

IPC-4204A

with Amendment 1
2013 - October

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

Supersedes IPC-4204A
October 2011

A standard developed by IPC

Association Connecting Electronics Industries



Copyright IPC-Association Connecting Electronics Industries
Provided by IHS under license with IPC
No reproduction or networking permitted without license from IHS
Full document details: IPC 4204A 2011



Licensee=Sandia National Lab/5932237100, User=sam, albert
Not for Resale, 05/28/2014 10:36:15 MDT

The Principles of Standardization

In May 1995 the IPC's Technical Activities Executive Committee (TAEC) adopted Principles of Standardization as a guiding principle of IPC's standardization efforts.

Standards Should:

- Show relationship to Design for Manufacturability (DFM) and Design for the Environment (DFE)
- Minimize time to market
- Contain simple (simplified) language
- Just include spec information
- Focus on end product performance
- Include a feedback system on use and problems for future improvement

Standards Should Not:

- Inhibit innovation
- Increase time-to-market
- Keep people out
- Increase cycle time
- Tell you how to make something
- Contain anything that cannot be defended with data

Notice

IPC Standards and Publications are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for his particular need. Existence of such Standards and Publications shall not in any respect preclude any member or nonmember of IPC from manufacturing or selling products not conforming to such Standards and Publication, nor shall the existence of such Standards and Publications preclude their voluntary use by those other than IPC members, whether the standard is to be used either domestically or internationally.

Recommended Standards and Publications are adopted by IPC without regard to whether their adoption may involve patents on articles, materials, or processes. By such action, IPC does not assume any liability to any patent owner, nor do they assume any obligation whatever to parties adopting the Recommended Standard or Publication. Users are also wholly responsible for protecting themselves against all claims of liabilities for patent infringement.

IPC Position Statement on Specification Revision Change

It is the position of IPC's Technical Activities Executive Committee that the use and implementation of IPC publications is voluntary and is part of a relationship entered into by customer and supplier. When an IPC publication is updated and a new revision is published, it is the opinion of the TAEC that the use of the new revision as part of an existing relationship is not automatic unless required by the contract. The TAEC recommends the use of the latest revision. Adopted October 6, 1998

Why is there a charge for this document?

Your purchase of this document contributes to the ongoing development of new and updated industry standards and publications. Standards allow manufacturers, customers, and suppliers to understand one another better. Standards allow manufacturers greater efficiencies when they can set up their processes to meet industry standards, allowing them to offer their customers lower costs.

IPC spends hundreds of thousands of dollars annually to support IPC's volunteers in the standards and publications development process. There are many rounds of drafts sent out for review and the committees spend hundreds of hours in review and development. IPC's staff attends and participates in committee activities, typesets and circulates document drafts, and follows all necessary procedures to qualify for ANSI approval.

IPC's membership dues have been kept low to allow as many companies as possible to participate. Therefore, the standards and publications revenue is necessary to complement dues revenue. The price schedule offers a 50% discount to IPC members. If your company buys IPC standards and publications, why not take advantage of this and the many other benefits of IPC membership as well? For more information on membership in IPC, please visit www.ipc.org or call 847/597-2872.

Thank you for your continued support.



IPC-4204A with Amendment 1

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

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

Supersedes:

IPC-4204A - October 2011

IPC-4204 - May 2002

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

Contact:

IPC
3000 Lakeside Drive, Suite 309S
Bannockburn, Illinois
60015-1249
Tel 847 615.7100
Fax 847 615.7105



This Page Intentionally Left Blank



Documents
Document Sharing Hub

Acknowledgment

Any document 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 IPC extend their gratitude.

