DEPARTMENT OF ECOLOGY
State of Washington

Washington State Department of Health

Alternatives to Deca-BDE in Televisions, Computers and Residential Upholstered Furniture

Implementation of RCW 70.76: Identifying safer and technically feasible alternatives to the flame retardant called Deca-BDE used in the electronic enclosures of televisions and computers and in residential upholstered furniture

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Alternatives to Deca-BDE in Televisions, Computers and Furniture

Implementation of RCW 70.76: Identifying safer and technically feasible alternatives
To the flame retardant called Deca-BDE used in the electronic enclosures of televisions and computers and in residential upholstered furniture

Draft

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Executive Summary

This report was written to fulfill the requirements of RCW 70.76, signed into law by Governor Gregoire in 2007. This law restricts the manufacture, sale and distribution of products containing a type of chemical flame retardant called PBDEs (polybrominated diphenyl ethers). The three types of PBDEs used in consumer products are Penta-BDE, Octa-BDE and Deca-BDE. The prohibition became effective for all products containing Penta-BDE and Octa-BDE, and for mattresses containing Deca-BDE in January, 2008. At the time the law was passed, safer alternatives for Deca-BDE had not been identified for other products, specifically, residential upholstered furniture, and electronic enclosures used in televisions and computers. RCW 70.76 lays out a process for identifying the availability of safer, technically feasible alternatives to Deca-BDE that meet fire safety standards for these applications. When safer alternatives are identified, the manufacture, sale or distribution of upholstery and electronic enclosures containing Deca-BDE will be prohibited two years from the date of identification.

As required by RCW 70.76, the Departments of Ecology (Ecology) and Health (DOH) reviewed risk assessments, scientific studies, and other relevant findings regarding alternatives to the use of Deca-BDE in residential upholstered furniture, televisions, and computers. The agencies identified a safer, technically feasible alternative chemical flame retardant for TVs and computers. Non-chemical alternatives were identified for upholstered furniture. These alternatives were presented to a committee of fire safety experts appointed by the governor to determine if they can provide appropriate fire retardant capacity. The Fire Safety Committee met on November 7, 2008 and found that the identified alternatives meet applicable fire safety standards. The Fire Safety Committee reported its findings to the Office of the State Fire Marshal who, on November 18, 2008, determined that the alternatives proposed meet applicable fire safety standards.

The alternatives assessment conducted by Ecology and DOH considered only those chemicals or technologies currently on the market and available to replace Deca-BDE in current products, while still maintaining fire protection.

Electronic Enclosures for TVs and Computers

In evaluating alternatives to the use of Deca-BDE in electronic enclosures, Ecology and DOH focused on non-halogenated flame retardants. Because halogenated flame retardants are more likely to persist in the environment and to bioaccumulate in organisms, Ecology and DOH decided to avoid alternatives that contain halogens and focus on non-halogenated alternatives. Non-halogenated alternatives also have the added benefit of being much more easily degraded than their halogen equivalents, thereby greatly reducing their potential long-term impact on human health and the environment.

The use of non-halogenated flame retardants in electronics requires a change in plastic from high impact polystyrene (HIPS), which is the plastic typically used with Deca-BDE in electronic enclosures to plastic blends such as HIPS/PPO (polyphenylene oxide).

After reviewing recent studies, reports and other information, Ecology and DOH narrowed their analysis to two possible phosphate-based flame retardants for final consideration: resorcinol bis diphenyl phosphate (RDP) and triphenyl phosphate (TPP). The agencies conducted additional review of these two flame retardants to help determine if these both could be recommended as a safer alternative to Deca-BDE. This additional review included a comparison of toxic effects levels observed in animal studies and an extended comprehensive evaluation of aquatic toxicity information. Based upon this evaluation, the agencies found that RDP is a safer and technically feasible alternative to Deca-BDE. TPP was eliminated due to concerns related to its aquatic toxicity.

Plastics used in electronic products are rated for their flame retardation capacity using a voluntary standard identified by the National Fire Protection Association (NFPA) in conjunction with the Underwriter's Laboratory (UL) which defines the specific method. The agencies presented information to the Fire Safety Committee on the performance of RDP compared with Deca-BDE when used in electronic enclosures. RDP performs as well as Deca-BDE, although a different type of plastic has to be used. As required by RCW 70.76, the Fire Safety Committee voted on whether or not RDP provides appropriate fire protection. The committee unanimously found that RDP meets applicable fire safety standards.

FINDING
A safer, technically feasible alternative to Deca-BDE, which meets applicable fire safety standards, is available for use in televisions and computers.

Residential Upholstered Furniture

For residential upholstered furniture, Ecology and DOH relied on information from the Consumer Product Safety Commission (CPSC) indicating the availability of furniture design options that do not require the addition of chemical flame retardants. Ecology and DOH decided that achieving fire safety by redesign without the use of flame retardants is the best possible way to replace Deca-BDE.

The CPSC recently published a proposed flammability standard for residential upholstered furniture. The proposed standard does not rely on the addition of chemical flame retardants, including Deca-BDE, for compliance. If the proposed standard is finalized as such, furniture manufacturers will have the option to meet fire safety requirements with design changes, rather than with Deca-BDE or another chemical alternative.

Under the CPSC's proposed standard, fire safety in upholstered furniture can be achieved through the use of compliant cover materials or internal barrier layers. The use of internal barrier materials may require the use of chemical flame retardants; however the CPSC estimates that barriers would likely be used in only about 5 percent of upholstered furniture. There are inherently flame retardant barrier technologies that could be used similar to those currently being used to achieve fire safety in mattresses. Flame retardants could be used on cover fabrics, but many cover fabrics, especially those made from natural fibers, would meet the proposed standard. Although the CPSC flammability standard for residential furniture has not been finalized, it is expected that design options will be available to meet any additional requirements in a final standard.

Based on furniture design options that are already available, the agencies concluded that safer, technically feasible non-chemical alternatives to Deca-BDE are available for residential upholstered furniture. The Fire Safety Committee voted on whether or not these non-chemical design changes can provide appropriate flame retardation. The committee unanimously found that non-chemical alternatives meet applicable fire safety standards for residential upholstered furniture.

FINDING
Safer, technically feasible alternatives to the use of Deca-BDE, which meet applicable fire safety standards, are available for use in residential upholstered furniture.

CONCLUSIONS

Safer, technically feasible alternatives to the use of Deca-BDE in TVs, computers and residential upholstered furniture are available and meet applicable fire safety standards. The restrictions on the use of Deca-BDE in these products as defined by RCW 70.76 will take effect on January 1, 2011.

Acronyms and Abbreviations

BAPP	Bisphenol A bis(diphenyl phosphate) (aka BDP)
BDP	Bisphenol A bis(diphenyl phosphate) (aka BAPP)
CAP	chemical action plan
CAS Nr.	Chemical Abstract Services Number
CPSC	U.S. Consumer Product Safety Commission
Deca-BDE	Decabrominated diphenyl ether commercial mixture
deca-BDE	decabrominated diphenyl ether specific congener
DOH	Washington Department of Health
Ecology	Washington Department of Ecology
Green Screen	The Green Screen For Safer Chemicals methodology from Clean Production Action
HIPS	high impact polystyrene
Octa-BDE	Octabrominated diphenyl ether commercial mixture
PBDE	polybrominated diphenyl ether
PC/ABS	polycarbonate/acrylonitrile/butadience/styrene blend
Penta-BDE	Pentabrominated diphenyl ether commercial mixture
PPO	polyphenylene oxide
RCW	Revised Code of Washington
RDP	resorcinol bis(diphenyl phosphate)
TPP	triphenyl phoshate

I. Introduction

This report on Alternatives to Deca-BDE in Electronics Enclosures and Residential Upholstered Furniture is a joint document of the Washington State Department of Ecology (Ecology) and Department of Health (DOH). The purpose of this document is to review risk assessments, scientific studies, and other relevant findings regarding alternatives to the use of the flame retardant Deca-BDE in residential upholstered furniture and television and computer electronic enclosures. The document identifies whether safer and technically feasible alternatives are available for these applications.

This report was written to fulfill the requirements of RCW 70.76, signed into law by Governor Gregoire in 2007. RCW 70.76 lays out a process for identifying the availability of safer, technically feasible alternatives to Deca-BDE that meet fire safety standards for the specific applications above. If alternatives are identified, the sale or distribution of products containing Deca-BDE for which there is an alternative will be prohibited two years from the date of identification.

Ecology and DOH completed a Chemical Action Plan (CAP) for PBDE flame retardants in 2006. At that time, there was not sufficient evidence that less toxic alternatives to Deca-BDE were available for furniture and electronic enclosures. Indeed, there are three other chemical flame retardants on Ecology's list of Persistent, Bioaccumulative, Toxic chemicals (PBTs) which would be unsafe substitutes for Deca-BDE. The drafters of RCW 70.76 considered this and delayed the prohibition on Deca-BDE until Ecology and DOH could identify at least one less toxic alternative and report those findings to the legislature.

Ecology and Health reviewed recent risk assessments, scientific studies and other relevant findings regarding alternatives to the use of the flame retardant Deca-BDE in residential upholstered furniture and television and computer electronic enclosures. The results of that review are provided in this report. Ecology and DOH identified a safer, technically feasible alternative chemical flame retardant for TVs and computers. Non-chemical alternatives were identified for upholstered furniture. These alternatives were presented to a committee of fire safety experts appointed by the governor to determine if these alternatives can provide appropriate flame retardant capability. The Fire Safety Committee met on November 7, 2009 and found that the alternatives identified by Ecology and DOH meet applicable fire safety standards. The Washington State Fire Marshal agreed with these findings on November 18, 2008.

