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Cover and Bonding Material for Flexible Printed Circuitry

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Association Connecting Electronics Industries



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IPC-4203A

Cover and Bonding Material for Flexible Printed Circuitry

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

Supersedes:

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Users of this standard are encouraged to participate in the
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Table of Contents

1 SCOPE	1	3.5 Visual Requirements	6
1.1 Classification System	1	3.5.1 Marking	6
1.1.1 Nonspecific Designation	1	3.5.2 Wrinkles, Creases, Streaks and Scratches	6
1.1.2 Specific Designation	1	3.5.3 Inclusions	7
1.1.2.1 Base Dielectric Material Type	2	3.5.4 Voids	7
1.1.2.2 Reinforcement Method	2	3.5.5 Holes, Tears and Delaminations	7
1.1.2.3 Reinforcement Type	2	3.6 Dimensional Requirements	7
1.1.2.4 Base Dielectric Material Thickness	3	3.6.1 Sheet Width and Length	7
1.1.2.5 Adhesive Type	3	3.6.2 Roll Width	7
1.1.2.6 Adhesive Thickness	3	3.6.3 Roll Length	7
1.2 Qualification	3	3.6.4 Dielectric Thickness	7
1.3 Quality Conformance	3	3.6.5 Adhesive Thickness	7
1.4 Material Characteristics	3	3.7 Physical Requirements	7
1.5 New Materials	3	3.7.1 Dimensional Stability	7
2 APPLICABLE DOCUMENTS	4	3.7.2 Peel Strength	8
2.1 IPC	4	3.7.2.1 Peel Strength As Received	8
2.2 American Society for Testing and Materials (ASTM)	4	3.7.2.2 Peel Strength After Solder Float	8
2.3 Underwriters Laboratories Standards	4	3.7.2.3 Peel Strength After Temperature Cycling	8
2.4 NCSL International	5	3.7.3 Flow	8
2.5 ISO	5	3.7.4 Volatile Content	8
3 REQUIREMENTS	5	3.8 Chemical Requirements	8
3.1 Terms and Definitions	5	3.8.1 Chemical Resistance	8
3.1.1 Qualification Testing	5	3.8.2 Solder Float	8
3.1.2 Quality Conformance Testing	5	3.9 Electrical Requirements	8
3.1.3 User Inspection Lot	5	3.9.1 Permittivity (Dielectric Constant)	8
3.1.4 Supplier Inspection Lot	5	3.9.2 Loss Tangent (Dissipation Factor)	8
3.1.5 Structurally Similar Construction	5	3.9.3 Volume Resistivity (Damp Heat)	8
3.1.6 Void	5	3.9.4 Surface Resistance (Damp Heat)	8
3.1.7 Inclusions	5	3.9.5 Dielectric Strength	8
3.1.8 Cover Material	5	3.10 Environmental Requirements	9
3.1.8.1 Coverlay	5	3.10.1 Fungus Resistance	9
3.1.8.2 Coverfilm	5	3.10.2 Moisture Absorption	9
3.1.8.3 Covercoat	5	3.10.3 Flammability	9
3.1.9 Bonding Material	5	3.10.4 Service Temperature	9
3.2 Specification Sheets	6	3.10.5 Moisture and Insulation Resistance	9
3.3 Conflict	6	3.11 Workmanship	9
3.4 Materials	6	4 QUALITY ASSURANCE PROVISIONS	9
3.4.1 Base Material	6	4.1 Responsibility for Inspection	9
3.4.2 Adhesive	6	4.2 Test Equipment and Inspection	9
3.4.3 Sheet Material	6	4.3 Preparation of Test Samples	9
3.4.4 Roll Material	6	4.3.1 Preparation of Cover Material Test Samples	10
		4.3.1.1 Cover Material - General Testing	

