANNEX C

(*Clauses* 5.2.1, 5.2.2 and 5.2.3.1)

PREPARATION AND TESTING OF RESIN GLASS FABRIC LAMINATE FOR CROSS-BREAKING STRENGTH

C-1 PRINCIPLE

C-1.1 A test laminate of 3.20 mm ± 0.25 mm thickness and 30 cm × 30 cm is prepared using sufficient number of glass cloths and polyester resins conforming to Type 3 of IS 6746 with a suitable catalyst and accelerator. The proportion of resin hardener and accelerator and subsequent curing of the laminate shall be in accordance with the instructions of the resin manufacturer. The glass fabric cut to size shall be dried in a ventilated oven for one hour at 100 °C ± 5 °C, and cooled in a desiccator and used immediately on removal. The fabric is impregnated with the resin to give a final resin content of 35 percent to 42 percent of the total weight when determined by ignition at 575 °C ± 25 °C. The laminating process shall be done at an ambient temperature of 17 °C to 28 °C.

C-2 PREPARATION OF POLYESTER LAMINATE

C-2.1 A suitable method of preparation of polyester laminate is as follows:

C-2.1.1 Mass of the resin necessary to give the required resin content is calculated from the mass of glass cloth to be used. A polished metal plate of 40 cm × 40 cm is covered with a layer of a regenerated cellulose film 0.05 mm thick. A layer of dried glass cloth of suitable size is laid on it. Sufficient amount of catalysed resin is poured on to the centre of the cloth and spread out uniformly with roller or thin metal strip until the cloth is evenly coated. The procedure is repeated with successive layers of cloth superimposed on the previous end with the warp thread parallel to these in the preceding ply. The whole process should not take more than 20 minutes.

C-2.1.2 The top layer is then covered with a layer of regenerated cellulose fibre followed by a second polished metal plate. Metal stops 3 mm thick are placed between lower and upper metal plates and whole build-up is placed between platens of a press and held under a pressure of 35 kN/m^2 to 70 kN/m^2 during the curing schedule. The laminate after curing in accordance with the

resin manufacturer's instructions is post-cured at 100 °C for 2 hours ensuring that it is free from visible voids and other defects. The laminate is allowed to cool to room temperature.

C-3 DETERMINATION OF FLEXURAL STRENGTH

C-3.1 Test Specimen — Ten rectangular strips each measuring 100 mm × 15 mm shall be cut with the longer direction parallel to the warp or weft for determining the flexural strength of the strips.

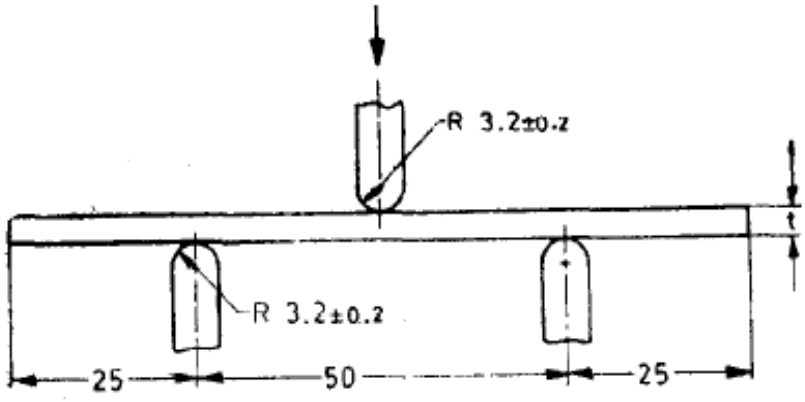
C-3.2 Conditioning of Test Specimens —The specimens to be tested in the 'dry condition' shall be conditioned for not less than 24 hours in an atmosphere of 65 percent ± 2 percent relative humidity and a temperature of 27 °C ± 2 °C prior to testing, and tested under the same conditions.

C-3.2.1 Specimens to be tested in the 'wet condition' shall be immersed in boiling distilled water for two hours and after that, the same shall be removed and cooled in distilled water at room temperature. The test shall be conducted on the wet specimens immediately after removal from distilled water.

C-3.3 Apparatus — A suitable flexural strength testing machine with a bend jig, which will permit the span being varied to suit the thickness of specimens, is used. The machine shall be properly calibrated and the error, if any, in the load measuring system shall not exceed ± 1 percent of the applied load. The contact surface of the supports and loading blocks shall have a radius of 3.2 mm ± 0.2 mm and shall not be less than 25 mm in length from each end.