Ecology is seeking public input on these findings before submitting this report to the appropriate committees of the legislature. The public comment period is from November 20 until December 17, 2008.

<u>Identifying Safer Alternatives</u>

Deca-BDE could be replaced in three ways:

1. An alternative flame retardant can be used.

2. A different type of material (such as plastic or foam) using an alternative flame retardant can be substituted for the existing product.
3. The product can be redesigned so that chemical flame retardants are no longer needed.

In evaluating alternatives in electronic enclosures, Ecology and DOH focused on options for using different types of plastics so that non-halogenated flame retardants could be considered. . Because halogenated flame retardants are more likely to persist in the environment and to bioaccumulate in organisms, Ecology and DOH decided upfront to avoid alternatives that contain halogens. The use of non-halogenated flame retardants in electronic enclosures requires a change in plastic from high impact polystyrene (HIPS), which is the plastic typically used with Deca-BDE.
For residential upholstered furniture, Ecology and DOH relied on information from the Consumer Product Safety Commission (CPSC) indicating the availability of furniture design options that do not require the addition of chemical flame retardants. Ecology and DOH decided that achieving fire safety by redesign without the use of flame retardants is the best possible way to replace Deca-BDE.

The alternatives assessment by Ecology and DOH considered only those chemicals or technologies currently on the market and available to replace Deca-BDE in current products, while still maintaining fire protection. For the purposes of this report, the term 'Deca-BDE' refers to the commercial flame retardant mixture which consists of approximately 97 percent of the deca-BDE congener and 3 percent nona- and octa-BDE congeners. The term 'deca-BDE' refers solely to the deca-BDE congener and will most often be found in sections dealing with scientific studies where the deca-BDE congener was used to determine toxicity and degradation products.

This report utilizes the information provided in the PBDE Chemical Action Plan (CAP) and updates the conclusion reached in the CAP by evaluating information which has become available since the CAP's completion. The new sources of information include the following:

- Maine DEP and Maine CDC, 2007
- Illinois EPA, 2007
- Danish EPA, 2007 & European Commission, 2007
- Clean Production Action, 2007
- Syracuse Research Corp., 2006
- EPA IRIS File for bde-209, 2008
- Troitzsch, Jürgen, 2007, 'Commercially Available Halogen free Alternatives to Halogen-Containing Flame Retardant Systems in Polymers',

Additional information on each of these sources will be provided later in this report.

These sources were reviewed and compared with the objectives of the alternatives assessment conducted in the CAP. The purpose of this review was to determine if the additional studies on Deca-BDE and its alternatives was sufficient to change the conclusion of the original alternatives assessment in the CAP, i.e. that no viable alternative to Deca-BDE could be identified at that point.

For electronic enclosures, the agencies reviewed information on alternatives provided in new assessment reports to decide whether a safer alternative is available. These reports included analyses of the toxicity, persistence, and bioaccumulation potential for a variety of flame retardants as well as information on the feasibility and cost of different alternatives. A summary of the new alternatives assessment reports reviewed by Ecology and DOH is presented in Appendix 1. Additionally, the agencies collected and reviewed other relevant information from sources including flame retardant manufacturers and fire safety-related publications. As noted above, Ecology and DOH limited the review of alternatives flame retardants to non-halogenated flame retardants.

Based on the review of reports and other information, Ecology and DOH narrowed their analysis to two possible phosphate-based flame retardants for final consideration: RDP and TPP. The agencies decided to conduct some additional analyses of these two flame retardants to help determine if both could be recommended as safer than Deca-BDE. These additional analyses included a comparison of toxic effects levels observed in animal studies and a comprehensive review of aquatic toxicity information. These additional analyses are described in Appendix 2. Ecology also calculated potential environmental releases of phosphate associated with the use of phosphate flame retardants to address questions about how these products might contribute to water quality phosphate loading levels. The assumptions and methods used for this calculation are presented in Appendix 4.

For alternatives in residential upholstered furniture, Ecology and DOH reviewed CPSC's new proposed flammability standard for these products and related information from CPSC and others. This review indicates that there are design options available that can be used in place of Deca-BDE and other flame retardants to meet flammability standards for residential upholstered furniture. These design options are similar to methods being used currently by manufacturers to comply with the mattress flammability standard that went into effect in 2007.

Based upon the review of this additional information and a more detailed evaluation of the impacts alternatives to Deca-BDE have upon human health and the environment, Ecology and DOH determined that a safer alternative exists for Deca-BDE used in plastics in electronic enclosures and in residential upholsterer furniture. Under the U.S. Consumer Products Safety Commission's (CPSC) proposed flammability standard for upholstered furniture, fire safety can be achieved using currently available design options that do not require the use of flame retardants. Although the CPSC standard has not been finalized, it is expected that design options that preclude the use of Deca-BDE will be available to meet any additional requirements in a final standard.

This draft is being made available to the public for input. The comment period will end on December 17, 2008.

II. Requirements of RCW 70.76 (PBDE legislation)

In 2007, Governor Christine Gregoire signed HB 1024 into law, placing restrictions on the sale of products containing PBDEs in Washington State. Bill 1024 created Chapter 70, Section 76 of the Revised Code of Washington (RCW), which details the provisions of the restrictions.

RCW 70.76 prohibits the manufacture, sale, or distribution of products containing PBDEs with the exception of products containing Deca-BDE. Other exemptions include:

- Vehicles and vehicle parts
- Products used in military and federally funded space program applications
- Fire safety equipment used in airplanes
- The sale of used products
- New products made from recycled material containing Deca-BDE
- Carpet cushion made from recycled foam containing less than one-tenth of one percent Penta-BDE
- Medical devices

Of products containing Deca-BDE, the manufacture, sale or distribution of three categories of consumer products are restricted by RCW 70.76.030:

1.) Mattresses
2.) Residential upholstered furniture
3.) Televisions or computers with Deca-BDE in the electronic enclosure

The manufacture, sale or distribution of mattresses containing Deca-BDE was prohibited as of January 1, 2008. Restrictions on the sale of upholstered furniture and televisions or computers are subject to the identification of available safer and technically feasible alternatives that meet applicable fire safety standards.

To identify available safer and technically feasible alternatives, RCW 70.76 requires that the Ecology and DOH review risk assessments, scientific studies, and other relevant findings regarding alternatives to the use of Deca-BDE in residential upholstered furniture, televisions, and computers. This report is written to satisfy that requirement.

RCW 70.76 requires that, if the Ecology and DOH jointly find that safer and technically feasible alternatives are available for these uses, Ecology must convene a Fire Safety Committee comprised of the following members:

1. A representative of Ecology, to chair the committee and act as an ex officio member
2. Five voting members, appointed by the governor, representing:
    a. The Office of the State Fire Marshal
    b. A statewide association representing the interests of fire chiefs
    c. A statewide association representing the interests of fire commissioners

d. A recognized statewide council affiliated with an international association representing the interests of firefighters
e. A statewide association representing the interests of volunteer firefighters

RCW 70.76 requires that the Fire Safety Committee determine, by simple majority vote, whether the alternatives identified by Ecology and DOH meet applicable fire safety standards. The State Fire Marshal then makes a determination based on the finding of the Fire Safety Committee as to whether the alternatives proposed meet applicable fire safety standards (See Appendix 6).

Ecology is required to report its and DOH's findings, the findings of the Fire Safety Committee, and the determination by the State Fire Marshall in the Washington State Register and to appropriate committees of the legislature by December 31, 2008. If safer and technically feasible alternative that meets fire safety standards is available, the manufacture, sale or distribution of products containing Deca-BDE is prohibited as of January 1, 2011.

If the report found that no safer, technically feasible alternative that meets fire safety standards is available, no prohibition will take effect. Instead, beginning December 31, 2009, and each successive year, Ecology and DOH would review and report on alternatives, using the process described above. If a safer, technically feasible alternative that meets fire safety standards was identified, a prohibition on the sale or distribution of products containing Deca-BDE for which there is an alternative would take effect two years after a report was submitted to the legislature.

This report does not satisfy the requirements of RCW 70.76.050. This section of the statute requires Ecology and DOH to continue to review new scientific information on alternatives to Deca-BDE for other products (i.e. other than TVs, computers and furniture) as well as the potential effect of PBDEs in the waste stream. Findings that result from this work must be reported to the legislature but do not trigger any further prohibition on the sale, manufacture or distribution of other Deca-BDE containing products.

In addition to the requirements already described, RCW 70.76 includes notification and recall provisions applicable to manufacturers, requires Ecology to assist manufacturers and retailers to the extent practical, allows retailers to exhaust existing stock after a prohibition becomes effective and provides for civil penalties for manufacturers who do not comply.

III. Background: Deca–BDE

Deca-BDE is one of a large class of chemical compounds which act as flame retardants when added to consumer products. Flame retardants like Deca-BDE either prevent products from catching on fire or allow products to burn more slowly if exposed to flame or high heat.

Beginning in the early 1970s, three different mixtures of flame retardants called polybrominated diphenyl ethers or PBDEs were commercially manufactured. Deca-BDE is the only remaining mixture still in use . Production of two others PBDE mixtures, Penta-BDE and Octa-BDE, was voluntarily stopped in the U.S. by their manufacturers in 2004. Products containing Penta-BDE and Octa-BDE were subsequently banned in several states, including Washington, due to environmental and human health concerns.

Use in Electronics Enclosures and Flammability Standards

Deca-BDE can be used in many different plastics. The largest application of Deca-BDE is in high impact polystyrene (HIPS) plastic used in television and computer enclosures. Television enclosures are reported to account for approximately 45 – 80 percent of the Deca-BDE use in the U.S.[1,2]

The use of Deca-BDE in electrical and electronic products was banned in the EU beginning July 1, 2008 under the European Restriction of Hazardous Substances (RoHS) directive. Therefore, Deca-BDE is no longer used in electronics sold in the EU. Deca-BDE was also banned in the State of Maine and is being considered in several other states throughout the U.S.

