Environmental Challenges and Materials Restrictions in Coated Wire and Cable

Elizabeth Harriman, Toxics Use Reduction Institute
Timothy Greiner, Greiner Environmental, Inc.
Vesela Veleva, Greiner Environmental, Inc.

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Introduction

The Toxics Use Reduction Institute at UMASS Lowell began the Wire and Cable Supply Chain Initiative in early 2001. Participants included businesses throughout the entire supply-chain – compounders, additive suppliers, extruders, OEMs, and recyclers. The goal was to look at different alternatives to lead, brominated flame retardants and other chemicals of concern used in the manufacturing of coated wire and cable. The first supply chain meeting was held in June 2001 and the participants expressed a strong interest in maintaining the dialogue and meeting periodically to get an update on legislative issues and the development of alternatives. Three more meetings have been conducted since then and a background technical report was developed[1]. In addition, TURI has sponsored research on alternatives at the Institute for Plastics Innovations, UMASS Lowell.

This paper presents some of the key materials restrictions and challenges related to flame retardants and environmental health and safety – a part of TURI's effort to help Massachusetts manufacturers comply with regulations and customer requirements in the US and abroad. Information is drawn from background research and a recent supply-chain meeting on flame retardants and fire safety, held in June 2003 in Boxborough, Massachusetts.

Flame Retardants

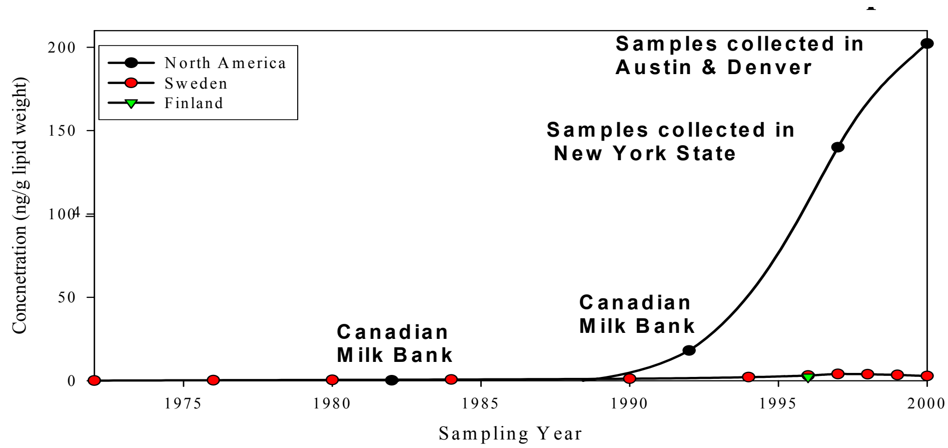
Flame-retardant substances are used in wire and cable coatings and other applications to slow the spread of an accidental fire and reduce the amount of heat and smoke released. One of the key properties of flame-retardants is to be self-extinguishing once the source of ignition has been removed. The three primary classes of flame-retardants are halogenated compounds, inorganic compounds (including antimony), and phosphorous compounds. Chemically acting flame-retardants (such as the halogenated bromine and chlorine systems) are very effective. Physically acting inorganic flame-retardants based on metal hydroxides and salts have a weaker effect. The performance of primary flame-retardants such as chlorine and bromine is enhanced by additives such as antimony other metal salts.

Environmental, Health and Safety Issues

Like all additives, flame-retardants are environmentally relevant, because they and their converted forms and decomposition products can be released into the environment during manufacturing, incorporation into polymers, and during the entire lifecycle of flame-retarded products. The discovery of toxicological and eco-toxicological characteristics of some flame-retardants and their decomposition products has been accompanied by studies demonstrating the growing accumulation in the environment of certain flame retardants - in sediments, water, indoor air, biota and humans[2]. For example, concentrations of polybrominated diphenyl ethers (PBDEs) in breast milk have risen dramatically since the early 1990's in the U.S (see Figure 1). Many studies have shown exponential increases in the amount of penta bromodiphenyl ether (penta-BDE) in mammalian tissue and milk, particularly in North America. Penta BDE, the most toxic and bioaccumulative in the family of

PBDEs, is used primarily in the US by the upholstered furniture industry. Because of emerging information on toxicity and the alarming evidence of persistence and bioaccumulation a growing number of legislative and voluntary actions worldwide have targeted their phase-out.

