Lead Free Laminates - Fact and Fiction

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FACT

ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES ®

IPC-4101B

Specification for Base Materials for Rigid and Multilayer Printed Boards

FACT

IPC-4101B Summary:

- IPC-4101 Revision B published 12 June 2006.
- Includes 6 specification sheets for FR-4 lead-free assembly compatible materials.
- Lead-free FR-4 specification sheets require improved thermal resistance, Z-Axis expansion and inter-laminar adhesion.
- Separate specifications for filled and unfilled FR-4s.
- Keywords / Search Terms part of document.

FACT

New FR-4 Lead-Free Material Requirements:

- **Td.**
- **Z-Axis Expansion Alpha 1 below Tg.**
- **Z-Axis Expansion Alpha 2 above Tg.**
- **% Z-Axis Expansion (50 to 260 degrees C).**
- **T-260.**
- **T-288.**
- **T-300.**
- **UL 94 Flammability.**
- **UL Maximum Operating Temperature.**

All of these additional requirements are designed to improve the probability of a base material being compatible with lead-free assembly.

FACT

IPC FR-4 Lead-Free Compatible Specifications:

- IPC-4101B/99 — High Tg FR-4, inorganic fillers, brominated flame retardant.
- IPC-4101B/101 — Low Tg FR-4, inorganic fillers, brominated flame retardant.

- IPC-4101B/121 — Low Tg FR-4, no fillers, brominated flame retardant.
- IPC-4101B/124 — High Tg FR-4, no fillers, brominated flame retardant.

- IPC-4101B/126 — Very high Tg, inorganic fillers, brominated flame retardant.
- IPC-4101B/129 — Very high Tg, no fillers, brominated flame retardant.

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IPC FR-4 Lead-Free Compatible Material (170 Tg):

- Reinforcement: Woven E-Glass
- Primary Resin System: Multifunctional Epoxy
- Secondary Resin System: Modified Epoxy or Non-Epoxy
- Filler: Filled
- Curing Agent: Not specified
- Flame Retardant: RoHS Compliant Bromine

IPC-4101B/99

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IPC FR-4 Lead-Free Compatible Material (170 Tg):

- Decomposition Temp: 325°C minimum.
- Z-Axis Expansion:
  - Alpha 1 60 ppm maximum.
  - Alpha 2 300 ppm maximum.
  - 50 to 260°C 3.5% maximum.
- T260 Resistance: 30 minutes minimum.
- T288 Resistance: 5 minutes minimum.
- T300 Resistance: AABUS (as agreed upon between user and supplier).
- CAF Resistance: AABUS.

IPC-4101B/99

Lead-Free Data Sheets IPC-4101B:

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Slash Sheet #	99	101	121	124	126	129
Tg min	150	110	110	150	170	170
Tg max						
Td min	325	310	310	325	340	340
Fillers	yes	yes	no	no	yes	no
Flame retardant	RoHS BR	RoHS BR	RoHS BR	RoHS BR	RoHS BR	RoHS BR
Curing Agent	N/A	N/A	N/A	N/A	N/A	N/A
Flammability	V-0	V-0	V-0	V-0	V-0	V-0
Z-Axis alpha 1 max	60	60	60	60	60	60
Z-Axis alpha 2 max	300	300	300	300	300	300
% max	3.5	4.0	4.0	3.5	3.0	3.0
T-260	30	30	30	30	30	30
T-288	5	5	5	5	15	15
T-300	AABUS	AABUS	AABUS	AABUS	2	2
UL MOT	AABUS	AABUS	AABUS	AABUS	130	130

FACT

KEYWORDS Are Part of IPC-4101B:

- **The original IPC-4101 had 33 specification sheets, the “B” revision has 55 in total and this number is going up.**
- **The original 8 specifications for FR-4 have expanded to 21.**
- **The original organizational structure has been overwhelmed and similar grades are scattered within the numeric sequence.**
- **The Keyword / Search Terms are a mechanism to find materials of similar composition, performance and application.**
- **The Keyword / Search Terms appear in Section 7 and the Summary Information listing.**

FICTION

KEYWORDS are Requirements:

From IPC-4101B:

Keywords, as part of the header section for each specification sheet, are intended to be used as search terms to provide information as to the typical properties, application, design and performance characteristics of that base material. The Keywords will assist the reader by providing detail not found in the composition or performance requirements sections. The Keywords are **not specification requirements** nor are they intended to be restrictive as to the use of the material described. Similarly, having a particular Keyword in the header section, does not guarantee the acceptability of this material for a specific application. Examples to clarify the use of Keywords are shown below:

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Example 1: A Keyword for IPC-4101B/10 shows “single-sided boards”. This Keyword indicates that the typical application for this base material grade is for single-sided PCBs. This Keyword does not suggest that this base material cannot be used for double-sided PCBs as well.