Deca-BDE is added to HIPS at 10-15 percent by weight to meet fire safety standards.[3] Plastics used in electronic products are rated for their flame retardation capability using a voluntary standard identified by the National Fire Protection Association (NFPA)[4] in conjunction with the Underwriter's Laboratory (UL) which defines the specific method. Although the NFPA standards are voluntary, they are often cited by Federal and State regulations as a definitive source for fire and combustion related technical information. In addition, products are typically manufactured to meet NFPA standards to minimize product liability concerns. The minimum fire safety standard in the U.S. for electronics enclosures is the UL94 V-0 flammability rating.

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[1] The Lowell Center for Sustainable Production, Decabromodiphenylether: An Investigation of Non-Halogen Substitutes in Electronic Enclosure and Textile Applications, University of Massachusetts Lowell, 2005.

[2] Business Communications Company, Inc. (BCC), 2003. Flame Retardant Chemicals, C-004A. ISBN 1-56965-772-6. Marcanne Greene, author.

[3] Agency for Toxic Substances and Disease Registry (ASTDR), (2004) Toxicological Profile for Polybrominated Biphenyls and Polybrominated Diphenyl Ethers (PBBs and PBDEs), p. 373.

[4] Information on the NFPA is available at: http://www.nfpa.org/categoryList.asp?categoryID=143&URL=About%20Us
Accessed 11/05/2008

UL Method 94, '*Test for Flammability of Plastic Materials for Parts in Devices and Appliances*,'[5] contains several tests which quantify the ability of plastics to withstand combustion. The V-0 rating is found in the 20 mm Vertical Burning Test section of UL94. In this test, 5 pieces of plastic are twice subjected to an open flame and discrete information is collected on how long the plastic continues to burn and smolder after the flame is removed. In addition, the combustion of the plastic is observed and it is noted if the plastic burns down to the clamp and if cotton placed beneath the plastic catches fire due to dripping, burning plastic. These criteria are subsequently compared to the various rankings (V-0, V-1, and V-2) with the V-0 being the most resistant to combustion. Therefore any alternative to Deca-BDE must meet this V-0 standard in order to maintain fire safety.

Use in Residential Upholstered Furniture and Flammability Standards

It is unclear how much Deca-BDE is currently used in residential upholstered furniture. Only California has a flammability standard for residential upholstered furniture; Deca-BDE could be used to comply with this standard. If this were the case, it is possible that furniture containing Deca-BDE to meet the California standard could also be sold in Washington. A DOH contact at the federal Consumer Product Safety Commission (CPSC) told DOH staff that Deca-BDE is not used currently in residential upholstered furniture.

Upholstered furniture in commercial settings in the United States is required to meet federal flammability standards and may utilize upholstery textiles that are flame retarded with a back coating containing Deca-BDE at 5 mg/m^2.[6]

The CPSC recently published a proposed flammability standard for residential upholstered furniture. However, the proposed standard does not rely on the addition of chemical flame retardants, including Deca-BDE, for compliance.[7] If the proposed standard is finalized as such, furniture manufacturers will have the option to meet fire safety requirements with design changes, rather than with Deca-BDE or a chemical alternative.

Health and Environmental Impacts

Deca-BDE has been identified as a persistent, bioaccumulative toxic chemical (PBT) by Ecology and DOH and has been banned in electronics in the EU and in several products sold in the State of Maine. Deca-BDE has been found to impact the developing nervous system. Recent studies have indicated neurodevelopmental and reproductive toxicity in animal studies with toxic effects as low as 6.7 mg/kg.[8] However, deca-BDE is generally considered to be less toxic than other forms of PBDEs. Additional concern about deca-BDE is driven by its potential to degrade in the

[5] The UL method can be found at: http://ulstandardsinfonet.ul.com/scopes/0094.html, accessed 11/4/2008
[6] Agency for Toxic Substances and Disease Registry (ASTDR), (2004) Toxicological Profile for Polybrominated Biphenyls and Polybrominated Diphenyl Ethers (PBBs and PBDEs), p. 374.
[7] Consumer Product Safety Commission, 16 CFR Part 1634: Standard for the Flammability of Residential Upholstered Furniture Proposed Rule, Federal Register, March 14, 2008.
[8] EPA, 2008. IRIS file for bde-209.

environment; the breakdown products of deca-BDE may be both more toxic and more bioaccumulative than Deca-BDE itself.

Many studies indicate that there is an increasing buildup of deca-BDE in the environment, in indoor environment, and in people.[9] The sources of exposure for this buildup are not well defined, although recent research indicates high levels of deca-BDE in house dust and possible linkage between house dust, electronics and human exposure.[10]

[9] Lorber, 2007. Review: Exposure of Americans to polybrominated diphenyl ether. Journal of Exposure Science and Environmental Toxicology, (2007): 1-18.
[10] For example: Allen et al., *Linking PBDEs in House Dust to Consumer Products using X-ray Fluorescence*, Environ. Sci. Technol., **2008,** *42,* 4222–4228

IV. Alternatives to Deca-BDE in Television and Computer Electronics Enclosures

Identifying alternatives to Deca-BDE

In the 2006 PBDE Chemical Action Plan (CAP), Ecology and DOH identified two phosphate flame retardants, RDP and BAPP, as promising alternatives to Deca-BDE in electronic enclosures.[11] These two flame retardants were identified from a review of alternatives being marketed by flame retardant manufacturers at that time and were evaluated in several reports published in the U.S. and Europe.

These alternatives were identified as promising because they did not appear to have PBT characteristics; i.e. they were not likely to persistent in the environment or to bioaccumulate into organisms. Additionally, available toxicity data for RDP and BAPP indicated less of a concern for human health or aquatic organisms compared to deca-BDE and its possible breakdown products. However, due to insufficient data at the time, the agencies decided that additional information was needed before these two alternatives could be recommended as safer alternatives to Deca-BDE.

Since the publication of the Chemical Action Plan, several new assessments of alternatives to Deca-BDE have become available. These new assessments include reports from:

- Maine DEP and Maine CDC, 2007
- Illinois EPA, 2007
- Danish EPA, 2007 & European Commission, 2007
- Clean Production Action, 2007

An overview of the methods and conclusions from each of these reports is provided in Appendix 1.

Based on the assessment of alternatives in the CAP and new analyses provided in these reports, the agencies decided to focus on non-halogenated alternatives to replace Deca-BDE in electronic enclosures to address requirements in RCW 70.76. Halogen-containing flame retardants tend to be more persistent in the environment and to accumulate in organisms. At least one halogenated flame retardant that has been identified as an alternative to Deca-BDE in electronic enclosures, tetrabromobisphenol A, is classified as PBTs under Ecology PBT Rule. Other brominated flame retardants reviewed in the Chemical Action Plan were found to be persistent or bioaccumulative.

The four reports above identified three possible non-halogenated alternatives to replace Deca-BDE in electronic enclosures: RDP, BDP (also referred to as BAPP), and triphenyl phosphate (TPP). Other information also indicated that these three non-brominated flame retardants could

[11] Ecology and DOH, 2006. Washington State Polybrominated Diphenyl Ether (PBDE) Chemical Action Plan: Final Plan. January 19, 2006.

be used to replace Deca-BDE and maintain a UL94 V-0 fire safety requirement.[12] Ecology and DOH focused on collecting information on these three alternatives to determine if they are safer than Deca-BDE and if they could be used to achieve the same degree of fire protection.

These three alternatives are currently marketed by flame retardant manufacturers for use in electronic enclosures. Information on all three is included in the following table:

Table 1: Alternative Flame Retardants for Use in Electronic Enclosures

Flame Retardant	CAS Nr.	Manufacturer
RDP Resorcinol bis(diphenyl phosphate)	125997-21-9 57583-54-7[13]	Reofos® RDP by Chemtura Fyroflex RDP by Supresta[14]
TPP Triphenyl phosphate	115-86-6	Reofos TPP by Chemtura Phosflex TPP by Akzo Nobel
BAPP or BDP Bisphenol A bis(diphenyl phosphate)	181028-79-5	Reofos® BAPP by Chemtura[15] Fyrolflex® BDP by Supresta[16]

The European Union banned the use of Deca-BDE in electronics enclosures as of July 1, 2008, under the Restriction on Hazardous Substances (RoHS) Directive.[17] To produce televisions for the European market, electronics manufacturers must have identified alternatives that are technically feasible and allow their products to meet European fire safety standards. It is unknown whether the alternatives in use are safer or whether they would allow final products to meet U.S. fire safety standards. Reports in 2007 indicated that manufacturers in Europe were moving away from brominated flame retardants and that alternatives to Deca-BDE exist which maintain fire safety and meet the UL94 V-0 rating.[18,19]

The following graph shows the flame retardant market in the European Union for 2005. Based upon this information, brominated flame retardants such as Deca-BDE comprise only 11 percent of the EU market while non-halogenated alternatives comprise 69 percent.[20] Phosphorous based flame retardants are only 8 percent of that market but, as manufacturers move away from halogenated alternatives, the percentage is expected to increase.