Figure 1. Comparison Between Concentrations of PBDEs in Breast Milk from North America and Europe[1]



Canadian Milk Bank and New York State from Ryan and Patry 2000, Denver and Austin results from Papke et al 2001; Swedish data from Meironyte Guvernius and Noren 2001, Finnish data from Strandman et al. 2000

The flame retardants under most pressure for restrictions and phase-out currently include: Pentabromodiphenyl ether (PentaBDE), Octabromodiphenyl ether (OctaBDE), Decabromodiphenyl ether (DecaBDE), Polybrominated Biphenyl Ethers (PBBs), antimony trioxide, and, in some instances, all brominated and halogenated flame-retardants.

- **PentaBDE –** is the main flame retardant used in polyurethane foam and furniture. It is highly toxic, persistent, and bioaccumulative and has been banned by the European Union as of 2005.
- **OctaBDE** is used in small amounts in wire and cable and other products and was banned by the EU as of August 2005, because of its high potential for bioaccumulation in the environment and humans.
- **DecaBDE, which is fully brominated,** by itself does not pose significant environmental and health hazards. The concerns over this widely used flame retardant include the possibility for debromination (degradation to lower congeners of BDEs, such as penta), formation of dioxins and furans in fires, processing and end-of-life handling, as well as its neurological effects and persistence. Additional studies are underway to clarify these uncertainties.
- **PBBs** are highly toxic, persistent and bioaccumulative chemicals that are no longer manufactured in the United States or Europe.
- **Antimony trioxide** is on the EPA's Toxics Release Inventory list and is classified by the International Agency for Research on Cancer (IARC) is a probable carcinogen. A European Union risk assessment is currently underway to bring more clarity on its environmental, health and safety (EHS) impacts.

[1] Source: Presentation by Tom A. McDonald, M.P.H., Ph.D. OEHHA, California EPA *Penta-BDE in Humans and the Environment*. at Brominated Flame Retardants and Foam Furniture Conference and Roundtable, April 29, 2003 (http://www.greenstart.org/efc9/bfrs/ppt/april03_conf/03_ephrp.ppt)

- Some OEMs and other organizations have targeted all **brominated and halogenated flame retardants**, arguing that these lead to the formation of dioxins and furans in accidental fires and end-of-life treatment.

National and International Action on Flame Retardants
This section summarizes some of the key initiatives worldwide related to fire safety, flame retardants and EHS:

- **European Electronics regulations:** The European Union (EU) Waste Electrical and Electronic Equipment Directive (WEEE) aims at promoting greater recycling of electronic equipment in the European Union and requires separation of some materials and chemicals at the end of the products' useful life. Brominated flame retardants fall under this category and manufacturers will be charged a fee both at the point of sale and at the point of collection of waste products, in order to cover the cost of separation and recycling. The companion EU Restriction of Hazardous Substances Directive (RoHS), which became law in early 2003, requires substitution PBBs and PBDEs. PBBs have not been manufactured in the United States since the 1970s. All PBDEs are currently scheduled for phase out in the Directive. EU risk assessments on PentaBDE and OctaBDE have been completed and have confirmed the need for phase-out beginning in August 2005. The EU will consider whether to grant an exemption for DecaBDE. when the results of its final risk assessment are available.

- **European Union End-of-Life Vehicle Directive (ELV):** The EU passed the ELV Directive in 2000. The Directive covers vehicles and their components and materials. It limits the use of hazardous substances in order to prevent release in the environment and promote safe recycling. Although the Directive restricts only a small number of chemicals, such as lead, mercury, cadmium, and hexavalent chromium, many automobile manufacturers now require that suppliers complete "materials declarations" covering a long list of substances of concern that may be present in their products. Antimony, for example, appears often on these lists. Lead is a common contaminant of antimony in the range of about 100 ppm (above the Directive's threshold level of 50 ppm) and wire and cable companies may have difficulty certifying their products as lead-free when using antimony trioxide.