Flexible Circuits Committee	Flexible Circuits Base Materials Subcommittee	Technical Liaison of the IPC Board of Directors
Chair Thomas F. Gardeski Gemini Sciences	Chair Clark F. Webster All Flex LLC	Dongkai Shangguan Flextronics International
Vice Chair Nick S. Koop Minco Products Inc.	Vice Chair Michael Beauchesne Amphenol Printed Circuits, Inc.	Shane Whiteside TTM Technologies
Flexible Circuits Base Materials Subcommittee		
Takahisa Akatsuka, Nippon Mektron Ltd.	Christine Coapman, Delphi Electronics and Safety	Mark Finstad, Flexible Circuit Technologies, Inc.
Diane Andercyk, Trace Laboratories - East	David J. Corbett, Defense Supply Center Columbus	Terry Fischer, Hitachi Chemical Co. America, Ltd.
Masamitsu (Matt) Aoki, JPCA-Japan Electronics Packaging and Circuits Association	Andrea Cote, Underwriters Laboratories Inc.	Thomas Fisher, DuPont
Lance Auer, Raytheon Missile Systems	Michelle Courier, Underwriters Laboratories Inc.	Lionel Fullwood, WKK Distribution Ltd.
Richard Barnett, Hewlett-Packard Company	Dr. G. Sidney Cox, DuPont	Mahendra Gandhi, Northrop Grumman Aerospace Systems
John Bauer, Rockwell Collins	Arthur Creidler, DuPont	Thomas Gardeski, Gemini Sciences, LLC
Roger Bell, Space Systems/Loral	Michael Crutchfield DuPont	Donna Gardner, DuPont
Mary Bellon, Boeing Satellite Development Center	Jay R. Desai, M-Flex (Multi-Fineline Electronix Inc)	Marc Goudreau, Vulcan Flex Circuit Corporation
Dr. Tad Bergstresser, Bekaert Specialty Films LLC	Peter DeWeese, Underwriters Laboratories Inc.	Ty Gragg, Unicircuit Inc.
Robert J. Black, Northrop Grumman Corporation	Michael Dickson, Underwriters Laboratories Inc.	Michael Green, Lockheed Martin Space Systems Company
Scott A. Bowles, L-3 Fuzing and Ordnance Systems	Joseph DiPalermo, M-Flex/Pica Sales & Engineering	Russell Griffith, Flexible Circuits Inc.
Tracy Cai, Guangdong Shengyi Sci.Tech Co. Ltd.	Mitsuharu Douwaki, Fujikura Ltd.	Alisha Groop, Lockheed Martin Space Systems Company
Byron Case, L-3 Communications	Russell Dudek, Compunetics Inc.	William Hazen, Raytheon Company
Shawn Chaput, Raytheon Missile Systems	C. Don Dupriest, Lockheed Martin Missiles and Fire Control	Todd Henninger, DDi Corp.
Wennei Y. Chen, Northrop Grumman Aerospace Systems	Jim Edmonds Shin-Etsu MicroSi	Scott Herrmann, DuPont
Jeffrey Ciesla, Defense Supply Center Columbus	Theodore Edwards, Dynaco Corp.	Rocky L. Hilburn, Insulectro
Greg Clements, Kaneka Texas Corporation	Alan Exley, Raytheon Company	William Jacobi, William Jacobi & Associates
	Thomas Farrell, Thomas G. Farrell Associates	Michael J. Jawitz, Boeing Research & Development
	David Fellows, Medtronic Microelectronics Center	John Jephson, Circuit Foil Trading, Inc.
	Jason Ferguson, NSW Crane	Tamotsu Kitagawa, ABC Corp.



Documents

Document Sharing Hub

Toru Koizumi, JPCA-Japan
Electronics Packaging and Circuits
Association

Nick Koop, Minco Products Inc.

Toshiaki Kuroiwa, UBE

Karin LaBerge, Microtek
Laboratories

Thomas D. Lantzer, DuPont

John Leschisin, Minco Products Inc.

Dr. Yanmei Li, Schlumberger Well
Services

Anne Lamonte, Draeger Medical
Systems, Inc.

Duane B. Mahnke, Mahnke
Consulting

Kenneth Manning, Raytheon
Company

John Marke, Underwriters
Laboratories Inc.

Martha Martinez, Underwriters
Laboratories Inc.

Eric Matuska, ALL Flex LLC

Dr. Thomas McCarthy, Taconic
Advanced Dielectric Division

Peter Menuetz, L-3 Communications -
Cincinnati Electronics

Roger J. Meidico, Raytheon
Company

Steve Morton, Exopack Advanced
Coatings

Steve A. Musante, Raytheon Missile
Systems

Michael L. Musich, Musich
Consulting.