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[12] J. Troitzsch, 2007. Commercially available halogen free alternatives to halogen-containing flame retardant systems in polymers.
[13] European Flame Retardants Association, "Flame Retardant Fact Sheet: Bisarylphosphates" http://www.flameretardants.eu/Objects/2/Files/BisarylphosphatesFactSheet.pdf, viewed 11 September 2008.
[14] Supresta Built In Defense, Safety Data Sheet, 29 November 2006, http://www.supresta.com/pdfs/FYROLFLEX%20RDP%20(English%20GB).pdf, viewed 11 September 2008.
[15] http://www.e1.greatlakes.com/fr/products/jsp/phosphorus_fr_prod.jsp?showAppMatrix=true#phosphorous_matrix, accessed 11/5/2008
[16] Karlsruhe Research Center, 2007
[17] http://www.endseuropedaily.com/articles/index.cfm?action=article&ref=25141 (April 2, 2008)
[18] European Commission report, 2007
[19] Karlsruhe Research Center, 2007
[20] Note: Although not a halogenated compound, Antimony trioxide is included in this group as it most often used in combination with a halogenated flame retardant

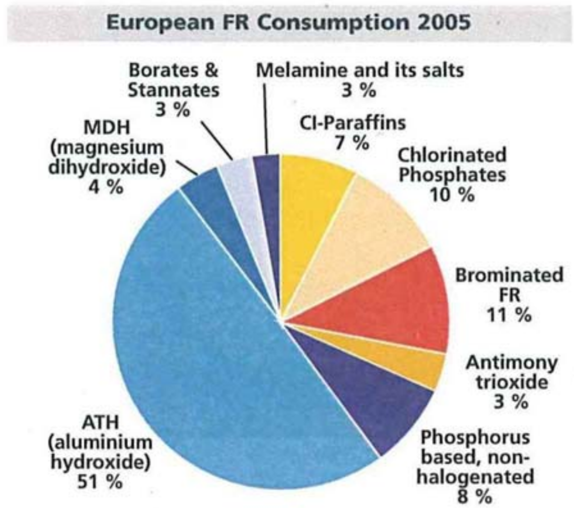

Figure 2: The current consumption of flame retardants in Europe, which amounts to a total of 463 800 metric tons (source: EFRA). Halogen-free FRs are shown in different shades of blue.

(From: Karlsruhe Research Center, 2007)

Although details are scarce, television manufacturers for the U.S. market also appear to be transitioning away from brominated flame retardants toward phosphate and alternative flame retardants.[21] Exact information is difficult to obtain. When working with suppliers, manufacturers typically define the characteristics of the product they want, for example, HIPS plastic that meets the UL94 V-0 flammability standard. Frequently, they do not require additional information, such as the type and amount of flame retardants used. As a result, the television manufacturers themselves often do not know what flame retardants have been used in the electronics enclosures of their products.

A major Deca-BDE manufacturer indicates on its website that several, phosphorous-based alternatives to Deca-BDE including RDP and TPP can be used in 'TV Housings' and other electronic consumer products.[22] More detailed information can be found in Appendix 5.

Sharp was reported to use bisphenol A diphosphate as a flame retardant in their Aquos LCD TVs, and Philips was reported to be using 'phosphate esters' in their plasma TV housings.[23]

[21] Lowell Institute, 2005
[22] Great Lakes website at http://www.e1.greatlakes.com/fr/products/jsp/phosphorus_fr_prod.jsp?showAppMatrix=true#phosphorous_matrix, accessed 10/27/2008
[23] Lowell Institute, 2005

Use in TV Enclosures and Compliance with Flammability Standards

RDP

One of the manufacturers of RDP identifies it as a flame retardant that can be used in TV housings and consumer electronics[24] that can be used in HIPS/PPO blends and in PC/ABS.[25]

RDP cannot be used in HIPS as a direct replacement for Deca-BDE. In order to use RDP, the manufacturer must use a different plastic to achieve the same fire rating.[26] Other plastic blends using RDP such as HIPS/PPO or PC/ABS have been identified as viable alternatives to Deca-BDE/HIPS TV enclosures.

RDP is added to plastic at up to 20 percent by weight. For a given amount of plastic, more RDP must be added than Deca-BDE to maintain fire safety, that is, to achieve UL94 V-0 rating. Recent information however indicates that fire safety and the UL94 V-0 rating can be maintained with much lower levels of RDP. The Karlsruhe Research Center reported in 2007 results of their testing which indicated that the V-0 standard can be maintained in PC/ABS blends with as little as 9 percent RDP.[27]

RDP is being used in the EU. The Danish Report '*Deca-BDE and Alternatives in Electrical and Electronic Equipment*' states that RDP is "Used throughout Europe - roughly 20,000 metric tons in the EU TV enclosure market" although the report goes on to say that this value has not been corroborated and that it seems high. The report also identifies RDP as a viable alternative to Deca-BDE. The report states: "Although the major producers have returned to V-1 or V-0 grade housings, they have not returned to Deca-BDE."[28]

The same Danish report also addresses the use of flame retardants in LCD and other flat-panel TVs. The report states: "The volume of flame retarded… plastic in enclosures of an average LCD panel TV-set, in which the back cover is typically flame retarded, is nearly the same as in an average CRT TV-set, because of the larger screen size of the LCD panel TV-sets. Therefore, the price estimate for FRs in CRT TV-sets may also be applied to the LCD panel TV-sets."[29]

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24 http://www.e1.greatlakes.com/fr/products/jsp/phosphorus_fr_prod.jsp?showAppMatrix=true#phosphorous_matrix, viewed, 11 September 2008.

25 Great Lakes Flame Retardants, Reofos® RDP, http://www.e1.greatlakes.com/freb/products/content/static/reofos_rdp.html, viewed 11 September 2008.

26 Troitzsch, 2007. Commercially available halogen free alternatives to halogen-containing flame retardant systems in polymers. Available at:

27 Karlsruhe Research Center, 2007

28 Danish Ministry of the Environment, "Deca-BDE and Alternatives in Electrical and Electronic Equipment" 2006

29 Danish Ministry of the Environment, 2006

A 2005 report from the Lowell Institute for Sustainable Production includes similar information: "Roughly 61% of CRT monitors are made with PC/ABS resin systems using phosphate type flame retardants."[30]

The Lowell Institute report also addresses the issue of the use of flame retardants in new flat-screen TVs. "In 2003, the Sharp AQUOS held 50.9 percent of the world LCD market. The TV casing is made from PC/ABS resin using a phosphorus-based flame retardant. The cabinet meets the UL V-0 fire resistance standard. A 30 inch unit compared with a CRT TV of equivalent size (32-inch), consumes 38 percent less power, is one-sixth the depth, and weighs only one-third of the CRT TV."[31]

TPP

Using TPP as a replacement for Deca-BDE would require manufacturers to switch from HIPS to HIPS/PPO plastic. TPP is added to HIPS/PPO at about 30 percent weight.[32] According to the Danish EPA, TPP is used in the EU as a substitute for Deca-BDE in electronics.[33]

Degradation of TPP, however, is a concern, especially for environmental effects. The primary degradation products from TPP are diphenyl phosphate and phenol. Ecology evaluated the acute and chronic aquatic toxicity for TPP and its degradation products and found that risks posed to the environment from TPP are more significant than for RDP (See Appendix 2).

BAPP (BDP)

Along with RDP, bisphenol A diphosphate (BAPP) is one of the most widely used non-halogenated flame retardants in electronic enclosures[34]. BAPP is a mixture of three components, two components with bisphenol A as a major constituent (>97 percent) and TPP (3 percent). Recent concern about the risks posed by bisphenol A suggests that more information is needed before this flame retardant can be considered as a safer alternative to Deca-BDE.

Health and Environmental Impacts

RDP

Ecology and DOH reviewed four new alternative assessments for Deca-BDE (Appendix 1). These assessments used different approaches for evaluating alternatives to Deca-BDE in electronic enclosures and other products. Three of these assessments, from Maine, Illinois and

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[30] Lowell Institute for Sustainable Production, "Decabromodiphenylether: An Investigation of Non-Halogen Substitutes in Electronic Enclosure and Textile Applications" 2005

[31] Lowell, 2005, page ??

[32] Karlsruhe Research Centre, 2007

[33] Danish EPA, 2007

[34] Green Screen, 2007, page 29

Clean Production Action, specifically evaluated RDP as an alternative to Deca-BDE in electronic enclosures as part of the main analysis. These three reports recommended RDP as a safer alternative to Deca-BDE in electronic enclosures.

Information summarized in these reports and from other sources indicates RDP is not likely to be persistent in the environment and is estimated to have moderate potential to bioaccumulate in organisms. Estimated half-life of RDP is 40 days in fresh water and 17 days in water at 20º C and pH 7 and its partitioning coefficient (log Kow) is estimated to be 4.93.[35] Based on criteria in Ecology PBT Rule, neither RDP nor its main breakdown products would qualify as a PBT in Washington.[36] Currently, deca-BDE and its breakdown products are on Ecology's PBT list.

One issue worth noting is that commercial RDP contains up to 5 percent of TPP (see below). Therefore, although it is difficult to completely separate the two chemicals, it is important to look at the toxicity of the major component as this will have the greatest impact on human health and the environment. Therefore because TPP is present at low levels in RDP, its impact is expected to be low because it is a minor component.

RDP itself can degrade to a number of constituents including its base components (resorcinol and diphenyl phosphate) and numerous methoxylates and hydroxylates. Upon further degradation, compounds with higher toxicity such as phenol are also possible. However, without more detailed study it is difficult to determine possible degradation pathways and products. Based upon degradation studies of other flame retardants, as much as 50 percent or more of the original compound cannot be identified indicating multiple and intricate degradation pathways.

Studies in Europe indicate that for some phosphate based flame retardants (typically TPP), 40-70 percent of the flame retardant is degraded during the waste water treatment process. Similar results are expected for RDP. Unlike deca-BDE and its degradation products, all of these compounds are readily degraded in the environment. Given the complexity of the processes involved and the likelihood that toxic compounds like phenol would contribute only a very small amount to the degradation process, Ecology and DOH decided to concentrate on the primary degradation products until additional information is available.

