



ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES®

IPC-4202

Flexible Base Dielectrics for Use in Flexible Printed Circuitry

IPC-4202

May 2002

A standard developed by IPC

Supersedes
IPC-FC-231C
with Amendment 1
October 1995

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Flexible Base Dielectrics for Use in Flexible Printed Circuitry

Developed by the Flexible Circuits Base Materials Subcommittee (D-13)
of the Flexible Circuits Committee (D-10) of IPC

Supersedes:

IPC-FC-231C with
Amendment 1 - October 1995
IPC-FC-231C - April 1992
IPC-FC-231B - February 1986
IPC-FC-231A
IPC-FC-231

Users of this standard are encouraged to participate in the
development of future revisions.

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Acknowledgment

Any Standard involving a complex technology draws material from a vast number of sources. While the principal members of the Flexible Circuits Base Materials Subcommittee (D-13) of the Flexible Circuits Committee (D-10) are shown below, it is not possible to include all of those who assisted in the evolution of this standard. To each of them, the members of the IPC extend their gratitude.

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Flexible Base Dielectrics for Use in Flexible Printed Circuitry

1 SCOPE

This standard establishes the classification system, the qualification and quality conformance requirements for flexible base dielectric materials to be used for the fabrication of flexible printed circuitry and flexible flat cable.

This specification supersedes IPC-FC-231C and the requirements herein meet or exceed the requirements for Class 3 in this superseded document. Note that conformance to Class 3 met or exceeded conformance to Classes 1 and 2. IPC-4202 no longer utilizes the 3-class system.

1.1 Classification System The system described in 1.1.1 through 1.1.2.4 identifies flexible base dielectrics.

1.1.1 Nonspecific Designation A nonspecific designation is intended for use by designers on master drawings to designate their material choice. Further specification details may be indicated by using the specific designation in drawing notes and purchase documents. At the end of this standard is a series of material specification sheets designated by individual nonspecific designators. Each sheet outlines engineering and performance data for a flexible base dielectric, indicating base material type and method of reinforcement. The sheets are provided with a number for ordering purposes. For example, if a user wishes to order from specification sheet number 1, the number "1" would be substituted for the "S" in the designation example (i.e., IPC-4202/1).

Example of nonspecific designation:

IPC-4202/S

Where *S* is specification sheet number

1.1.2 Specific Designation The specific designation **shall** be in the following form and is intended for use on purchase orders (see 6.1). The specific designation **shall** not be used by designers on master drawings to indicate their material selection. Master drawings **shall** indicate the material design by the nonspecific designation supplemented in notes with the material specification details as defined by the specific designation. This procedure is necessary because the specific designation is normally lengthy and will not fit the field for most computer cataloging.

Example of specific designation:

IPC-4202/S -C1E2

Where:

IPC-4202/S – Nonspecific Designation (see 1.1.1)

C – Base Dielectric Type Designation (see 1.1.2.1)

1 – Reinforcement Method Designation (see 1.1.2.2)

E – Reinforcement Type Designation (see 1.1.2.3)

2 – Base Dielectric Thickness Designation (see 1.1.2.4)

1.1.2.1 Base Dielectric Material Type The type of dielectric material **shall** be designated per Table 1-1.

Table 1-1 Base Dielectric Type Designation

Designation	Base Dielectric Type
A	Polyvinylfluoride (PVF)
B	Polyethylene Terephthalate Polyester (PET)
C	Fluorinated Ethylene-Propylene Copolymer (FEP)
D	Polytetrafluorethylene (PTFE)
E	Polyimide
F	Aramid
G	Polyamide-imide
H	Epoxy
J	Polyetherimide
K	Polysulfone
L	Polyethylene Naphthalate (PEN)
M	Thermotropic Liquid Crystal Polymer

1.1.2.2 Reinforcement Method The reinforcement method **shall** be designated per Table 1-2.

Table 1-2 Reinforcement Method Designation

Designation	Reinforcement Method
1	Non-reinforced
2	Nonwoven reinforcement
3	Woven reinforcement
4	Combination woven and nonwoven reinforcement

1.1.2.3 Reinforcement Type The reinforcement type **shall** be designated per Table 1-3.

Table 1-3 Reinforcement Type Designation

Designation	Reinforcement Type
A	Glass
B	Polyester
C	Aramid
D	Cellulose
E	Film (non-reinforced)

Note: Combinations will use two letters separated by slash.

1.1.2.4 Base Dielectric Material Thickness The base material thickness **shall** be designated per Table 1-4.

1.2 Qualification The flexible base dielectrics materials that meet all the requirements of this standard **shall** be qualified products (see 4.8).

Table 1-4 Nominal Dielectric Thickness Designation

Designator	Thickness*
1	25 µm [0.000984 in]
2	50 µm [0.00197 in]
3	75 µm [0.00295 in]
4	100 µm [0.003937 in]
5	125 µm [0.004921 in]
A	2.5 µm [0.0000984 in]
B	5 µm [0.00020 in]
C	7.5 µm [0.000295 in]
D	10 µm [0.000394 in]
E	13 µm [0.000512 in]
F	15 µm [0.000591 in]
H	18 µm [0.000709 in]
J	20 µm [0.000787 in]
K	23 µm [0.000906 in]
L	40 µm [0.00157 in]
X	Specified on purchase order

*See 3.6.4.

1.3 Quality Conformance This standard establishes a quality conformance system for the manufacturers to demonstrate the continual conformance of a flexible base dielectrics material to the quality requirements of the standard. See 4.9 for quality conformance inspection requirements.

1.4 Material Characteristics The flexible materials made to this standard use established requirements to enable the material to be applied in a broad range of applications. Materials made to this standard may have characteristics that meet a specific enhanced performance need. Both the user and supplier should review these enhancements.

1.5 New Materials The flexible base dielectrics contained in this standard represent known materials. As new materials become available, they will be added to future revisions. Users and material developers are encouraged to supply information on new flexible materials using the blank specification sheet at end of this standard for review by the IPC Flexible Circuits Committee (D-13). Users who wish to invoke this standard for flexible materials not listed **shall** list a zero for the specification sheet number (i.e., IPC-4202/0).

New or revised specification sheets may become approved by the committee independent from revision of the standard. When this occurs, the new or revised specification sheet **shall** become part of the standard. Per 6.1, the specification sheet revision date **shall** be specified in the order.

1. www.ipc.org

2. Current and revised IPC Test Methods are available through IPC-TM-650 subscription and on the IPC Web site (www.ipc.org/html/testmethods.htm).

3. www.astm.org

4. www.ul.com

2 APPLICABLE DOCUMENTS

The following documents of the issue currently in effect form a part of this standard to the extent specified herein.

2.1 IPC¹

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

IPC-TM-650 Test Methods Manual²

2.1.13 Inspection for Inclusions and Voids in Flexible Printed Wiring Materials

2.2.4 Dimensional Stability, Flexible Dielectric Materials

2.3.2 Chemical Resistance of Flexible Printed Wiring Materials

2.4.15 Surface Finish, Metal Foil

2.4.16 Initiation Tear Strength, Flexible Insulating Materials

2.4.17.1 Propagation Tear Strength, Flexible Insulating Material

2.4.19 Tensile Strength and Elongation, Flexible Printed Wiring Materials

2.5.5.3 Permittivity (Dielectric Constant) and Loss Tangent (Dissipation Factor) of Materials (Two Fluid Cell Method)

2.5.17 Volume Resistivity and Surface Resistance of Printed Wiring Materials

2.6.1 Fungus Resistance Printed Wiring Materials

2.6.2 Moisture Absorption, Flexible Printed Wiring

IPC-9191 General Requirements for Implementation of Statistical Process Control

2.2 American Society For Testing and Materials (ASTM)³

ASTM-D-149 Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

ASTM-D-374 Standard Test Methods for Thickness of Solid Electrical Insulation

2.3 Underwriters Laboratories Standards⁴

UL 94 Standard Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 746B Polymeric Materials - Long Term Property Evaluations

2.4 NCSL International⁵

ANSI/NCSL Z 540-1-1994 General Requirements for Calibration Laboratories and Measuring and Test Equipment

2.5 ISO⁶

ISO 10012-1 Quality Assurance Requirements For Measuring Equipment - Part 1: Metrological Confirmation System For Measuring Equipment

3 REQUIREMENTS

3.1 Terms and Definitions The definition of terms **shall** be in accordance with IPC-T-50 and as stated in 3.1.1 through 3.1.7.

3.1.1 Qualification Testing Qualification testing is performed to demonstrate the vendor's ability to meet all of the requirements of the standard invoked by the user.

3.1.2 Quality Conformance Testing Quality conformance testing is performed on a regular basis following qualification testing to demonstrate that the vendor is continually meeting the quality requirements of the standard.

3.1.3 User Inspection Lot A user inspection lot **shall** consist of all of the flexible base dielectrics of the same type and same designation as far as practicable, produced from the same or equivalent batches or lots of constituent materials under essentially the same conditions and offered for inspection at one time.