Bob Neves, Microtek Laboratories

Steven M. Nolan, Lockheed Martin
Maritime Systems & Sensors

Dominique Numakura, DKN
Research

Debora Obitz, Trace Laboratories -
Baltimore

Yuri Okazaki, Toray

William Ortloff, Raytheon Company

Dr. J. Lee Parker, JLP

Dr. Arvind Partha, Somers Thin Strip

Joel S. Peiffer, 3M Company

Anthony Plemel, PFC Flexible
Circuits Ltd.

Jim Ryan, Integral Technology

Matthew Saari, Multek Flexible
Circuits, Inc.

Sakaguchi, Shin-Etsu Chemical Co.,
Ltd.

Jerome S. Sallo, Sallo Consulting
Services

Edward Sandor, Taconic Advanced
Dielectric Division

Kenji Sasahara, Kyosha Company,
Ltd.

Takeshi Sasaki, Nippon Steel
Chemical Company

Rolland Savage, High Performance
Copper Foil Inc.

Charles Scharnberg, Raytheon
Missile Systems

Dr. Michael Schen, NIST

Joseph Schmidt, Raytheon Missile
Systems

Julie Scopel, Underwriters
Laboratories Inc.

Gilbert Shelby, Raytheon Missile
Systems

Robert Sheldon, Pioneer Circuits Inc.

Terry Shepler, Electro-Materials, Inc.

Lowell Sherman, Defense Supply
Center Columbus

HyunJoon Shin, UL Korea Ltd.

Caroline Simonian-Owens,
Underwriters Laboratories Inc.

Carl Siviter, Induflex NV

Joseph Slanina, Honeywell FM & T

Douglas J. Sober, Kaneka Texas
Corporation

Vern Solberg, Solberg Technical
Consulting

Valerie A. St. Cyr, Teradyne Inc.

Herb Stark, Flexible Circuits Inc.

Darin Stotz, Northfield Automation
Systems Inc.

Brent Sweitzer, Multek Flexible
Circuits, Inc.

Dung Q. Tiet, Lockheed Martin
Space Systems Company

John Tobin, Underwriters
Laboratories Inc.

Randy E. Tolbert, NSW Crane

Crystal E. Vanderpan, Underwriters
Laboratories Inc.

Steve J. Vetter, NSW Crane

Nicholas Watts, Intel Corporation

Vern Weik, Molex Copper Flex
Products

Dewey Whittaker, Honeywell Inc. Air
Transport Systems

Jay Wu, Taiflex Scientific Co., Ltd.

Katsuya Yamada, Sumitomo Electric
Printed Circuits Inc

Miou Yamaoka, Meiko Electronics
Co. Ltd.

