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BFRs: International ESH Directives Can and Do Affect Boeing

As a global enterprise, Boeing must be aware of international, as well as domestic, issues that may affect its business ventures. International environmental safety and health (ESH) concerns about certain brominated flame retardants (BFRs) are an example. They are a class of chemicals that are used in a variety of products because of their flame retarding properties. They save lives. However, with the stated rational of addressing ESH concerns, the European Union (EU) has recently issued two directives that will ban or severely restrict the use of some of these materials in a wide variety of applications, some of which may impact Boeing products. Boeing uses BFRs in its commercial aircraft production chemicals (e.g. resins, sealants) and in articles used on aircraft (e.g. floor panels, storage bins). Customer furnished equipment may also contain such flame retardants. Depending on how EU states implement the directives, they have the potential to affect future sales and maintenance of Boeing aircraft and aircraft parts and electronic equipment, thus affecting not only Boeing, but it's customers and suppliers as well.

What are Brominated Flame Retardants?

Brominated flame retardants (BFRs) are part of the halogenated flame retardant family. Common products that utilize these materials are electronics (computers, televisions, etc.) and textiles. BFRs act primarily by a chemical interfering with the radical chain mechanism taking place in the gas phase during combustion. High-energy OH and H radicals formed during combustion are removed by bromine released from the flame retardant. (Fig. 1). Although BFRs are a highly diverse group of compounds the flame-retardancy mechanism is basically the same for all compounds. However, there are differences in flame-retardancy performance of the brominated compounds. In general aliphatic bromine compounds are easier to break down and hence more effective at lower temperatures, but also less temperature resistant than aromatic retardants.

Brominated flame retardants (BFRs) may be defined as non-organophosphorus compounds where one or more hydrogen atoms are replaced by bromine. BFRs usually contain 50-85% of bromine (by weight). The most common BFRs (Fig. 2) are tetrabromobisphenol A (TBBPA), polybrominated diphenyl ethers (PBDE),

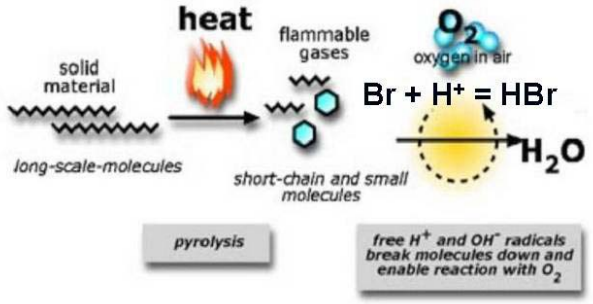

*Fig. 1 How BFRs Work **

polybrominated biphenyls (PBB) and hexabromocyclododecane (HBCD). Their recent use in the Western Hemisphere is given in Fig. 3.

Brominated diphenyl ethers are a group of aromatic brominated compounds in which one to ten hydrogens in the diphenyl oxide structure are replaced by bromine. The polybrominated diphenyl ethers (PBDEs) with three to ten bromine atoms are used in commercial flame retardants. The compounds are designated tri (3), tetra (4), penta (5), hexa (6), hepta (7), octa (8), nona (9) and decabromodiphenyl ether. Commercial products are not pure substances. Three different PBDE flame retardants are commercially available. They are referred to as

penta-, octa- and decabromodiphenyl ether, but each product is a mixture of brominated diphenyl ethers.

The commercially supplied pentabromodiphenyl ether (pentaBDE) is a mixture of brominated diphenyl ethers. It contains typically 50-60% pentaBDE and 24-38% tetraBDE and 4-8% hexaBDE. The chemical structure of the pure pentabromodiphenyl ether is similar to the structure of octabromodiphenyl ether, but with only five bromine atoms. PentaBDE has traditionally been used as an additive flame retardant in epoxy resins, polyesters, polyurethanes and textiles.