Example 2: A Keyword for IPC-4101/99 shows “lead-free FR-4”. The Keyword “lead-free FR-4” indicates that the base material is intended to be compatible for lead-free assembly. Other FR-4 base materials not having a Keyword “lead-free FR-4” may be suitable for use in lead-free soldering.

Example 3: A Keyword for IPC-4101/03 shows “consumer electronics”. The Keyword indicates that the base material is typically used in consumer electronics. The Keyword does not indicate that IPC-4101/03 cannot be used for other electronic applications than consumer.

FICTION

KEYWORDS Guarantee Performance:

In the front of each IPC standard the following words can be found:

IPC Standards and Publications are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitate interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with a minimum delay the proper product for his particular need.

There is no guarantee that a material certified to a lead-free specification sheet will assemble properly, the probability of success is simply greater.

FICTION

KEYWORDS Exclude Other Suitable Materials:

- **The Keywords show a “typical use” not an “only use”.**
- **Although not shown as “lead-free” in the Keywords, other materials such BT, polyimide and cyanate ester can be used for lead-free assembly.**
- **In fact, CEM-1 or FR-2 can be used for lead-free assembly if it is agreed upon between the user and supplier.**
- **A home exists for almost all of the commercial FR-4 base materials within the 6 published specification sheets.**

FACT

IPC-TM-650 Test Method 2.4.24.6

- Thermal Decomposition Temperature (Td) of Laminate Materials using TGA.
- IPC Task Group 3-11.
- Sample size 10 to 30 mg.
- Precondition at 110 degrees C for 24 hours.
- Heat rate of 10 degrees C per minute.
- Purge gas nitrogen.
- Endpoint is 5% weight loss from 50 degrees C.

FACT

IPC FR-4 Lead-Free Compatible Material:

- Flammability: Changed from V-1 minimum from IPC-4101A revision to V-0 minimum for IPC-4101B revision.
- Flammability Test Method: UL-94.

This represents a significant change to the current requirements as laminates will be mandated to be V-0 regardless of thickness or resin content.

FICTION

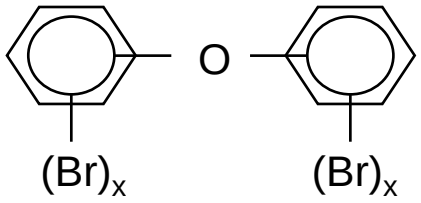
RoHS Compliance Bans Bromine:

- RoHS does not ban all brominated materials used currently as a flame retardant for circuit boards.
- Bromine containing compounds that are outlawed by RoHS are those that remain as independent molecules within the polymeric matrix. These include:
  - poly biphenyl ethers or oxides (PBDE or PBBO)
  - poly brominated biphenyls (PBB)
- Bromine containing compounds that are acceptable by RoHS include those that react to become a chemical part of the polymeric matrix.
  - Tetra-Bromo Bis-Phenol A (TBBPA)

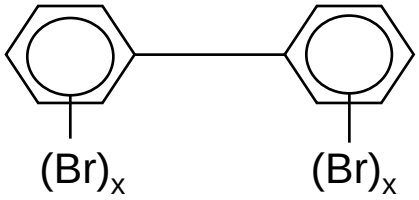
FACT

RoHS Compliant Bromine Requirement:

These brominated flame retardants are banned by RoHS and IPC-4101B:



Polybrominated Biphenyl Oxide (PBBO or PBDE)