Ricky Yeung, Meadville Holdings
Limited

George Zahr, DuPont

Sarah Zarrin, Seagate Technology

Table of Contents

1	SCOPE	1	3.4.4	Sheet Material	7
1.1	Classification System	1	3.4.5	Roll Material	7
1.1.1	Nonspecific Designation	1	3.5	Visual Requirements	7
1.1.2	Specific Designation	1	3.5.1	Marking	7
1.1.2.1	Base Material Type	2	3.5.2	Wrinkles, Creases, Streaks and Scratches	7
1.1.2.2	Reinforcement Method	2	3.5.3	Inclusions	8
1.1.2.3	Reinforcement Type	2	3.5.4	Voids	8
1.1.2.4	Base Material Thickness	3	3.5.5	Holes, Tears and Delaminations	8
1.1.2.5	Adhesive Type	3	3.5.6	Pits and Dents	8
1.1.2.6	Adhesive Thickness	3	3.5.7	Discoloration	8
1.1.2.7	Metal Cladding	3	3.6	Dimensional Requirements	8
1.1.2.7.1	Metal Foil	4	3.6.1	Sheet Width and Length	8
1.1.2.7.2	Metal Foil Type	4	3.6.2	Roll Width	8
1.1.2.7.3	Foil Designation	4	3.6.3	Roll Length	8
1.1.2.7.4	Nominal Metal Cladding Thickness	4	3.6.4	Dielectric Thickness	9
1.1.2.7.5	Bond Enhancement Treatment	5	3.6.5	Adhesive Thickness	9
1.2	Qualification	5	3.6.6	Metal Foil Thickness	9
1.3	Quality Conformance	5	3.7	Physical Requirements	9
1.4	Material Characteristics	5	3.7.1	Dimensional Stability	9
1.5	New Materials	5	3.7.2	Peel Strength	9
			3.7.2.1	Peel Strength As Received	9
2	APPLICABLE DOCUMENTS	5	3.7.2.2	Peel Strength After Solder Float	9
2.1	IPC	5	3.7.2.3	Peel Strength After Temperature Cycling	9
2.2	American Society For Testing and Materials (ASTM)	6	3.7.3	Initiation Tear Strength	9
2.3	Underwriters Laboratories Standards	6	3.7.4	Propagation Tear Strength	9
2.4	NCSL International	6	3.7.5	Flexural Endurance	9
2.5	ISO	6	3.7.6	Low Temperature Flexibility	10
			3.8	Chemical Requirements	10
3	REQUIREMENTS	6	3.8.1	Chemical Resistance	10
3.1	Terms and Definitions	6	3.8.2	Solder Float	10
3.1.1	Qualification Testing	6	3.8.3	Solderability	10
3.1.2	Quality Conformance Testing	6	3.9	Electrical Requirements	10
3.1.3	User Inspection Lot	6	3.9.1	Permittivity (Dielectric Constant)	10
3.1.4	Supplier Inspection Lot	6	3.9.2	Loss Tangent (Dissipation Factor)	10
3.1.5	Structurally Similar Construction	6	3.9.3	Volume Resistivity (Damp Heat)	10
3.1.6	Void	7	3.9.4	Surface Resistance (Damp Heat)	10
3.1.7	Inclusions	7	3.9.5	Dielectric Strength	10
3.2	Specification Sheets	7	3.10	Environmental Requirements	10
3.3	Conflict	7	3.10.1	Fungus Resistance	10
3.4	Materials	7	3.10.2	Moisture Absorption	10
3.4.1	Base Material	7	3.10.3	Flammability	10
3.4.2	Adhesive	7	3.10.4	Service Temperature	11
3.4.3	Metal-Cladding	7	3.10.5	Moisture and Insulation Resistance	11

3.11	Workmanship	11	4.10	Statistical Process Control (SPC)	15
4	QUALITY ASSURANCE PROVISIONS	11	4.10.1	Reduction of Quality Conformance Testing	15
4.1	Responsibility for Inspection	11	5	PREPARATION FOR DELIVERY	15
4.2	Test Equipment and Inspection Facilities	11	5.1	Packaging	15
4.3	Preparation of Samples	11	6	NOTES	15
4.4	Standard Laboratory Conditions	11	6.1	Ordering Data	15
4.5	Tolerances	11	6.2	Specific Chemical Exposure	16
4.6	Classification of Inspections	12			
4.7	Materials Inspection	12			
4.8	Qualification Inspection	12			
4.8.1	Characterization Testing	12			
4.8.2	Frequency	12			
4.9	Quality Conformance Inspection	12			
4.9.1	Inspection of Product for Delivery	12			
4.9.2	Sample Unit	14			
4.9.2.1	Sampling Plan	14			
4.9.3	Group A Inspection	14			
4.9.3.1	Failures	14			
4.9.3.2	Rejected Lots	14			
4.9.4	Group B Inspection	14			
4.9.4.1	Sampling Plan	14			
4.9.4.2	Failures	14			
4.9.4.3	Noncompliance of Material	14			
4.9.5	Group C Inspection	14			
4.9.5.1	Sampling Plan	14			
4.9.5.2	Failures	15			
4.9.5.3	Noncompliance of Material	15			

Tables

Table 1-1	Base Dielectric Type Designation	2
Table 1-2	Reinforcement Method Designation	2
Table 1-3	Reinforcement Type Designation	2
Table 1-4	Base Dielectric Thickness Designation or Adhesive Thickness Designation	3
Table 1-5	Adhesive Type Designation	3
Table 1-6	Specification Designation from IPC-4562	4
Table 1-7	Copper Thickness Designator	4
Table 3-1	Point Values Assigned to Pits and Dents Based on Their Longest Dimension	8
Table 3-2	Allowable Deviation from Nominal Thickness of Base Dielectric	9
Table 3-3	Allowable Deviation from Nominal Thickness of Adhesive	9
Table 4-1	Test Method Frequency	13
Table 4-2	Sampling Plan for Group A and Group B Inspection for Sheet Goods	14
Table 4-3	Sampling Plan for Group A and Group B Inspection for Roll Goods	14