The commercially supplied octabromodiphenyl ether (octaBDE) is an off-white mixture of brominated diphenyl ethers typically consisting of 31-35% octaBDE. The other main components are hexaBDE (10.5-12%), heptaBDE (around 44%), nonaBDE (9.5-11.3%) and decaBDE (0-0.7%). The product is a solid of low water solubility and vapor pressure.

Decabromodiphenyl ether (decaBDE) is a fine, white to off-white crystalline powder. A typical composition for modern products would be 97-98% decaBDE. Decabromodiphenyl ether is mostly used for applications in plastic and textiles. It is an additive flame retardant, i.e. it is physically combined with the material being treated rather than chemically combined.

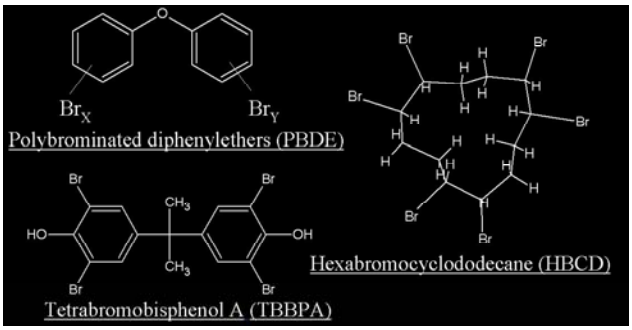

*Fig. 2 BFRs of Recent Concern **

What are the environmental and health concerns associated with Brominated Flame Retardants?

Regulators in Europe have expressed concern about the possible impacts of BFRs on the environment and human health The basis for the concern is not entirely clear, however, since there aren't any studies that demonstrate conclusively that the BFRs have caused serious adverse effects in humans. There are studies, primarily with rats and mice, that report adverse effects from doses that appear to be in excess of those found currently in nature. The PBDEs have chemical formulations that appear similar to PCBs, and from the literature it appears this similarity has given rise to concerns that the flame retardants might exhibit similar properties. This view is not held by all scientists. In addition to a lack of established scientific basis to determine whether there is a threat, there also is no definitive information to establish whether there are safe concentrations that can be used without concern for adverse impacts.

Like PCBs, studies have suggested that PBDEs spread widely in the environment, and accumulate up the food chains and in the sediment, where they only degrade very slowly. Detections have been reported in human breast milk, adipose tissue and blood as well as in whale blubber. If confirmed, those detections might indicate that these substances can spread into many different types of environment. In addition, studies have reported that PBDEs formed the toxic polybrominated disbenso furans (PBDF) and polybrominated disbenso dioxins (PBDD) during extrusion, which is part of the plastic recycling process. Detections of high concentrations of PBDEs in the blood of workers in recycling plants have been reported. The studies reporting those detections opine that PBDEs might act as endocrine disrupters.

What are the current European Union (EU) activities concerning Brominated Flame Retardants and the resultant effect domestically?

Given the current lack of definitive knowledge to establish ill effects of these substances in the environment or human health, the regulatory efforts in the European Union appear to be an application of the Precautionary Principle. The Precautionary Principle states that **"When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof."**

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Whether it is a correct application of the principle thus becomes a critical question. This EU approach of applying the Precautionary Principle differs dramatically from that of the U.S. where restrictions on chemical use are made only after a showing of proof by the regulatory agencies. It should be noted that the study of BFRs is not complete, and further studies may indicate that these materials are not as big a risk as the EU directives may suggest.

PBDE Directive

The EU Directive 2003/11/EC of 2/6/03 relating to restrictions on the marketing and use of certain dangerous substances and preparations (pentaBDE and octaBDE) directs member states to adopt and publish the laws, regulations and administrative provisions necessary to comply with the Directive no later than 2/15/04 and apply those measures from 8/15/04. It amended Annex I of Directive 76/769/EEC by noting that the above may not be placed on the market or used as a substance or as a constituent of substances or of preparations in concentrations higher than 0.1% by mass. Also, articles may not be placed on the market if they, or flame-retarded parts thereof, contain these substances in concentrations greater than 0.1% by mass. Although implementing legislation has not yet been published, there is no apparent military exemption in the directive. This directive focuses on non-electronic uses of BDEs. Further, this directive neither approved or banned decaBDE, rather calling for continued study of the flame retardant.