4.3.1.2	Cover Material - Peel Testing	10	4.9.4.1	Sampling Plan	13
4.3.2	Preparation of Supported Bonding Material Test Samples	10	4.9.4.2	Failures	13
4.3.2.1	Supported Bonding Material - General Testing	10	4.9.4.3	Noncompliance of Material	14
4.3.2.2	Supported Bonding Material - Peel Testing ...	10	4.10	Statistical Process Control (SPC)	14
4.3.3	Preparation of Unsupported Bonding Material Test Samples	10	4.10.1	Reduction of Quality Conformance Testing ...	14
4.3.3.1	Unsupported Bonding Material - General Testing	10	4.11	Change Notification and Authorization	14
4.3.3.2	Unsupported Bonding Material - Peel Testing	11	4.12	Certificate of Conformance	15
4.4	Standard Laboratory Conditions	11	5	PREPARATION FOR DELIVERY	15
4.5	Tolerances	11	5.1	Packaging	15
4.6	Classification of Inspections	11	6	NOTES	15
4.7	Materials Inspection	11	6.1	Ordering Data	15
4.8	Qualification Inspection	11	6.2	Specific Chemical Exposure	15
4.8.1	Characterization Testing	12	6.3	Storage/Shelf Life	15
4.8.2	Frequency	12	6.4	References	15
4.9	Quality Conformance Inspection	12		Tables	
4.9.1	Inspection of Product for Delivery	12	Table 1-1	Base Dielectric Type Designation	2
4.9.2	Group A Inspection	12	Table 1-2	Reinforcement Method Designation	2
4.9.2.1	Sampling Plan	12	Table 1-3	Reinforcement Type Designation	2
4.9.2.2	Failures	12	Table 1-4	Base Dielectric Thickness or Adhesive Thickness Designation	3
4.9.2.3	User Sampling Plan	12	Table 1-5	Adhesive Type Designation	3
4.9.2.4	Rejected Lots	12	Table 3-1	Allowable Deviation from Nominal Thickness of Base Dielectric	7
4.9.3	Group B Inspection	12	Table 3-2	Allowable Deviation from Nominal Thickness of Adhesive	7
4.9.3.1	Sampling Plan	12	Table 4-1	Cleaning Process for Bright Copper	11
4.9.3.2	Failures	12	Table 4-2	Test Method Frequency	13
4.9.3.3	Noncompliance of Material	12	Table 4-3	Sampling Plan for Group A and Group B Inspection for Sheet Goods	13
4.9.4	Group C Inspection	13	Table 4-4	Sampling Plan for Group A and Group B Inspection for Roll Goods	14



Cover and Bonding Material for Flexible Printed Circuitry

1 SCOPE

This standard establishes the classification system, the qualification and quality conformance requirements for dielectric films coated with an adhesive on one or both sides which are to be used as cover material for flexible printed circuitry as well as supported or unsupported adhesive films to be used in the fabrication of flexible printed circuitry. It does not cover non-flexible adhesives designed to be used in the rigid board areas of rigid flex constructions which are covered in IPC-4101. Materials such as liquid-applied covercoat (see 3.1.8.3) are covered in IPC-SM-840 and are excluded from this document.

This specification supersedes both IPC-FC-232C and IPC-FC-233A and the requirements herein meet or exceed the requirements for Class 3 in these superseded documents. Note that conformance to Class 3 meets or exceeds conformance to Classes 1 and 2. IPC-4203 no longer utilizes the 3-class system.

1.1 Classification System The system described in 1.1.1 through 1.1.2.6 identifies adhesive coated dielectric films and flexible adhesive bonding films.

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 cover sheet and bonding film indicating base material type, adhesive 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-4203/1). Example of nonspecific designation: *IPC-4203/S* Where *S* is specification sheet number.

1.1.2 Specific Designation The specific designation should be as shown in the following example and is intended for use on purchase orders (see 6.1). The specific designation should 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.