- **Japanese and Chinese initiatives:** Japanese companies have agreed voluntarily to phase-out all PBBs and PBDEs except OctaBDE and DecaBDE. This includes both manufacturing and import of products. China recently drafted a legislation to eliminate certain chemical substances in electronic products. The proposed law is very similar to the EU RoHS Directive and if passed, will ban the use of all PBBs and PBDEs.

- **U.S. focus on BFRs:** Several initiatives in the United States have targeted certain flame retardants. DecaBDE and antimony are on the Toxics Release Inventory (TRI) list. PentaBDE, OctaBDE and DecaBDE are being examined under the Voluntary Children's Chemical Evaluation Program (VCCEP). All major flame retardants fall under the EPA's High Production Volume (HPV) Program, which challenged the chemical industry to make basic hazard data available on 2,800 chemicals used at or above 1 million pounds per year. A recently proposed California Assembly Bill 302 aims to regulate PBDEs. The bill was passed by the CA Assembly in May 2003 and is expected to be approved by the Senate. As amended, it would ban the use of PentaBDE and OctaBDE in 2008.

- **OEM requirements**: A growing number of OEMs, particularly in the electronics and automobile industries, are introducing supplier materials declarations, which include long lists of restricted chemicals. Some of the OEMs such as the High Packaging User Group (Dell, HP, IBM, and Nokia) are even conducting tests to verify supplier compliance.

- **Market forces for green labeling and take-back:** Several European Eco-labels, such as the German Blue Angel and the Nordic Swan, prohibit the use of certain brominated flame retardants. In addition, some government and other groups (e.g., Silicon Valley Toxics Coalition) promote purchasing of products free of certain flame retardant substances.

In response to these various actions, a growing number of "green" products are becoming available that use alternatives to the restricted substances. Alternatives include metal hydroxides, zinc borate, glass-reinforced PET, ammonium polyphosphate, phosphorous-based flame retardants, and new innovative materials. .

Flame Retardants in Coated Wire and Cable

The use of flame retardant materials for many wire and cable applications is critical to assuring adequate fire safety. With the rapidly growing cabling of offices and homes the use of flame retardants in wire and cable has also increased significantly.

The primary fire retardants used in coated wire and cable include:

- Alumina trihydrate (ATH)
- Antimony trioxide
- Brominated phthalate ester - in PVC plenum cable
- Decabromodiphenyl ether (DecaBDE)
- Ethane 1,2 bis (pentabromophenyl) (EBT or Saytex® 8010)
- Ethylene 1,2 bis (tetrabromophthalimide) (EBTBP or Saytex® BT-93)
- Magnesium hydroxide
- Zinc borate

As stated earlier, DecaBDE and antimony trioxide have been under increasing scrutiny. Antimony trioxide is used as a synergist with other halogens, particularly in PVC resins.

US and EU Fire Safety Standards for Wire and Cable

Fire safety requirements in the United States are outlined in the U.S. National Electrical Code (NEC). NEC does not specify which materials must be used in wire and cable construction. It only specifies the wire or cable's performance.

The most severe test a cable construction must pass to meet the National Electrical Code is the UL 910 – also referred to as Steiner Tunnel Test. A recent report by NFPA revealed that there is a significant accumulation of sizable fire load in the plenum. Communications cables are the single largest contributor to plenum fire load due to the proliferation of telecommunication and computer networks. To address this problem the 2002 amendment of the NEC (NFPA 70) for the first time requires the removal of abandoned communications cable from the plenum space.

The U.S. NEC differs from the electrical code in other countries. One of the principle differences is the flame retardancy standard in the U.S. and the European Union. Generally, the United States has more stringent flammability requirements, which is in part due to the different construction practices (in Europe plenum cables are rarely used). For plenum applications there are few resin formulations other than those based on fluoropolymers and PVC that can meet the performance standards. Thus products that meet fire protection requirements in Europe may not meet the stricter US standards. For example, the European market for data and communications cable is dominated by nonhalogenated compounds consisting of polyolefin resin (typically polyethylene or its major copolymers) and such flame retardants as aluminum trihydrate and magnesium hydroxide. These materials pass the JEC 60332 test for riser cable, which is the most stringent fire test mandated in Europe, but not the NFPA plenum cable test.

