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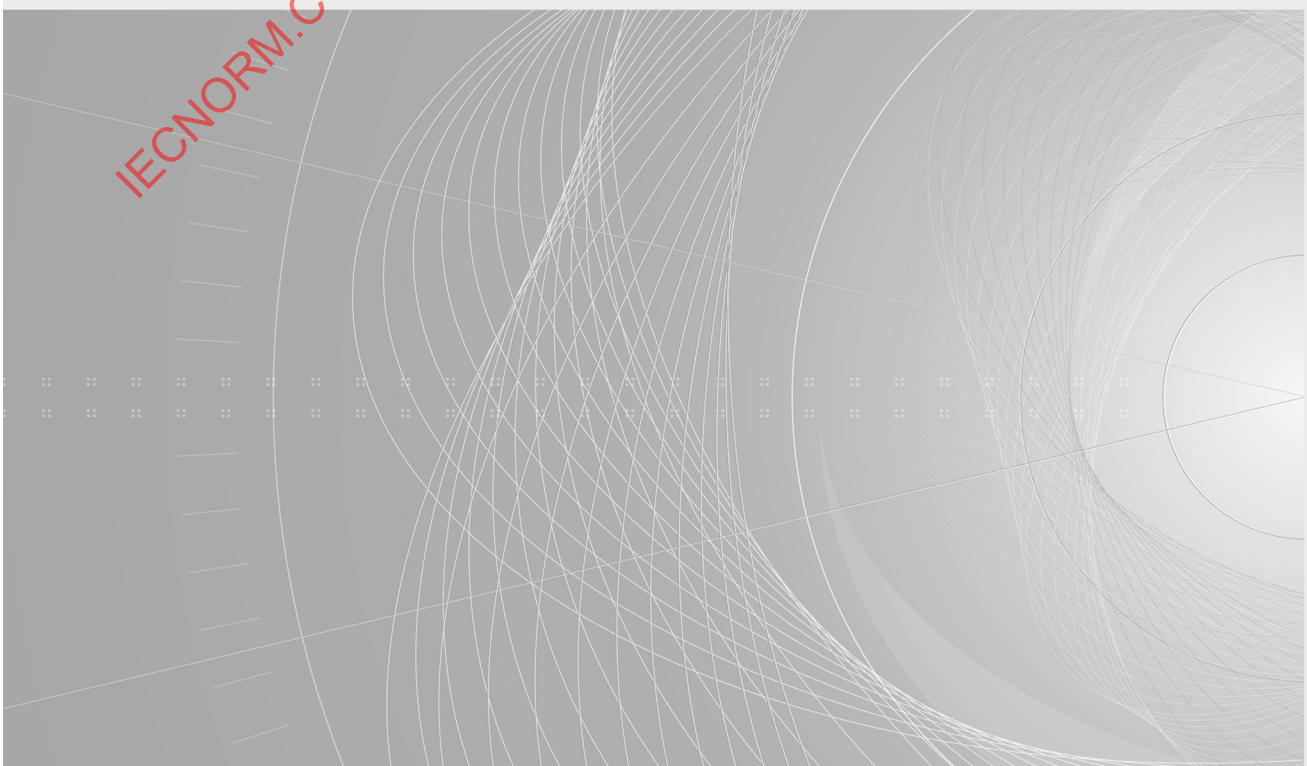
PUBLICLY AVAILABLE SPECIFICATION

Specification for finished fabric woven from "E" glass for printed boards



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Specification for finished fabric woven from "E" glass for printed boards

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SPECIFICATION FOR FINISHED FABRIC WOVEN FROM "E"GLASS FOR PRINTED BOARDS

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IEC-PAS 61249-6-3 has been processed by IEC technical committee 91: Electronics assembly technology.

The text of this PAS is based on the following document:

This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document

Draft PAS	Report on voting
91/956/PAS	91/961/RVD

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SPECIFICATION FOR FINISHED FABRIC WOVEN FROM “E”GLASS FOR PRINTED BOARDS

1 Scope

This specification covers finished fabrics woven from :E” glass electrical grade glass fiber yarns that are intended as a reinforcing material in laminated plastics for electrical and electronic use. All fabrics covered by this specification are plain weave.

1.1 Purpose

This specification determines the nomenclature, definitions, general and chemical requirements for the glass, and physical requirements for finished woven glass fiber fabrics.

1.2 Designation

Appendix II of this standard provides a style designator for each finished fabric glass style, with specifications on yarn, fabric count, thickness and weight in both SI and US system. Fabrics listed in Appendix II also categorize fabrics by their current availability status.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

2.1 IPC

IPC-T-50, *Terms and Definitions for Interconnecting and Packaging Electronic Circuits*

IPC-9191, *General Guidelines for Implementation of Statistical Process Control (SPC)*

2.2 American Society for Testing and Materials (ASTM)

ASTM-D578, *Standard Specification for Glass Fiber Strands*

ASTM-D1776, *Standard Practice for Conditioning Testing Textiles*

2.3 International Standards

ISO 9001, *Quality Management Systems – Requirements*

2.4 National Conference of Standards Laboratories (NCSL)

NCSL Z 540-1, *General Requirements for Calibration Laboratories and Measuring and Test Equipment*

3 Terms and definitions

The definition of terms shall be in accordance with IPC-T-50 and the following:

3.1
AQL (Acceptable Quality Level)
maximum number of defects per hundred units that can be considered satisfactory as a process average

3.2
bias
filling yarns are off-square to the warp ends

3.3
bow
filling yarns lie in an arc across the width of the fabric

3.4
creases
a ridge in the fabric caused by a fold or wrinkle being placed under pressure

3.5
defects
a substandard area in a fabric

3.6
major defect
a defect that is likely to result in failure, or to reduce materially the usability of the unit of product for its intended purpose

3.7
minor defect
a defect that is not likely to reduce materially the usability of the unit of product for its intended purpose.

