An introduction to Brominated Flame Retardants

19 October 2000

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1. Brominated Flame Retardants

Executive Summary:

- Bromine is a natural element widely found in nature, principally in seawater, salt lakes and earth stone.
- The major areas of bromine production are Israel, Jordan, the United States, China, UK, France and Japan.
- Flame retardants (FRs) are chemicals, which added to materials during or after manufacture, inhibit or even suppress the combustion process.
- FRs cover a number of different « families » such as: brominated flame retardants, chlorinated flame retardants, phosphorous-containing flame retardants, nitrogen-containing flame retardants, inorganic flame retardants.

Description of Bromine

Bromine was identified as a chemical element in 1826, by the French chemist Antoine Balard. Bromine is a naturally occurring element widely found in nature, principally in seawater, salt lakes, inland seas and earth crust. Bromine is prevalent in the environment in combination with other organic and inorganic elements, known as bromides.

Organic bromine and bromides are naturally formed in plants, edible food, and animal tissues including human blood. Brominated phenols and diphenyl oxides (ethers) are produced by some sponges and marine bacteria. The major source of dietary bromide is table salt.

The major areas of bromine production in the world are from the Dead Sea in Israel and Jordan, from salt brines found in the United States and China, and from ocean water in UK, France and Japan.

Today, 470 thousand tones of bromine are produced annually, used in water purification (treatment in swimming pools), agriculture (pesticides, fumigants), cars (batteries for electric cars), healthcare (analgesics, sedatives, antihistamines), photography (black and white film). However, the largest use - and most important life safety benefit - of bromine is in flame retardants.

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Function of a flame retardant

Flame retardants (FRs) are chemicals, which added to materials (e.g. printed circuit board resins) during or after manufacture, inhibit or even suppress the combustion process.

They interfere with combustion at various stages of the process, e.g. during heating, decomposition, ignition or flame spread. They prevent the spread of fires or delay the time of flashover so that people can escape.

The use of flame retardants in the manufacture of electronic equipment, upholstered furniture, construction materials and textiles has been shown to save many lives from fire.

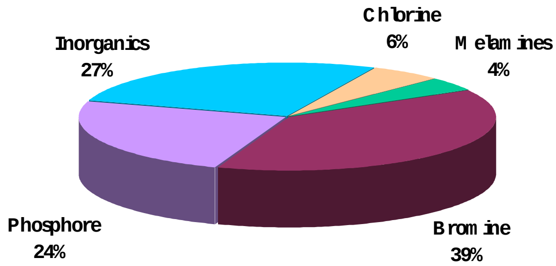
Different types of flame retardants

There are a number of different "families" of flame retardants:

- Brominated flame retardants
- Chlorinated flame retardants
- Phosphorous-containing flame retardants
- Nitrogen-containing flame retardants (i.e. Melamines)
- Inorganic flame retardants.

The choice of a given flame retardant frequently depends on the type of application. Their suitability is subject to variables such as the material to be flame-retarded, the fire safety standards with which the product must comply, cost considerations and recyclability.

FR WORLDWIDE MARKET
2,200 MM$ IN 1998



Source: Townsend-Tarnell

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Halogenated flame retardants

Bromine, chlorine, fluorine and iodine, are the elements in the chemical group known as halogens. The word halogen derives from Greek, meaning ‘salt-former’, because these elements are commonly found in nature reacted with metals to form salts. For example, sodium chloride, or table salt, is the most common example of a halogen salt.

Fluorine and iodine based flame retardants are not used in practice because neither type interferes with the combustion process: Fluorine has too strong bond and iodine too loose bond to carbon.

Chlorinated flame retardants are mainly used in plastics. They offer good light stability but compared to brominated flame retardants, higher quantities are needed for achieving comparable flame retardancy.

Brominated flame retardants are often the most effective flame retardant when both performance and cost are considered.

Different types of Brominated Flame Retardants (BFRs)

TBBPA:		Tetrabromobisphenol -A
HBCD:		Hexabromocyclododecane
Deca-BDE (Decabromodiphenyl ether) Octa-BDE (Octabromodiphenyl ether) Penta-BDE (Pentabromodiphenyl ether)	PBDEs:	Polybrominated diphenyl ethers
PBB:		Polybrominated biphenyls

Each of these Brominated Flame Retardants has very different properties and should not consequently be assimilated when referred to.

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How do BFRs work

In addition to reducing the likelihood that an item will ignite, flame retardants hinder the spread of the fire, and provide valuable extra time in the early stages of a fire when it is much easier to escape. A room fire can very quickly escalate to the point where enough heat is generated that all combustible material in the room bursts into flames. This situation is known as "flash-over" and can occur in a matter of minutes from ignition. Flame retardants slow down the initial burn rate and thereby can help increase the time to flash-over, giving the occupant more time to escape.

<u>For Further explanation:</u>

a. on the different types of flame retardants, see the article "Overview of Flame Retardants" by Dr. Jürgen Troitzsch, published in the January-February 1998 edition of Chimica Oggi/Chemistry Today.

b. P. Hedemalm et al., “Brominated Flame Retardants, a global status report”, Orango AB, March 2000

c. on the sources of Bromine, see "The Natural Production of Organobromine Compounds" Department of Chemistry, by Dr. Gordon W. Gribble, Dartmouth College, Hanover, New Hampshire, 03755 USA, June 1999.