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

1 SCOPE

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

1.1 Classification System The system described in 1.1.1 through 1.1.2.7 identifies flexible metal-clad dielectrics.

1.1.1 Nonspecific Designation A nonspecific designation is intended for use by *designers* on master drawings to designate their material choice. At the end of this standard is a series of material specification sheets identified by specification sheet numbers. Each sheet outlines engineering and performance data for a flexible metal-clad dielectrics, indicating base material type, adhesive type and method of reinforcement.

Example of nonspecific designation:

IPC-4204/I, where “I” refers to the specification sheet detailing copper-clad polyimide dielectric with acrylic adhesive. If further material specification details (such as dielectric, adhesive or copper thicknesses) are required, they should be highlighted in cross sectional views or notes on the master drawing.

1.1.2 Specific Designation The specific designation should be in the form shown in the following example, and is intended for use on material purchase orders by *fabricators* (see 6.1). The specific designation should not be used by designers on master drawings to indicate their material selection, as the designation is lengthy and requires fabricator level knowledge in making the detailed selections.

NOTE: The alpha character “Z” replaces and is entirely equivalent to the alpha character “O” (ref: Table 1-5) 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 1-5)] may continue to be used. Supplier material certifications will reflect the current IPC standard’s revision, and accordingly, the alpha character “Z” in the designation.

Example of specific designation:

IPC-4204/I – E1E2M2/2 CU-W7-1P/1P

Where:

IPC-4204/I – Nonspecific Designation (see 1.1.1) specifying copper-clad dielectric with acrylic adhesive

E – Base Dielectric Type Designation (see 1.1.2.1) specifying polyimide

1 – Reinforcement Method Designation (see 1.1.2.2) specifying non-reinforced

E – Reinforcement Type Designation (see 1.1.2.3) specifying non-reinforced film

2 – Base Dielectric Thickness Designation (see 1.1.2.4) specifying 50microns [0.002 in]

M – Adhesive Type Designation (see 1.1.2.5) specifying acrylic adhesive

2/2 – Adhesive Thickness Designation (see 1.1.2.6) specifying 50 micron both sides (Not used for adhesiveless product)

CU-W7-1P/1P – Metal Cladding Designation (see 1.1.2.7) specifying wrought rolled annealed copper, 35 microns both sides with no treatment

1.1.2.1 Base 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
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 specified 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 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)

Note: Combinations will use two letters separated by slash.

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

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

Designator	Nominal Thickness (See 3.6.4)
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

1.1.2.5 Adhesive Type The adhesive **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
U	Polyetherimide
Y	Cynate Ester
Z	Adhesiveless ("Z" replaces "O" from previous revision)

1.1.2.6 Adhesive Thickness Adhesive thickness is expressed by a designator (see Table 1-4). The adhesive thicknesses on each side of the base dielectric are separated by a slash.

1.1.2.7 Metal Cladding Metal foil **shall** be specified per IPC-4562, Metal Foil for Printed Board Applications. 1.1.2.7.1 through 1.1.2.7.5 represent excerpts from the current version of IPC-4562 at the time of publication of IPC-4204, except that all reference to profile of foils is omitted. If foil profile is required, this **shall** be included in the procurement documentation.

Example of metal foil designation:

CU-W7-1P/IP

Where

CU – Foil Metal Designation (see 1.1.2.7.1)

W – Foil Type Designation (see 1.1.2.7.2)

7 – Foil Grade Designation (see 1.1.2.7.3)

1 – Foil Thickness Designation (see 1.1.2.7.4)

P – Bond Enhancement Treatment Designation (see 1.1.2.7.5)



1.1.2.7.1 Metal Foil The metal foil **shall** be designated by a suitable two- or three-letter code:

CU Copper

NI Nickel

XX Other

1.1.2.7.2 Metal Foil Type Metal foil types **shall** be distinguished by their process of manufacture and **shall** be designated as:

E Electrodeposited

W Wrought (Rolled)

O Other

1.1.2.7.3 Foil Designation Foil specification designations **shall** be distinguished according to the foil specification designations per Table 1-6.

