



IPC-WP/TR-584B

IPC White Paper and Technical Report on the Use of Halogenated Flame Retardants in Printed Boards and Assemblies

Developed by 3-13 Halogen-Free Subcommittee

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

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1 SCOPE

This document summarizes the IPC position on the use of tetra-bromobisphenol-A (TBBPA), a halogenated flame retardant that is reacted into materials for the electronics industry.

2 PURPOSE

This paper is the follow-up to IPC-WP/TR-585, originally published in April 2003 and an “A: revision dated August 2007. The white paper contains updated content from the past two decades of industry use and research. This document was developed over a period of three years by a team representing every level of the electronics supply chain and has been reviewed, balloted and accepted. This document is applicable to materials for interconnecting electronics including but not limited to copper-clad laminates and prepregs, resin-coated copper foils, flexible materials, and solder masks. It describes the role and importance of flame retardants and TBBPA in electronics, and is intended to inform the industry about, and to help understand potential concerns from working with TBBPA. This document reflects the state of the industry as of July 2022.

3 CONCLUSION

Due to the nature of composition and function, printed boards (PBs) require ignition protection. Flame retardant materials, which prevent ignition and spread of flames should ignition occur, present a number of manufacturing challenges in terms of performance and fire safety as well as health, environmental, and regulatory issues.

Tetrabromobisphenol-A (TBBPA) is an organic molecule whose composition includes bromine and thus falls under the broad classification of halogenated flame retardants. In other applications, TBBPA may be mixed into the polymer compound, but for printed boards, TBBPA is reacted into the precursor polymer matrix, so it effectively ceases to exist as an independent molecule. Its presence in the printed board manufacturing process is thus limited to the TBBPA manufacturers themselves and the suppliers of the upstaged polymer, a limited number of suppliers and sites where unintended release to the environment can be restricted and monitored.

Even though several non-halogenated flame retardants are now available for the printed board market, all printed boards contain trace amounts of halogens inherent to the manufacturing process. The use of TBBPA in printed boards does not create additional environmental exposure while providing a cost effective flame retardant, compatible with printed board electronics, and qualified for use on a worldwide basis.

4 INTRODUCTIONS TO FIRE SAFETY AND PRINTED BOARD FLAME RETARDANTS

4.1 Fire Safety and Electronics Despite modern advances in building construction codes, fire alarms, suppression systems, and firefighting capabilities, fire-related incidents continue to take a tremendous toll on humanity. A primary focus of fire hazard and risk reduction is to decrease the seriousness of the fire itself. This can be achieved by suppressing or delaying ignition and by avoiding or delaying flashover, the point at which nearby materials spontaneously burst into flames.

Flame retardants are intended to reduce the seriousness of a fire by decreasing the probability of ignition and, if ignition occurs, limit the rate of fire growth. They are often added to products such as furnishings, building and construction materials, and electronics. The effectiveness of flame retardants in products such as upholstered furniture and clothing must be balanced with the impact of those retardants on the environment and consumer health as some jurisdictions have scaled back or eliminated flame retardant requirements in response to those concerns, or eliminated use of flame retardants in such products through regulation. [CA BUS & PROF § 19100-19104, retrieved from <https://codes.findlaw.com/ca/business-and-professions-code>] [ME REV ST Tit. 38, § 1609-A, retrieved from <https://codes.findlaw.com/me/title-38-waters-and-navigation>]

Electronics can be particularly susceptible to ignition due to potentially high heating around possible sources of ignition, examples of which are electrical sparks, battery chemicals, wire insulation and copper-clad laminates. Flame retardants have been used in such materials since the 1970s, as electronic products began expanding through consumer markets in the 1950s, and, through fire prevention practices such as flame retardants, the overall percent of fires originating in electronic equipment is low. The National Fire Protection Association reported that, out of 366,554 U.S. home structure fires from 2007-2011, 1,491 originated in entertainment equipment including televisions and radios, causing \$48 million in direct property damage and no civilian deaths. Another 732 home structure fires originated in office equipment including computers and related peripherals, causing \$28 million in direct property damage and 11 civilian deaths. These categories represent less than one percent of such fires. [Hall, J.R., “Home Structure Fires by Equipment Involved in Ignition,” NFPA, February 2013, retrieved from <https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Building-and-life-safety/oshomefiresequipmentignition.ashx?la=en>]