3.8
defect per hundred units

$$\frac{\text{Number of Defects}}{\text{Number of Units Inspected}} X\ 100$$

3.9
E glass (electrical grade glass fiber)
E glass, which is to be used for PWB applications, is a continuous filament glass yarn with a chemical composition by weight that is within the following limits:

B_2O_3	5 %–10 %
CaO	16 %–25 %
Al_2O_3	12 %–16 %
SiO_2	52 %–56 %
MgO	0 %–5 %
Na_2O and K_2O	0 %–2 %
TiO_2	0 %–0.8 %
Fe_2O_3	0.05 %–0.4 %
F_2	0 %–1.0 %

Composition is to be certified by yarn supplier as requested.

3.10
end missing
a very small portion of the warp in the fabric that may have been broken in the pick-out of waste

3.11
feather length
length of distance from last warp end to the end of the pick

3.12
fabric finish
treatment of fabric to aid in compatibility with resins

3.13
fish eye
small area of fabric which resists resin wetting and can be caused by the resin system, fabric and treatment

3.14
leno end out
missing wrapper warp end from the edge of the fabric

3.15
lot or batch size
a collection of units produced in one continuous, uninterrupted finish run from which a sample is drawn and inspected or tested to determine conformance with the acceptability criteria

3.16
mark
heavy or light area in fabric due to excessive or less filling yarns

3.17
heavy mark
a filling defect extending across the width of the fabric containing two picks/inch in excess of the nominal count

3.18
light mark
a filling defect extending across the width of the fabric containing two picks/inch less than the nominal count

3.19
pick
filling yarn running crosswise the entire width of a fabric

3.20
broken pick
a filling yarn missing from a portion of the width of the fabric

3.21
mis-picks
break in the pattern of cloth from selvage to selvage caused by a missing filling yarn

3.22
plain weave
a fabric configuration where each warp end should go over one pick and under the next, and each pick should go over one warp end and under the next

3.23
splits
an opening in the fabric resulting from either the pick or end breaking in two. This is usually caused by the fabric folding over and creasing

3.24
tears
a large rip in the fabric usually caused by excessive tension being applied during processing. Could be caused by weak fabric

3.25
TEX system
a system for expressing linear density of yarn or other textile strand. The unit is equivalent to grams/kilometer.

3.26
waste
a lump or collection of yarn or filament woven into the fabric where accumulated contamination off the loom has found its way into the fabric

3.27
waviness
cloth is woven under varying tensions preventing even placement of picks resulting in alternating thick and thin places

4 Requirements

4.1 Yarn nomenclature

There are two systems of identifying fiber glass yarns: the US system and system international (SI)/metric. Consider the following exmple: ECD 450 1/2 in US system or EC5 11 1x2 in SI.

4.1.1 US system

For the ‘‘ECD’’ in ‘‘ECD 450 1/2,’’ the first letter represents the grade of glass; the second indicates whether the yarn is continuous (“C”) or staple (“S” – fibers of a cut length), and the third represents the filament diameter (see 3.4.8). “ECD” is then read as an “E” glass electrical grade fiber of “C” (continuous) length and with the filament diameter of “D.” The “450” in ECD 450 1/2 represents the linear density of the yarn in units of yards per pound divided by 100. The 450 in ECD 450 ½ indicates that the nominal single yarn measuremet in yards per pound is 450 x 100 = 45,000 yards per pound.

The “1/2” indicates the number of single yarns twisted together into a strand/the number of twisted strands plied together. Thus, the “1/2” in ECD 450 1/2 indicates that one single yarn is twisted (becomes the strand) and two twisted strands are plied together. By convention, a “1/0” means that the yarn is a singles yarn (no or “zero” plying required).

Since this specification is for E grade glass where all yarns are continuous, the ECD 450 1/2 nomenclature can be shortened to the D 450 1/2 nomenclature.

4.1.2 SI/metric

For the “EC5” in EC5 11 1x2, the first letter represents the grade of glass; the second indicates whether the yarn is continuous (“C”) or staple (“S” – fibers of a cut length). The number represents the filament diameter (see 3.4.8). “EC5” is then read as an “E” glass electrical grade fiber of “C” (continuous) length and with the nominal filament diameter of 5 μm (rounded to the nearest μm). The “11” in EC5 11 1x2 represents the TEX number of

linear density. The 11 in EC5 11 1x2 indicates that the nominal single yarn measurement is 11 g/km or 90,716 m/kg.

The “1x2” indicates the number of single yarns twisted together into a strand x the number of twisted strands plied together. Thus, the “1x2” in EC5 11 1x2 indicates that one single yarn is twisted (becomes the strand) and two twisted strands are plied together. By convention, a “1x0” means that the yarn is a singles yarn (no or “zero” plying required).

Since this specification is for E grade glass where all yarns are continuous, the EC5 11 1x2 nomenclature can be shortened to the 5 11 1x2 nomenclature.

4.1.3 Conversion from US system to SI

To convert from the US system to SI, the changes are:

1) The alphabetical filament diameter designation in US System to be changed to a numerical designation (filament diameter in micrometers) in SI, e.g., “D” to be changed to “5” {see 3.4.8).
2) The linear density indicator to be changed from a number with an unit of hundred yards per pound in US System to a TEX number of grams per kilometer equivalent, e.g., “450” to be changed to “11” (see 3.4.9).
3) The “/” sign in the US System to be changed to a “x” sign in SI for the number of single yarns twisted together into a strand and the number of twisted strands plied together. e.g., “1/2” to be changed to “1x2.”