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2. Uses of Brominated Flame Retardants

Executive Summary:

- During the twentieth century, new materials such as plastics for appliances and polyurethane foam / fiber-based fillings for furniture, began to replace traditional materials such as wood and metal.

- The development of flame retardants allowed a safe use of these flammable materials by minimizing the chances of ignition and the rate of combustion, consequently saving lives from fire.

- Compared to other alternative solutions, bromine is the most effective, as it requires a lower quantity of flame retardant for the highest fire resistance.

- Alternative flame retardants are less effective in terms of production costs, fire safety and less well understood as for the environmental impact than less recyclable brominated flame retardants.

- 2.5% of all E&E plastics contain BFRs.

- E&E all equipment accounts for 56% of the BFRs market.

- Nearly two thirds (59%) of the E&E industry's BFR consumption is destined for housings; printed wiring boards account for 30%; connectors & relays for 9% and wire & cabling for 2%.

- Consumption of BFRs in Western Europe accounts for 15% of worldwide consumption, evaluated from 205 to 265 kt.

- TBBPA represents half of BFR volumes and is contained in 96% of printed wiring boards.

Purposes

During the twentieth century, manufacturers of furniture and appliances began to replace traditional materials such as wood and metal by new materials such as plastics for electronic appliances and polyurethane foam and fibre-based fillings for furniture. While these new materials provided many benefits, they were unfortunately more flammable, and once alight, combusting more rapidly, then giving people less time to escape.

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The development of flame retardants allowed a safe use of these materials by minimizing the chances of ignition and the rate of combustion. The use of flame retardants in the manufacture of electronic equipment, upholstered furniture and textiles has been shown to save 1 000 lives from fire.

European Plastics Convertors (EuPC) stated that "Halogenated flame retardants…are the most efficient category of flame retardants because they act chemically and because they interfere at the gas phase of the combustion process. Their use is indispensable to meet very high fire safety standards. (…) These different types of brominated flame retardants are needed to meet different technical and standard requirements".

Alternative solutions

In order to achieve the same level of fire protection, higher quantities of other flame retardants (chlorinated, phosphorous, nitrogen, inorganic) need to be used compared to brominated flame retardants.

Not only does this place a more important potential burden on the environment (in terms of an increased level of plastic additive manufactured and transported), but costs are also often enhanced.

Brominated flame retardants provide a unique combination of efficacy, in that they allow a plastic resin to retain its durability and performance characteristics, while imparting flame retardancy at a reasonable cost.

In certain plastic resins like HIPS, ABS, and PBT, there are currently no cost-effective alternative flame retardants which can provide good flame retardancy and good mechanical properties.

By comparison to alternative flame retardants, the toxicology and environmental effects of brominated flame retardants are relatively well understood, following their detailed study in the last 10 years.

Some plastics, notably PVC, do not require the addition of flame retardants due to their inherent fire-resistant properties. However, fire safety is just one criterion in the choice of a plastic for a given application. Thus, plastics requiring the use of brominated flame retardants, may, in many cases, be the preferred option, taking into account requirements such as product performance, recyclability, appearance, strength and stability.

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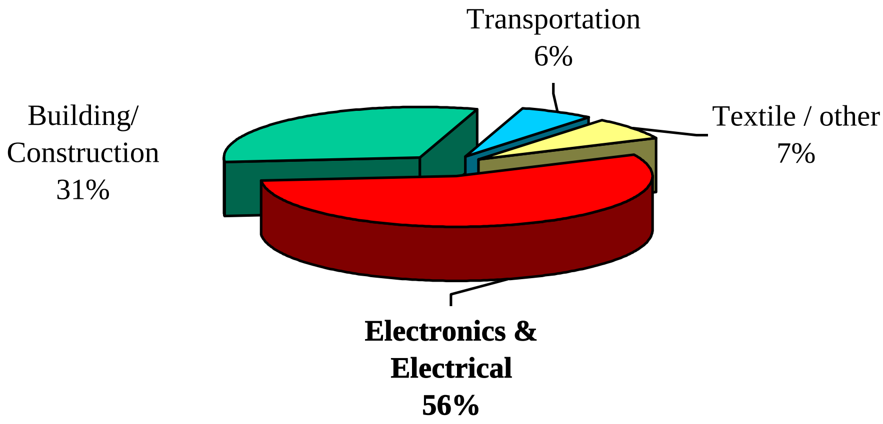
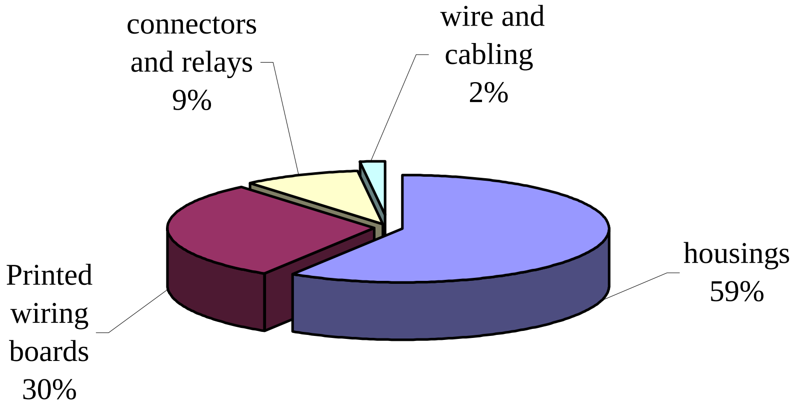
Applications