More recently, according to the Consumer Product Safety Commission, Samsung recalled 1.9 million Galaxy Note7 cellular phones due to “serious fire and burn hazards.” As of October 2016, the CPSC noted “Samsung has received 96 reports of batteries in Note7 phones overheating in the U.S., including 23 new reports since the September 15 recall announcement. Samsung has received 13 reports of burns and 47 reports of property damage associated with Note7 phones.” [CPSC, “Samsung Expands Recall of Galaxy Note7 Smartphones Based on Additional Incidents with Replacement Phones; Serious Fire and Burn Hazards,” October 2016, retrieved from <https://www.cpsc.gov/recalls/2017/samsung-expands-recall-of-galaxy-note7-smartphones-based-on-additional-incidents-with-replacement-phones>]

Since electronics continue to be a source of fires, effective flame retardants remain vital to mitigate ignition. When ignition does occur, flame retardants reduce the rates of heat release, substrate consumption, and generation of toxic gases or incapacitating atmosphere

4.2 Flame Retardancy in the Printed Board Industry There are four main families of flame-retardant chemistries:

- Inorganic flame retardants, including aluminum tri-hydroxide, magnesium hydroxide, ammonium polyphosphate, and red phosphorus
- Halogenated flame retardants, based on bromine
- Organophosphorus flame retardants, primarily phosphate esters
- Nitrogen-based organic flame retardants, which are used for a limited number of polymers

Depending on their nature, flame retardants can act chemically and/or physically in the solid or gas phase to reduce the likelihood and/or intensity of a fire by interfering with combustion during a particular stage – heating, decomposition, ignition, or flame spread. Furthermore, it is important to note that substituting one type of flame retardant for another consequently means a change in the mechanisms of flame retardancy.

There are eight ANSI laminate classifications that require flame retardancy:

FR-1: Phenolic resin/paper, general purpose

FR-2: Phenolic resin/paper, higher quality, tested for electrical properties

FR-3: Epoxy resin/paper

FR-4: Epoxy resin/glass cloth, higher peel strength

FR-5: Epoxy resin/glass cloth, higher heat resistance

FR-6: Polyester resin/glass cloth

CEM-1: Epoxy resin/glass cloth/cellulose core

CEM-3: Epoxy resin/glass cloth/glass fiber core

All the above must pass NEMA LI-1, Flammability Classification 1, except the CEM grades that must pass classification 0. Classification 1 is essentially equal to UL 94 V-1; classification 0 is equal to V-0. In practice however, almost all applications require materials rated for UL 94 V-0, so almost every material on the market meets this rating regardless of resin type or construction.

In addition to UL’s general standards for devices and appliances, some industries, such as aerospace, have requirements for electronics flammability from industry-specific regulation. [UL 94 rev 6, 2013, retrieved from https://standardscatalog.ul.com/standards/en/standard_94] [Airworthiness standards, U.S. code of federal regulations, retrieved from <https://www.ecfr.gov/current/title-14/section-23.2325>]

UL 94 ratings can be and also have been granted to a variety of other laminate materials on a specific product or product category basis not covered by the above grades.

5 TBBPA AND OTHER HALOGEN-CONTAINING COMPOUNDS IN PRINTED BOARDS

5.1 Flame Retardants Used in Printed Boards

5.1.1 Tetrabromobisphenol A (TBBPA) TBBPA is the most common halogenated flame retardant used in the printed board industry.