California has followed the EUs lead by issuing, on 8/11/03, Assembly Bill 302, Polybrominated Diphenyl Ethers, that bans the manufacture, processing, or distribution in California of products containing more than a tenth of a percent of pentaBDE and octaBDE after 1/1/08. It is not yet clear how the state will address the restriction in implementing regulations. Lawmakers in Maine are considering a ban, and the Governer of Washington state signed an executive order requiring development of a plan by state government to address PBDEs. and Naval Air Systems Command (NAVAIR) has stated their need for a uniform policy for all states. The California legislation may signal a trend towards nationwide restrictions on the chemicals use.

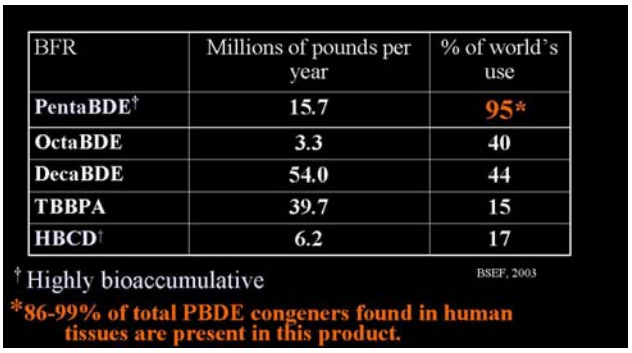

Fig. 3 Use in the Western Hemisphere (2001 est.) *

Additionally, Great Lakes Chemical is voluntarily phasing out penta and octaBDEs by the end of 2004. Because there are no other U.S. based producers of penta and octaBDEs the Great Lakes phaseout will likely have nationwide effects.

RoHS Directive

The EU Directive 2002/95/EC of 1/27/03 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS), a companion directive to Directive 2002/96/EC on waste electrical and electronic equipment (WEEE), directs member states to ensure that, from 7/1/06, new electrical and electronic equipment put on the market does not contain, among other specific chemicals, polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyls (PBBs). Member states are to bring into force the laws, regulations and administrative provisions necessary to comply with the Directive before 8/13/04. The directive does not apply to spare parts for the repair, or to the reuse, of electrical and electronic equipment put on the market before 7/1/06. It also appears intended to have the same scope as the WEEE. An interpretive letter issued by the EU's Directorate General-Environmental states that the RoHS is intended to follow the WEEE's applicability limitations, thus it does not apply to electronic equipment (part of equipment that isn't within the WEEE's scope). This should result in implementing legislation or regulation in member states that contains an exemption for applications in products having military and national security implications

As an example of a member states response to this scope issue, it was found that the British Government published, on 12/3/03, a consultation paper on their implementation of the above RoHS Directive by 8/13/04 that noted, apparently in agreement with the Directorate General's interpretive letter, the following interpretation:

"Article 2.3 of the WEEE Directive states that equipment (specifically) connected with national security or military purposes (not dual military/civilian applications) is excluded from the scope of the Directive. The RoHS Directive does not provide for a similar exemption but the [British] Government considers that the RoHS Directive is broadly reflected in the WEEE Directive and so the exemption will apply equally to products covered by the RoHS Directive."

The British consultation document doesn't specifically address the applicability of the RoHS to electronic products incorporated into products not falling within the list of product types in the WEEE, which was the precise issue addressed by the Directorate General's interpretive letter. However, the rationale for extension of the national security/military exemption to the RoHS should apply equally to an extension of the WEEE exemption for electronics incorporated into products, such as aircraft and missiles, that do not fall within a product category listed in the WEEE.