Existing data summarized in recent assessments and from other sources indicate that RDP has lower toxicity than deca-BDE. RDP and its major constituents are less toxic to aquatic organisms than deca-BDE (Appendix 2). RDP has not been shown to cause the types of human health-related toxic effects observed for deca-BDE including developmental and reproductive toxicity and neurotoxicity. A direct comparison of toxic effects levels across different types of animal studies shows that deca-BDE produces toxicity at lower levels than RDP (Appendix 2). Unfortunately, there are only a limited number of animal toxicity studies for RDP with which to evaluate its toxicity. A recent assessment predicted RDP's toxicity based on its chemical structure. These predictions indicate a low concern for most toxic effects.[37]

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[35] Supresta, 2007. Environmental summary – bioaccumulation of Fyroflex RDP.
[36] Chapter 173-333 WAC (PBT Rule) criteria for persistence is half-life in water, soil, or sediments ≥ 60days, and for bioaccumulation is log Kow > 5 or BCF or BAF > 1,000.
[37] Syracuse Research Corp., 2006. Flame Retardant Alternatives: an assessment of potential health and environmental impacts of RDP and BAPP, two phosphate-based alternatives to Deca-BDE for use in electronics.

TPP

The Danish EPA identified TPP as a less hazardous alternative.[38] The assessment by the Illinois EPA found TPP to be potentially problematic mainly due to its aquatic toxicity. TPP was included as part of the evaluation in Clean Production's Green Screen analysis of RDP and BAPP because it is a constituent in commercial RDP and BAPP products. Based on the Green Screen methodology, TPP was identified as a safer alternative (qualifies as Benchmark 2 in the Green Screen – see Appendix 1). While TPP was shown to have a favorable human health profile in the Green Screen methodology, this methodology gives aquatic toxicity a lower priority than human health-related effects.

Information summarized in the new assessment reports and from other sources indicates TPP is not likely to be persistent in the environment and is estimated to have low potential to bioaccumulation in organisms.[39] Based on criteria in Ecology PBT Rule, TPP would not qualify as a PBT in Washington.

Unlike RDP, there are several toxicity studies available for TPP with which to evaluate toxicity related to human health and environmental organisms.[40] These studies indicate a mostly low potential for human health toxicity, but a high toxicity for aquatic organisms. Based on an indication of high aquatic toxicity in the reports from Illinois and Clean Production Action, Ecology conducted a comprehensive review of aquatic toxicity data for TPP (Appendix 2). This analysis indicates that TPP's aquatic toxicity precludes it from being recommended as a safer alternative to Deca-BDE.

BAPP (BDP)

BAPP was evaluated as an alternative to Deca-BDE in electronic enclosures in the Maine, Illinois and Clean Production Action reports. The Illinois assessment did not address the toxicity of one of BAPP's breakdown products, bisphenol A. Bisphenol A has been identified as an endocrine disruptor in recent animal toxicity studies. The Maine assessment concluded that BAPP was not a suitable alternative to Deca-BDE because of its persistence and degradation to bisphenol A. Clean Production's Green Screen analysis of BAPP concluded it was a chemical of high concern due the high toxicity concern associated with bisphenol A.

Due to concern about the endocrine disrupting effects of bisphenol A as a breakdown product of BAPP, Ecology and DOH cannot recommend it as a safer alternative to Deca-BDE.

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[38] Danish EPA, 2007. Health report on alternatives…
[39] Syracuse Research Corp., 2006. Flame Retardant Alternatives: an assessment of potential health and environmental impacts of RDP and BAPP, two phosphate-based alternatives to Deca-BDE for use in electronics.
[40] Syracuse Research Corp., 2006. Flame Retardant Alternatives: an assessment of potential health and environmental impacts of RDP and BAPP, two phosphate-based alternatives to Deca-BDE for use in electronics.

Fire Safety

The Fire Safety Committee was convened on November 7, 2009 to consider whether RDP meets applicable fire safety standards for electronic enclosures in TVs and computers. Ecology presented the following information to the committee:

- A description of the alternatives considered
- A detailed description of the UL Method 94 testing protocol
- A comparison of Deca-BDE and RDP
- Documentation of the performance of both flame retardants

Four out of five committee members were present as was the Washington State Fire Marshal and one representative of the public. After discussion, a motion was made in which the Fire Safety Committee found that RDP meets applicable fire safety standards. All four members present agreed. The absent member received all the presentation materials and subsequently agreed with his colleagues and voted with the majority. Subsequently, the Washington State Fire Marshal reviewed these findings and determined that RDP meets applicable fire safety standards (See Appendix 6).

Conclusions

The alternative identified for Deca-BDE in electronic enclosures, is resorcinol bis(diphenyl phosphate) (RDP). RDP is a safer and feasible alternative to Deca-BDE. RDP's low environmental persistence, moderate bioaccumulation potential and moderate toxicity based on existing data, make it a safer alternative than Deca-BDE for use in electronic enclosures.

RDP provides comparable fire safety (UL94 V-0) to Deca-BDE for plastics used in electronic enclosures. The use of RDP in electronic enclosures requires the use of a different plastic than what is typically used with Deca-BDE. However, this switch in plastic is anticipated to be feasible and cost effective.[41]

The Fire Safety Committee and the State Fire Marshal found that RDP will meet applicable fire safety standards for televisions and computers.

Two other phosphate flame retardants were considered by Ecology and DOH as safer alternatives to Deca-BDE. These alternatives are BAPP and TPP. BAPP was identified initially as a feasible alternative to Deca-BDE; however one of its breakdown products, bisphenol A, has been identified as an endocrine disruptor in animal studies. Therefore the agencies determined that BAPP is not a safer alternative to Deca-BDE because of concerns about its toxicity. TPP was identified is a feasible alternative; however the agencies determined that concerns about its aquatic toxicity preclude it from being a safer alternative.

[41] Illinois report, 2007.

V. Alternatives to Deca-BDE in Residential Upholstered Furniture

Background on CPSC proposed flammability standard for residential upholstered furniture

Upholstered furniture design is complicated and involves many different materials. Currently, there are no federal flammability performance requirements for residential upholstered furniture, though federal standards exist for upholstered furniture in commercial and institutional settings.

In March, 2008, the U.S. Consumer Product Safety Commission (CPSC) proposed a standard for flammability performance requirements of residential upholstered furniture. The proposed standard is a performance-based standard which allows manufacturers to meet the standard using one of two approaches. They could use cover materials that are sufficiently smolder-resistant to meet a cigarette ignition performance test. They could also place fire barriers that meet smoldering and open flame resistance tests between the cover fabric and interior filling materials.[42] Chemical flame retardants would not be required to meet the standard as proposed, though they could be used in fabric backing on cover materials. The CPSC indicates that furniture manufacturers have expressed interested in staying away from the use of flame retardants due to consumer concerns.

The CPSC accepted public comment on the proposed standard through May 2008. Comments submitted to the CPSC on the proposed standard included concerns about the lack of an open-flame test for cover fabrics, concerns about the lack of a standard for foam materials (similar to the California standard, see below), support for the standard because it doesn't require chemical flame retardants, concerns that the standard needs to reflect known and expected causes of household fires, concerns about the burdensome testing and reporting requirements, and comments about consistency with existing standards and testing procedures.[43]

One of the comments that the CPSC is considering for their final rule is related to comments submitted by the National Association of State Fire Marshals about concerns that the proposed standard is not protective enough because it doesn't account for ignition of foam materials. An open-flame test for foam materials was included in CPSC previous proposed standard in 2005. Comments submitted on the 2008 proposed standard asked that this requirement be added back into the standard to be consistent with California's standard and to address foam as cause of home fires.

In light of these public comments, CPSC may choose to modify the performance requirements to include an open flame standard for foam materials. However, Deca-BDE is not used in foam materials and would not be required to achieve compliance with an open flame standard for foam

[42] Consumer Product Safety Commission, 73 Fed. Reg., 11,702 (proposed 4 March 2008)
[43] CPSC, public comment rulemaking, standard for the flammability of residential upholstered furniture. Available at: http://www.cpsc.gov/library/foia/foia08/pubcom/pubcom.html

materials. Therefore, alternatives to Deca-BDE for this use would not be needed. Upholstered furniture manufacturers would still have the option to meet the overall flammability standard without chemical flame retardants by choosing to use compliant fire barriers between the cover fabric and interior filling materials.

The CPSC is currently conducting additional analysis on the proposed standard and it is unknown when it will be made final or what specific testing requirements will be included in the standard.

California is currently the only state that has flammability performance requirements for residential upholstered furniture. The California flammability standards for residential furniture have been in effect since 1975. Flammability tests for residential upholstered furniture sold in California are described in California Technical Bulletins 116 (1980) and 117 (2000). In these standards, full scale pieces of furniture must comply with cigarette smoldering tests (TB 116) and upholstery filling materials and other non-frame components must comply with small open-flame and cigarette smoldering tests (TB 117).[44, 45, 46]

On March 28, 2008, Gov. Gregoire signed Senate Bill 5642, which requires that only self-extinguishing cigarettes be sold in Washington.[47] This may reduce the number of fires caused by cigarettes.

Cover fabrics

Use in Residential Upholstered Furniture and Flammability Standards

The proposed CPSC flammability standard for residential upholstered furniture allows the use of cover materials that resist smoldering test, meant to mimic fires caused by cigarettes, to comply with standard.

Health and Environmental Impacts

Chemical flame retardants are not required to be used in cover materials to meet the proposed residential upholstered furniture flammability standard. The CPSC predicts that 14 percent of

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[44] Polyurethane Foam Association (PFA), Joint Industry Foam Standards and Guidelines. Available at: http://209.85.173.104/search?q=cache:gcTamMwFnYkJ:www.pfa.org/jifsg/jifsgs14.html+Technical+Bulletin+117&hl=en&ct=clnk&cd=2&gl=us . Accessed Oct. 22, 2008.