NOTE: The alpha character “N” replaces and is entirely equivalent to both the alpha character “O” (ref: Table 1-1) and the digit “0” (ref: Table 1-3) in the original release (prior revision) of this IPC standard. This interchange of characters within the designation will help alleviate confusion from using both the alpha character “O” and the digit “0” from the original release of this IPC standard. Legacy designs that utilize a designation and material description from the original release of this IPC standard [alpha character “O” (from Table 1-1) and/or digit “0” (from Table 1-3)] may continue to be used. Supplier material certifications will reflect the current IPC standard’s revision, and accordingly the alpha character “N,” in the designation.

Example of specific designation: *IPC-4203/S - C1E2M3/3*

Where:

IPC-4203/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)

M - Adhesive Type Designation (see 1.1.2.5)

3/3 - Adhesive Thickness Designation (see 1.1.2.6)

Note: The letter “X” **shall** be entered into the designation where an item is not specified (e.g., dielectric thickness).

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

Table 1-1 Base Dielectric Type Designation

Designation	Base Dielectric Type
B	Polyethylene Terephthalate Polyester (PET)
C	Fluorocarbon
E	Polyimide
F	Aramid
H	Epoxy
L	Polyethylene Naphthalate (PEN)
M	Thermotropic Liquid Crystal Polymer
N	None (Adhesive Only) [<i>Alpha character "N" replaces alpha character "O" from previous revision</i>]

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

Table 1-2 Reinforcement Method Designation

Designation	Reinforcement Method
0	No supporting dielectric film
1	(None) Non-reinforced
2	Nonwoven reinforcement
3	Woven reinforcement
4	Combination woven and nonwoven

1.1.2.3 Reinforcement Type The reinforcement type **shall** be specified 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)
N	None [<i>Alpha character "N" replaces digit "0" (zero) from previous revision</i>]

Note: Combinations of reinforcements will use two letters separated by a slash (i.e., A/C).

1.1.2.4 Base Dielectric Material Thickness The base material thickness is expressed by a designator (see Table 1-4).

**Table 1-4 Base Dielectric Thickness
or Adhesive Thickness Designation**

Designator	Thickness*
0	0 μm [0 in]
1	25 μm [984 μin]
2	50 μm [1970 μin]
3	75 μm [2950 μin]
4	100 μm [3900 μin]
5	125 μm [4900 μin]
A	2.5 μm [98.4 μin]
B	5 μm [200 μin]
C	7.5 μm [295 μin]
D	10 μm [390 μin]
E	12.5 μm [490 μin]
F	15 μm [590 μin]
H	18 μm [710 μin]
J	20 μm [790 μin]
K	23 μm [910 μin]
L	38 μm [1500 μin]
X	Specified on purchase order

*See 3.6.4.

1.1.2.5 Adhesive Type The adhesive type **shall** be specified per Table 1-5.

Table 1-5 Adhesive Type Designation

Designation	Adhesive Type
L	Epoxy
M	Acrylic
N	Polyester
P	Butyral phenolic
R	Fluorinated Polymer
S	Nitrile phenolic
T	Polyimide

1.1.2.6 Adhesive Thickness Adhesive thickness is expressed by a designator (see Table 1-4). The thickness on each side of two side-coated adhesive bonding films is separated by a slash. If there is no second side adhesive required, the '0' is not required.

1.2 Qualification The adhesive coated dielectric film or adhesive bonding material that meets all the requirements of this standard **shall** be qualified products (see 4.8).

1.3 Quality Conformance This standard establishes a quality conformance system for the manufacturers to demonstrate the continual conformance of an adhesive coated dielectric film or adhesive bonding material to the quality requirements of the standard. See 4.9 for quality conformance inspection requirements.

1.4 Material Characteristics The adhesive coated dielectric film or adhesive bonding material 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 adhesive coated dielectric film or adhesive bonding material 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 the end of this standard.

for review by the IPC Flexible Circuits Base Materials Subcommittee (D-13). Users who wish to invoke this specification for flexible materials not listed **shall** list a zero for the specification sheet number (i.e., IPC-4203/0).