The different fire safety requirements and construction practices in the U.S. and Europe have led to considerable controversy and confusion in the last few years. For example, there were concerns in the U.S. that EU efforts to restrict flame-retardants would result in adoption of less stringent fire safety standards in the U.S. or the prohibition of these materials in the U.S. without adequate replacements to ensure wire and cable products would meet U.S. standards. Neither of these scenarios is likely. Instead, there have been significant advances at the international level to encourage the development and global market acceptance of products meeting the highest possible standards for human health, fire safety, and environment (see http://clean-and-safe.org).

Key Challenges Facing the Wire and Cable Industry

Pressed between the growing materials restrictions, OEM demands and cost barriers, the wire and cable industry is facing many challenges today. Key challenges include:

- **Identifying "acceptable" substitutes**: How do companies know which chemicals will be restricted and which will not in the presence of scientific and regulatory uncertainty? What are the national and international actions to restrict FRs? TURI's work has been instrumental in keeping Massachusetts industry informed about the recent legislative changes and available substitutes.
- **Testing for restricted substances**: Testing for DecaBDE and other BFRs is difficult and expensive. Another challenge is lead. Lead is a naturally occurring substance in antimony and is present at about 100 ppm. One key issue for industry is how to measure and certify its presence (or lack of it) in products.
- **Fulfilling materials declarations**: OEMs today have different and constantly changing requirements. In some cases one OEM can have different specifications for different products. There is a need to harmonize the various OEM supplier declarations. The automobile manufacturers' effort to develop a common reporting system is a step in this direction.
- **Market split**: There is a major market split today – Europe is demanding zero-halogen products, while the strong fire safety requirements in US push for the use of BFRs and halogenated resins. This is a major challenge for the wire and cable industry operating in a global economy.

Meeting Human Health, Fire Safety, and Environmental Requirements

Our research, which has included a literature review, numerous industry meetings, and discussions with industry experts, points to three main approaches for meeting the highest standards for human health, fire safety and environmental protection.

- **Switching to materials that do not require flame retardant additives**: For example, Fluoropolymers such as Teflon are inherently flame-retardant and can meet even the most stringent fire safety standards, such as the Steiner Tunnel test. FEPs are accepted in the EU, can be easily recycled and can be used in any wire and cable application. Their disadvantages include the high cost and the presence of halogens.

- **Using other processes to ensure flame retardence**: For example, cross-linking of polymers such as polyethylene (XLPE) allows avoiding the use of BFRs. The resulting polymer, however, is not recyclable.

- **Substituting DecaBDE and other BFRs with environmentally safer alternatives:** Using metal salts, such as alumina trihydrate, ammonium polyphosphate, magnesium hydroxide, and zinc borate, can reduce the EHS impacts of coated wire and cable applications but can compromise electrical properties. Such alternatives may be used in some applications but not in cases where high flame retardancy is required (e.g., in plenum applications).

Conclusion

Addressing the environmental, health and safety issues of flame retardants while maintaining high fire safety performance is not a simple and straightforward process. Some of the key barriers are the cost of alternatives, electrical performance and processability. A one size-fits-all approach is currently not feasible, therefore different solutions will have to be sought for different applications. The process of developing and using alternatives to PBDEs and other halogenated FRs has already begun, spurred by European legislative changes and customer demands. Several Massachusetts companies have reported success and are poised to fill these emerging market niches. TURI will continue to be actively involved in facilitating these changes, by maintaining a dialogue with all parts of the supply chain, providing information and supporting research on safer alternatives. These activities will keep Massachusetts companies competitive in the global economy while reducing the use of toxic chemicals.

REFERENCES:

1. Greiner Environmental, Inc, "Environmental, Health and Safety Issues in the Coated Wire and Cable Industry", Technical Report 51, Toxics Use Reduction Institute, May 2002, website: http://www.turi.org/publications/institute_pub.htm
2. McDonald, T., "A perspective on the potential health risks of PBDEs", *Chemosphere,* Volume 46, 2002, pp. 755-755.