The British Government agreed that any decision about the possible exemption of decaDBE, should be delayed until the results of the risk reduction strategy had been completed.

Coincidently, the day before, on 12/2/03, the risk assessment ordered by the European Commission concluded that decaBDE does not pose a proven, significant threat to human health and the environment. Even so, there are new reports that indicate it may be bioaccumulating in birds and mammals and there will be continuing pressure to restrict its use. The risk assessment has not been finalized as the authors are continuing to look at some aspects of human health. Final results are expected sometime this March or April.

Again, California followed the EUs lead by issuing, on 9/25/03, Senate Bill 20, the Electronic Waste Recycling Act of 2003, that among other requirements, includes forbidding the sale, after 1/1/07, of devices containing materials prohibited by the EU 2002/95/EC, the RoHS Directive. Implementation of these California regulations is pending Gov. Schwartzenegger's review processes.

The Boeing Response

A company-wide Boeing team has been actively pursuing elimination of non-electronic uses of PBDEs. According to Billy Glover, Director of Environmental Performance and Strategy for Boeing Commercial Airplanes, "the trick is finding safer alternatives that work chemically with the resins and plastics used in airplane production."

BCA has taken the lead in the Boeing response to the impending PBDE ban because of the need to ensure that all commercial airplanes slated for delivery to the EU after 8/14/04 will meet the penta and octaBDE content limitations. Their effort involves: identification of which airplane components contain PBDEs, identification of manufacturing locations where PBDEs are currently being used, assessment of the supplier components likely to contain the subject materials, and assessment of the availability of material alternatives.

A qualification effort, including supplier issues, that considers the timing required is being made to meet the potential limited use restrictions stated in EU Directive 2003/11/EC. Also a recommended implementation approach to support any necessary airplane processes, material and component changes as a result of the assessment is being followed. Buyer furnished equipment and seller furnished equipment is being included in the assessment.

BCA suppliers have been contacted to assure their awareness of the EU PBDE legislation affecting the marketing of products in the European Union and of their contractual obligation to notify Boeing if there are compliance issues precipitated by it. Suppliers were advised that, beginning 4/1/04, all shipments to Boeing Commercial Airplanes for spares or for incorporation into any commercial aircraft should meet the EU Directive objectives, as appropriate.

One of the positive aspects of the assessment effort is how it has fostered improved internal and external communication. In BCA Airplane Programs alone, personnel from Environmental Strategy, Business Operations, Boeing Material Technology, Manufacturing R&D units of Product Development, as well as 717 Program M&P have been involved. Support has also been given by BCA Engineering & Product Integrity, Supplier Management, Supply Management & Procurement, the Spares, Tech Services & Modifications, and SHEA (Safety, Health & Environmental Affairs) units of Commercial Aviation Services, BCA & Corporate SHEA, Corporate Legal, and IDS M&P

Beyond BCA activities, Environmental Assurance conducted a preliminary search for non-electronic PBDE use in specific IDS programs having EU sales potential and has determined that BCA activity is addressing the majority of IDS applications. However, in response to a growing domestic concern, a thorough search of all IDS programs for non-electronic use of PBDEs, in St. Louis is planned for this year.

These efforts enable Boeing to improve the quality of our products as well as fulfill our commitment to protect human health and the environment. They also prepare appropriately for the future in order to maintain Boeing compliance with applicable ESH regulations, both international and domestic.

***Graphics source:** *"Overview of Brominated Flame Retardants", a 2003 presentation, available on the internet, given by Leif Magnuson, EPA Region 9 P2 Coordinator, **magnuson.leif@epa.gov** (415) 972-3286.*

For more information, contact:
*Maury Hedlund at (425) 234-5639, email: **maurice.c.hedlund@boeing.com**, Chris Zervas at (425) 237-7956, email: **chris.t.zervas@boeing.com**, or Paul Rempes at (314) 233-1541, email: **paul.e.rempes@boeing.com***