4.2 Visual requirements

When specified by purchase contract, fabric is examined in accordance with 4.4.1. Visual defects shall be identified and classified per Table 1 and meet the AQL defined in 4.3.2 or 4.3.3 as specified.

4.3 Physical requirements

4.3.1 Fabric count

Fabric count shall be evaluated in accordance with 4.4.2. The nominal fabric count for each style shall be as specified in Appendix II. For fabrics not listed, the nominal fabric count shall be as agreed upon between user and supplier. The actual average count of warp ends or filling picks shall be within ± 2/inch of the nominal count.

4.3.2 Weave type

Weave type shall be determined in accordance with 4.4.3. This specification only addresses plain weave.

4.3.3 Fabric thickness

Fabric thickness shall be determined in accordance with 4.4.4. The nominal fabric thickness for each style shall be as specified in Appendix II.

4.3.4 Fabric weight

Fabric weight shall be determined in accordance with 4.4.5. The nominal fabric weight for each style shall be as specified in Appendix II and shall meet the tolerance listed.

4.3.5 Fabric length

Fabric length shall be determined in accordance with 4.4.6 and shall be as specified on the purchase order. The length of the fabric shall be within ± 1 % of the value specified.

4.3.6 Fabric width

Fabric width shall be determined in accordance with 4.4.7 and shall be as specified on the purchase order. The width of the fabric shall be within -0/+13 mm [-0.000/+0.512 in] of the value specified. If the fabric has coated and cut (C&C) edges, the width shall be -0/+5 mm [-0.000/0.197 in] of value specified.

4.3.7 Feather length

Feather length shall not exceed 5.0 mm [0.197 in].

Table 1 – Classification of Defects

Visual Defect	Description	Classification
Bias or bowed filling*	Pick line distortion from horizontal by more than 2.5 % for entire width	Major
Baggy or wavy cloth	Clearly noticeable per 4.4.1	Major
Cut or tear	> 6.5 mm [0.256 in] in any direction (body only)	Major
Spots, streaks, stains, foreign inclusions	Clearly noticeable	Major
Broken or missing ends or picks	2 or more continuous, regardless of length	Major
Light marks	> 6.5 mm [0.256 in] in width	Major
	2 picks/inch less than nominal	Minor
Heavy marks	Puckering clearly noticeable	Major
	2 picks/inch more than nominal	Minor
Crease	Hard embedded and folded over on self	Major
Waste	Clearly noticeable > 6.5 mm [0.256 in]	Major
	Clearly noticeable 6.5 mm [0.256 in]	Minor
Weave Separation	Clearly noticeable > 3.175 mm [0.125 in]	Major
Leno ends out	> 5 meters [5.47 yards]	Major
	5 meters [5.47 yards	Minor
Feather length	> 5 mm [0.197 in] running > 4.5 m [4.92 yards]	Major
	> 5 mm [0.197 in] running 4.5 m [4.92 yards]	Minor

*It is important that as a target for the future the non-homogeneous bow (i.e., a bow not stretching across the width of material) should be reduced.

4.3.8 Filament diameter

The filament diameters shall be determined in accordance with ASTM D578. The nominal filament diameter and the range of averages for products used in electrical laminates are as given in Table 2.

NOTE Filament diameters are to be certified by yarn supplier as requested.

Table 2 – Filament Diameter Designations

Designation		Nominal Diameter		Range of Averages	
SI	US System	(μm)	(10^{-5} in)	(μm)	(10^{-5} in)
4	BC	4	15.7	3.50 to 4.70	13.78 to 18.50
4.5	C	4.5	17.7	3.56 to 5.08	14.02 to 20.00
5	D	5	21.0	4.80 to 5.87	18.90 to 23.11
6	DE	6	25.6	5.84 to 7.16	22.99 to 28.19
7	E	7	28.0	6.40 to 7.82	25.20 to 30.79
9	G	9	37.0	8.46 to 10.34	33.31 to 40.709

4.3.9 Bare glass nominal measurement

Bare glass nominal measurement (yardage) shall be as defined in Table 3.

4.4 Chemical requirements

4.4.1 Finish level (organic content)

The finish level of the fabric shall be determined in accordance with 4.4.8. The organic content of the finish fabric shall be no less than 0.05 % and no more than 0.30 %, unless otherwise agreed upon between user and supplier. See ASTM D-579 point 39 for additional information.

4.5 Workmanship

Unless otherwise specified, the maximum allowable number of splices is one per 915 m (1000 yd), with a minimum length between splices of 137 m (150 yd). All splices shall be flagged and compatible with resin solvents. Splices shall not lose strength and shall withstand coater stresses.

4.6 Laser machinability performance

Laser machinability performance is recognized as a significant fabric style attribute. Requirements for laser machinability will be considered as a specification sheet element at such time that a standardized test method and performance level requirements are developed. Until then, the test method and performance level requirements shall be as agreed upon between user and supplier.

4.7 Alternate fabric styles and weaves

For alternate fabric styles and weaves not covered by this specification, requirements shall be as agreed upon between user and supplier.