3.1.4 Vendor Inspection Lot A vendor inspection lot **shall** consist of all sheets or rolls fabricated within a period not to exceed one month from the same materials, using the same processing procedures, produced under the same conditions and offered for inspection at one time.

3.1.5 Structurally Similar Construction When testing products at the primary stage of manufacture, materials whose thickness details will not affect the results of a dimensionally independent test will be considered structurally similar (e.g., fungus resistance can be done on a single thickness dielectric since thickness will not affect the test results of a product with structurally similar construction).

3.1.6 Void The absence of the specified material in a localized area, such as caused by a bubble, hole, or delamination.

3.1.7 Inclusions Foreign particles, metallic or nonmetallic, that are entrapped (cannot be wiped off with a cloth) in the specified material and were not intended as part of the material formulation.

3.2 Specification Sheets The individual item requirements **shall** be as specified herein and in accordance with the applicable specification sheets. Where there is no specification sheet available, the individual requirements **shall** be as specified in complimentary documents such as master drawings or ordering data sheets (see 6.1). In the event of any conflict between requirements in the specification sheet and other sections of this standard, the former **shall** govern.

New or revised specification sheets may become approved by the committee independent from revision of the standard. When this occurs, the new or revised specification sheet **shall** become part of the standard. Per 6.1, the specification sheet revision date **shall** be specified in the purchase order.

3.3 Conflict In the event of conflict, the following order of precedence **shall** apply:

1. Purchase order as agreed upon between user and vendor.
2. Master drawing (see 6.1D).
3. Specification sheets of this standard.
4. Other sections of this standard.
5. Applicable documents (see Section 2).

3.4 Materials Requirements The flexible base dielectrics **shall** be free from deleterious substances and formulated or prepared to meet the requirements of this standard.

3.4.1 Sheet Material Each sheet of flexible base dielectric material **shall** meet the requirements of 3.5 through 3.11.

3.4.2 Roll Material Each roll of flexible base dielectric material **shall** meet the requirements of 3.5 through 3.11. Defects are allowed such that the total of all defective areas **shall** not exceed 5% of the total roll area (roll length x roll width). Each defect area **shall** be defined in a 60 cm x 60 cm [23.6 in x 23.6 in] increment and suitably marked or flagged. Each defect area may contain single or multiple defects which are constrained within a square no larger than 30 cm x 30 cm [11.8 in x 11.8 in] centered within the defect area. If multiple defects are spaced such that they cannot be contained with a single 30 cm x 30 cm [11.8 in x 11.8 in] area, then more than one 60 cm x 60 cm [23.6 in x 23.6 in] defect area **shall** be marked or flagged on the roll.

3.5 Visual Requirements When tested in accordance with the following paragraphs, the material **shall** meet the visual requirements specified in 3.5.1 through 3.5.5. Any

5. www.ncsli.org

6. www.iso.org

defect within 6.5 mm [0.256 in] from the outside edges of the sheet or roll **shall** be disregarded.

The entire test specimen (sample unit per 4.9.2) **shall** be examined with 20/20 vision for the requirements of 3.5.

If inclusions are seen with 20/20 vision, the worst appearing 50.0 mm x 50.0 mm [1.969 in x 1.969 in] area **shall** be examined with 10X magnification to determine the size of the inclusions. If no inclusions are seen with 20/20 vision, the entire specimen **shall** be recorded as having no defects against the requirements of 3.5.3.

3.5.1 Marking Each material **shall** have a unique lot number traceable to all raw materials and processing parameters. Each package **shall** contain evidence of compliance.

3.5.2 Wrinkles, Creases, Streaks and Scratches The depth of scratches and height of streaks **shall** be measured with a surface profilometer with a stylus capable of measuring to 0.004 mm [160 μ m] (see IPC-TM-650, Method 2.4.15).

The material **shall** be free of wrinkles, creases, streaks and scratches to the extent specified in 3.4.1 and 3.4.2. The allowable depth, width and quantity of scratches and the allowable height, width and quantity of streaks **shall** be agreed upon between vendor and user depending upon the requirements of the application.

3.5.3 Inclusions The area of the 50.0 mm x 50.0 mm [1.969 in x 1.969 in] specimen affected by inclusions **shall** be tested in accordance with ASTM-D-149 and **must** withstand 500 Vac minimum for one minute. The size of the inclusions **shall** not be >0.25 mm [>0.00984 in] any direction.

3.5.4 Voids When tested in accordance with IPC-TM-650, Method 2.1.13, the size of the voids **shall** not be >0.075 mm [>0.00295 in] in any direction.

3.5.5 Holes, Tears and Delaminations The material **shall** be free of these defects so as to be usable for the intended applications.

3.6 Dimensional Requirements

3.6.1 Sheet Width and Length The width and length of sheets of flexible base dielectric **shall** be as specified in the procurement document (see 6.1). The width and length **shall** be within ± 6.0 mm [± 0.236 in] of the value specified.

3.6.2 Roll Width The width of the flexible base dielectric **shall** be measured with a suitable instrument and **shall** be as specified in the procurement document (see 6.1). The

width of the material **shall** be within ± 1.5 mm [± 0.0591 in] of the values specified or as agreed upon between user and vendor.

3.6.3 Roll Length The length of the flexible base dielectric **shall** be as specified in the procurement document (see 6.1). The length of each roll **shall** be within $\pm 5\%$ of the value specified. Length **shall** be determined by a distance counter accurate to within 2%.

3.6.4 Thickness Thickness of flexible base dielectric material **shall** be measured to the nearest 3 μ m [0.12 mil]. When tested in accordance with ASTM-D-374, Method A or C, the deviation from the nominal thickness of the base dielectric material **shall** be within the allowable range as specified in Table 3-1.

Table 3-1 Allowable Deviation from Nominal Thickness

Nominal Thickness Range	Allowable Deviation
Thickness ≥ 0.075 mm [Thickness ≥ 0.00295 in]	$\pm 10\%$
0.025 mm \leq Thickness < 0.075 mm [0.000984 in \leq Thickness < 0.00295 in]	$\pm 12.5\%$
0.020 mm \leq Thickness < 0.025 mm [0.000787 in \leq Thickness < 0.000984 in]	$\pm 15\%$
Thickness < 0.020 mm [Thickness < 0.000787 in]	$\pm 30\%$

3.7 Physical Requirements

3.7.1 Dimensional Stability When specimens are tested in accordance with IPC-TM-650, Method 2.2.4, Method A, the dimensional stability **shall** be as indicated in the applicable specification sheet.

3.7.2 Tensile Strength and Elongation When specimens are tested in accordance with IPC-TM-650, Method 2.4.19, the tensile strength and elongation **shall** be as indicated in the applicable specification sheet.

3.7.3 Initiation Tear Strength When specimens are tested in accordance with IPC-TM-650, Method 2.4.16, the initiation tear strength **shall** be as indicated in the applicable specification sheet.

3.7.4 Propagation Tear Strength When specimens are tested in accordance with IPC-TM-650, Method 2.4.17.1, the propagation tear strength **shall** be as indicated in the applicable specification sheet.

3.8 Chemical Requirements

3.8.1 Chemical Resistance When specimens are tested in accordance with IPC-TM-650, Method 2.3.2, Method B, the tensile strength and elongation following chemical

exposure **shall** be as indicated in the applicable specification sheet.

3.9 Electrical Requirements

3.9.1 Dielectric Constant When specimens are tested in accordance with IPC-TM-650, Method 2.5.5.3, at 1 MHz, the maximum dielectric constant **shall** be as indicated in the applicable specification sheet. As values may change with thickness, environmental and operating frequency variations, it is recommended that materials supplier be contacted to verify the dielectric constant requirement.

3.9.2 Dissipation Factor When specimens are tested in accordance with IPC-TM-650, Method 2.5.5.3, at 1 MHz, the maximum dissipation factor **shall** be as indicated in the applicable specification sheet. As values may change with thickness, environmental and operating frequency variations, it is recommended that materials supplier be contacted to verify the dissipation factor requirement.

3.9.3 Volume Resistivity (Damp Heat) When specimens are tested in accordance with IPC-TM-650, Method 2.5.17, the minimum volume resistivity **shall** be as indicated in the applicable specification sheet.

3.9.4 Surface Resistance (Damp Heat) When specimens are tested in accordance with IPC-TM-650, Method 2.5.17, the minimum surface resistance **shall** be as indicated in the applicable specification sheet.

3.9.5 Dielectric Strength When specimens are tested in accordance with ASTM-D-149 using the short-time test with a 500 V/s rate of voltage increase, the minimum dielectric strength **shall** be as indicated in the applicable specification sheet.

3.10 Environmental Requirements

3.10.1 Fungus Resistance When specimens are tested in accordance with IPC-TM-650, Method 2.6.1, the specimen **shall** resist fungus growth.