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.

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
- 2.3.17.1 Resin Flow of Adhesive Coated Films and Unsupported Adhesive Films
- 2.3.37 Volatile Content of Adhesive Coated Dielectric Films
- 2.4.9 Peel Strength, Flexible Printed Wiring Materials
- 2.4.13 Solder Float Resistance Flexible Printed Wiring Materials
- 2.4.15 Surface Finish, Metal Foil
- 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 Material
- 2.6.2 Moisture Absorption, Flexible Printed Wiring
- 2.6.3.2 Moisture and Insulation Resistance, Flexible Base Dielectric
- 2.6.21 Service Temperature of Metal-Clad Flexible Laminate, Cover Material and Adhesive Bonding Films

IPC-4101 Specification for Base Materials for Rigid and Multilayer Printed Boards

IPC-4202 Flexible Base Dielectrics for Use in Flexible Printed Circuitry

IPC-4204 Flexible Metal-Clad Dielectrics for Use in Fabrication of Flexible Printed Circuitry

IPC-4562 Metal Foil for Printed Wiring Applications

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

1. www.ipc.org

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

3. www.astm.org

4. www.ul.com

2.4 NCSL International⁵

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

2.5 ISO⁶

ISO 17025 General Requirements for the Competence of Testing and Calibration Laboratories

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 3.1.9.

3.1.1 Qualification Testing Qualification testing is performed to demonstrate the supplier'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 the supplier 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 adhesive coated dielectric film or adhesive bonding material of the same type and of the 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 Supplier Inspection Lot An 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, material combinations and materials whose construction 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 representative cover sheet, since the details of construction 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.

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.

3.1.8 Cover Material A thin dielectric material used to encapsulate circuitry, most commonly for flexible circuit applications.

3.1.8.1 Coverlay Film and adhesive made from separate layers of generically different chemistries (see Cover Material).

3.1.8.2 Coverfilm Film made from i) a homogeneous, single component; ii) separate layers of generically similar chemistries; or, iii) as a composite blend (see Cover Material).

3.1.8.3 Covercoat Material deposited as a liquid onto the circuitry that subsequently becomes a permanent dielectric coating (see Cover Material). This material is addressed in IPC-SM-840 (Qualification and Performance Specification of Permanent Solder Mask and Flexible Cover Materials) and is excluded from this document.

3.1.9 Bonding Material A material used to bond layers of flexible circuits together containing a film with adhesive on both sides or a free adhesive, supported or unsupported. The adhesive can be thermoset or thermoplastic.

5. www.ncsli.org

6. www.iso.org

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 IPC Flexible Printed Circuits Base Materials Subcommittee (D-13) 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 supplier.
2. Master drawing (see 6.1-D).
3. Specification sheets of this standard.
4. Other sections of this standard.
5. Applicable documents (see Section 2).

3.4 Materials The specification sheets indicate specification limits for the material on either side of double-sided bonding film. Both sides of the adhesive bonding film **shall** be evaluated for those requirements that are impacted. See specific test methods for applicability.

3.4.1 Base Material Base materials listed in 1.1.2.1 **shall** meet the requirements of IPC-4202.

3.4.2 Adhesive Adhesives listed in 1.1.2.5 **shall** be selected so the composite meets the requirements of this standard.

3.4.3 Sheet Material Each sheet of flexible adhesive coated dielectric film or adhesive bonding film **shall** meet the requirements of 3.5 through 3.12.

3.4.4 Roll Material Each roll of flexible base dielectric film or adhesive bonding material **shall** meet the requirements of 3.5 through 3.12. 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 length no longer than 30 cm [11.8 in] in the machine direction centered within the defect area. If defects run longer in the machine direction than 30 cm [11.8 in] such as a streak or a scratch, a length in increments of 60 cm [23.6 in] equal to the total distance of the defect-containing area plus 30 cm [11.8 in] on either end **shall** be marked or flagged on the roll. For example, if a streak 1.5 m [59 in] long is present, a total length of material 2.1 m [83 in] long **shall** be marked, beginning 30 cm [11.8 in] before the streak and ending 30 cm [11.8 in] beyond the streak.