Table 1-6 Specification Designation from IPC-4562

Specification Sheet	Designation
1	Standard electrodeposited (STD-Type E)
2	High ductility electrodeposited (HD-Type E)
3	High temperature elongation electrodeposited (HTE-Type E)
5	As rolled-wrought (AR-Type W)
7	Annealed-wrought (ANN-Type W)
8	As rolled-wrought low temperature annealable (LTA-Type W)
9	Nickel, standard electrodeposited
10	Electrodeposited low temperature annealable (LTA-Type E)
11	Electrodeposited annealable (A-Type E)

1.1.2.7.4 Nominal Metal Cladding Thickness The area weight and nominal thickness for copper **shall** be as identified in Table 1-7. For claddings other than copper, thickness **shall** be indicated by dimensions to the nearest 0.025 mm [approx. 0.001 in]. If no metal cladding is required on second side, the '0' is not required.

Table 1-7 Copper Thickness Designator

Foil Designation	Common Industry Terminology	Metric		English	
		Area Weight	Nominal Thickness	Area Weight	Nominal Thickness
		(g/m ²)	(µm)	(oz./ft. ²)	(10 ⁻³ in)
E	5 µm	45.1	5.1	0.148	0.20
Q	9 µm	75.9	8.5	0.249	0.34
T	12 µm	106.8	12.0	0.350	0.47
H	1/2 oz	152.5	17.1	0.500	0.68
M	3/4 oz	228.8	25.7	0.750	1.01
1	1 oz	305.0	34.3	1	1.35
2	2 oz	610.0	68.6	2	2.70
3	3 oz	915.0	102.9	3	4.05
4	4 oz	1220.0	137.2	4	5.40
5	5 oz	1525.0	171.5	5	6.75
6	6 oz	1830.0	205.7	6	8.1
7	7 oz	2135.0	240.0	7	9.45
10	10 oz	3050.0	342.9	10	13.50
14	14 oz	4270.0	480.1	14	18.90
µn	n µm	Specified on purchase order			

1.1.2.7.5 Bond Enhancement Treatment The bond enhancement treatment used on the metal foil **shall** be designated as one of the following:

- N No treatment; no stain proofing.
- P No treatment; stain proofing both sides.
- S Single-sided bond enhancement treatment (matte side); stain proofing on both sides.
- D Double-sided bond enhancement treatment; stain proofing on both sides.
- R Reverse-treated bond enhancement (cathode side); stain proofing on both sides.

1.2 Qualification The flexible metal-clad dielectric materials that meet all the requirements of this standard **shall** be qualified products (see 4.7).

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 4.8 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 metal-clad 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 Base Materials Subcommittee (D-13). 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 Printed Wiring Materials
- 2.4.3 Flexural Endurance
- 2.4.13 Solder Float
- 2.4.15 Surface Finish, Metal Foils
- 2.4.16 Initiation Tear Strength, Flexible Insulating Materials
- 2.4.17.1 Propagation Tear Strength, Flexible Insulating Materials
- 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)
- 2.5.5.5 Stripline Test for Permittivity and Loss Tangent (Dielectric Constant and Dissipation Factor) at X-Band
- 2.5.5.9 Permittivity and Loss Tangent, Parallel Plate, 1 MHz to 1.5 GHz
- 2.5.17 Volume and Surface Resistivity of Printed Wiring Materials
- 2.6.1 Fungus Resistance, Printed Wiring Material
- 2.6.2 Moisture Absorption, Flexible Printed Wiring
- 2.6.18 Low Temperature Flexibility
- 2.6.21 Service Temperature of Metal-Clad Flexible Laminated, Cover Material and Adhesive Bonding Films

1. www.ipc.org

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



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

IPC-4203 Cover and Bonding Material for Flexible Printed Circuitry

IPC-4562 Metal Foil for Printed Board Applications

IPC-9191 General Requirements for Implementation of Statistical Process Control

2.2 American Society For Testing and Materials (ASTM)³

ASTM-D-149 Dielectric Breakdown Voltage and Dielectric Strength of Electrical Insulating Materials at Commercial Power Frequencies

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

ASTM D-2520 (Optional) Standard Test Methods for Complex Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials at Microwave Frequencies and Temperatures to 1650 °C

2.3 Underwriters Laboratories Standards⁴

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

2.4 NCSL International⁵

ANSI/NCSL Z 540-1 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

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 3.1.7.