3.10.2 Moisture Absorption When specimens are tested in accordance with IPC-TM-650, Method 2.6.2, the maximum moisture absorption **shall** be as indicated in the applicable specification sheet.

3.10.3 Flammability When specimens are tested in accordance with UL 94, the flammability classification **shall** be as indicated on the applicable specification sheet.

3.10.4 Relative Thermal Index (RTI) When specimens are tested in accordance with UL 746B, the temperature index for either electrical or mechanical properties, which-

ever is lowest, **shall** be as indicated on the applicable specification sheet.

3.11 Workmanship Requirements The flexible base dielectric **shall** be processed in such a manner as to be uniform in quality and devoid of defects that will affect life, serviceability, processability, or appearance as specified in 3.6.

4 QUALITY ASSURANCE PROVISIONS

The supplier **shall** comply with IPC-9191 when providing product meeting or exceeding requirements specified herein. This section defines the allowable methods (options) of assuring product meets customer specifications.

4.1 Responsibility for Inspection Unless otherwise specified in the purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the purchase order, the supplier may use his own or any other facility suitable for the performance 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 standard where such inspections are deemed necessary to assure supplies and service are performed to the prescribed requirements.

4.2 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 Z 540-1-1994, ISO 10012-1, or alternative statistically sound calibration procedures.

4.3 Preparation of Samples Unless otherwise specified herein, 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 vendor.

4.4 Standard Laboratory Conditions Unless otherwise specified in the appropriate test method, laboratory conditions **shall** be established and documented by the manufacturer.

4.5 Tolerances Unless otherwise specified, all laboratory equipment/conditions **shall** have tolerances of $\pm 5\%$.

4.6 Classification of Inspections The inspections specified herein are classified as follows:

1. Material Inspection (see 4.7).

2. Qualification Inspection (see 4.8).
3. Quality Conformance Inspection (see 4.9).

4.7 Materials Inspection Materials inspection **shall** consist of certified test data verifying the material is in accordance with the referenced specification or requirements prior to such fabrication.

4.8 Qualification Inspection Qualification testing **shall** be performed on the test specimens that are produced with equipment and procedures normally used in production. The vendor **shall** supply upon request data certifying the flexible base dielectric meets the requirements of this standard using the test methods described herein. Qualification testing samples may be combined for those lots with structurally similar construction. Where the test is dimensionally dependent, combination is not permitted.

4.8.1 Characterization Testing Group D testing in Table 4-1 is only required for characterization purpose for the qualification of a material. Group D properties are those properties that would be useful for design and/or are characteristics of the material.

4.8.2 Frequency Each material (as outlined in the specification sheets) **shall** undergo qualification once. The vendor, upon demand, **shall** provide certified data that shows the supplied material is qualified to this standard. Qualification retesting is not required unless agreed upon between user and vendor.

4.9 Quality Conformance Inspection Quality conformance inspection **shall** consist of Group A, B and C testing as listed in Table 4-1. The frequency of each group of inspections is as follows:

- Group A On a lot basis
- Group B Every three months
- Group C Every 12 months

4.9.1 Inspection of Product for Delivery The sample specimens **shall** be subjected to the inspections specified in Table 4-1. Inspection of product for delivery **shall** consist of Group A and B inspections. Products that have passed Group A inspection may be shipped prior to obtaining the results of Group B inspection.

4.9.2 Sample Unit The definition of a sample unit **shall** be a minimum of 0.50 m² [5.38 ft²] for sheet goods and 1.00 m [3.281 ft] for roll goods.

4.9.3 Group A Inspection

4.9.3.1 Sampling Plan Sampling plans sufficient to ensure an acceptability quality level (AQL) of 1% **shall** be as documented in the material suppliers' manufacturing quality system. If a documented quality system does not exist, the conformance testing **shall** meet or exceed the sampling requirements found in Table 4-2 and Table 4-3. Additional testing required by the user must be included in the procurement documentation.

Table 4-1 Test Method Frequency

Requirement Paragraph	Test	Test Method	Group
3.5.2	Wrinkles, Creases, Streaks and Scratches	Visual	A
3.5.3	Inclusions	Visual, ASTM D-149	A
3.5.4	Voids	IPC-TM-650, Method 2.1.13	C
3.5.5	Holes, Tears and Delaminations	Visual	A
3.7.1	Dimensional Stability	IPC-TM-650, Method 2.2.4, Method A	A
3.7.2	Tensile Strength	IPC-TM-650, Method 2.4.19	A
3.7.2	Elongation	IPC-TM-650, Method 2.4.19	A
3.7.3	Initiation Tear Strength	IPC-TM-650, Method 2.4.16	C
3.7.4	Propagation Tear Strength	IPC-TM-650, Method 2.4.17.1	C
3.8.1	Chemical Resistance	IPC-TM-650, Method 2.3.2, Method C	B
3.9.1	Dielectric Constant	IPC-TM-650, Method 2.5.5.3	D
3.9.2	Dissipation Factor	IPC-TM-650, Method 2.5.5.3	D
3.9.3	Volume Resistivity	IPC-TM-650, Method 2.5.17	D
3.9.4	Surface Resistance	IPC-TM-650, Method 2.5.17	D
3.9.5	Dielectric Strength	ASTM-D-149	B
3.10.1	Fungus Resistance	IPC-TM-650, Method 2.6.1	D
3.10.2	Moisture Absorption	IPC-TM-650, Method 2.6.2	B
3.10.3	Flammability	UL-94	D
3.10.4	Relative Thermal Index	UL-746B	D

Group A: On a lot basis.
Group B: Every three months.

Group C: Every 12 months.
Group D: Only required for characterization.

Table 4-2 Sampling Plan for Group A and Group B Inspection for Sheet Goods

Total Number of Sheets Produced	Sample Size	Allowable Rejects
≤200	1	0
201 to 1000	2	0
1001 to 10,000	3	0
≥10,001	4	0

Table 4-3 Sampling Plan for Group A and Group B Inspection for Roll Goods

Total Linear Dimensions of Material Produced	Sample Size	Allowable Rejects
≤730.0 m [≤2395.0 ft]	1	0
730.0 m < Dimensions <20,100.0 m [2395.0 ft < Dimensions <65,944.08 ft]	2	0
≥20,100.0 m [≥65,944.08 ft]	3	0

4.9.3.2 Failures If one or more specimens fail, the sample **shall** be considered to have failed. So called “true value” corrected test results may not be used for release purposes unless specifically described as part of the test method specified therein.

4.9.3.3 User Sampling Plan It is recommended a user of the flexible base dielectric inspect at least one sample unit per inspection lot (see 3.1.3).

4.9.3.4 Rejected Lots If an inspection lot is rejected, the supplier may rework it to correct the defects or screen out the defective units and resubmit for reinspection. Resubmitted lots **shall** be inspected using tightened inspection. Such lots **shall** be separate from new lots and **shall** be clearly identified as reinspected lots while the material is within the manufacturer’s facility. If the defect cannot be screened out, the supplier **shall** sample additional lots and make processing corrections as necessary. If the additional lots inspected show the same defect, it **shall** be the supplier’s responsibility to contact the user(s) regarding the problem.

4.9.4 Group B Inspection Group B inspection **shall** consist of the tests specified in Table 4-1. Group B inspection **shall** be made on sample units selected from inspection lots that have passed Group A inspection. Group B testing may be combined for those lots with structurally similar construction. Where the test is dimensionally dependent, combination is not permitted.

4.9.4.1 Sampling Plan Sampling plans sufficient to ensure an acceptability quality level (AQL) of 1% **shall** be as documented in the material suppliers’ manufacturing quality system. If a documented quality system does not exist, the conformance testing **shall** meet or exceed the sampling requirements found in Table 4-2 and Table 4-3. Additional testing required by the user must be included in the procurement documentation.

4.9.4.2 Failures If one or more specimens fail, the sample **shall** be considered to have failed. So called “true value” corrected test results may not be used for release purposes unless specifically described as part of the test method specified therein.

4.9.4.3 Noncompliance of Material If a sample fails to pass Group B inspection, product produced since the last test of that property **shall** be subject to review and subsequent disposition. Corrective action **shall** be taken on the materials or processes, as warranted and on all units of product that can be corrected, which were manufactured under essentially the same condition, with essentially the same materials, processes, etc. Acceptance of the product **shall** be discontinued until corrective action has been taken. Group B inspection **shall** be repeated on additional sample units to confirm corrective action was successful. In the event of failure of any inspection, information concerning the failure and corrective action taken **shall** be furnished to the user.

4.9.5 Group C Inspection Group C inspection **shall** consist of the tests specified in Table 4-1. Group C inspection **shall** be made on sample units selected from inspection lots that have passed Group A and B inspection. Group C testing may be combined for those lots with structurally similar construction. Where the test is dimensionally dependent, combination is not permitted.