Table 3 – Bare Glass Nominal Measurements

Yarn		Nominal Length per Unit Weight	
SI Nomenclature	**US System Nomenclature**	**SI** m/kg	**US System** yards/pound
4 2.20 1x0	BC 2250 1/0	453,571	225,000
4 3.31 1x0	BC 1500 1/0	302,385	150,000
4.5 2.76 1x0	C 1800 1/0	362,864	180,000
4.5 4.13 1x0	C 1200 1/0	241,905	120,000
5 2.75 1x0[1]	D 1800 1/0[1]	362,864	180,000
5 5.5 1x0	D 900 1/0	181,432	90,000
6 8.27 1x0	DE 600 1/0	120,955	60,000
5 11 1x0	D 450 1/0	90,716	45,000
6 16.5 1x0	DE 300 1/0	60,477	30,000
7 22 1x0	E 225 1/0	45,358	22,500
9 33 1x0	G 150 1/0[2]	30,239	15,000
6 33 1x0	DE 150 1/0	30,239	15,000
7 41 1x0	E 125 1/0	25,199	12,500
7 45 1x0	E 110 1/0[3]	22,175	11,000
6 49 1x0	DE 100 1/0	20,159	10,000
9 68 1x0	G 75 1/0[4]	14,716	7,300

Yarn		Nominal Length per Unit Weight	
SI Nomenclature	**US System Nomenclature**	**SI** m/kg	**US System** yards/pound
9 74 1x0	G 67 1/0	13,507	6,700
9 99 1x0	G 50 1/0[5]	10,080	5,000
9 134 1x0	G 37 1/0[6]	7,459	3,700

1) 1/0 or 1x0 = Single yarn which has not been combined.
2) In Europe, yarn used is G 146 1/0 (9 34 1x0).
3) Some suppliers may use E 113 1/0 (7 44 1x0).
4) The actual yardage is 14,716 m/kg [7,300 yds/lb.], but the product isdesignated G 75 1/0.
5) In Europe, yarn used is G 49 1/0 (9 102 1x0).
6) In Europe, yarn used is G 36 1/0 (9 136 1x0). This is the input yarn for glass style 7642.

5 Quality assurance

5.1 Statistical process control (SPC)

SPC utilizes systematic statistical techniques to analyze a process or its outputs. The purpose of these analyses is to take appropriate actions to achieve and maintain a state of statistical control, and to assess and improve process capability. The primary goal of SPC is to continually reduce variation in processes, products or services in order to provide product meeting or exceeding real or important customer requirements.

Implementation of SPC shall be in accordance with IPC-9191. Depending on the progress made in implementing SPC on a particular product, an individual supplier may demonstrate compliance to specification with any of the following:

- Quality Conformance Evaluations
- End-Product Control
- In-Process Product Control
- Process Parameter Control

An individual supplier may choose to use a combination of the four assurance techniques listed to prove compliance. For example, a product with 15 characteristics may meet specifications by quality conformance evaluations on two characteristics, in-process evaluations on five characteristics, and process parameter control for five characteristics.

The remaining three characteristics meet specifications by a combination of in-process control and quality conformance evaluations. Evidence of compliance to the specification at the level of SPC implementation claimed is auditable by the customer or appointed third party.

Requirements are dynamic in nature and are based on what is accepted in the worldwide market. Requirements may be stated as a reduction of variation around a target value, as opposed to just meeting the specification, drawing, etc.

5.2 Responsibility for inspection

If specified on the purchase order, all fabrics shall be inspected as per 4.3, according to the test methods specified herein. Except as otherwise specified in the purchase order, the supplier may use his own or any other facility suitable for the execution of the inspection requirements herein, unless disapproved by the procuring authority. The procuring authority reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and service are performed to the prescribed requirements.

5.2.1 Test equipment and inspection facilities

Test and measuring equipment and inspection facilities of sufficient accuracy, quality, and quantity to permit performance of the required inspection shall be established and maintained by the supplier. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with ANSI/NCSL Z540-1 or ISO 10012-1.

5.2.2 Preparation of samples

Unless otherwise specified herein or in the test methods, samples shall be prepared in accordance with standard in-house procedures. If a referee method is required, it shall be as agreed upon between user and supplier.

5.2.3 Standard laboratory conditions

Unless otherwise specified herein, all sample conditioning and testing shall be performed in accordance with the test conditions specified in the general requirements of ASTM-D1776.

5.3 Inspection requirements and acceptability

The acceptability of the product shall be in accordance to 4.3.2 or 4.3.3 as specified in the purchase order. Registration of a supplier's quality system to ISO-9001 or other equivalent standard may be acceptable in lieu of the final inspection of product as agreed between user and supplier.

5.3.1 Sample size

The definition of a sample size for use shall be in proportion to the size of the lot, i.e., the number of rolls and/or total yards to be shipped, per Table 4 and Table 5.

Table 4 – Sample Size per Number of Rolls Shipped

Number of rolls shipped	Number of rolls to be inspected	Code letter
2-8	2	A
9-15	3	B
16-25	5	C
26-50	8	D
51-90	13	E
91-150	20	F

Table 5 – Sample size per yardage of individual roll shipped and the acceptable quality level

Roll size (m) [yard]	Sample size (m) [yard]	Code letter	2.5 % AQL	
			Accept	Reject
138 – 256 [151 – 280]	30 [32.8]	G	2	3
257 – 457 [281 – 500]	45 [49.2]	H	3	4
458 – 1097 [501 – 1200]	73 [79.8]	J	5	6
1098 – 2926 [1201 – 3200]	115 [125.8]	K	7	8
2927 – 9145 [3201 – 10000]	180 [196.8]	I	10	11

5.3.2 Sampling plans

Sampling plans sufficient to ensure an AQL of 2.5 % shall be used (see Table 4 and Table 5) and shall be substantiated by the supplier and available for inspection by the user on request. For small lots, one or more defects shall be cause for rejection. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be separated from new lots and shall be clearly identified as reinspected lots.

5.3.3 Acceptable quality level (AQL)

No 1 m [1.1 yards] shall be penalized with more than one major defect.