BFR Consumption by Final Applications



E&E Components using BFRs



Source: BSEF internal information

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Main Uses of BFRs in E&E

TBBPA	Mainly printed circuit boards such as PCs. Also in plastic housings (e.g. office equipment)
Deca-BDE	Mainly in plastic housings and smaller components (e.g. PC, office equipment)
Octa-BDE	Mainly in plastic housings and smaller components (e.g. office equipment)

Source: BSEF internal information

Volumes

Major Brominated Flame Retardants Volume Estimates
Total Market Demand By Region in 1999

[MT]	Europe	Americas	Asia	Total
TBBPA	13,800	21,600	85,900	121,300
HBCD	8,900	3,100	3,900	15,900
Deca-BDE	7,500	24,300	23,000	54,800
Octa-BDE	450	1,375	2,000	3,825
Penta-BDE	210	8,290	--	8,500
Total	30,860	58,665	114,800	204,325
	15.1%	28.7%	56.2%	100%

Source: Bromine Science and Environmental Forum, July 2000

BFRs Volume by E&E application

	UK(t.)	Rest of Europe (t.)	Europe Total (t.)
Totals for BFRs in TVs	350+	2450+	2800
Totals for BFRs in Business machines	85+	460+	545+
Totals for BFRs in other consumer E & E products	85+	460+	545+
Total	410	3370+	3890+

Source: "Risks and Benefits of the Use of Flame Retardants in Consumer Products; a report for the Department of Trade and Industry - Consumer Safety Unit", University of Surrey, UK, January 1999

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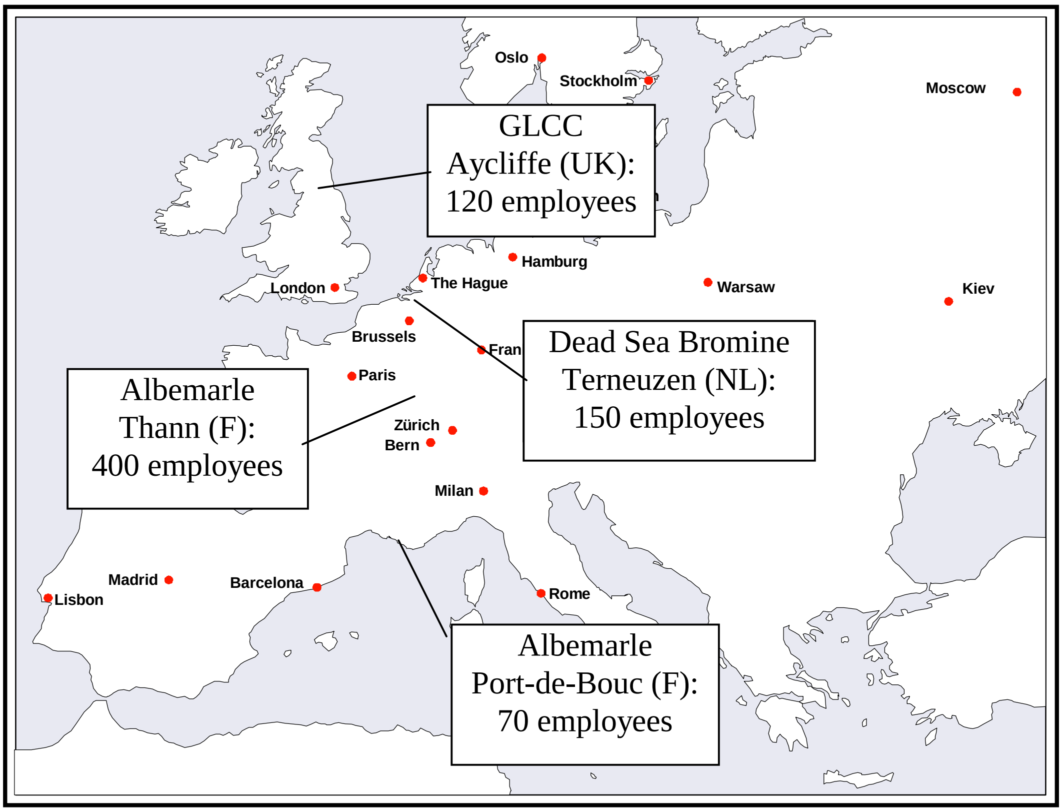
BFRs manufacturing plants in Europe



<u>For Further explanation:</u>

a. Stevens; G.C. and Mann, A.H., "Risks and Benefits of the Use of Flame Retardants in Consumer Products; a report for the Department of Trade and Industry - Consumer Safety Unit", Polymer Research Centre, School of Physical Sciences and School of Biological Sciences, University of Surrey, UK, January 1999

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3. Fire Safety of Electrical & Electronic Equipment

Executive Summary:

- Fire prevention is essential from a number of perspectives: protection of life, protection of property and protection of the environment, through prevention of immediate local pollution to air and water not to speak of the lesser-known long-term effects.