4.9.5.1 Sampling Plan Two specimens taken uniformly over the period **shall** be prepared once every 12 months.

4.9.5.2 Failures If one or more specimens fail, the sample **shall** be considered to have failed. So called “true value” corrected test results may not be used for release purposes unless specifically described as part of the test method specified therein.

4.9.5.3 Noncompliance of Material If a sample fails to pass Group C inspection, the supplier **shall** take corrective action on the materials or processes, as warranted. The supplier **shall** also take corrective action on all units of product that can be corrected, which were manufactured under essentially the same conditions, with essentially the same materials, process, etc. Acceptance of the product **shall** be discontinued until corrective action acceptable to the procuring authority has been taken. After the corrective action has been taken, Group C inspection **shall** be repeated on additional sample units (all inspection or the inspection that the original sample failed, at the option of the procuring authority). Group A and B inspections may be reinstated; however, final conformance **shall** be withheld until the Group C reinspection has shown the corrective action was successful. In the event of failure of any inspection, information concerning the failure and corrective action taken **shall** be furnished to the procuring authority.

4.10 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 implied 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 above to prove compliance. For example, a product with 15 characteristics may meet specifications by quality conformance evaluations on two characteristics, in-process product evaluations on five characteristics and process parameter control for five characteristics. The three remaining characteristics meet the specification 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.

The path described in 4.10.1 through 4.10.5 may be used to achieve control of these three types of parameters:

4.10.1 Parameter Identification Parameter identification can be achieved by defining, selecting and ranking candidate parameters for control by applying statistical methods, as well as confirming capability of measurement systems. Complete the top of Figure 4-1 and all of Figure 4-2.

4.10.2 Parameter Diagnostics Parameter diagnostics can be achieved by identifying and classifying major sources of existing parameter variation into major unique categories such as within-piece, piece-to-piece and time-to-time. Complete all of Figure 4-2 and the first three columns of Figure 4-3. Break down and rank the patterns of variation in the end product characteristics and in-process product characteristics identified in Figure 4-3.

4.10.3 Parameter Control Parameter control can be achieved by defining objectives or targets, collecting appropriate data, analyzing the data, continually moving the process closer to target and taking steps to reduce its variability. Complete the control plan in Figure 4-1 and submit it to the customer for approval. Revise the control plan after changes to the process (including equipment or materials), product specifications, measurement methods, control methods, sample size/frequency and/or out-of-control action plan.

4.10.4 Parameter Capability Assessment Parameter capability assessments can be achieved by defining objectives, characterizing the process parameter's shape, defining specification or operating limits and target values, measuring the inherent long-term capability and short-term variability of process, product, or service parameters and continually improving process capability. Follow the control plan in Figure 4-1 to assess process capability.

4.10.5 Parameter Analysis Parameter analysis can be achieved by defining objectives, selecting test variables, establishing test settings, developing test plans, establishing sampling requirements, conducting tests, analyzing test data, confirming test results and using data to manage the process. Complete Figure 4-3 at the hypothesis stage and revise after completing the analysis.

Note: The steps detailed in 4.10.1 through 4.10.5 are illustrated in detail in Figure 4-1, Figure 4-2 and Figure 4-3.

4.10.6 Reduction of Quality Conformance Testing The primary goal of SPC is not the reduction of quality conformance testing. 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 implied customer requirements. However, as a result of the understanding and control of highly capable process and product parameters, quality conformance testing may be reduced in an orderly fashion to an audit function. Once the following criteria have been met, the reduction of end product testing may be accomplished.

- The end product parameter displays statistical control and capability per IPC-9191, through end-product, in-process product and/or process parameter evaluation.
- Current quality evaluation techniques have not exhibited any nonconformance for a period of time or a number of lots.
- An implemented control plan exists to monitor, maintain and continually improve the control and capability claimed above.

Figure 4-4 is recommended for planning and documenting your path toward increased process control and reduced testing. As an alternative, the reduction table should be added to the existing quality conformance test and frequency tables already in the document (i.e., Group A, B, or

Figure 4-1 Control Plan

Product Name:		Date Plan Implemented:									
Product No:											
Product Characteristics:											
Code	Description	Code	Description	Code	Description	Code	Description	Code	Description	Code	Description
A		E									
B		F									
C		G									
D		H									
Physical Control Location or Event No.	Code of Characteristic Affected	Product/Process Detail	Target Value	Target Control Limits	How Contained/ Tested if Not Capable	Measurement Method	Analysis Control Method	Sample Size & Frequency	*Out-of-Control Action Plan (Refer Layout)		

* Any nonconforming product found must prompt 100% conformance testing and/or material hold/disposition action.

Submitted by: _____ Date: _____ Customer Approval _____ SQA: _____ Date: _____
 Responsibility: _____ Other: _____ Date: _____

Figure 4-2 Process Flow and Control/Inspection Points Chart

Product Name:		Supplier:		Submitted by:	
Product No.:		Location:		Date:	
Event Symbols		Event Description		Measurement/Inspection/Control Action if Any	
Operation Transportations Inspections Delays Storages	E V E N T N O.	Brief Description	Brief Description— e.g., Fixtured Gage \bar{X} , R Chart		Prod. Char. Code if Applic. (from Control Plan)
⬡ ○ ◻ ◯ ◻					

Figure 4-4 Quality Conformance Test Reduction Chart

Product Name:		Supplier:		Repeat for All Classes				
Product No:		Location:		Class:				
Characteristic Inspected/Tested	Requirement Reference	Test Method Reference	Test Unit(s) P = Production A = Test Coupon Part A B = Test Coupon Part B C = Test Coupon Part C	Test Coupon by Board Type if Applicable	P = Population (100%) S = Sample C = Coupon Made to Represent Sample	Conditions for Reduced Testing	Reduced Testing Sample Size/Frequency	Condition for Audited Control Plan Only

C). We recommend the three additional columns, which are explained below, to be added to allow testing to be reduced in the steps:

4.10.6.1 Conditions for Reduced Testing Verify you have attained or exceeded Cpk, Cp, or PPM values per the specified number of units (see Note). Demonstrate that your processes are in statistical control (per the control plan in Figure 4-1), prepare a process flow and control/inspection points chart and identify the product characteristics in Figure 4-2. Evaluate measurement systems per IPC-9191. Figure 4-4 also gives an example of conditions for reduced testing.

Note: Time constraints are unacceptable because time lapsed and quality attained are not likely to correlate. Lot requirements are unacceptable because lot size may range from one to a large number.

4.10.6.2 Reduced Testing Sample Size The performance specification group **shall** analyze individual conformance test requirements for logical reduced sample size (see Figure 4-4).

4.10.6.3 Conditions for Audited Control Plan Suppliers should verify they have exceeded conditions for the reduced testing sample size. Suppliers should also show processes are well known so that out-of-conformance conditions are highly unlikely. Suppliers should also specify any conditions that are exceeded (see Figure 4-4).

5 PREPARATION FOR DELIVERY

5.1 Packaging Flexible metal-clad dielectric **shall** be packed in a manner that will afford adequate protection against corrosion, deterioration and physical damage during shipment and storage. The container **shall** conform to the requirements of the consolidated freight classification rules in effect at the time of shipment, except the fiber board, when used, **shall** be able to withstand storage, rehandling and reshipment without the necessity of repackaging.

6 NOTES

6.1 Ordering Data Purchase orders should specify the following:

- A. Title, number and date of the standard.
- B. Specification sheet number and revision date.
- C. Specific exemptions to the specifications, if any.
- D. Title, number and date of any applicable drawing.
- E. Information for preparation of delivery, if applicable (see Section 5).
- F. Part identification and marking instructions.
- G. Specify preproduction inspection if applicable (see Section 4).
- H. Specific Designation (see 1.1).
- I. Thickness, width and length of material (see 3.6.4).
- J. Other exceptions as agreed upon between user and vendor.

6.2 Chemical Resistance It is not possible to establish a complete set of requirements for chemical resistance, since no flexible base dielectric can be expected to be resistant to all of the chemicals used in the industry. Therefore, consultation should be made with the vendor when chemicals and processes to be used are other than those specified in this standard and its associated test methods.