[45] California Dept. of Consumer Affairs, Bureau of Home Furnishings and Thermal Insulation, 2000. California Technical Bulletin 117. Requirements, Test Procedure and Apparatus for Testing Flame Retardance of Resilient Filling Materials Used in Upholstered Furniture. March 2000. Available at: http://www.bhfti.ca.gov/industry/bulletin.shtml

[46] California Dept. of Consumer Affairs, Bureau of Home Furnishings and Thermal Insulation, 1980. California Technical Bulletin 116. Requirements, Test Procedures and Apparatus for Testing the Flame Retardance of Upholstered Furniture. January 1980. Available at: http://www.bhfti.ca.gov/industry/bulletin.shtml

[47] Washington State Legislature, SB 5642 2007 – 2008, http://apps.leg.wa.gov/billinfo/summary.aspx?bill=5642&year=2008, viewed 16 September 2008.

existing fabrics would fail. Furniture manufacturers whose existing fabrics fail could comply with the proposed standard without using chemical flame retardants by modifying fabric or adding fire-resistant interior barriers (see below). The CPSC predicts the use of chemical flame retardants is possible to make complying cover fabrics, but is unlikely.[48]

Conclusions

The draft flammability standard for cover materials can be met without the use of chemical flame retardants. Therefore, there are safer and feasible alternatives to the use of Deca-BDE as a back coating in cover materials because no chemical flame retardants would be required to meet the CPSC proposed flammability standards.

Barriers

Use in Residential Upholstered Furniture and Flammability Standards

The proposed CPSC flammability standard for residential upholstered furniture allows the use of interior barriers that resist open flame and smoldering tests to comply with standard.

Health and Environmental Impacts

CPSC finalized a new mattress flammability standard in 2006.[49] Some of the barrier technologies used to meet the mattress standard could also be used to comply with the proposed flammability standards for residential upholstered furniture. Six flame retardants were identified by the CPSC for use in barriers in mattresses:

1. Ammonium polyphosphate
2. Antimony trioxide
3. Boric acid/Zinc borate
4. Deca-BDE
5. Melamine
6. Vinylidene chloride

The CPSC quantitatively estimated exposures and resulting health effects from the use of these flame retardants in mattress barrier materials.[50] The CPSC evaluation concluded that use of these six flame retardants presented no appreciable risk of health effects to consumers. Their conclusions for antimony trioxide, boric acid, and Deca-BDE were based on estimates of

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[48] Personal communication with Dale Ray, CPSC, Sept. 4, 2008.
[49] Consumer Product Safety Commission, 2006. Standard for the flammability (open flame) of mattress sets; final rule. March 15, 2006. 16 CFR 1633. Available at: http://frwebgate5.access.gpo.gov/cgi-bin/PDFgate.cgi?WAISdocID=786714252713+0+2+0&WAISaction=retrieve
[50] CPSC, 2006. Quantitative assessment of potential health effects from the use of fire retardant (FR) chemicals in mattresses. Available at: http://www.cpsc.gov/library/foia/foia06/brief/briefing.html (Tab D).

exposure that were much lower than toxic effect levels. Their conclusion for vinylidene chloride was based on the CPSC finding of no measurable migration of this flame retardant from mattresses indicating no potential for exposure. The CPSC determined that ammonium polyphosphate and melamine did not meet the definition of "toxic" under the Federal Hazardous Substances Act (FHSA) and exposures to these two flame retardants were not evaluated further.

The CPSC found that the use of these six flame retardants presents no appreciable health risks to consumers. This conclusion was based on the CPSC's risk assessment to support their mattress flammability standard in 2006. Since that time EPA has set a new lower toxicity value for Deca-BDE that was not available in 2006. Additionally, the CPSC assessment did not account for background exposures in the home or the degradation of Deca-BDE to other more toxic PBDE congeners. Therefore, Ecology and DOH do not agree with the findings of the CPSC risk assessment on Deca-BDE indicating that is does not present an appreciable health risk.

It is possible to avoid the use of these flame retardants altogether by relying on complying cover fabrics or inherently flame retardant barriers that require no added chemical flame retardants.

Fire Safety

The Fire Safety Committee was convened on November 7, 2009 to consider whether non-chemical alternatives to Deca-BDE in residential upholstered furniture meet applicable fire safety standards. DOH presented the following information to the committee:

- A description of the types of alternatives considered
- A detailed description of the CPSC mattress standard
- A detailed description of the proposed CPSC rule for upholstered furniture
- A description of the California furniture rule

Four out of five committee members were present as was the Washington State Fire Marshal and one representative of the public. After discussion, a motion was made in which the Fire Safety Committee found that non-chemical alternatives to Deca-BDE meet applicable fire safety standards. All four members present agreed. The absent member received all the presentation materials and subsequently agreed with his colleagues and voted with the majority. Subsequently, the Washington State Fire Marshal reviewed these findings and determined that non-chemical alternatives to Deca-BDE for residential upholstered furniture meet applicable fire safety standards (See Appendix 6).

Conclusions

The use of internal barrier materials may require the use of chemical flame retardants. The CPSC estimates that barriers would be used in only about 5 percent of upholstered furniture to meet the standard. Internal barriers are not required if compliant cover fabrics are used. Flame retardants could be used on cover fabrics, but the CPSC has indicated that fabric suppliers are unlikely to use flame retardants.

Overall Conclusions

For assessing available alternatives to Deca-BDE in residential upholstered furniture, Ecology and DOH relied on information from the CPSC regarding compliance options for meeting their proposed flammability standard. This information indicates that there are currently design options to meet the proposed standard that do not require the addition of any flame retardants, including Deca-BDE. Although the CPSC flammability standards have not been finalized, it is expected that design options that preclude the use of Deca-BDE will be available to meet any additional requirements in a final standard.

The Fire Safety Committee and the State Fire Marshal found that non-chemical design changes meet applicable fire safety standards for residential upholstered furniture.

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UL standards: http://www.ul.com/plastics/flame.html

Appendix 1: Recent Deca-BDE Alternatives Assessment Reports

Alternatives to Deca-BDE for use in electronic enclosures have been evaluated by other governmental and non-governmental organizations since the Chemical Action Plan was published in January 2006. These evaluations provided useful methods and other information for identifying safer alternatives. Four reports that evaluated the availability and safety of alternatives to Deca-BDE were identified and reviewed:

1. Maine DEP and CDC, 2007. Brominated Flame Retardants, 3rd Annual Report to the Maine Legislature.
2. Illinois EPA, 2007. Report on Alternatives to the Flame Retardant DecaBDE: Evaluation of Toxicity, Availability, Affordability, and Fire Safety Issues.
3. Danish EPA, 2007. Health and Environmental Assessment of Alternatives to Deca-BEE in Electrical and Electronic Equipment.
4. Clean Production Action, 2007. The Green Screen for Safer Chemicals: Evaluating Flame Retardants for TV Enclosures.

The following section provides summaries of these recent reports and their main conclusions about alternatives.

1. Maine DEP and CDC, 2007. Brominated Flame Retardants, 3rd Annual Report to the Maine Legislature.

This report was required under Maine's PBDE law of 2004.[51] Maine's PBDE law contains the intention to institute measures to reduce the risk posed by Deca-BDE beginning in 2008 "if a safer, nationally available alternative is identified." Maine's report included a detailed summary of the toxicity and environmental characteristics of Deca-BDE from the published literature available at the time.

Maine's report evaluated alternatives to Deca-BDE for several different consumer products including uses in plastics in electronic enclosures of TVs and computers, plastics in other electronic parts, wire and cables, and textiles in mattresses and upholstered furniture. Maine's report included several assumptions and exclusions identified ahead of time that guided their evaluation. For example, they reviewed only alternatives that met fire safety standards, they assumed that redesign options not requiring added flame retardants were safer, they excluded PBTs from possible safer alternatives, and they specifically wanted to avoid chemicals that were persistent and bioaccumulative, chemicals that might end up in the indoor environment, and chemicals that were carcinogenic, mutagenic or reproductive toxicants.

[51] An act to reduce the contamination of breast milk and the environment from the release of brominated chemicals in consumer product, PL 2003, c. 629, Sec. 1. 38 MRSA §1609, effective July 30, 2004.

Maine's process for evaluating alternatives relied on reviewing available information on alternatives and evaluating these alternatives relative to Deca-BDE and to the exclusions they identified up front (chemicals that were PBTs, persistent, carcinogenic, etc., were not safer). Their evaluation did not establish or use a numerical ranking or prioritization scheme.

For alternatives in textiles, the Maine report concluded that alternatives are available that do not require the use of chemical flame retardants and therefore this approach is safer. For alternatives to Deca-BDE in HIPS plastic used for TV and computer enclosures, Maine identified two alternatives: bisphenol A diphosphate (BAPP or BPADP) and resorcinol bis (diphenylphosphate) (RDP). The Maine report concluded that BAPP was not a suitable alternative due to its environmental persistence characteristics and its ability to degrade to bisphenol A, which is associated with toxic effects. The Maine report identified RDP as presenting a lower human health and environmental risk than Deca-BDE for use in HIPS plastic. The Maine report also concluded that there was limited data available with which to evaluate alternatives to Deca-BDE for other uses besides plastics used in electronic enclosures.

2. Illinois EPA, 2007. Report on Alternatives to the Flame Retardant DecaBDE: Evaluation of Toxicity, Availability, Affordability, and Fire Safety Issues.