- Brominated flame retardants have saved thousands of lives. The Commission itself has gone on record that, in the last 10 years, a 20% reduction in fire deaths is a result of the use of flame retardants[1]. We are not aware of any case of a brominated flame retardant costing a life.

- The TV set industry moved in the early 1990s to stop using any flame retardant in the plastic housings of its appliances for the European market. This has increased TV sets fires in Europe, with resultant deaths and injuries. US and Asian consumers are preserved from the risk of TV set fires by the TV set industry's decision to maintain use of primarily the brominated FR, Deca-BDE in its housings for the markets.

Standards

Fire safety should not be an option for E&E equipment. Electricity is a fire hazard. Time and again fire statistics demonstrate that one of the primary root causes of fire is electrical. In particular, the benefits of using plastics in E&E appliances come hand in hand with the need to manage the risk of fire. Plastics are after all hydrocarbons with a high energy content which can help fuel a fire. Their increased use in E&E appliances over the years has only been possible by the parallel development and application of flame retardants.

Fires can result from faulty product design but are often the result of misuse or abuse of the appliance. Educating the consumer to remove the dust from the appliance backplate, not to places candles or smoking materials on the appliance, or to avoid carrying out do-it-yourself repairs is a long-term process. At the same time, certain E&E appliance design and use trends work against fire safety. For example, appliances are often left unattended and are increasingly designed to be permanently switched on. Efforts to prevent ignition through the use of flame-retarded materials therefore represent an essential pillar in any integrated fire safety strategy for the E&E industry.

[1] "Flame retardants", DG Environment, European Commission, 21 April 2000 (Video)

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We may all be aware of the regular reports of television set fires in local newspapers throughout Europe. However, the increasing trend for television set fires has yet to be widely appreciated. Published evidence of increasing fires in Europe in television sets emphasises the need for caution when regulators and the E&E industry approach issues directly related to E&E appliance fire safety.

The increasing incidence of television set fires appears to be linked to the television set industry's decision back in the early 1990s no longer to apply the higher UL 94 V-0 fire safety level for housings and backplates and to only use the low UL 94 HB fire safety level specified in standard IEC 65. By contrast, outside Europe, the same television set manufacturers ensure the supply of UL 94 V-0 compliant materials only.

By contrast, some E&E manufacturers adopt a 'precautionary approach' to fire safety in that they specify more than the minimum fire safety level in their material specifications. This is the case with IBM, which specifies compliance with UL 5VA, the most stringent of the UL vertical burning tests, for certain internal electronic parts. Following extensive testing, IBM has concluded that "the only formulation that meets flammability class 5VA requirements is one that is compounded with brominated fire retardants".

BFRs prevent fires from occurring but even when the fire source is intense enough to make fire ignition inevitable, they help slow down fire spread and dramatically increase the crucial parameter in population fire safety, escape time.

For some polymers widely used in E&E applications (e.g. High Impact Polystyrene – HIPS), BFRs represent the only way in which the basic fire safety level set by UL 94 V-0 can be met while maintaining the necessary polymer properties such as strength and recyclability.

In summary, restrictions on brominated flame retardants would discourage Original Equipment Manufacturers (OEMs) from specifying ever-greater fire safety for the following reasons:

- OEMs would rely on minimum fire safety standards, which are sometimes inadequate and based on a lowest common denominator approach;

- Some materials would no longer be able to be used for E&E applications without reducing fire safety levels;

- OEMs would not be able to specify the highest fire safety standards.

This minimalist approach to fire safety goes in the opposite direction of the precautionary approach which many OEMs currently implement.

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Statistics

UK and EU Use of FRs in E&E applications in 1999

TVs	Main FR used	UK (tonnes)	Rest of Europe (tonnes)	Europe Total (tonnes)
Backcasings	• Mainly brominated (DBDPEs, TBBPA) • Antimony trioxide • Other phosphate esters, triphenyl phosphates, chlorinated phosphates, melamine cyanide800	300+ 100 100	2100+ 700 700	2400 800 800
Printed circuit boards	• Brominated FRs (TBBPA) • Antimony trioxide • Halogen free phosphorous based FRs, red phosphorous, chlorinated FRs, magnesium or aluminium hydroxide	50 10 5	350 70 15	400 80 20
Total TV		565	3935	4500

Business machines in the home	Main FR used	UK (tonnes)	Rest of Europe (tonnes)	Europe Total (tonnes)
PC monitors casings, internal components PCs, printers, fax machines, copiers	• Brominated (TBBPA) • Antimony trioxide • Phosphate esters • Aromatic phosphorus FRs	85+ 15 <25 <25	460+ 90 <50 <50	545+ 105 <75 <75

Other consumer E & E products	Main FR used	UK (tonnes)	Rest of Europe (tonnes)	Europe Total (t.)
Vacuum cleaners, coffee machines, printed circuit boards, plugs, sockets	• Mainly brominated FRs • Antimony trioxide • Other phosphate esters, aromatic phosphorus based FRs, red phosphorus, chlorinated FRs, magnesium/aluminium hydroxide	85+ 15 <15	460+ 90 <75	545+ 105 <100

Source: "Risks and Benefits of the Use of Flame Retardants in Consumer Products; a report for the Department of Trade and Industry - Consumer Safety Unit", University of Surrey, UK, January 1999

For Further explanation:

"Fire safety concerns play key role in the material selection process" by Dr Inder Wadehra, IBM Corporation, MPI Handbook, 1999

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4. Political & regulatory aspects of BFRs

Executive Summary:

- The EU risk assessment process will be finalised after completion of the latest studies in early 2001 for Deca-BDE and Octa-BDE. Preliminary conclusions (August 1999) found no reason for risk reduction measures to be involved for these flame retardants [2].