6.3 References

Dodge, H. F. and Romig, H., "Sampling Inspection Tables Single and Double Sampling," Second Edition, John Wiley & Sons, Inc., New York, 1969

Schilling, E. G., "Acceptance Sampling in Quality Control," Marcel Dekker, Inc., New York, 1982

Specification Sheets for Flexible Base Dielectric

SPECIFICATION SHEET #	: IPC-4202/1
SUPERCEDES	: IPC-FC-231/1, IPC-FC-231/11, IPC-FC-231/12 AND IPC-FC-231/16
MATERIAL TYPE	: POLYIMIDE FILM
MATERIAL DESIGNATION	: E1E__

SPECIFICATION SHEET #	: IPC-4202/2
SUPERCEDES	: IPC-FC-231/2
MATERIAL TYPE	: FLUOROCARBON FILM
MATERIAL DESIGNATION	: C1E__

SPECIFICATION SHEET #	: IPC-4202/3
SUPERCEDES	: IPC-FC-231/3, IPC-231/15
MATERIAL TYPE	: POLYETHYLENE TERAPHTHALATE (PET) FILM
MATERIAL DESIGNATION	: B1E__, L1E__

SPECIFICATION SHEET #	: IPC-4202/4
SUPERCEDES	: IPC-FC-231/4, IPC-FC-231/5, IPC-FC-231/6, IPC-231/7
MATERIAL TYPE	: REINFORCED EPOXY
MATERIAL DESIGNATION	: H3A__

SPECIFICATION SHEET #	: IPC-4202/8
SUPERCEDES	: IPC-FC-231/8
MATERIAL TYPE	: VINYL FILM
MATERIAL DESIGNATION	: A1E__

SPECIFICATION SHEET #	: IPC-4202/9
SUPERCEDES	: IPC-FC-231/9
MATERIAL TYPE	: ARAMID PAPER
MATERIAL DESIGNATION	: F1E__

SPECIFICATION SHEET #	: IPC-4202/10
SUPERCEDES	: IPC-FC-231/10, IPC-FC-231/13 AND IPC-FC-231/14
MATERIAL TYPE	: POLYETHERIMIDE FILM
MATERIAL DESIGNATION	: E1E__, J1E__

SPECIFICATION SHEET #	: IPC-4202/11
SUPERCEDES	: N/A
MATERIAL TYPE	: POLYETHYLENE NAPHTHALATE (PEN)
MATERIAL DESIGNATION	: L1E__

SPECIFICATION SHEET #	: IPC-4202/12
SUPERCEDES	: N/A
MATERIAL TYPE	: LIQUID CRYSTAL POLYMER
MATERIAL DESIGNATION	: M1E__0

Revision Date: May 2002

Specification Sheet						
Specification Sheet # : IPC-4202/1						
Supersedes : IPC-FC-231/1, IPC-FC-231/11, IPC-FC-231/12 and IPC-FC-231/16						
Material Type : Polyimide Film						
Material Designation : E1E__						
Property to be tested	Requirement		Units	Test Method	Reference Paragraph	
1. Wrinkles, Creases, Streaks and Scratches	Pass		—	Visual	3.5.2	
2. Inclusions	Pass		—	Visual ASTM D-149	3.5.3	
3. Voids	Pass		—	IPC-TM-650, Method 2.1.13	3.5.4	
4. Holes, Tears and Delaminations	Pass		—	Visual	3.5.5	
5. Dimensional Stability, maximum	0.10 ^{t3}	N/A	%	IPC-TM-650, Method 2.2.4, Method A	3.7.1	
6. Tensile Strength, minimum	13.8 E+7 [20.02 E+3] ^{t3}	16.5 E+7 [23.93 E+3] ^{t4}	Pa [psi]	IPC-TM-650, Method 2.4.19	3.7.2	
7. Elongation, minimum percent	25 ^{t3}	25 ^{t4}	%	IPC-TM-650, Method 2.4.19	3.7.2	
8. Initiation Tear Strength, minimum	100 [3.527] ^{t3}	500 [17.64] ^{t4}	g [oz]	IPC-TM-650, Method 2.4.16	3.7.3	
9. Propagation Tear Strength, minimum	1 [0.035] ^{t3}	4 [0.141] ^{t5}	15 [0.529] ^{t11}	25 [0.882] ^{t12}	g [oz]	IPC-TM-650, Method 2.4.17.1
10. Chemical Resistance Tensile Strength, minimum Elongation, minimum	13.8 E+7 [20.02 E+3] ^{t3} 25 ^{t3}	16.5 E+7 [23.93 E+3] ^{t4} 25 ^{t4}	Pa [psi] %	IPC-TM-650, Method 2.3.2, Method C	3.8.1	
11. Dielectric Constant, maximum (at 1 MHz)	4.0 ^{t3}	4.0 ^{t4}	—	IPC-TM-650, Method 2.5.5.3	3.9.1	
12. Dissipation Factor, maximum (at 1 MHz)	0.012		—	IPC-TM-650, Method 2.5.5.3	3.9.2	
13. Volume Resistivity (Damp Heat), minimum	10 ⁶		MΩ-cm	IPC-TM-650, Method 2.5.17	3.9.3	
14. Surface Resistance (Damp Heat), minimum	10 ⁵		MΩ	IPC-TM-650, Method 2.5.17	3.9.4	
15. Dielectric Strength, minimum	78.74 [2000.0]		V/μm [V/mil]	ASTM-D-149	3.9.5	
16. Fungus Resistance	Non-nutrient		—	IPC-TM-650, Method 2.6.1	3.10.1	
17. Moisture Absorption, maximum	4.0		%	IPC-TM-650, Method 2.6.2	3.10.2	
18. Flammability, minimum	VTM-0		—	UL-94	3.10.3	
19. Relative Temperature Index, minimum	200		—	UL-746B	3.10.4	

N/A = Not applicable

^{t3} Flexible base dielectric materials with thickness <0.025 mm [<0.984 mil]^{t4} Flexible base dielectric materials with thickness ≥0.025 mm [≥0.984 mil]^{t5} Flexible base dielectric materials with 0.025 mm ≤ thickness <0.050 mm [0.984 mil ≤ thickness <1.97 mil]^{t11} Flexible base dielectric materials with 0.050 mm ≤ thickness <0.102 mm [1.97 mil ≤ thickness <4.016 mil]^{t12} Flexible base dielectric materials with thickness ≥0.102 mm [thickness ≥4.016 mil]

Revision Date: May 2002

Specification Sheet

Specification Sheet # : IPC-4202/2
Supercedes : IPC-FC-231/2
Material Type : Fluorocarbon Film
Material Designation : C1E__

Property to be tested	Requirement	Units	Test Method	Reference Paragraph
1. Wrinkles, Creases, Streaks and Scratches	Pass	—	Visual	3.5.2
2. Inclusions	Pass	—	Visual ASTM D-149	3.5.3
3. Voids	Pass	—	IPC-TM-650, Method 2.1.13	3.5.4
4. Holes, Tears and Delaminations	Pass	—	Visual	3.5.5
5. Dimensional Stability, maximum	5.0	%	IPC-TM-650, Method 2.2.4, Method A	3.7.1
6. Tensile Strength, minimum	17.2 E+6 [2.495 E+3]	Pa [psi]	IPC-TM-650, Method 2.4.19	3.7.2
7. Elongation, minimum percent	175	%	IPC-TM-650, Method 2.4.19	3.7.2
8. Initiation Tear Strength, minimum	N/A	g [oz]	IPC-TM-650, Method 2.4.16	3.7.3
9. Propagation Tear Strength, minimum	75 [2.64] ^{t6} 90 [3.17] ^{t8} 90 [3.17] ^{t12}	g [oz]	IPC-TM-650, Method 2.4.17.1	3.7.4
10. Chemical Resistance Tensile Strength, minimum Elongation, minimum	17.2 E+6 [2.495 E+3] 175	Pa [psi] %	IPC-TM-650, Method 2.3.2, Method C	3.8.1
11. Dielectric Constant, maximum (at 1 MHz)	2.2	—	IPC-TM-650, Method 2.5.5.3	3.9.1
12. Dissipation Factor, maximum (at 1 MHz)	0.0007	—	IPC-TM-650, Method 2.5.5.3	3.9.2
13. Volume Resistivity (Damp Heat), minimum	10 ⁷	MΩ-cm	IPC-TM-650, Method 2.5.17	3.9.3
14. Surface Resistance (Damp Heat), minimum	10 ⁷	MΩ	IPC-TM-650, Method 2.5.17	3.9.4
15. Dielectric Strength, minimum	98.43 [2500.1]	V/μm [V/mil]	ASTM-D-149	3.9.5
16. Fungus Resistance	Non-nutrient	—	IPC-TM-650, Method 2.6.1	3.10.1
17. Moisture Absorption, maximum	0.1	%	IPC-TM-650, Method 2.6.2	3.10.2
18. Flammability, minimum	VTM-0	—	UL-94	3.10.3
19. Relative Temperature Index, minimum	N/A**	—	UL-746B	3.10.4

N/A = Not applicable

** Low melt point prohibits measurement in accordance with UL 746B.

^{t6} Flexible base dielectric materials with thickness <0.038 mm [<1.50 mil]^{t8} Flexible base dielectric materials with 0.038 mm ≤ thickness <0.102 mm [1.50 mil ≤ thickness <4.016 mil]^{t12} Flexible base dielectric materials with thickness ≥0.102 mm [thickness ≥4.016 mil]

Revision Date: May 2002

Specification Sheet

Specification Sheet # : IPC-4202/3
Supercedes : IPC-FC-231/3, IPC-231/15
Material Type : Polyethylene Terapthalate (PET) Film
Material Designation : B1E_, L1E_