C-3.4 Measurement of Dimensions — The width and the thickness at the centre of span shall be measured to the nearest 0·01 mm. The span shall be measured to the nearest 0.2 mm

C-3.5 Procedure — The specimen shall be placed symmetrically over the supports in the bend jig (*see* Fig. 1) which are 50 mm apart (between 16 to 18 times the thickness of the specimen). Align the loading block and the supports so that the axes of the cylindrical surfaces are parallel and the loading block is midway between the supports. Apply the load to the specimen at the specified cross-head rate of 5 mm/minute to 6.5 mm/minute till the specimen fractures. The load at fracture shall be noted.



t = Thickness of Specimen

All dimensions in millimetres.

Fig. 1 Flexural Test for Glass Fibre Laminate

C-3.6 Calculation and Reporting — Flexural strength or the modulus of rupture in bending is the maximum load sustained by the specimen converted to maximum fibre stress using the following formula:

$$S = 15 \times \frac{wl}{bt^2}$$

Where,

S = flexural strength in mN/m^2;

w = load at fracture in N;

l = span in mm;

b = breadth of specimen in mm; and

t = thickness of specimen in mm.

C-3.6.1 The average of five determinations in each direction and tested in each state, that is, dry and wet, shall be reported as the flexural strength.

ANNEX D

(*Clause* 5.4)

METHODS OF TEST FOR DRAPABILITY AND FLEXIBILITY

D-1 PRINCIPLE

D-1.1 The method outlined here is a cantilever test suitable for woven fabrics. In this test, a strip of fabrics is laid in a direction parallel to its long dimensions, so that its ends project from the edge of the horizontal surface. The length of overhang is measured when the tip of the test specimen is depressed under its own weight to a point where the line joining the tip to the edge of the platform makes an angle of 41.5 ° with the horizontal. One half of this length is the bending length of the specimen. The cube of this quantity multiplied by the mass per unit area of the fabric is the drape stiffness value.

D-2 APPARATUS

D-2.1 A horizontal platform with a minimum area of 50 mm × 200 mm having a smooth low friction flat surface together with an indicator inclined at an angle of 41.5 ° below the plane of the platform surface.

D-2.2 A metallic strip of size 25 mm × 200 mm and of thickness 3 mm.

D-2.3 A levelling bubble**.**

D-3. PREPARATION OF TEST SPECIMENS

D-3.1 Cut three test specimens of 25 mm × 200 mm size with the long dimensions parallel to warp and three with the long dimensions parallel to weft. The specimens shall be cut in such a way that no two warp specimens contain the same warp yarns for the warp direction tests and no two weft specimens contain the same weft yarns for the weft direction tests. Avoid selvedges, and pieces and creased or folded places and handle the specimens as little as possible.

D-4 CONDITIONING OF TEST SPECIMENS

D-4.1 Prior to testing, the test specimens shall be conditioned for not less than 6 hours in an atmosphere with relative humidity of 65 percent ± 2 percent and temperature of 27 °C ± 2 °C.

D-5 PROCEDURE

D-5.1 Set the test platform with the inclination indicator at eye level.

D-5.2 Adjust the platform to be horizontal using a levelling bubble.

D-5.3 Place a specimen on the platform with the metallic strip on top of it so that the leading edges coincide. Holding the metallic strip in a horizontal plane, slide the specimen and metal strip steadily until the leading edges of the specimen projecting beyond the edge of the platform fall and coincide with the inclination indicator. If the specimen has a tendency to twist, take the reference point at the centre of the leading edge. Discard specimens which twist more than 45 °. Read the length of the overhang (*l*) from the scale to the nearest 1 mm.

D-5.4 Take four readings from each specimen with each side up, first at one end and then at the other end.

D-5.5 Determine the mass of the fabric (*M*) and express in mg/cm^2.

D-6 CALCULATIONS

D-6.1 Calculate the drape stiffness *(G)* as follows:

$$G \text{ (mg cm units)} = M \times (l/2)^3$$

Where,

M = mass of fabric in mg/cm^2; and
l = length of the overhang measured in cm.

D-6.2 Calculate the average drape stiffness of four readings for each specimen.

D-6.3 Report the average drape stiffness of all the three specimens in warp and weft direction, separately.

D-6.4 If an overall average figure for the fabric is required, calculate the geometric mean of the average values obtained for warp and weft direction as follows:

$$G_0 = \sqrt{G_w \times G_f}$$

Where,

G_o = overall drape stiffness;
G_w = warp way drape stiffness; and

G_f = weft way drape stiffness

NOTE —The test shall be carried out in the standard atmosphere of 65 percent ± 2 percent relative humidity and 27 °C ± 2 °C temperature.