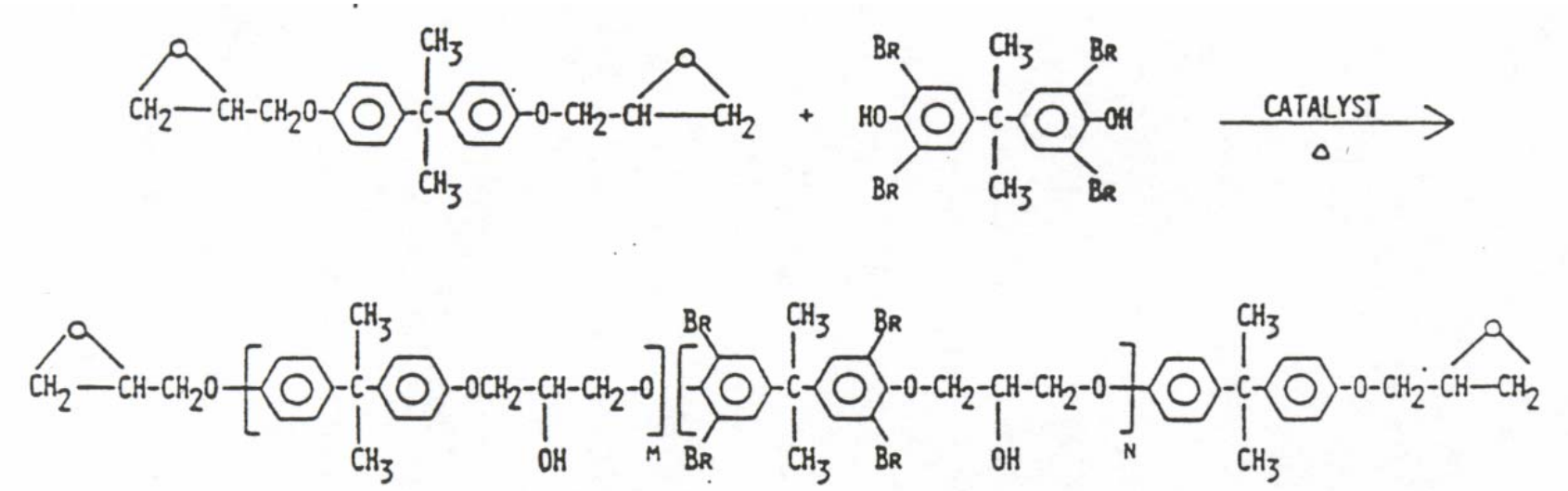


Polybrominated Biphenyl (PBB)

FACT

RoHS Compliant Bromine Requirement:

These brominated flame retardants are acceptable by RoHS and IPC-4101B:



Brominated epoxy resin for FR-4 production

FACT

Low Halogen, Lead-Free Base Materials are not covered in IPC-4101B:

- Development of these requirements will begin shortly.
- Specification IPC-4101/127 and IPC-4101/128 reserved.
- Requirements will be similar to IPC-4101B/99.
- Halogen requirements:
  - 900 ppm maximum bromine.
  - 900 ppm maximum bromine
  - 1500 ppm total halogen.

FACT

IPC-4101B Specification Sheet 126 and 129:

- 170 degrees C minimum Tg.
- 340 degrees C minimum Td.
- 15 minutes minimum T-288.
- 2 minutes minimum T-300.
- UL MOT must be 130 degrees C.
- 3.0% Z-axis expansion.
- IPC-4101B/126 is filled.
- IPC-4101B/129 is unfilled.

All other requirements are the same as IPC-4101B/99.

FICTION

IEC will have similar lead-free standards:

- **The member countries of the International Electro-technical Commission (IEC) have voted to allow IPC-4101 to be the defacto standard for lead-free base materials.**

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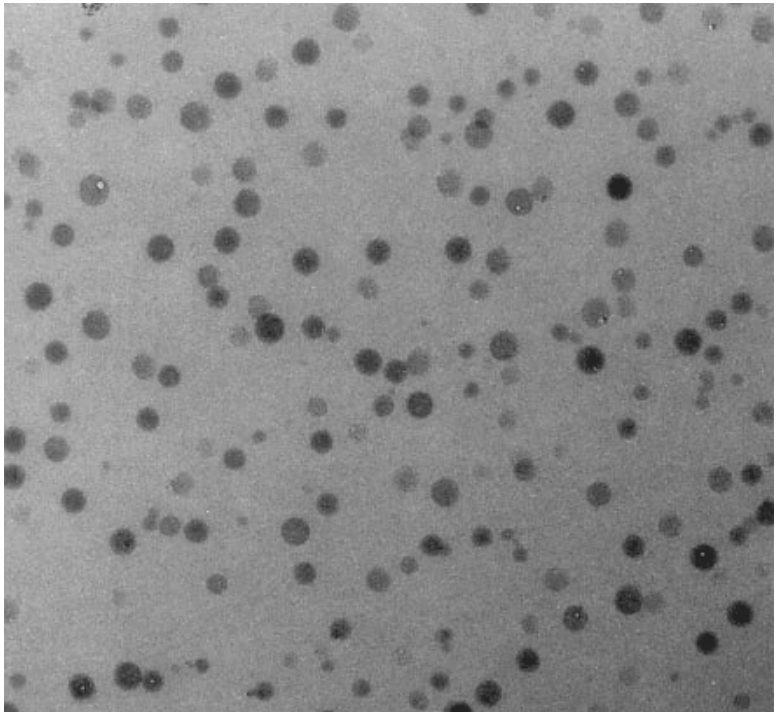

Suppliers of toughening agents for lead-free compatible base materials for PCBs.