3.5 Visual Requirements When tested in accordance with the following paragraphs, the material **shall** meet the visual requirements specified in 3.5.2 through 3.5.5. Any defect within 6.5 mm [0.25 inch] of the outside edges of the sheet or roll **shall** be disregarded. Visual inspection may be carried out under ambient temperature and humidity conditions.

The entire test specimen (sample unit per 4.3) **shall** be examined with normal or corrected 20/20 (also termed 6/6 or 1.0) vision for the requirements of this paragraph.

If inclusions are observed, the worst appearing 50.0 mm x 50.0 mm [approx. 2 in x 2 in] area **shall** be examined with 10X magnification to determine the size of the inclusions. If no inclusions are located, 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 allowable depth, width and quantity of wrinkles, creases, streaks and scratches and the allowable height, width and quantity of wrinkles, creases and streaks **shall** be agreed upon between supplier and user depending upon the requirements of the application. The adhesive layer **shall** be free of streaks, scratches,

voids, gel particles, or contamination to the extent agreed upon by supplier and user, depending upon the requirements of the application.

3.5.3 Inclusions The area of the 50.0 mm x 50.0 mm [approx. 2 in x 2 in] specimen affected by inclusions **shall** be tested in accordance with ASTM D-149 and **must** withstand 500 V minimum for one minute. The size of the inclusions **shall** not be ≥ 0.50 mm [$\geq$ approx. 0.020 in] in any direction. Inclusions **shall** not violate the adhesive thickness tolerance defined in 3.6.5.

3.5.4 Voids The specimen **shall** be produced from a sample laminate prepared in accordance with 4.3 and tested in accordance with IPC-TM-650, Method 2.1.13. The size of the voids **shall** be not be >0.075 mm [$>$ approx. 0.003 in] in any direction.

3.5.5 Holes, Tears and Delaminations The material **shall** be free of holes, tears and delaminations 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 **shall** be as specified in the procurement document (see 6.1). The width and length **shall** be within ± 6.0 mm [± 0.24 in] of the value specified.

3.6.2 Roll Width The roll width **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 [± 0.059 in] of the value specified or as agreed upon between user and supplier.

3.6.3 Roll Length The length of the roll **shall** be as specified in the procurement document (see 6.1). The actual length of each roll **shall** be within $+10\%/ -0\%$ of the value reported by the supplier. Length **shall** be determined by a distance counter accurate to within 2%.

3.6.4 Dielectric Thickness When tested in accordance with ASTM D-374, Method A or C or equivalent test method, 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 of Base Dielectric

Nominal Thickness Range	Allowable Deviation
Thickness ≥ 0.075 mm [≥ 2950 μ in]	$\pm 10\%$
0.025 mm $\leq$ Thickness < 0.075 mm [984 μ in $\leq$ Thickness < 2950 μ in]	$\pm 10\%$
0.020 mm $\leq$ Thickness < 0.025 mm [787 μ in $\leq$ Thickness < 984 μ in]	$\pm 12.5\%$
Thickness < 0.020 mm [< 787 μ in]	$\pm 15\%$

3.6.5 Adhesive Thickness When tested in accordance with ASTM D374, or equivalent test method, the deviation from the nominal thickness of the adhesive **shall** be within the allowable range as specified in Table 3-2.