- The only one PBB flame retardant in use has ceased production in May 2000.

- Penta-BDE is expected to be probably phased-out by the European Commission before end 2003.

- The European Commission has proposed on June 2000 two draft Directives: the first one on Waste Electrical & Electronic Equipment (WEEE) which main objective is to shift the responsibility for the collection, recycling and re-use of end-of-life E&E products onto E&E producers; The second directive proposal on the restriction of substances (ROS) contains a list of substances proposed to be phased out of use in the production of E&E equipment by the year 2004.

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- The Commission has informed EBFRIP that eco-label systems, such as "German Blue Angel", excluding the use of certain BFRs, are a voluntary certification without any obligation on producers or providers to join it.

- In 1995, the brominated flame retardants industry entered into a Voluntary Industry Commitment (VIC) with OECD. The brominated flame retardants included in the VIC are the polybrominated biphenyls (PBBs) & the polybrominated diphenyl ethers (PBDEs).

EU Risk assessments

The EU risk assessment process was designed to provide the regulator with a scientific process by which to assess the need for risk reduction measures concerning individual chemical substances. Being science-based, it takes time to amass and analyse the scientific data. It is therefore fortunate that the WEEE & ROS Directives come at a time when one of the major groups of BFRs – the 3 PBDEs flame retardants – is soon to be the subject of finalised conclusions under the EU risk assessment process. While finalised conclusions are expected beginning 2001, preliminary conclusions indicate that there is no need for risk reduction measures as concerns the main PBDEs used in E&E applications: Octa-BDE and, in particular, Deca-BDE.

[2] Risk assessment of bis(pentabromophenyl)ether (decabromodiphenyl ether), Final Draft, August 1999

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The EU risk assessment of the 3 PBDEs represents the most comprehensive assessment of these products and takes into account all scientific data submitted up to 15 April 1999. Thus concerns related primarily to the presence of two PBDEs (Tetra-BDE and Penta-BDE) in the environment and in biota have been taken into account, and Penta-BDE shall be subject to a phase-out[3] as a result of the widespread presence of its constituents in the marine environment

Waste Electrical and Electronic Equipment (WEEE) and Restriction of Substances (ROS) Directive proposals

The European Union has tabled on June 2000 a proposal for a Directive on Waste Electrical & Electronic Equipment (WEEE). The main objective of this proposed legislation is to shift the responsibility for the collection, recycling and re-use of end-of-life E&E products onto E&E producers.

The second draft Directive contains a list of substances proposed to be phased out of use in the production of E&E equipment by the year 2004. An early list included lead, cadmium, mercury and all halogenated flame retardants, including TBBPA. However, the scope of this list has now been reduced in the Commission's proposal to cover just the three PBDE FRs and the one PBB.

Therefore, there is no European legislation planned which would regulate against the use of, for example, TBBPA in electrical/electronic equipment.

Eco-labels

Concerned by reports that various players of the electric/electronic (E&E) industry were interpreting the Blue Angel and the Nordic White Swan schemes as mandatory market entry requirements -thus targeting brominated flame retardants for exclusion- and that some government bodies were specifying eco-label criteria as being mandatory rather than voluntary requirements to comply with public procurement contracts, the European Commission confirmed, in a letter to EBFRIP dated 26 February 1999, that "products which…do not comply with the (German Blue Angel) eco-label system, can be marketed in Germany without any hindrance".

The Commission has informed EBFRIP that this is recognized by "... the German authorities (who) pointed out that the German eco-label system is a voluntary certification scheme system without any obligation on producers or providers to join it."

[3] Phase-out under the Marketing and Use Directive 76/769/EEC

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Brominated flame retardants can be used in ecolabelled products parts under 25g and for some Blue Angel and White Swan product groups, notably copiers. The reason for this is that BFR-containing plastics are have been shown to be easier to recycle than other available alternatives[4]. In such cases, the restrictions are limited to excluding the use of PBDEs and PBBs.

The extent to which eco-labels such as the Blue Angel provide brands with market advantage remains questionable. Indeed, for televisions there appears to be little or no interest on the part of manufacturers, no Blue Angel having been awarded so far.

OECD

In 1995, the brominated flame retardants industry entered into a Voluntary Industry Commitment (VIC) with OECD. The brominated flame retardants included in the VIC are the polybrominated biphenyls (PBBs), polybrominated diphenyl ethers (PBDEs) and TBBPA. No specific measures were included in the VIC regarding TBBPA because OECD did not identify any areas of concern.

The 1995 OECD Voluntary Industry Commitment has committed BSEF to meet certain levels of purity for the major brominated flame retardants in use today and our industry's latest report to the OECD shows that we are meeting our commitments:

· Advice to customer industries has been carried out to improve product handling.