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 that 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 the metal-clad laminates of the same type, and of the same type 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. www.astm.org

4. www.ul.com

5. www.ncsli.org

6. www.iso.org

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, conductive or nonconductive, 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).

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, issued as an Amendment.

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

1. Purchase Order.
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 The flexible base dielectrics **shall** be free from deleterious substances and formulated or prepared to meet the requirements of this standard. Both sides of double-sided laminate **shall** be evaluated for those requirements that are impacted by the copper/laminate relationships. 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 that the composite meets the requirements of IPC-4203.

3.4.3 Metal-Cladding Copper foil **shall** meet the requirements of IPC-4562. Metal cladding not described in IPC-4562 **shall** meet the requirements as agreed upon between user and supplier.

3.4.4 Sheet Material Each sheet of flexible metal-clad dielectric material **shall** meet the requirements of 3.5 through 3.11.

3.4.5 Roll Material Each roll of flexible metal-clad 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 that 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 constrained within 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 or identified AABUS.

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 3.5.6. Any defect within 6.5 mm [0.256 in] of the outside edges of the sheet or roll **shall** be disregarded. The entire test specimen **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 seen with normal or corrected 20/20 (also termed 6/6 or 1.0) vision, 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 seen with normal or corrected 20/20 (also termed 6/6 or 1.0) vision, the entire specimen **shall** be recorded as having no defects against the requirements of 3.5.3. The locations of pits and dents on the clad side(s) **shall** be determined by examination with normal or corrected 20/20 (also termed 6/6 or 1.0) vision. The longest dimension of each located pit or dent **shall** be determined with 10X magnification and a point value assigned per 3.5.6.

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 Scratches are not permitted where any part of the defect is $\geq 20\%$ of the nominal foil thickness (i.e., $3.4\ \mu\text{m}$ [$134\ \mu\text{in}$] for $17\ \mu\text{m}$ [$669\ \mu\text{in}$] metal) or have more than five occurrences per $300\ \text{mm} \times 300\ \text{mm}$ [$11.8\ \text{in} \times 11.8\ \text{in}$]. Any scratch with a depth $> 5\%$ of the nominal foil thickness **shall not** be counted, regardless of length. The maximum allowable scratch length is $100\ \text{mm}$ [$3.937\ \text{in}$] for any scratch with a depth $\geq 5\%$ and $< 20\%$ of the nominal foil thickness. Any wrinkles and creases are AABUS. The allowable depth, width and quantity of wrinkles and creases and the allowable height, width and quantity of streaks **shall** be AABUS. After etching of the metal cladding, the adhesive layer **shall** be free of streaks, scratches, voids, gel particles, or contamination, AABUS.

3.5.3 Inclusions The area of the $50.0\ \text{mm} \times 50.0\ \text{mm}$ [approx. $2\ \text{in} \times 2\ \text{in}$] 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 $>0.50\ \text{mm}$ [$> \text{approx. } 0.020\ \text{in}$] in any direction. Inclusions **shall not** violate the adhesive thickness tolerance defined in 3.6.5. Any inclusion in the metal cladding **shall** meet the requirements of 3.4.3.

3.5.4 Voids When tested in accordance with IPC-TM-650, Method 2.1.13, the size of the voids **shall not** be $>0.075\ \text{mm}$ [$>295\ \mu\text{in}$] 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.

3.5.6 Pits and Dents Unless otherwise specified, there **shall** be no pits or dents with the longest dimension greater than $0.50\ \text{mm}$ [approx. $0.020\ \text{in}$] and the maximum average point count **shall** be five per clad side per $30.0\ \text{cm} \times 30.0\ \text{cm}$ [$11.81\ \text{in} \times 11.81\ \text{in}$]. The average point count **shall** be computed by averaging the total point value of the whole specimen surface over an area of $30.0\ \text{cm} \times 30.0\ \text{cm}$ [$11.81\ \text{in} \times 11.81\ \text{in}$]. Point value for each pit or dent is determined by its longest dimension in Table 3-1.