A continuous defect shall be counted as one defect for each warp-wise meter or fraction thereof in which it occurs.

The occurrence of an average of eight major defects in 100 m [109.4 yards], or the single major defect of ‘‘baggy or wavy cloth,’’ shall constitute cause for rejection of the roll in which the defects occur. Four minor defects shall be considered as the equivalent of one major defect.

Latent defects or defects that appear during or after treatment can occur to make the product unacceptable for its intended use. The acceptable level of these defects and the resolution of any rejects arising must be negotiated between user and supplier. Latent defects that are difficult to identify on the fabric before treatment are:

- Broken glass filaments that result in protrusion of glass filaments and resin.
- Discolorations caused by binder streaks or incomplete heat cleaning.
- Fish eyes (see 3.1.10).

5.4 Test methods

5.4.1 Fabric appearance

Fabric shall be inspected while traversing over a flat viewing area of at least one linear meter by the full width of the fabric.

The light source should be mounted on a different plane parallel to the viewing surface of the fabric so as to illuminate the surface with overhead perpendicular light.

View and inspect the fabric from a distance of approximately 1 meter [1.1 yard].

Count all defects except where two or more defects represent a single local condition (all within one linear meter). In this case, count only the more serious defect as one defect. A continuous defect is counted as one defect for each linear meter or fraction thereof in which it appears. Classify the defects as listed in Table 1.

5.4.2 Fabric count

Lay fabric sample on a flat surface free of tension, creases, or wrinkles. Using any suitable magnifying or counting device (such as pick glass or ruler) count the number of yarns in a cm^2 or in^2 area for both warp and fill directions. Five successive counts should be made, evenly spaced on a diagonal across the width of the sample. Counts should not be made within 1/10th of the width of the sample from the edge.

Average the five counts and round off to the nearest individual yarn per inch for US system. For SI, round off to the nearest 0.1 yarn count per cm. Report results, stating the warp count first.

Example: Fabric count for 7628 Style Fabric = 17.3 × 12.2 per cm [44 × 31 per inch].

5.4.3 Weave type

Place the fabric sample on a flat surface with the warp direction extending away from the observer. Examine the sample with either the naked eye or low power magnification (if needed).

Select a starting point on the surface of the fabric where a warp end is raised over a filling pick – raiser yarn. (A filling pick raised over a warp end is a sinker yarn.)

Plot the weave construction on graph paper. Plot from left to right from the first raiser yarn, showing raiser yarns as marked blocks and sinker yarns as unmarked blocks until a minimum two repeats of the pattern are observed. In a like manner, plot up from the first raiser yarn until a minimum of two repeats of the pattern are observed corresponding to each designated block in the left-right pattern.

A plain weave fabric plot will exhibit a uniform checker board pattern.

5.4.4 Fabric thickness

Fabric thickness is measured with apparatus equipped with a 6.35 mm [0.250 in] diameter presser foot and anvil and 1.76 kg/cm^2 [25.03 psi] load. (Tester TMI 549 MS$_5$[1] or equivalent.)

Make ten thickness measurements across the width of the sample; record to the nearest 0.0025 mm [0.0984 mil]. Do not measure within 1/10th the sample width from the edge.

Average the ten readings and report the fabric thickness to the nearest 0.0025 mm [0.1 mil].

5.4.5 Weight per unit area

Prepare a fabric specimen or a number of smaller die cut specimens having a total minimum area of 290 cm^2 [44.95 in^2]. Do not take specimens closer than 1/10 of the fabric width to a selvage or cut edge. Measure specimen dimensions to the nearest 0.5 mm [0.020 in].

Weigh specimen (or small specimens together) to within ± 0.01 % of the weight on a balance. (Note: Care must be taken during cutting and weighing so any loose yarns unraveling from the cut are also weighed with the specimen.)

Report average of the side, center, side specimens, or indicate if only a single determination per fabric specimen were made.

[Calculate the weight in grams per square meter.]

[Grams per Square Meter (GSM) = G / A]

[Calculate the weight in ounces per square yard as follows:]

[Ounces per Square Yard (OSY) = 0.02949 x (G / A)]

Where,

G = Total weight of specimen(s) in grams.

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1 Tester Model – TMI 549 MS (1/4″ anvil 25 psi load) obtainable from Testing Machines, Inc., 400 Bayview Avenue, Amityville – Long Island, NY 11701

A = Total area of specimen(s) in length by width measured in square meters.

5.4.6 Fabric length

The fabric roll length shall be measured by the clock method. The measuring device consists of a wheel or pair of wheels mounted on a free running axle connected to a counting mechanism graduated to read in meters and centimeters [yards and eighths of a yard].

The surfaces of the wheels are to be covered with a friction material to prevent slippage. The circumference of the wheel is to be known and synchronized with the mechanism to read in meters [yards].

The measuring device is to be mounted in such a way that movement of the fabric through the machine will turn the wheels. The roll will be measured from beginning to end and the length reported to the nearest meter [yard].

5.4.7 Fabric width

Lay the fabric on a smooth horizontal surface without tension in any direction. Measure the width to the nearest 2.5 mm [0.1 in] perpendicular to the edges using a measuring stick or steel tape. In the case of ‘‘feathered’’ or ‘‘fringed’’ edge material, the measurement will be from the outermost warp yarns on each side of the fabric.

5.4.8 Finish level (organic content)

Cut a fabric specimen from the center of the fabric with a weight of 6 g [0.21 oz] or total minimum area of 290 cm^2 [44.95 in^2]. Fold the sample in from all edges and tuck it into a compact square or triangle with no loose strings exposed.