Table 3-2 Allowable Deviation from Nominal Thickness of Adhesive

Nominal Thickness Range	Allowable Deviation
Thickness ≥ 0.075 mm [≥ 2950 μ in]	$\pm 10\%$
0.025 mm $\leq$ Thickness < 0.075 mm [984 μ in $\leq$ Thickness < 2950 μ in]	$\pm 15\%$
0.020 mm $\leq$ Thickness < 0.025 mm [787 μ in $\leq$ Thickness < 984 μ in]	$\pm 20\%$
Thickness < 0.020 mm [< 787 μ in]	$\pm 30\%$
For woven, or combination of woven and nonwoven reinforcement, Thickness ≥ 0.025 mm [≥ 984 μ in]	$\pm 20\%$

(As a referee, a cross-sectional test method AABUS should be used.)

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 Peel Strength

3.7.2.1 Peel Strength As Received When specimens are tested in accordance with IPC-TM-650, Method 2.4.9, Method A or B, the minimum peel strength **shall** be as indicated in the applicable specification sheet.

3.7.2.2 Peel Strength After Solder Float When specimens are tested in accordance with IPC-TM-650, Method 2.4.9, Method C or D, the minimum peel strength after solder float **shall** be as indicated in the applicable specification sheet.

3.7.2.3 Peel Strength After Temperature Cycling When specimens are tested in accordance with IPC-TM-650, Method 2.4.9, Method E or F, the minimum peel strength after temperature cycling **shall** be as indicated in the applicable specification sheet.

3.7.3 Flow When specimens are tested in accordance with IPC-TM-650, Method 2.3.17.1, the flow **shall** be as indicated in the applicable specification sheet. This method applies to coverlay and coverfilm materials only. The flow value is expressed as a ratio of Flow-to-Adhesive Thickness.

3.7.4 Volatile Content When specimens are tested in accordance with IPC-TM-650, Method 2.3.37, Method A or B, the volatile content **shall** be as indicated in the applicable specification sheet.

3.8 Chemical Requirements

3.8.1 Chemical Resistance Specimens **shall** be produced from a sample laminate prepared in accordance with 4.3 and tested in accordance with IPC-TM-650, Method 2.3.2, Method A. The minimum retained peel strength following sequential chemical exposure **shall** be as indicated in the applicable specification sheet.

3.8.2 Solder Float The specimen **shall** be produced from a sample laminate prepared in accordance with 4.3 and tested in accordance with IPC-TM-650, Method 2.4.13. The specimens **shall** exhibit no evidence of blistering, delamination, wrinkling, cracking, or other defects that can affect serviceability.

3.9 Electrical Requirements As values may change with construction, environmental and operating frequency variations, it is recommended that the material supplier be contacted to verify the electrical properties.

3.9.1 Permittivity (Dielectric Constant) When specimens are tested in accordance with IPC-TM-650, Method 2.5.5.3, at 1 MHz; Method 2.5.5.9 or (optional) ASTM D-2520 at 1 GHz; Method 2.5.5.5 or (optional) ASTM D-2520 at 10 GHz, the maximum or range (preferred) of permittivity **shall** be as indicated in the applicable specification sheet. As values may change with thickness, environmental and operating frequency variations, it is recommended that the materials supplier be contacted to verify the specific permittivity values.

3.9.2 Loss Tangent (Dissipation Factor) When specimens are tested in accordance with IPC-TM-650, Method 2.5.5.3 at 1 MHz; Method 2.5.5.9 or (optional) ASTM D-2520 at 1 GHz; Method 2.5.5.5 or (optional) ASTM D-2520 at 10 GHz, the maximum loss tangent **shall** be as indicated in the applicable specification sheet. As values may change with thickness, environmental and operating frequency variations, it is recommended that the materials supplier be contacted to verify the specific loss tangent values.

3.9.3 Volume Resistivity (Damp Heat) The specimen **shall** be produced from a sample laminate prepared in accordance with 4.3 and 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) The specimen **shall** be produced in accordance with 4.3 and 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 the base material (core) dielectric is tested and recorded in IPC-4202, the minimum dielectric strength for the clad version of the same dielectric **shall** be reported in the applicable specification sheet(s) of IPC-4203. For unsupported bonding material, the value of dielectric strength **shall** be measured directly.