Property to be tested	Requirement	Units	Test Method	Reference Paragraph
1. Wrinkles, Creases, Streaks and Scratches	Pass	—	Visual	3.5.2
2. Inclusions	Pass	—	Visual ASTM D-149	3.5.3
3. Voids	Pass	—	IPC-TM-650, Method 2.1.13	3.5.4
4. Holes, Tears and Delaminations	Pass	—	Visual	3.5.5
5. Dimensional Stability, maximum	1.0	%	IPC-TM-650, Method 2.2.4, Method A	3.7.1
6. Tensile Strength, minimum	13.8 E+7 [20.02 E+3]	Pa [psi]	IPC-TM-650, Method 2.4.19	3.7.2
7. Elongation, minimum percent	50	%	IPC-TM-650, Method 2.4.19	3.7.2
8. Initiation Tear Strength, minimum	800 [28.22]	g [oz]	IPC-TM-650, Method 2.4.16	3.7.3
9. Propagation Tear Strength, minimum	8 [0.28] ^{t6} 20 [0.71] ^{t8} 50 [1.76] ^{t12}	g [oz]	IPC-TM-650, Method 2.4.17.1	3.7.4
10. Chemical Resistance Tensile Strength, minimum Elongation, minimum	13.8 E+7 [23.9 E+3] 50	Pa [psi] %	IPC-TM-650, Method 2.3.2, Method C	3.8.1
11. Dielectric Constant, maximum (at 1 MHz)	3.5	—	IPC-TM-650, Method 2.5.5.3	3.9.1
12. Dissipation Factor, maximum (at 1 MHz)	0.022	—	IPC-TM-650, Method 2.5.5.3	3.9.2
13. Volume Resistivity (Damp Heat), minimum	N/A	MΩ-cm	IPC-TM-650, Method 2.5.17	3.9.3
14. Surface Resistance (Damp Heat), minimum	N/A	MΩ	IPC-TM-650, Method 2.5.17	3.9.4
15. Dielectric Strength, minimum	78.74 [2000]	V/μm [V/mil]	ASTM-D-149	3.9.5
16. Fungus Resistance	Non-nutrient	—	IPC-TM-650, Method 2.6.1	3.10.1
17. Moisture Absorption, maximum	0.8	%	IPC-TM-650, Method 2.6.2	3.10.2
18. Flammability, minimum	VTM-2	—	UL-94	3.10.3
19. Relative Temperature Index, minimum	105	—	UL-746B	3.10.4

N/A = Not applicable

DBD = Data being developed

^{t6} Flexible base dielectric materials with thickness <0.038 mm [<1.50 mil]^{t8} Flexible base dielectric materials with 0.038 mm ≤ thickness <0.102 mm [1.50 mil ≤ thickness <4.016 mil]^{t12} Flexible base dielectric materials with thickness ≥0.102 mm [thickness ≥4.016 mil]

Revision Date: May 2002

Specification Sheet

Specification Sheet # : IPC-4202/4
Supersedes : IPC-FC-231/4, IPC-FC-231/5, IPC-FC-231/6, IPC-231/7
Material Type : Reinforced Epoxy
Material Designation : H3A__

Property to be tested	Requirement	Units	Test Method	Reference Paragraph
1. Wrinkles, Creases, Streaks and Scratches	Pass	—	Visual	3.5.2
2. Inclusions	Pass	—	Visual ASTM D-149	3.5.3
3. Voids	Pass	—	IPC-TM-650, Method 2.1.13	3.5.4
4. Holes, Tears and Delaminations	Pass	—	Visual	3.5.5
5. Dimensional Stability, maximum	0.25	%	IPC-TM-650, Method 2.2.4, Method A	3.7.1
6. Tensile Strength, minimum	34.5 E+6 [5.0 E+3]	Pa [psi]	IPC-TM-650, Method 2.4.19	3.7.2
7. Elongation, minimum percent	2.5	%	IPC-TM-650, Method 2.4.19	3.7.2
8. Initiation Tear Strength, minimum	2000 [70.55]	g [oz]	IPC-TM-650, Method 2.4.16	3.7.3
9. Propagation Tear Strength, minimum	36 [1.27]	g [oz]	IPC-TM-650, Method 2.4.17.1	3.7.4
10. Chemical Resistance Tensile Strength, minimum Elongation, minimum	N/A	Pa [psi] %	IPC-TM-650, Method 2.3.2, Method C	3.8.1
11. Dielectric Constant, maximum (at 1 MHz)	N/A	—	IPC-TM-650, Method 2.5.5.3	3.9.1
12. Dissipation Factor, maximum (at 1 MHz)	N/A	—	IPC-TM-650, Method 2.5.5.3	3.9.2
13. Volume Resistivity (Damp Heat), minimum	10 ⁴	MΩ-cm	IPC-TM-650, Method 2.5.17	3.9.3
14. Surface Resistance (Damp Heat), minimum	10 ²	MΩ	IPC-TM-650, Method 2.5.17	3.9.4
15. Dielectric Strength, minimum	4.72 [120]	V/μm [V/mil]	ASTM-D-149	3.9.5
16. Fungus Resistance	Non-nutrient	—	IPC-TM-650, Method 2.6.1	3.10.1
17. Moisture Absorption, maximum	1.5	%	IPC-TM-650, Method 2.6.2	3.10.2
18. Flammability, minimum	V-0	—	UL-94	3.10.3
19. Relative Temperature Index, minimum	105	—	UL-746B	3.10.4

N/A = Not applicable

Revision Date: May 2002

Specification Sheet							
Specification Sheet # : IPC-4202/8 Supercedes : IPC-FC-231/8 Material Type : Vinyl Film Material Designation : A1E__							
Property to be tested	Requirement			Units	Test Method	Reference Paragraph	
1. Wrinkles, Creases, Streaks and Scratches	Pass			—	Visual	3.5.2	
2. Inclusions	Pass			—	Visual ASTM D-149	3.5.3	
3. Voids	Pass			—	IPC-TM-650, Method 2.1.13	3.5.4	
4. Holes, Tears and Delaminations	Pass			—	Visual	3.5.5	
5. Dimensional Stability, maximum	8.0			%	IPC-TM-650, Method 2.2.4, Method A	3.7.1	
6. Tensile Strength, minimum	7.0 E+3 [1.02] ^{t3}	62.0 E+6 [8.992 E+3] ^{t4}		Pa [psi]	IPC-TM-650, Method 2.4.19	3.7.2	
7. Elongation, minimum percent	95			%	IPC-TM-650, Method 2.4.19	3.7.2	
8. Initiation Tear Strength, minimum	420 [14.81]			g [oz]	IPC-TM-650, Method 2.4.16	3.7.3	
9. Propagation Tear Strength, minimum	16 [0.564] _{t3}	28 [0.988] _{t5}	82 [2.89] _{t11}	N/A t12	g [oz]	IPC-TM-650, Method 2.4.17.1	3.7.4
10. Chemical Resistance Tensile Strength, minimum Elongation, minimum	N/A N/A			Pa [psi] %	IPC-TM-650, Method 2.3.2, Method C	3.8.1	
11. Dielectric Constant, maximum (at 1 MHz)	5.8			—	IPC-TM-650, Method 2.5.5.3	3.9.1	
12. Dissipation Factor, maximum (at 1 MHz)	0.013			—	IPC-TM-650, Method 2.5.5.3	3.9.2	
13. Volume Resistivity (Damp Heat), minimum	N/A			MΩ-cm	IPC-TM-650, Method 2.5.17	3.9.3	
14. Surface Resistance (Damp Heat), minimum	10 ⁶			MΩ	IPC-TM-650, Method 2.5.17	3.9.4	
15. Dielectric Strength, minimum	129.92 [3299.97]			V/μm [V/mil]	ASTM-D-149	3.9.5	
16. Fungus Resistance	Non-nutrient			—	IPC-TM-650, Method 2.6.1	3.10.1	
17. Moisture Absorption, maximum	0.5			%	IPC-TM-650, Method 2.6.2	3.10.2	
18. Flammability, minimum	HB			—	UL-94	3.10.3	
19. Relative Temperature Index, minimum	125			—	UL-746B	3.10.4	

N/A = Not applicable

^{t3} Flexible base dielectric materials with thickness <0.025 mm [<0.984 mil]^{t4} Flexible base dielectric materials with thickness ≥0.025 mm [≥0.984 mil]^{t5} Flexible base dielectric materials with 0.025 mm ≤ thickness <0.050 mm [0.984 mil ≤ thickness <1.97 mil]^{t11} Flexible base dielectric materials with 0.050 mm ≤ thickness <0.102 mm [1.97 mil ≤ thickness <4.016 mil]^{t12} Flexible base dielectric materials with thickness ≥0.102 mm [thickness ≥4.016 mil]