· Incineration studies have demonstrated the lack of increased polybrominated dibenzo-p-dioxins and dibenzofurans even from waste with artificially high levels of brominated flame retardants.

· Product tests by independent testing laboratories demonstrate German Dioxin Decree compliance.

· On-going studies are testing the dioxin content of recycled plastics.

[4] Ricoh Presentation to BSEF Seminar in Tokyo, November 6, 1998

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For Further explanation:

a. Risk assessments under EU Council Regulation 93/793

b. Voluntary Industry Commitment by the US and European Producers of Selected Brominated Flame Retardants covered under the OECD's Risk Reduction Programme, 30 June 1995

c. Risk assessment of bis (pentabromophenyl)ether (decabromodiphenyl ether), Final Draft, August 1999

d. WEEE & ROS Directives proposals COM(2000) 347

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5. Health and Environment

Executive Summary:

- Octa-BDE and Deca-BDE are not bio-accumulative.
- Penta-BDE has been found in the environment, but levels are already declining. The European Commission is scheduled to table a proposal to phase-out the use of Penta-BDE by end 2000.
- The EU risk assessment is currently studying whether Deca and Octa BDE debrominate into Penta-BDE in the environment.
- Traces of Penta and Tetra-BDE in human breast milk are of concern, but no health risk related has been identified and the only correlation identified has been to smoking.
- Plastics containing BFRs are superior to other plastics in term of recyclability and may be recycled up to five times in compliance with legislations on dioxin emissions.
- Energy recovery and bromine recycling are important solutions for the integrated waste management of plastics containing BFRs.

Environmental Concerns

Octa-BDE and Deca-BDE, which are not classified as dangerous substances, are not bio-accumulative, i.e. they do not stay and accrue in the human body. Their persistence represents a limited risk for the environment and an advantage in term of stability during recycling.

Constituents of one flame retardant (Penta-BDE) were found in increasing quantities during the 1980’s in the environment, but levels are declining the early 1990’s. Furthermore, levels of Penta and Tetra-BDE were found in the environment 40 years before commercialisation of any PBDE flame retardant, which would suggest that part of the quantities originate from natural sources. The Levels found in the 1980s could be explained by the brief use of Penta-BDE by the oil industry in the North Sea (as an oil chemical and not as a flame retardant).

The theory that Octa-BDE and Deca-BDE could debrominate, i.e. degrade down to form Penta-BDE and Tetra-BDE, is currently being tested under the EU risk assessment results for which will be available early 2001.

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Traces of Penta-BDE and Tetra-BDE have been found, among hundreds of other chemicals, in human breast milk. No health risk has been identified as the levels are low and should fall if they are related to the already decreasing levels found in the environment. The same study could only identify a correlation between the levels found and smoking, and did not identify any link with the presence of PBDE as flame retardant, in electronic equipment.

The WHO, as part of its International Program on Chemical Safety, undertook a full scientific assessment of the environmental and human health impacts of TBBPA. Its findings were as follows: TBBPA has little potential for bio-accumulation – "the compound has not normally been found in environmental biological samples." Environmental detection was limited to a few sediment/soil samples. "The risk for the general population is considered to be insignificant."

A recent study presented at the Dioxin 99 conference showed no endocrine effects of TBBPA. Further, none of the repeated dose studies conducted in vivo has shown any indication of an effect on the endocrine system.

PBB, which is not any longer used in E&E equipment and which ceased production in May 2000, is the only brominated flame retardant referred to in an initial Commission list of potential endocrine disrupting chemicals.

Deca-BDE has been detected in a study on recycling workers' blood. The level detected is way below the established regulatory occupational exposure limits, and there is no evidence of any health risk, as Deca-BDE has a very low toxicity. Nevertheless such findings are of concern and should be part of a broader issue of workers' heath and safety working conditions in the recycling industry.

Concerns over dioxin and furan formation during incineration have been rendered a thing of the past by the advanced incinerator technology that is now available and mandated by EU legislation. As to any potential risk from exposure to dioxins and furans from accidental fires, studies have shown that even fire-fighters, who face a high number of accidental fires, are not adversely affected.

When considering the relative health impact of products with or without brominated flame retardants, it is appropriate to take into account the consumer safety benefits (prevention of fires and resulting pollution) that brominated flame retardants can impart to products that are susceptible to fire.

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Waste recovery Issues

There is a perception that BFRs in some way affect adversely the potential to recover plastics. In fact there is a wide range of data and practical experience demonstrating that the end-of-life (EOL) management of plastics containing BFRs is fully compatible with an integrated waste management concept, in line with EU waste policy. Such reports suggest that BFRs in E&E equipment will not prevent the recovery, including recycling, of materials currently in use. In fact any move to restrict the use of BFRs in E&E equipment would preclude the development of products and processes which may provide the best solution for future recovery and recycling goals.