1) Condition in oven at 121 ± 5 °C [249.8 ± 9 °F] for a minimum of one hour.*
2) Cool in desiccator for a minimum of 10 minutes.*
3) Weigh the sample to the nearest 0.1 mg and record as W_1.
4) Place the sample in a muffle furnace at 625 ± 30 °C [1157 ± 54 °F] for 20 ± 2 minutes.
5) Cool in desiccator for a minimum of 10 minutes.
6) Reweigh the sample to the nearest 0.1 mg, record as W_2, and calculate the organic content as follows:

$$\% \text{ Organic Content} = \left[\frac{(W_1 - W_2)}{W_1}\right] \times 100$$

W_1 = Initial weight

W_2 = Burned off weight

*Conditioning is often omitted in current lab practices, but must be used to resolve finish level conflicts between user and supplier.

5.4.9 Bias or bowed filling

Place the glass fabric or prepreg against a right angle ruler or over a right angle edge of a flat table. (Handle the glass gently and evenly so not to distort it during testing). The warp (machine) direction or the length of the cloth should be running in the line of sight, the fill (width of fabric) should be perpendicular.

Pick-up the fill yarn at one corner of the table or rightangle fixture and follow it as it runs across the full width of the web. It should approximately be parallel to the base line. If it is running under an angle, mark with a felt marker on the end of the yarn on the opposite side of the corner that you started from. Measure the maximum distance between the mark and the baseline.

$$\left[\frac{\text{Distance}}{\text{Fabric Width}}\right] \times 100 = \text{ \% distortion from horizontal}$$

Other methods for measuring distortion may be used as agreed between user and supplier.

6 Preparation for delivery

6.1 Preservation and packaging

Preservation and packaging shall be in such a manner as to ensure delivery in a condition that will pass the requirements of this specification.

6.2 Packing

Packing shall be as specified (see 6.1).

6.3 Marking

In addition to any special marking required by the contract or order, each unit package, exterior container and unitized load shall be clearly marked to assure product identity.

7 Notes

7.1 Ordering data

The subcontract or purchase order should specify the following:

a. Title number and date of this specification.
b. Style designation (see Appendix II).
c. Fabric dimensions.
d. Levels of preservations, packaging and packing.
e. Marking.
f. Any deviations from this specification.

7.2 New Styles

A new or altered woven fiber glass style shall be considered for addition to IPC-4412 when the appropriate style and yarn designations and format as listed in Appendix II are submitted to the IPC. When a new style is submitted from a US system supplier, the conversion to SI units will be done. When a new style is submitted from a SI system supplier, the conversion to the US system will be done. The IPC Woven Glass Reinforcement Task Group chairman shall make the determination to approve the request, ballot the task group, or reject the request. If approved the style shall be in the next printing of IPC-4412, and a written notification shall be made to the task group members of record of the addition.

Annex A

The European members of the IPC Woven Glass Reinforcement Task Group developed this appendix. It is intended to provide the user with a cross reference between the IPC-4412 requirements and ISO specifications applicable to woven glass.

Table A.1 – Cross Reference Between IPC-4412, Standards Called Out by IPC-4412, and ISO Documents

Paragraph	Standards called out by IPC-4412	ISO Standards	Remarks
2.1	IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits	ISO 6344 Textile glass - Vocabulary	Documents are not identical. ISO Contains textile glass definitions only.
	IPC-9191	ISO 9001 Quality Management Systems Requirements ISO 9004 Quality Management And Quality System Elements – Guidelines For Performance Improvements	The ISO standards define the requirements to quality systems and quality assurance.
2.2	ASTM D578 Standard Specification for Glass Fiber Strands ASTM D1776 Standard Practice for Conditioning Testing Textiles	ISO 2078 Textile Glass – Yarns – Designation ISO 3598 Textile Glass – Yarns – Basis For A Specification	The ASTM Standard is very detailed. It contains description of test methods and requirements (with tolerances). US system and SI are addressed in ASTM. ISO standards are more general and contain SI only.
3.4.8 Filament Diameter	ASTM D578 Standard Specification for Glass Fiber Strands	ISO/DIS 1888 Textile Glass – Staple Fibres Of Filaments – Determination Of Average Diameter	The longitudinal method of ISO 1888 corresponds to the test method in ASTM D578.

Table A.2 – Cross Reference Between IPC-4412, ASTM and ISO Documents

Paragraph	ASTM Documents not Called out by IPC-4412	ISO Documents	Remarks
4.4.2 Fabric Count	ASTM D3775 Standard Test Method for Fabric Count of Woven Fabric	ISO 4602 Reinforcement – Woven Fabrics – Determintation Of Number Of Yarns Per Unit Length Of Warp And Welt	The methods are identical. ASTM considers US and SI. ISO considers SI only.
4.4.3 Weave type	ASTM D579 Standard Specification for Greige Woven Glass Fabrics		ISO Standard not known.
4.4.4 Thickness	ASTM D1777 Standard Test Method for Thickness of Textile Materials ASTM D579 Standard Specification for Greige Woven Glass Fabrics	ISO/DIS 4603 Textile Glass – Woven Fabrics – Determination Of Thickness	ASTM specifies a presser foot diameter of 6.35 mm and a pressure of 158 to 186 KPa (for ''sheet metal''). ISO specifies a presser foot diameter of 56 mm and a pressure of 2 KPa.