Revision Date: May 2002

Specification Sheet

Specification Sheet # : IPC-4202/9
Supercedes : IPC-FC-231/9
Material Type : Aramid Paper
Material Designation : F1E__

Property to be tested	Requirement	Units	Test Method	Reference Paragraph
1. Wrinkles, Creases, Streaks and Scratches	Pass	—	Visual	3.5.2
2. Inclusions	Pass	—	Visual ASTM D-149	3.5.3
3. Voids	Pass	—	IPC-TM-650, Method 2.1.13	3.5.4
4. Holes, Tears and Delaminations	Pass	—	Visual	3.5.5
5. Dimensional Stability, maximum	0.65	%	IPC-TM-650, Method 2.2.4, Method A	3.7.1
6. Tensile Strength, minimum	27.6 E+6 [4.003 E+3]	Pa [psi]	IPC-TM-650, Method 2.4.19	3.7.2
7. Elongation, minimum percent	4	%	IPC-TM-650, Method 2.4.19	3.7.2
8. Initiation Tear Strength, minimum	N/A	g [oz]	IPC-TM-650, Method 2.4.16	3.7.3
9. Propagation Tear Strength, minimum	50 [1.76] ^{t9} 70 [2.47] ^{t10}	g [oz]	IPC-TM-650, Method 2.4.17.1	3.7.4
10. Chemical Resistance Tensile Strength, minimum Elongation, minimum	27.6 E+6 [4.003 E+3] N/A	Pa [psi] %	IPC-TM-650, Method 2.3.2, Method C	3.8.1
11. Dielectric Constant, maximum (at 1 MHz)	3.0	—	IPC-TM-650, Method 2.5.5.3	3.9.1
12. Dissipation Factor, maximum (at 1 MHz)	0.013	—	IPC-TM-650, Method 2.5.5.3	3.9.2
13. Volume Resistivity (Damp Heat), minimum	10 ⁶	MΩ-cm	IPC-TM-650, Method 2.5.17	3.9.3
14. Surface Resistance (Damp Heat), minimum	10 ⁶	MΩ	IPC-TM-650, Method 2.5.17	3.9.4
15. Dielectric Strength, minimum	15.35 [389.89]	V/μm [V/mil]	ASTM-D-149	3.9.5
16. Fungus Resistance	Non-nutrient	—	IPC-TM-650, Method 2.6.1	3.10.1
17. Moisture Absorption, maximum	13.0	%	IPC-TM-650, Method 2.6.2	3.10.2
18. Flammability, minimum	V-0	—	UL-94	3.10.3
19. Relative Temperature Index, minimum	220	—	UL-746B	3.10.4

N/A = Not applicable

^{t9} Flexible base dielectric materials with thickness <0.050 mm [<1.97 mil]^{t10} Flexible base dielectric materials with thickness ≥0.050 mm [≥1.97 mil]

Revision Date: May 2002

Specification Sheet					
Specification Sheet # : IPC-4202/10 Supersedes : IPC-FC-231/10, IPC-FC-231/13 and IPC-FC-231/14 Material Type : Polyetherimide Film Material Designation : E1E_, J1E_					
Property to be tested	Requirement	Units	Test Method	Reference Paragraph	
1. Wrinkles, Creases, Streaks and Scratches	Pass	—	Visual	3.5.2	
2. Inclusions	Pass	—	Visual ASTM D-149	3.5.3	
3. Voids	Pass	—	IPC-TM-650, Method 2.1.13	3.5.4	
4. Holes, Tears and Delaminations	Pass	—	Visual	3.5.5	
5. Dimensional Stability, maximum	0.10	%	IPC-TM-650, Method 2.2.4, Method A	3.7.1	
6. Tensile Strength, minimum	96.5 E+6 [14.00 E+3] ^{t3}	10.3 E+7 [14.94 E+3] ^{t4}	Pa [psi]	IPC-TM-650, Method 2.4.19	3.7.2
7. Elongation, minimum percent	35	%	IPC-TM-650, Method 2.4.19	3.7.2	
8. Initiation Tear Strength, minimum	500 [17.64]	g [oz]	IPC-TM-650, Method 2.4.16	3.7.3	
9. Propagation Tear Strength, minimum	5 [0.18]	g [oz]	IPC-TM-650, Method 2.4.17.1	3.7.4	
10. Chemical Resistance Tensile Strength, minimum Elongation, minimum	96.5 E+6 [14.00 E+3] ^{t3} 35 ^{t3}	10.3 E+7 [14.94 E+3] ^{t4} 35 ^{t4}	Pa [psi] %	IPC-TM-650, Method 2.3.2, Method C	3.8.1
11. Dielectric Constant, maximum (at 1 MHz)	4.0	—	IPC-TM-650, Method 2.5.5.3	3.9.1	
12. Dissipation Factor, maximum (at 1 MHz)	0.010	—	IPC-TM-650, Method 2.5.5.3	3.9.2	
13. Volume Resistivity (Damp Heat), minimum	10 ⁶	MΩ-cm	IPC-TM-650, Method 2.5.17	3.9.3	
14. Surface Resistance (Damp Heat), minimum	10 ⁴	MΩ	IPC-TM-650, Method 2.5.17	3.9.4	
15. Dielectric Strength, minimum	78.74 [2000.0]	V/μm [V/mil]	ASTM-D-149	3.9.5	
16. Fungus Resistance	Non-nutrient	—	IPC-TM-650, Method 2.6.1	3.10.1	
17. Moisture Absorption, maximum	3.0	%	IPC-TM-650, Method 2.6.2	3.10.2	
18. Flammability, minimum	VTM-0	—	UL-94	3.10.3	
19. Relative Temperature Index, minimum	140	—	UL-746B	3.10.4	

N/A = Not applicable

^{t3} Flexible base dielectric materials with thickness <0.025 mm [<0.984 mil]^{t4} Flexible base dielectric materials with thickness ≥0.025 mm [≥0.984 mil]

Revision Date: May 2002

Specification Sheet

Specification Sheet # : IPC-4202/11
Supersedes : N/A
Material Type : Polyethylene Naphthalate (PEN)
Material Designation : L1E__

Property to be tested	Requirement	Units	Test Method	Reference Paragraph			
1. Wrinkles, Creases, Streaks and Scratches	Pass	—	Visual	3.5.2			
2. Inclusions	Pass	—	Visual ASTM D-149	3.5.3			
3. Voids	Pass	—	IPC-TM-650, Method 2.1.13	3.5.4			
4. Holes, Tears and Delaminations	Pass	—	Visual	3.5.5			
5. Dimensional Stability, maximum	0.30	%	IPC-TM-650, Method 2.2.4, Method A	3.7.1			
6. Tensile Strength, minimum	17.2 E+7 [24.95 E+3]	Pa [psi]	IPC-TM-650, Method 2.4.19	3.7.2			
7. Elongation, minimum percent	60	%	IPC-TM-650, Method 2.4.19	3.7.2			
8. Initiation Tear Strength, minimum	1000 [35.270]	g [oz]	IPC-TM-650, Method 2.4.16	3.7.3			
9. Propagation Tear Strength, minimum	4 [0.14] ^{t3}	8 [0.28] ^{t5}	20 [0.705] ^{t11}	40 [1.41] ^{t12}	g [oz]	IPC-TM-650, Method 2.4.17.1	3.7.4
10. Chemical Resistance Tensile Strength, minimum Elongation, minimum	17.2 E+7 [24.95 E+3] 60	Pa [psi] %	IPC-TM-650, Method 2.3.2, Method C	3.8.1			
11. Dielectric Constant, maximum (at 1 MHz)	4.0	—	IPC-TM-650, Method 2.5.5.3	3.9.1			
12. Dissipation Factor, maximum (at 1 MHz)	0.010	—	IPC-TM-650, Method 2.5.5.3	3.9.2			
13. Volume Resistivity (Damp Heat), minimum	10 ⁶	MΩ-cm	IPC-TM-650, Method 2.5.17	3.9.3			
14. Surface Resistance (Damp Heat), minimum	10 ⁵	MΩ	IPC-TM-650, Method 2.5.17	3.9.4			
15. Dielectric Strength, minimum	78.74 [2000.0]	V/μm [V/mil]	ASTM-D-149	3.9.5			
16. Fungus Resistance	Non-nutrient	—	IPC-TM-650, Method 2.6.1	3.10.1			
17. Moisture Absorption, maximum	1.0	%	IPC-TM-650, Method 2.6.2	3.10.2			
18. Flammability, minimum	VTM-2	—	UL-94	3.10.3			
19. Relative Temperature Index, minimum	160	—	UL-746B	3.10.4			

N/A = Not applicable

^{t3} Flexible base dielectric materials with thickness <0.025 mm [<0.984 mil]^{t5} Flexible base dielectric materials with 0.025 mm ≤ thickness <0.050 mm [0.984 mil ≤ thickness <1.97 mil]^{t11} Flexible base dielectric materials with 0.050 mm ≤ thickness <0.102 mm [1.97 mil ≤ thickness <4.016 mil]^{t12} Flexible base dielectric materials with thickness ≥0.102 mm [thickness ≥4.016 mil]