The Illinois EPA prepared a report on alternatives to Deca-BDE in 2007 at the request of their Governor as a follow-up to their 2006 report on the review of scientific research on Deca-BDE.[52] The purpose of the 2007 alternatives report was to answer critical questions remaining from their 2006 report and to determine whether safer and affordable alternatives to Deca-BDE were available that met fire protection standards.

The Illinois report evaluated alternatives to Deca-BDE for use in HIPS plastic of electronic enclosures, wire and cable, and textiles. They limited their evaluation to non-halogenated alternative flame retardants already in use or expected to be in use in the future. Their report also included a detailed evaluation of the cost of switching to various alternatives.

Illinois EPA developed a ranking scheme for evaluating alternatives to Deca-BDE. Their scheme consisted of first collecting information on and evaluating several toxicity endpoints including cancer, reproductive effects, developmental effects, systemic toxicity, local effects (direct contact), toxicity to environmental organisms, and environmental persistence and bioaccumulation potential. The level of concern for each endpoint was ranked as high, moderate, low or no evidence meeting specific criteria. Based on the evaluation of individual toxicity and environmental endpoints, each alternative was placed into one of four categories to reflect their overall assessment: potentially unproblematic, potentially problematic, insufficient data, and not recommended.

The Illinois EPA evaluated several flame retardants that have been identified by the U.S. Consumer Product Safety Commission for use in flame retarding textiles. The Illinois EPA concluded two of these were potentially problematic (boron compounds and antimony trioxide),

[52] Illinois EPA, 2006. DecaBDE Study: A Review of Available Scientific Research; A Report to the General Assembly and the Governor in Response to Public Act 94-100. http://www.epa.state.il.us/reports/decabde-study/index.html

that there was insufficient data for two other flame retardants (melamine and ammonium polyphosphates), and that one was not recommended (zinc borate). However, in Illinois' 2006 Deca-BDE review report, they concluded that there are several ways to achieve flame retardancy in textiles that do not require chemical flame retardants and are therefore without toxicity concerns.

For use in HIPS plastic in electronic enclosures, Illinois EPA evaluated non-halogen flame retardants that could be used in other plastic resins to replace Deca-BDE in HIPS plastic. Phosphate flame retardants that were identified as feasible alternatives to Deca-BDE cannot be used in straight HIPS. Instead, manufacturers using phosphate flame retardants would have to switch to a HIPS blend (HIPS/PPO) or different plastic (PC/ABS). Illinois EPA identified three organic phosphorus compounds that could be used in PC/ABS and HIPS/PPO resins: triphenyl phosphate (TPP), resorcinol bis (diphenylphosphate) (RDP), and bisphenol A diphenyl phosphate (BDP). Illinois EPA concluded that two of these phosphate flame retardants (RDP and BDP) were potentially unproblematic and that the other flame retardant (TPP) was potentially problematic based on concerns about aquatic toxicity.

3. Danish EPA, 2007

The Danish EPA evaluated human health and environmental impacts of alternatives to Deca--BDE used in electrical and electronic equipment. They identified alternatives to be evaluated as those being used in the EU based on a market analysis. The market analysis was sponsored by the Danish EPA and identified eighteen possible halogenated and non-halogenated substitutes for Deca-BDE in various polymers.[53] From the eighteen alternatives identified in the market analysis, six were chosen for further evaluation of their health and environmental impacts based on a screening of data availability and a preliminary evaluation of PBT and CMR (carcinogenic, mutagenic and reproductive toxic) properties. The six flame retardants that were evaluated in their environmental and health assessment were: ethylene bistetrabromophthalimide (EBTPI), tetrabromobisphenol A (TBBPA), tetrabromobisphenol A carbonate oligomer, triphenyl phosphate, red phosphorus, and diethylphosphinic acid, aluminum salt.

The Danish EPA evaluated the selected alternatives by conducting a survey of each chemical's physical-chemical characteristics, ecotoxicity and environmental fate information, and toxicological data. Each alternative was then qualitatively compared to Deca-BDE in terms of five toxicity endpoints (carcinogenicity, mutagenicity, reproductive toxicity, endocrine disrupting effects and sensitization) and environmental characteristics (persistence, bioaccumulation and aquatic toxicity). The report concludes that all six flame retardants evaluated do not appear to have more negative impacts on the environment, health or consumer safety than Deca-BDE. Triphenyl phosphate is the only non-halogenated alternative evaluated in the Danish report to replace Deca-BDE in HIPS used in electronic enclosures. Use of triphenyl phosphate requires a change in plastic to PC/ABS or HIS/PPO.

[53] Danish EPA, 2006. Deca-BDE and Alternatives in Electrical and Electronic Equipment. Carsten Lassen and Sven Havelund (COWI A/S, Denmark), Andre Leisewitz (Öko-Recherche GmbH, Germany) and Peter Maxson (Concorde East/West Sprl, Belgium)

4. Clean Production Action, 2007

Clean Product Action is a non-governmental organization that promotes the use of safer and cleaner consumer products. The group developed the Green Screen for Safer Chemicals methodology as a tool to help businesses, governments, and individuals make decisions about chemicals they use or promote. This methodology is similar to EPA's Design for the Environment (DfE) alternatives assessment tool.[54] The Green Screen takes EPA's DfE process one step further by placing the chemicals evaluated into one of four categories that describes their overall health and environmental safety: Benchmark 1 – Avoid, chemical of high concern; Benchmark 2 – Use but search for safer substitutes; Benchmark 3 – Use but still opportunity for improvement; and Benchmark 4 – Preferred safer chemical. The characteristics that are used to place a chemical in each Benchmark are listed in Table 2.

Table 2: Green Screen Benchmarks and Characteristics

Benchmark	Characteristics	Conclusion
4	1. Readily biodegrades (low P) and, 2. Low bioaccumulation and, 3. Low human toxicity and, 4. Low ecotoxicity	Preferred chemical
3	1. Moderate persistence and bioaccumulation 2. Moderate ecotoxicity 3. Moderate human toxicity 4. Moderate flammability or explosiveness	Use, but still opportunity for improvement
2	1. Moderate persistence, bioaccumulation and toxicity (human or ecotoxicity) 2. High persistence and bioaccumulation 3. High persistence or high bioaccumulation with moderate toxicity 4. High flammability or explosiveness	Use but search for safer substitutes
1	1. High persistence, bioaccumulation and toxicity 2. Very high persistence and bioaccumulation 3. Very high persistence or bioaccumulation with high toxicity 4. High human toxicity for any priority effect (carcinogenicity, mutagenicity, reproductive or developmental toxicity, endocrine disruption, or neurotoxicity)	Avoid – Chemical of High Concern

As a case study for their newly developed Green Screen methodology, Clean Product Action evaluated Deca-BDE and two phosphate flame retardants (RDP and BAPP). These two phosphate flame retardants were chosen for evaluation because they can be used to replace Deca-BDE in TVs, which is Deca-BDE's primary use, and because the market for flame retardants in

[54] EPA Design for the Environment, 2005. Environmental Profiles of Chemical Flame-Retardant Alternatives for Low-Density Polyurethane Foam. EPA/742-R-05-002A and B. Available at: http://www.epa.gov/dfe/pubs/index.htm#ffr

electronics is moving towards the use of non-halogenated chemicals. The Green Screen also included the evaluation of triphenyl phosphate (TPP), another identified alternative to Deca-BDE in electronic enclosures, as part of both RDP and BAPP commercial mixtures.

The Green Screen methodology consists of ranking the level of concern for a range of human health and environmental toxicity endpoints and environmental characteristics. The human health-related effects included in the ranking for each chemical are: carcinogenic, mutagenic, reproductive, developmental, endocrine disruption, neurological, acute toxicity, systemic/organ effects, sensitization, irritation, and immune system effects. Acute and chronic ecological toxicity effects are included in the ranking as well as persistence and bioaccumulation potential. Breakdown products are explicitly included in the ranking as metabolites and degradation products. Each endpoint or characteristic is ranked for its level of concern as Low, Moderate, or High or very High based on a comparison to defined criteria. As is done in the EPA DfE methodology, the Green Screen indicates whether the toxicity and environmental fate information used in the ranking is based on experimental data or is predicted from modeled or analogue data.

Table 3, below, from the Green Screen summarizes the hazard profiles for Deca-BDE, RDP and BAPP. Although not one of the products explicitly evaluated in the Green Screen, Table 3 includes information about TPP. Clean Production Action, in their Green Screen report, summarizes toxicity data for several different health impacts (cancer, developmental toxicity, etc.) for Deca-BDE, RDP, and TPP. Each health impact is ranked as low, moderate, or high concern based on criteria developed in the Green Screen methodology. In addition to the level of concern for each endpoint, Table 3 indicates whether information about a particular health effect is based on experimental or is predicted based on modeling, analogue data or professional judgment. Shading in Table 3 indicates that endpoint is evaluated based on modeled or otherwise predicted information.

Most human health-related effects for RDP, TPP and their breakdown products are ranked as low or moderate concern. The one exception to this is phenol, which is a minor breakdown product and, as indicated earlier, is not expected to contribute greatly to the toxicity of RDP. Several of the different health effects for RDP listed in Table 3 are associated with modeled or predicted information. This indicates there are some data gaps in the toxicity testing of RDP. Additional toxicity testing of RDP to fill these data gaps is recommended.

The Green Screen assessment of Deca-BDE alternatives in electronics concludes that RDP and TPP meet the Benchmark 2 criteria: Use by search for safer alternatives. BAPP is categorized as Benchmark 1: Avoid due to it breakdown to bisphenol A which exhibits toxicity for a high priority endpoint (endocrine disruption). Deca-BDE is also categorized as Benchmark 1 – Avoid due to its breakdown to PBT compounds.