Paragraph	ASTM Documents not Called out by IPC-4412	ISO Documents	Remarks
4.4.5 Weight per Unit Area	ASTM D3776 Standard Test Methods for Mass Per Unit Area (Weight) of Fabric ASTM D579 Standard Specification for Greige Woven Glass Fabrics	ISO 4605 Textile Glass – Woven Fabrics – Determination Of Mass Per Unit Area	The methods are identical. ASTM Considers US and SI, ISO SI only.
4.4.6 Fabric Length 4.4.7 Fabric Width	ASTM D579 Standard Specification for Greige Woven Glass Fabrics	ISO 5025 Reinforcement Products – Woven Fabrics – Determiantation Of Width And Length	The methods are identical. ASTM considers US and SI, ISO considers SI only.
4.4.8 Finish Level	ASTM D578 Standard Specification for Glass Fiber Strands	ISO 1887 Textile Glass – Determination Of Combustible-Matter Content	The methods are identical.
	ASTM D579 Standard Specification for Greige Woven Glass Fabrics	ISO 3344 Reinforcement Products – Determination Of Moisture Content	Moisture content not currently defined in IPC-4412.
	ASTM D5035 Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)	ISO 4606 Textile Glass – Woven Fabric – Determination Of Tensile Breaking Force And Elongation At Break By The Strip Method	The ISO differs from ASTM in – gauge length – rate of elongation

Annex B

Finished Fabric Glass Styles

Table B.1 – Finished Fabric Glass Styles in SI Units

Style	Fabric Count Warp x Fill (per cm)	Yarn (SI)	Thickness (mm) (Reference only)	Nominal Weight (g/m^2)	Weight Tolerance (g/m^2)	Availability[1]
101	29.5 x 29.5	5 2.75 1x0 5 2.75 1x0	0.024	16.3	15.2 – 17.3	1
104	23.6 x 20.5	5 5.5 1x0 5 2.75 1x0	0.028	18.6	18.0 – 19.3	1
106	22.0 x 22.0	5 5.5 1x0 5 5.5 1x0	0.033	24.4	23.4 – 25.4	1
107	21.3 x 21.3	5 11 1x0 5 11 1x0	0.043	47.8	46.8 – 49.2	1
1080	23.6 x 18.5	5 11 1x0 5 11 1x0	0.053	46.8	45.1 – 48.5	1
1081	27.6 x 23.6	5 11 1x0 5 11 1x0	0.060	58.3	56.4 – 60.6	1
1280	23.6 x 23.6	5 11 1x0 5 11 1x0	0.056	52.9	51.5 – 54.2	1
1500	19.3 x 16.5	7 45* 1x0 7 45* 1x0	0.149	164.1	157.7 – 170.5	1
1501	18.1 x 17.7	7 45* 1x0 7 45* 1x0	0.140	165.0	158.0 – 171.0	1
1504	23.6 x 19.7	6 33 1x0 6 33 1x0	0.125	148.0	142.8 – 153.2	1
1651	20.0 x 10.8	9 33 1x0 9 74 1x0	0.135	146.2	142.1 – 150.3	1
1652	20.5 x 20.5	9 34* 1x0 9 34* 1x0	0.114	138.3	133.6 – 143.1	1
1674	15.7 x 12.6	9 34* 1x0 9 34* 1x0	0.097	96.6	92.9 – 100.4	1
1675	15.7 x 12.6	6 33 1x0 6 33 1x0	0.101	96.3	92.6 – 100.0	1
1678	15.7 x 15.7	9 34* 1x0 9 34* 1x0	0.091	103.5	102.7 – 111.6	1
2113	23.6 x 22.0	7 22 1x0 5 11 1x0	0.079	78.0	75.6 – 80.4	1
2114	22.0 x 18.9	7 22 1x0 7 22 1x0	0.084	90.9	88.5 – 93.2	1
2116	23.6 x 22.8	7 22 1x0 7 22 1x0	0.094	103.8	100.7 – 106.8	1
2117	26.0 x 21.7	7 22 1x0 7 22 1x0	0.095	108	104.8 – 111.2	1
2125	15.7 x 15.4	7 22 1x0 9 34* 1x0	0.091	87.5	82.7 – 90.9	1
2157	23.6 x 13.8	7 22 1x0 9 68 1X0	0.130	148.0	144.0 – 152.0	1
2165	23.6 x 20.5	7 22 1x0 9 34* 1x0	0.101	122.4	116.3 – 126.1	1
2166	23.6 x 15.0	7 22 1x0 9 68 1X0	0.140	155.0	150.0 – 160.0	1
2313	23.6 x 25.2	7 22 1x0 5 11 1x0	0.084	81.4	79.0 – 83.7	1
3070	27.6 x 27.6	6 16.5 1x0 6 16.5 1x0	0.078	93.6	90.9 – 96.3	1
3080	20.0 x 12.0	6 16.5 1x0 6 16.5 1x0	0.059	53.4	51.5 – 55.3	1
3313	23.6 x 24.4	6 16.5 1x0 6 16.5 1x0	0.084	81.4	79.0 – 83.7	1
7628	17.3 x 12.2	9 68 1x0 9 68 1x0	0.173	203.4	198.0 – 208.9	1
7629	17.3 x 13.4	9 68 1x0 9 68 1x0	0.180	210.0	204.5 – 215.3	1
7635	17.3 x 11.4	9 68 1x0 9 102* 1x0	0.201	232.3	226.5 – 238.0	1
7642	17.3 x 7.9	9 68 1x0 9 136* 1x0 (texturized)	0.254	227.8	221.1 – 234.7	1
108	23.6 x 18.5	5 5.5 1x2 5 5.5 1x2	0.061	47.5	46.1 – 48.8	2
1027	29.5 x 29.5	4 3.31 1x0 4 3.31 1x0	0.019	19.9	19.0 – 20.7	2
1035	26.0 x 26.8	5 5.5 1x0 5 5.5 1x0	0.028	30.0	27.2 – 32.6	2
1037	27.6 x 28.7	4.5 4.1 1x0 4.5 4.1 1x0	0.027	23.0	22.2 – 24.1	2
1065	22.0 x 22.0	5 11 1x0 5 5.5 1x0	0.053	37.3	35.6 – 39.0	2