Energy recovery

Incineration tests, pyrolysis and combustion studies have demonstrated that waste from E&E equipment can be safely added to today's municipal solid waste to generate useful energy in an environmentally sound manner. The formation of brominated dioxins/furans (PBDDs/Fs) is not altered by the presence of the bromine-containing waste, and remains well within emission standards in these processes. The OECD came to the same conclusions. OECD noted that the highest formation rates for PBDDs/Fs from PBDEs during theoretical laboratory experiments were associated with a combination of abnormally low temperatures and pyrolitic conditions. Modern waste-to-energy facilities are specifically designed to avoid these conditions. A report from the European Commission came to the same conclusions[5].

Mechanical recycling

Several studies, such as the recent one by Techno Polymer in Japan concluded that ABS plastics containing BFRs was superior to other plastics in terms of recyclability.[6]

Plastic containing BFRs meets the strict PBDD/F limit values of the German "Dioxin Ordinance" in the recyclate if recycling is carried out according to standard health and safety practices.

Further independent studies sponsored by the industry on the recycling of BFR plastics and on related potential workplace exposure are currently in process.

[5] "Techno-Economic Study on the Reduction of Industrial Emissions to Air, Discharges to Water and the Generation of Wastes from the Production Processing and Destruction (by incineration) of BFRs" ISBN 92-827-5577-0, European Commission, 1995

[6] A practical study to compare recyclability between non-halogen PC/ABS (HIPS) alloy and FR-ABS flame retarded by brominated epoxy oligomer, Takateru Imai, Techno Polymer Co. Ltd.

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Studies have also shown that High-Impact Polystyrene with Deca-BDE can be recycled five times in full compliance with the German legislation on dioxin/furan product content and emission limit values, the strictest such legislation in the world.[7]

Additionally, work has been carried out and will continue with a view to optimising identification and separation processes for plastics containing BFRs so as to enable the separate treatment of this type of plastics on an operational scale.

Moreover, the copiers industry convinced the German Environmental Agency (UBA) and the Nordic Countries to delay eco-label criteria discriminating against BFRs (Blue Angel, White Swan) precisely because BFR plastics were preferable from the point of view of recyclability.

Certain plastics/BFR combinations are actually already being specified by leading manufacturers of photocopiers in part because of their comparative stability in the recycling process, and recycling is already taking place with 30% of some new copiers containing recycled plastic with brominated flame retardants[8]. This is feasible for large appliances in a closed loop of ownership and would not be helped by the required separation of all plastics containing BFRs. The inclusion of plastics containing BFRs in Annex II thus represents an unjustified stigma against these materials.

Feedstock recycling

APME has concluded [9] that feedstock recycling of plastics from WEEE is one potential option and is an environmentally sound method for recovering HFR plastics. Tests have been carried out on a commercial scale successfully. The bromine industry is currently undertaking a feasibility study to determine the economic and technical viability of bromine recovery from plastics containing BFRs. This would close the bromine loop, ensuring the sustainability of bromine production.

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[7] Studies led by Dr. S. Hamm GfA (Gesellschaft für Arbeitsplatz- und Umweltanalytik) mbH, September 1999.

[8] "Ideal Resin Reclaiming Process Learned from Office Automation (OA) Equipment", Nikkei Mechanical, no. 542, November 1999.

[9] Executive summary of PB Kennedy & Donkin pre-feasibility study on feedstock recycling , May 1999

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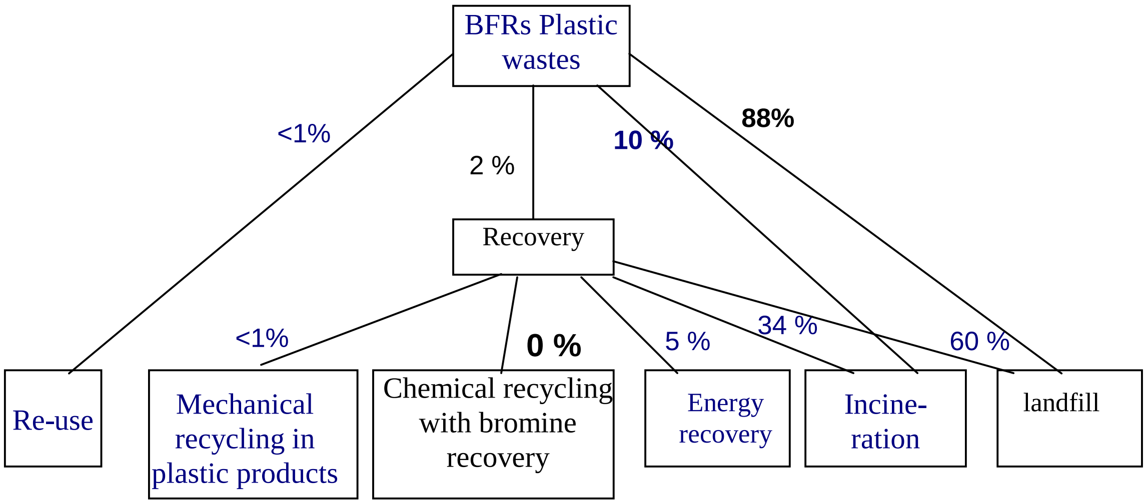
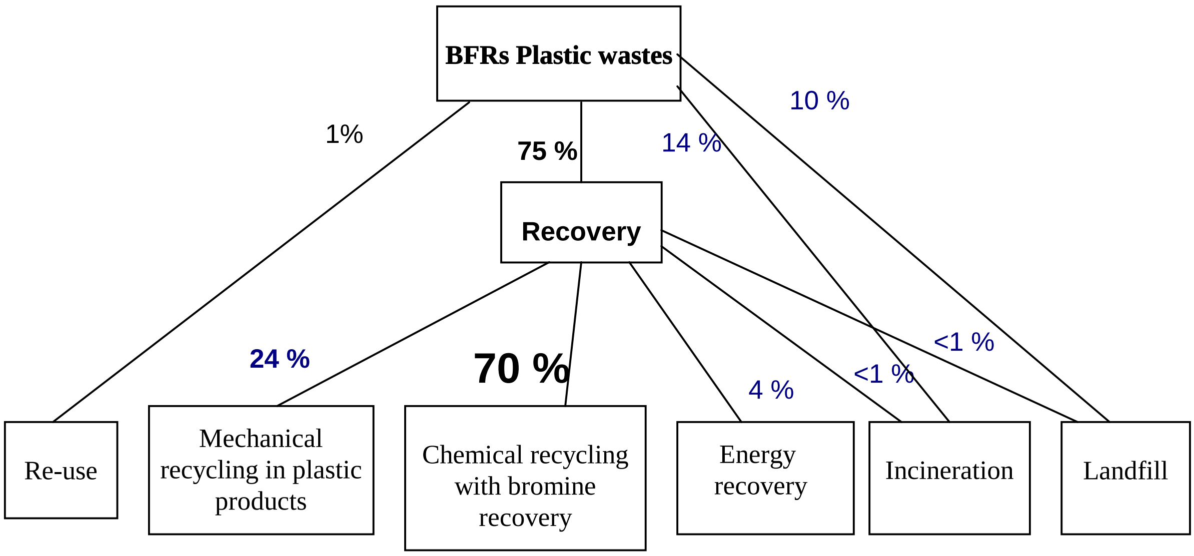
Current situation in Europe



