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INTERNATIONAL STANDARDS UPDATE FOR BASE MATERIALS

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OUTLINE OF TOPICS:

- **IPC-4101B Lead-Free Assembly Compatible Base Materials:**
  - **New specification sheets**
  - **Compositional requirements**
  - **Performance requirements**
  - **RoHS compliant bromine**
  - **Keywords**
- **IEC 61249 Lead-Free Assembly Compatible Base Materials.**
- **IEC 61249 Halogen-Free Base Materials.**
- **IPC-4101B Halogen-Free Base Materials.**
- **Underwriters' Laboratories Grouping of FR-4.**

Lead-Free Misconceptions* :

- **Lead-free assembly will have only a minor effect on laminate and prepreg base materials.**
- **New material types will not be needed, but more applications will switch to existing high Tg materials.**
- **Most existing materials can be used in lead-free assembly without a significant problem.**
- **140°C Tg FR-4s are not compatible with lead-free assembly processes.**

* **Ed Kelley** **Polyclad Laminates**
Cookson Electronics

IPC Lead-Free Activities:

- IPC-4101 Revision B under development.
- Includes specification sheets for lead-free assembly compatible materials.
- Improved thermal resistance, Z-Axis and inter-laminar adhesion.
- Requirements finalized for both 140 and 170°C Tg FR-4 materials.
- UL forced separate specifications for filled and unfilled FR-4s.
- Publication due December 2005

IPC FR-4 Lead-Free Compatible Specifications:

• IPC 4101B/99	170 degree C Tg Inorganic fillers
• IPC 4101B/101	140 degree Tg Inorganic fillers
• IPC 4101B/121	140 degree C Tg No fillers
• IPC 4101B/124	170 degree C Tg No fillers

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: With Inorganic Fillers
- Curing Agent: Non-Dicy
- Flame Retardant: RoHS Compliant Bromine

IPC-4101B/99

IPC FR-4 Lead-Free Compatible Material (140 Tg):

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

IPC-4101B/101

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: No Fillers
- Curing Agent: Non-Dicy
- Flame Retardant: RoHS Compliant Bromine

IPC-4101B/124

IPC FR-4 Lead-Free Compatible Material (140 Tg):

- Reinforcement: Woven E-Glass
- Primary Resin System: Multifunctional Epoxy
- Secondary Resin System: Modified Epoxy or Non-Epoxy
- Filler: No Fillers
- Curing Agent: Not Specified
- Flame Retardant: RoHS Compliant Bromine

IPC-4101B/121

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

- Decomposition Temp: 330°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
IPC-4101B/124

IPC FR-4 Lead-Free Compatible Material (140 Tg):

- Decomposition Temp: 310°C minimum
- Z-Axis Expansion:
  - Alpha 1 60 ppm maximum
  - Alpha 2 300 ppm maximum
  - 50 to 260°C 4.0% maximum
- T260 Resistance: 30 minutes minimum
- T288 Resistance: 5 minutes minimum
- T300 Resistance: AABUS
- CAF Resistance: AABUS

IPC-4101B/101
IPC-4101B/121

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

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.

RoHS Compliant Bromine Requirement:

- 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:

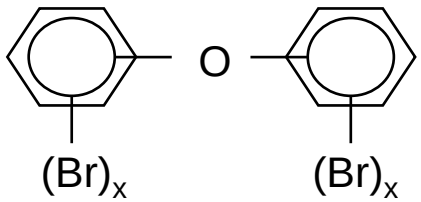
  - poly biphenyl ethers or oxides (PBDE or PBBO)
  - poly brominated biphenyls (PBB)

- Bromine containing compounds that are acceptable by RoHS include those that react to become a chemical part of the polymeric matrix.

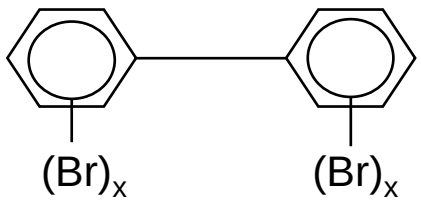
  - Tetra-Bromo-Bis-Phenol A (TBBPA)

RoHS Compliant Bromine Requirement:

These brominated flame retardants are banned by RoHS:



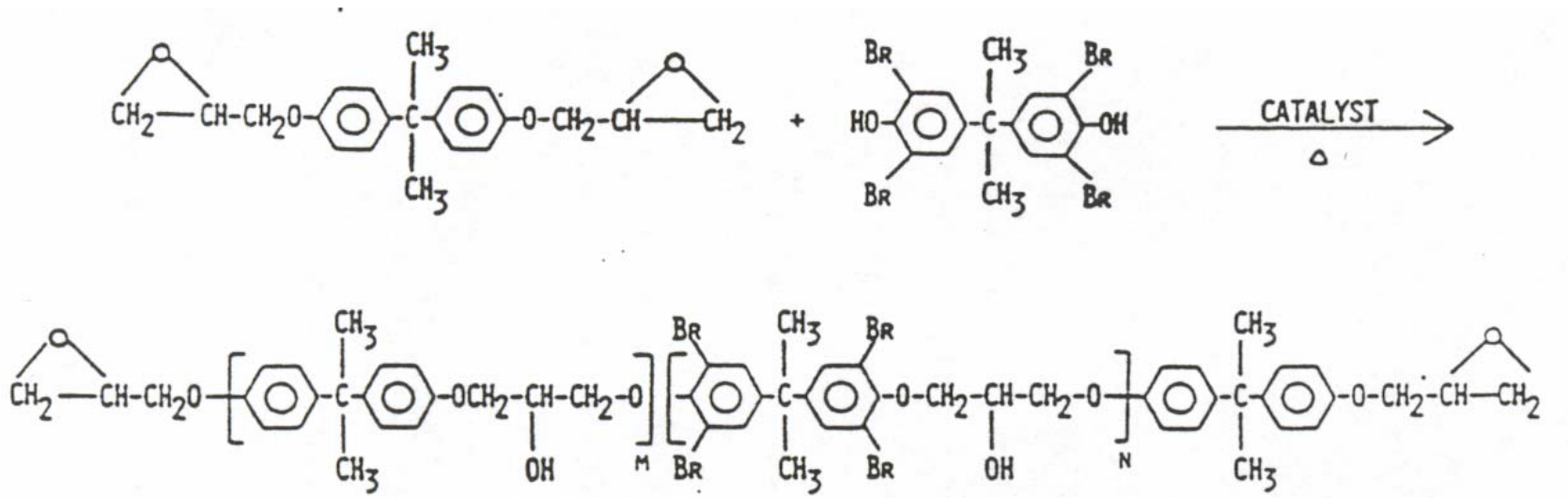
Polybrominated Biphenyl Oxide (PBBO or PBDE)



Polybrominated Biphenyl (PBB)

RoHS Compliant Bromine Requirement:

These brominated flame retardants are acceptable by RoHS:



Brominated epoxy resin for FR-4 production

RoHS Compliant Bromine Requirement:

Being RoHS compliant does not mean the base material must be halogen free. Certain brominated flame retardants including the most popular brominated flame retardant for FR-4, TBBPA, are accepted by RoHS.

IPC FR-4 Lead-Free Compatible Material:

- All specification sheets have keywords to assist searching for specific information as to composition, common applications and other pertinent performance characteristics.

- The keywords are not a requirement.

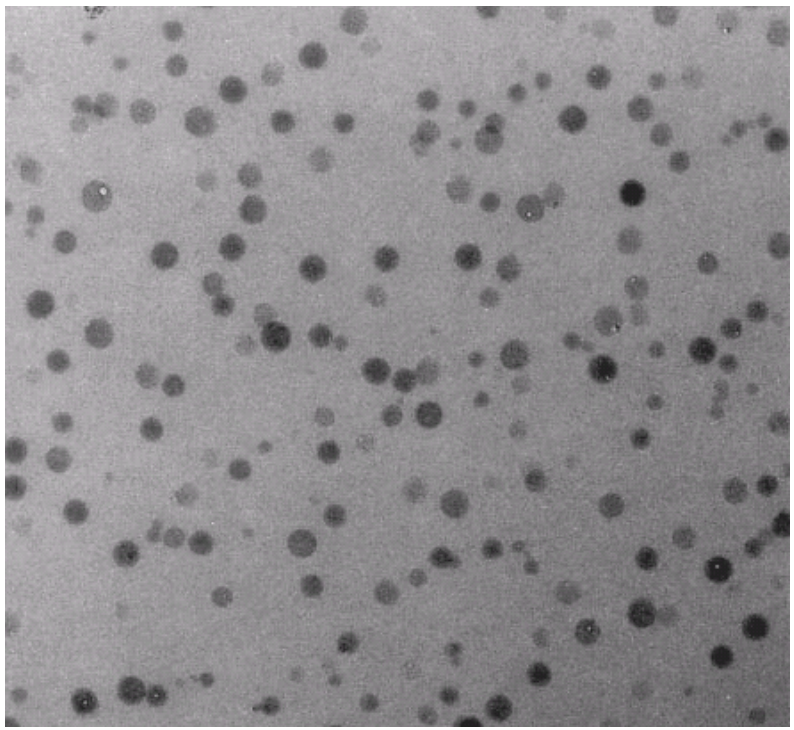
IEC Lead-Free Compatible Standards:

- **IEC 61249-2-35** Materials for interconnecting structures – Part 2: Sectional specification set for reinforced based materials, clad and unclad – Section 35: Modified epoxide woven glass fabric copper-clad sheet of defined flammability for lead-free assembly

- **IEC 61249-4-15** Materials for interconnecting structures – Part 4: Sectional specification set for prepreg materials, unclad (for the manufacture of multilayer boards) – Section 15: Multifunctional epoxide woven E-glass prepreg of defined flammability for lead-free compatible assembly

Requirements to be identical to IPC-4101B

Core Shell Rubber Toughening Agents:



- Improve Z-Axis expansion:
  - alpha 1
  - alpha 2
  - overall %
- Improve T-260 and T-288.
- peel strength.
- Do not depress the Tg.

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Halogen-Free Laminate Specifications Per IEC:

- Total Chlorine: 900 ppm maximum
- Total Bromine: 900 ppm maximum
- Total Halogens: 1500 ppm maximum
- Test Method: IEC 61189-2C12

Halogen-Free Laminate Specifications Per IEC:

- IEC 61249-2-21: FR-4 120°C minimum
  Published November 2003
- IEC 61249-2-22: FR-4 150-190°C Tg
  Published January 2005
- IEC 61249-2-23: FR-2
  Published January 2005
- IEC 61249-2-26: CEM-3
  Published January 2005

Halogen-Free Prepreg Specifications Per IEC:

- IEC 61249-4-11: FR-4 120°C minimum Tg
- IEC 61249-4-12: FR-4 150-190°C Tg

To be published in October 2005

Based on laminate sample after curing according to the supplier's instructions.

- Total Chlorine: 900 ppm maximum
- Total Bromine: 900 ppm maximum
- Total Halogens: 1500 ppm maximum

Halogen-Free RoHS:

- RoHS compliance does not mean halogen free.
- Halogen free does not mean RoHS compliant.

Halogen-Free Laminate Specifications Per IPC-4101:

- IPC-4101B/92: FR-4 110-150° Tg Phosphorus
- IPC-4101B/93: FR-4 110-150°C Tg Alumina tri-hydrate
- IPC-4101B/94: FR-4 150-200°C Tg Phosphorus
- IPC-4101B/95: FR-4 150-200°C Tg Alumina tri-hydrate

Halogen-Free Laminate Specifications Per IPC-4101:

- IPC-4101B/05: FR-2
- IPC-4101B/14: CEM-3
- IPC-4101B/57: non-woven aramid / epoxy

All have the same requirements:

- **900 ppm maximum bromine**
- **900 ppm maximum chlorine**
- **1500 ppm maximum total halogen**

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UL Re-Classification of FR-4:

- Project began in 1996.
- “What is FR-4” now?
- “What is FR-4” in the future?
- IR Scan is main criteria for new groupings.

UL Re-Classification of FR-4:

- Group 1 — Compare favorably to original IR scans for FR-4. Dicy-cured epoxy brominated resin (no fillers).
- Group 2 — Some missing peaks (dicy). Novolak cured systems.
- Group 3 — Inorganic filled systems (some additional peaks).
- Group 4 — Everything not found in Groups 1, 2, 3. Non-halogen epoxy systems. Epoxy plus secondary resins.

UL Group 1 and 2:

- 14 Reference Scans which now define FR-4:
  - Brominated Epoxy
  - Dicy or Novolak Cured
  - Woven E-glass Reinforcement
- Products from Group 1 & 2 only define references for standard FR-4.
- Testing must be conducted to demonstrate compatibility of mixed Groups. For example: Group 4 inner layers with Group 1 or 2 prepregs.

UL Re-Classification of Group 4:

- Non-Epoxy Resins (BT, cyanate ester, hydrocarbon)
- Halogen-Free Systems
- Other Unusual Additives or Components

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