Style	**Fabric Count Warp x Fill** (per cm)	**Yarn** (SI)	**Thickness** (mm) (Reference only)	**Nominal Weight** (g/m^2)	**Weight Tolerance** (g/m^2)	**Availability**[1]
1067	27.6 x 27.6	5 5.5 1x0 5 5.5 1x0	0.035	30.7	29.5 – 31.9	2
1634	20.0 x 12.0	9 33 1x0 9 33 1x0	0.095	105.4	101.6 – 109.2	2
1647	20.0 x 12.0	9 33 1x0 7 44 1x0	0.105	120.5	116.1 – 124.9	2
1649	20.0 x 15.0	9 33 1x0 7 44 1x0	0.120	135.9	130.9 – 140.8	2
1657	20.0 x 11.6	9 33 1x0 9 74 1x0	0.150	154.2	149.9 – 158.5	2
1697	17.3 x 15.0	9 34* 1x0 9 34* 1x0	0.092	111.2	105.1 – 113.9	2
2112	15.7 x 15.4	7 22 1x0 7 22 1x0	0.081	69.0	67.0 – 71.0	2
3113	20.0 x 12.0	7 22 1x0 9 33 1x0	0.081	84.8	82.2 – 87.4	2
3323	23.6 x 18.1	6 16.5 1x0 7 22 1x0	0.086	81.3	78.0 – 84.0	2
6060	23.6 x 23.6	6 8.27 1x0 6 8.27 1x0	0.048	39.0	37.6 – 40.3	2
7196	17.3 x 13.0	9 74 1x0 9 74 1X0	0.200	230.0	223.0 – 237.0	2
7624	17.3 x 9.4	9 68 1x0 9 68 1x0	0.163	184.4	179.0 – 190.0	2
7640	17.3 x 13.4	9 68 1x0 9 102* 1X0	0.249	258.0	250.0 – 266.0	2
7652	12.6 x 12.6	9 102* 1x0 9 102* 1x0	0.220	257.7	249.2 – 266.2	2
7667	17.3 x 12.2	9 74 1x0 9 74 1x0	0.185	220.0	215.0 – 225.0	2
7669	17.3 x 12.2	9 68 1x0 9 74 1x0	0.178	209.0	203.0 – 215.0	2
7688	17.3 x 13.8	9 68 1x0 9 74 1x0	0.190	220.0	214.0 – 226.0	2
112	15.7 x 15.4	5 11 1x2 5 11 1x2	0.092	70.5	68.5 – 72.6	3
113	23.6 x 25.2	5 11 1x2 5 .5 1x2	0.086	81.0	78.7 – 83.4	3
116	23.6 x 22.8	5 11 1x2 5 11 1x2	0.102	105.0	101.7 – 107.8	3
119	21.3 x 19.7	5 11 1x2 5 11 1x2	0.091	91.8	89.2 – 94.6	3
1012	27.6 x 27.6	4 2.20 1x0 4 2.20 1x0	0.018	12.3	11.8 – 12.8	3
1015	37.8 x 37.8	4 2.20 1x0 4 2.20 1x0	0.015	16.9	16.5 – 17.3	3
1020	21.7 x 21.7	4.5 2.76 1x0 4.5 2.76 1x0	0.025	12.2	11.5 – 12.8	3
1044	17.3 x 17.3	6 51 1x0 6 51 1x0	0.142	171.0	166.0 – 176.0	3
1047	18.5 x 18.5	6 51 1x0 6 51 1x0	0.147	184.0	179.0 – 189.0	3
1070	23.6 x13.8	5 11 1x0 5 5.5 1x0	0.046	34.2	32.8 – 35.6	3
1116	23.6 x 22.8	5 22 1x0 5 22 1x0	0.089	104.0	100.7 – 106.8	3
1165	23.6 x 20.5	5 11 1x2 9 34* 1x0	0.101	123.0	116.9 – 127.8	3
1180	23.6 x 19.7	5 11 1x0 5 11 1x0	0.058	49.0	47.5 – 50.5	3
1316	24.0 x 24.0	5 22 1x0 5 22 1x0	0.102	108.0	105.0 – 111.0	3
1502	20.5 x 19.7	7 42 1x0 7 42 1x0	0.150	162.0	156.3 – 167.7	3
1503	25.2 x 18.1	6 33 1x0 6 33 1x0	0.135	148.0	142.8 – 153.2	3
1676	22.0 x 18.9	6 33 1x0 6 33 1x0	0.122	138.0	132.0 – 143.0	3
2119	21.3 x 19.7	7 22 1x0 7 22 1x0	0.086	90.2	87.5 – 92.9	3
2316	24.0 x 24.0	7 22 1x0 7 22 1x0	0.096	106.0	103.0 – 109.0	3
2319	23.6 x 19.3	7 22 1x0 7 22 1x0	0.086	92.2	89.5 – 94.9	3
3132	23.6 x 23.6	5 11 1x0 7 22 1x0	0.071	79.0	76.0 – 82.0	3
7627	17.3 x 11.8	9 68 1x0 9 68 1x0	0.165	199.0	193.0 – 205.0	3
7637	17.3 x 8.7	9 68 1x0 9 136* 1x0	0.224	228.0	221.0 – 235.0	3
7650	17.3 x 9.1	9 68 1x0 9 102* 1x0	0.190	208.0	201.0 – 214.0	3
7660	11.8 x 11.8	9 68 1x0 9 68 1x0	0.150	160.4	156.0 – 164.0	3