Situation in Europe after 2004



Source: BSEF internal

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Conclusion

Any presumption that BFRs make plastics recovery more complex requires justification as it could be argued that any plastics additive makes plastics recovery a more complicated process. The fact is that without additives, plastics would no longer be able to be used in the vast majority of applications. BFRs add value to E&E plastics by enabling E&E equipment manufacturers to go beyond minimum fire safety standards in order to enhance consumer safety levels. The widespread use of BFRs in E&E appliances over the last ten years is all the more reason to ensure that these high value plastics can clearly be identified, thus avoiding their disposal and enabling their separation for recovery, including their reuse and recycling.

For Further explanation:

a. SP, The Swedish National Research and Testing Institute, "LCA study of flame retardants in TV enclosures", Margaret Simonson, February 2000.

b. EBFRIP paper “BFRs and WEEE – An industry Perspective “, June 1999

c. ECN reports on industry study to minimise worker exposure, July 1999

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6. Industry sponsored research and Activities

With the view of facilitating open communication about bromine products across the globe, BSEF:

- Support the work of the industry's regional industry panels/sector groups, such as the US-based Brominated Flame Retardant Panel (BFRIP) and its European counterpart, EBFRIP;

- Sponsor independent scientific assessments of bromine products and their applications (such as flame retardants, pharmaceuticals, water treatment, etc.);

- Seek to ensure that scientific information on its products is advanced and more widely understood by the public and regulatory groups;

- Initiate and publish balanced, scientific information from leading independent scientific experts on bromine industry products to assist government regulators, customers, and others in their decision-making;

- Prepare summaries of scientific and other source information dealing with health, safety, and environmental issues;

- Work with downstream customers to develop product stewardship programs;

- Support training and education to ensure safe use and protection of health and environment (including via management systems such as Responsible Care, ISO 14000 or EMAS);

- Further the understanding of the role bromine chemicals play in providing consumers with safer products (e.g. clean water and increased fire safety in the home and office);

- Actively seek opportunities to co-operate with all interested stakeholder groups.

- BSEF is convinced that improvements in fire safety are a major step to saving lives. Brominated flame retardants provide a significant safety margin for users and improvements in fire safety help save lives. Despite this fact, some European countries have attempted to discourage their use for alleged environmental reasons. Therefore, BSEF will commission independent research in this area and will share study results with the public.

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Acronyms:

ABS	Acrylonitrile-butadiene-styrene
BSEF	Bromine Science and Environmental Forum
BFR	Brominated flame retardant
E&E	Electrical and electronic
EBFRIP	European Brominated Flame Retardant Industry Panel
EOL	End of Life
EU	European Union
DTI	UK Department of Trade and Industry
FR	Flame retardant
HFRs	Halogenated flame retardants
HIPS	High-impact polystyrene
LCA	Life-cycle assessment
OECD	Organisation for Economic Cooperation and Development
OEM	Original equipment manufacturer
PBBs	Polybrominated biphenyls
PBDEs	Polybrominated diphenyl ethers
PC/ABS	Polycarbonate/Acrylonitrile-butadiene- styrene
ROS	Restriction of Substances
SP	Swedish National Research and Testing Institute
TBBPA	Tetrabromobisphenol A
TBPE	1,2- (tribromophenoxy) ethane
WEEE	Waste from Electrical and Electronic Equipment

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