Table 3-1 Point Values Assigned to Pits and Dents Based on Their Longest Dimension

Longest dimension, l	Point Value
$0.13\ \text{mm} < l \leq 0.25\ \text{mm}$ [$512\ \mu\text{in} < l \leq 984\ \mu\text{in}$]	1
$0.25\ \text{mm} < l \leq 0.50\ \text{mm}$ [$984\ \mu\text{in} < l \leq 1970\ \mu\text{in}$]	2

The location of pits and dents on the clad side(s) **shall** be determined by examination with normal or corrected 20/20 (also termed 6/6 or 1.0) vision. The longest dimension of each located pit or dent **shall** be determined with 10X magnification and a point value assigned per Table 3-1. The allowable depth, height, longest dimension and quantity of pits and dents may be AABUS.

3.5.7 Discoloration of the copper surface **shall** be permissible when easily removed by standard commercial cleaning practices, unless specifically excluded under 6.1.

3.6 Dimensional Requirements

3.6.1 Sheet Width and Length The width and length of sheets of flexible metal-clad dielectric **shall** be as specified in the procurement document (see 6.1). The width and length **shall** be within $+6.0\ \text{mm}/-0.00\ \text{mm}$ [$+0.236\ \text{in}/-0.0\ \text{in}$] of the value specified.

3.6.2 Roll Width The width of the flexible metal-clad 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 $\pm 1.5\ \text{mm}$ [$\pm 0.059\ \text{in}$] of the values specified.

3.6.3 Roll Length The length of the flexible metal-clad dielectric **shall** be as specified in the procurement document (see 6.1). The length of each roll **shall** be within $+5\%/-0\%$ of the value specified. 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, 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 3-2.

Table 3-2 Allowable Deviation from Nominal Thickness of Base Dielectric

Nominal Thickness Range	Allowable Deviation
Thickness ≥ 0.075 mm [Thickness ≥ 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 [Thickness < 787 μ in]	$\pm 15\%$

3.6.5 Adhesive Thickness When tested in accordance with ASTM-D-374, or equivalent test method, the deviation from the nominal thickness of the adhesive **shall** be within the allowable range as specified in Table 3-3.

Table 3-3 Allowable Deviation from Nominal Thickness of Adhesive

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

3.6.6 Metal Foil Thickness The metal foil thickness **shall** be as specified in the procurement document (see 6.1) and **shall** conform to the tolerances of IPC-4562. Microsectioning **shall** be used as a referee method.

3.7 Physical Requirements

3.7.1 Dimensional Stability When specimens are tested in accordance with IPC-TM-650, Method 2.2.4, Method B and C, 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 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 on 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. When calculating the propagation tear strength, only the base material film thickness **shall** be used.

3.7.5 Flexural Endurance When specimens are tested in accordance with IPC-TM-650, Method 2.4.3, the flexural fatigue **shall** be as indicated in the applicable specification sheet.

3.7.6 Low Temperature Flexibility When specimens are tested in accordance with IPC-TM-650, Method 2.6.18, the low temperature flexibility **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 A, the minimum retained peel strength following chemical exposure **shall** be as indicated in the applicable specification sheet.

3.8.2 Solder Float When specimens are 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.

3.8.3 Solderability When the specimens are tested in accordance with IPC J-STD-003, Test A, Edge Dip Test, the specimen **shall** meet the requirements of IPC J-STD-003.

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) 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 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-4204.

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 the 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 flexible dielectric specimens are tested in accordance with UL 94, the flammability rating **shall** be reported by the manufacturer for applicable constructions and configurations. The UL 94 specification rates flexible materials either with a V rating (*vertically* suspended strip of unclad dielectric) or with a VTM rating (*vertically* suspended *thin material*.)

The VTM test is intended to be performed on materials that due to their thinness, either distort, shrink and/or are consumed up to the holding clamp when tested using the test described in the UL 94 20 mm Vertical Burn Test. The VTM test **shall** only be performed after it has been determined that the test specimens cannot meet the requirements of the 20 mm Vertical Burn Test. The test specimens **shall** also possess physical properties that allow a 200 mm $\pm$ 5 mm (nominal) length of material to be tested.