Revision Date: May 2002

Specification Sheet

Specification Sheet # : IPC-4202/12
Supercedes : N/A
Material Type : Liquid Crystal Polymer
Material Designation : M1E_0

Property to be tested	Requirement	Units	Test Method	Reference Paragraph
1. Wrinkles, Creases, Streaks and Scratches	Pass	—	Visual	3.5.2
2. Inclusions	Pass	—	Visual ASTM D-149	3.5.3
3. Voids	Pass	—	IPC-TM-650, Method 2.1.13	3.5.4
4. Holes, Tears and Delaminations	Pass	—	Visual	3.5.5
5. Dimensional Stability, maximum	0.05	%	IPC-TM-650, Method 2.2.4, Method A	3.7.1
6. Tensile Strength, minimum	9.8 E+7 [14,200]	Pa [psi]	IPC-TM-650, Method 2.4.19	3.7.2
7. Elongation, minimum percent	14	%	IPC-TM-650, Method 2.4.19	3.7.2
8. Initiation Tear Strength, minimum	1400 [49.4]	g [oz]	IPC-TM-650, Method 2.4.16	3.7.3
9. Propagation Tear Strength, minimum	7 [0.25]	g [oz]	IPC-TM-650, Method 2.4.17.1	3.7.4
10. Chemical Resistance Tensile Strength, minimum Elongation, minimum	DBD DBD	Pa [psi] %	IPC-TM-650, Method 2.3.2, Method C	3.8.1
11. Dielectric Constant, maximum (at 1 MHz) (at 500 MHz) (at 1 GHz)	DBD 2.9 2.9	—	IPC-TM-650, Method 2.5.5.3 Method 2.5.5.5.1 Method 2.5.5.5.1	3.9.1
12. Dissipation Factor, maximum (at 1 MHz) (at 500 MHz) (at 1 GHz)	DBD 0.004 0.003	—	IPC-TM-650, Method 2.5.5.3 Method 2.5.5.5.1 Method 2.5.5.5.1	3.9.2
13. Volume Resistivity (Damp Heat), minimum	10 ¹²	MΩ-cm	IPC-TM-650, Method 2.5.17	3.9.3
14. Surface Resistance (Damp Heat), minimum	10 ¹⁰	MΩ	IPC-TM-650, Method 2.5.17	3.9.4
15. Dielectric Strength, minimum	137.80 [3500.12]	V/μm [V/mil]	ASTM-D-149	3.9.5
16. Fungus Resistance	Pass	—	IPC-TM-650, Method 2.6.1	3.10.1
17. Moisture Absorption, maximum	0.05	%	IPC-TM-650, Method 2.6.2	3.10.2
18. Flammability, minimum	VTM-0	—	UL-94	3.10.3
19. Relative Temperature Index, minimum	DBD	—	UL-746B	3.10.4

Submission Date:**Blank Specification Sheet for New Material Submission**

Specification Sheet # : IPC-4202/0

Supercedes :

Material Type :

Material Designation :

Property to be tested	Requirement	Units	Test Method	Reference Paragraph
1. Wrinkles, Creases, Streaks and Scratches		—	Visual	3.5.2
2. Inclusions		—	Visual ASTM D-149	3.5.3
3. Voids		—	IPC-TM-650, Method 2.1.13	3.5.4
4. Holes, Tears and Delaminations		—	Visual	3.5.5
5. Dimensional Stability, maximum		%	IPC-TM-650, Method 2.2.4, Method A	3.7.1
6. Tensile Strength, minimum		Pa [psi]	IPC-TM-650, Method 2.4.19	3.7.2
7. Elongation, minimum percent		%	IPC-TM-650, Method 2.4.19	3.7.2
8. Initiation Tear Strength, minimum		g [oz]	IPC-TM-650, Method 2.4.16	3.7.3
9. Propagation Tear Strength, minimum		g [oz]	IPC-TM-650, Method 2.4.17.1	3.7.4
10. Chemical Resistance Tensile Strength, minimum Elongation, minimum		Pa [psi] %	IPC-TM-650, Method 2.3.2, Method C	3.8.1
11. Dielectric Constant, maximum (at 1 MHz)		—	IPC-TM-650, Method 2.5.5.3	3.9.1
12. Dissipation Factor, maximum (at 1 MHz)		—	IPC-TM-650, Method 2.5.5.3	3.9.2
13. Volume Resistivity (Damp Heat), minimum		MΩ-cm	IPC-TM-650, Method 2.5.17	3.9.3
14. Surface Resistance (Damp Heat), minimum		MΩ	IPC-TM-650, Method 2.5.17	3.9.4
15. Dielectric Strength, minimum		V/μm [V/mil]	ASTM-D-149	3.9.5
16. Fungus Resistance		—	IPC-TM-650, Method 2.6.1	3.10.1
17. Moisture Absorption, maximum		%	IPC-TM-650, Method 2.6.2	3.10.2
18. Flammability, minimum		—	UL-94	3.10.3
19. Relative Temperature Index, minimum		—	UL-746B	3.10.4



ASSOCIATION CONNECTING
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All commands (such as subscribe and signoff) must be sent to listserv@ipc.org. Please DO NOT send any command to the mail list address, (i.e. <mail list>@ipc.org), as it would be distributed to all the subscribers.

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To: LISTSERV@IPC.ORG

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Subject:

Message: signoff DesignerCouncil

Please note you must send messages to the mail list address ONLY from the e-mail address to which you want to apply changes. In other words, if you want to sign off the mail list, you must send the signoff command from the address that you want removed from the mail list. Many participants find it helpful to signoff a list when travelling or on vacation and to resubscribe when back in the office.

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Example:

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The associated e-mail message text will be distributed to everyone on the list, including the sender. Further information on how to access previous messages sent to the forums will be provided upon subscribing.

For more information, contact Keach Sasamori

tel 847/790-5315

fax 847/504-2315

e-mail: sasako@ipc.org

www.ipc.org/html/forum.htm

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The first step is to join IPC. An application for membership can be found in the back of this publication. Once you become a member, the opportunities to enhance your competitiveness are vast. Join a technical committee and learn from our industry's best while you help develop the standards for our industry. Participate in market research programs which forecast the future of our industry. Participate in Capitol Hill Day and lobby your Congressmen and Senators for better industry support. Pick from a wide variety of educational opportunities: workshops, tutorials, and conferences. More up-to-date details on IPC opportunities can be found on our web page: www.ipc.org.

For information on how to get involved, contact:

Jeanette Ferdman, Membership Director
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Application for Site Membership

Thank you for your decision to join IPC members on the “Intelligent Path to Competitiveness”! IPC Membership is **site specific**, which means that IPC member benefits are available to all individuals employed at the site designated on the other side of this application.

To help IPC serve your member site in the most efficient manner possible, please tell us what your facility does by choosing the most appropriate member category. *(Check one box only.)*

Independent Printed Board Manufacturers

This facility manufactures and sells to other companies, printed wiring boards (PWBs) or other electronic interconnection products on the merchant market. What products do you make for sale?

- One-sided and two-sided rigid printed boards Multilayer printed boards Other interconnections
 Flexible printed boards

Name of Chief Executive Officer/President _____

Independent Electronic Assembly EMSI Companies

This facility assembles printed wiring boards, on a contract basis, and may offer other electronic interconnection products for sale.

Name of Chief Executive Officer/President _____

OEM–Manufacturers of any end product using PCB/PCAs or Captive Manufacturers of PCBs/PCAs

This facility purchases, uses and/or manufactures printed wiring boards or other interconnection products for use in a final product, which we manufacture and sell.

What is your company's primary product line? _____

Industry Suppliers

This facility supplies raw materials, machinery, equipment or services used in the manufacture or assembly of electronic interconnection products.

What products do you supply? _____

Government Agencies/Academic Technical Liaisons

We are representatives of a government agency, university, college, technical institute who are directly concerned with design, research, and utilization of electronic interconnection devices. (Must be a non-profit or not-for-profit organization.)



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- \$1,000.00 Annual dues for Primary Site Membership (Twelve months of IPC membership begins from the time the application and payment are received)
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Standard Improvement Form

IPC-4202

The purpose of this form is to provide the Technical Committee of IPC with input from the industry regarding usage of the subject standard.

Individuals or companies are invited to submit comments to IPC. All comments will be collected and dispersed to the appropriate committee(s).

If you can provide input, please complete this form and return to:

IPC
2215 Sanders Road
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1. I recommend changes to the following:

Requirement, paragraph number _____
 Test Method number _____, paragraph number _____

The referenced paragraph number has proven to be:

Unclear Too Rigid In Error
 Other _____

2. Recommendations for correction:

3. Other suggestions for document improvement:

Submitted by:

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