Conclusions

Three recent assessments have identified RDP as a safer and feasible alternative to Deca-BDE for electronic uses. In Maine, the state legislature passed a law banning the use of Deca-BDE in electronics and furniture based on the evaluation of alternatives done by the Maine EPA and

CDC. While the assessment by Maine, Illinois and Clean Production Action acknowledge toxicity data deficiencies for RDP, they conclude that available data indicates RDP is not a PBT and that available information indicates that it has lower toxicity than Deca-BDE.

Table 3: Excerpted from Table 5 in The Green Screen, Evaluating Flame Retardants for TV Enclosures (Clean Production Action, 2007).

			Human health effects												
	% in formulation		**carcinogen**	**mutagen**	**reproductive toxicity**	**developmenta l toxicity**	**endocrine disruption**	**neurotoxicity**	acute toxicity	systemic toxicity	skin sensitivity	respiratory sensitivity	skin irritation	eye irritation	immune system
Chemical (Flame retardants)		CAS #													
RDP Mixture (mixture of following 3 components)		125997-21-9													
RDP (Resorcinol bis(diphenylphosphate))	65-80	57583-54-7	L	L	L	L	ND	L	L	M	L	ND	L	M	L
Phosphoric acid, bis [3-[(diphenoxyphos phinyl) oxy] phenyl] phenyl ester	15-30	98165-92-5	L	L	L	L	ND	L	L	M	L	ND	L	M	L
TPP (Triphenylphosphate)	<5	115-86-6	L	L	L	L	ND	L	L	M	L	ND	L	M	L
Breakdown products:															
Phenol		108-95-2	L	M	L	L	L	M	M	H	L	L	H	H	M
Resorcinol		108-46-3	L	L	L	L	M	M	M	ND	M	ND	M	M	ND
Diphenylphosphate (DPP)		838-85-7	Insufficient Data												
deca-BDE	97	1163-19-5	M	L	L	M	M	M	L	L	L	ND	L	L	ND
penta-BDE		32534-81-9	ND	L	M	M	H	M	L	H	L	L	M	M	ND
octa-BDE		32536-52-0	ND	L	M	H	M	M	L	H	L	ND	L	L	ND

ND = not data
Bold health effects indicates "priority effects" defined in the Green Screen.
Shaded (darker) cell colors for L, M or H indicates based on modeled or analogue data.

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UL standards: http://www.ul.com/plastics/flame.html

Appendix 2: Comparison of toxicity information for Deca-BDE, RDP and TPP

Human Health Toxicity Comparison of Deca-BDE, RDP and TPP

Table 4 summarizes the animal toxicity studies and toxic effect levels observed in these studies for Deca-BDE, RDP and TPP. This information includes the types of toxicity studies conducted for each chemical, the doses that were tested in these studies, and the doses that produced an observed toxic effect. This summary is meant to give a sense of the different types of toxicity tests conducted for Deca-BDE compared to those for RDP and TPP, and how the toxic effect levels differ between the three. The terms NOAEL and LOAEL are used in this table to indicate the highest dose in a study that did not produce an observed toxic effect (NOAEL) and the lowest dose for which a toxic effects was observed (LOAEL).

This information is mainly taken from a review of toxicity information for RDP and TPP compiled by Syracuse Research Corporation under contract for the Washington State Department of Ecology. Information about Deca-BDE toxicity studies is mainly derived from EPA's new IRIS file for Deca-BDE released in 2008.

Deca-BDE has been tested for developmental neurotoxicity, reproductive effects and immunotoxic effects in rodents. The effects levels observed in these animal studies range from between 6 mg/kg-day for developmental and immune system effects to 500 mg/kg-day for reproductive effects. These studies have been conducted in the last several years and are reviewed in the EPA IRIS file for Deca-BDE as support for their new toxicity assessment. Older studies of Deca-BDE include a 2 year chronic oral bioassay in rats, a subchronic bioassay in rats and a 2-year cancer study, which looked at different types of health effects that are not as sensitive as the developmental effects observed in the more recent studies.

Based on existing toxicity studies, Deca-BDE produces toxicity at much lower doses than RDP. None of the RDP animal toxicity studies have identified a toxicity effect level (LOAEL). The NOAELs found for RDP range from between 1000 mg/kg to 5000 mg/kg-day. The animal studies for TPP also indicate lower toxicity than Deca-BDE, with LOAEL ranging from 345 – 700 mg/kg-day.

It should be noted that the types of toxicity studies done for RDP and TPP are different than the studies done for Deca-BDE. For example, the types of developmental toxicity studies done with Deca-BDE have not been conducted with RDP and TPP. Having different types of studies makes it difficult to directly compare the toxicity of each chemical. The toxicity studies of RDP and TPP are generally older than the studies of Deca-BDE and were mainly carried out by their manufacturers. In contrast, many of the Deca-BDE developmental studies are recent and have been conducted by researchers not affiliated its manufacturing. In addition, there are fewer toxicity studies available on RDP and TPP compared with Deca-BDE which also makes the comparison between these chemicals difficult.

Table 4: Comparison of human health-related toxic effect levels for Deca-BDE, RDP and TPP:

Flame Retardant	Type of toxicity study/endpoint	NOAEL	LOAEL	Comments/reference
Deca-BDE	Developmental neurotoxicity (in rats) (Viberg et al., 2007)	Not determined	6.7 mg/kg (behavior changes)	One dose on postnatal day 3, unusual study design (EPA IRIS, 2008)
	Developmental neurotoxicity (in mice) (Viberg et al., 2003)	2.22 mg/kg [Basis for new RfD]	20.1 mg/kg (behavior changes)	One dose on postnatal day 3, 10 or 19, unusual study design (EPA IRIS, 2008)
	Developmental and immune system effects (male and female mice) (Rice et al., 2007)	Not determined	6 mg/kg-day (reduced thyroid hormone levels; abnormal behavior and activity)	Exposure post natal days 2-15; 99.5% purity BDE-209 (EPA IRIS, 2008)
	Reproductive effects (in mice) (Tseng, 2006)	100 mg/kg-day	500 mg/kg-day (reduced sperm activity)	(EPA IRIS, 2008)
	Thyroid effects; serum thyroid levels and hepatic enzymes (Zhou, 2001)	100 mg/kg-day	Not determined	Dose levels: 0, 0.3, 1, 3, 10, 30, 60, 100 mg/kg-dy (EPA IRIS, 2008)
	2 year chronic oral bioassay (in rats). Endpoints: blood work, food consumption, organ and body weight, and neoplastic lesions. (Kociba et al., 1975)	1.0 mg/kg-day [Basis for old RfD of 0.01 mg/kg-day	Not determined	Dose levels: 0, 0.01, 0.1, 1.0 mg/kg-day. Deca product contained ~77% deca-BDE; effects may be related to other congeners. (EPA IRIS, 1995)
	Subchronic (30 day) oral bioassay (in rats) (Norris et al., 1973, 1975)	8 mg/kg-day	80 mg/kg-day (liver enlargement)	Deca product contained ~77% deca-BDE. (EPA IRIS file, 1995)
	2-year cancer study (NTP, 1986). Studies conducted in rats and mice; both sexes.	Not determined	2500 – 5000 g/kg-day (neoplastic nodules; males only at 2500)	High doses: 2500 g/kg-day = 2,500,000 mg/kg-day (Birnbaum and Staskal, 2004)

Flame Retardant	Type of toxicity study/endpoint	NOAEL	LOAEL	Comments/reference
RDP	2 generation rodent study (31 weeks); developmental/ reproductive effects; reprod. performance & fertility, body + organ weights (Henrich et al., 2000)	>20,000 ppm (2%) (equivalent to 1203 mg/kg-day, males; 1305 mg/kg-day females)	Not determined	Technical products, Fyrolflex RDP, unreported % of RDP. Incomplete histopathology per guidelines. (Syracuse Research Corp., 2006)
	Subchronic (28 day) toxicity study (Arthur Little, 1989); male and female rats.	1000 mg/kg (liver weights)	Not determined	Unknown RDP content in test mixture. (Syracuse Research Corp., 2006)
	Prenatal developmental toxicity study in rabbits; exposure gestational days 6-28 (Ryan et al., 2000)	1000 mg/kg	Not determined	Unknown RDP content in product. (Syracuse Research Corp., 2006)
	Immunotoxicity. Battery of immune function tests, survival + bodyweight (in mice). Subchronic, 28 days (Sherwood et al., 2000)	5000 mg/kg-day	Not determined	Incomplete histopathology. (Syracuse Research Corp., 2006)
	Genotoxicity: Negative gene mutation in bacteria + chromosomal aberration, in vitro + in vivo	-	-	(Syracuse Research Corp., 2006)
TPP	Reproductive/ developmental. 91 days prior to mating, gestational day 20. Fertility + gross pathology. (Welsh et al., 1987)	Not determined	690 mg/kg-day (decreased body weight)	Lacks histopathology per current guidelines. (Syracuse Research Corp., 2006)
	Neurotoxicity; neurobehavioral effects. 4 month diet study in male rats. (Sobotka et al., 1986)	161 mg/kg-day	345 mg/kg-day (decreased body weight)	(Syracuse Research Corp., 2006)
	Immunotoxicity study. 4 month diet study in male and female rats. (Hinton, 1987)	517 mg/kg-day	700 mg/kg-day (decreased body weight)	(Syracuse Research Corp., 2006)

NOAEL = No observed adverse effect level,
LOAEL = Lowest observed adverse effect level

Aquatic Toxicity of Alternatives to Deca-BDE

Although an assessment of the aquatic toxicity impacts of RDP was included in several of the new sources reviewed by Ecology and DOH for this update of the safer chemical alternatives assessment, the increased importance being placed on improving the health of the Puget Sound warranted a more detailed review. Therefore an assessment of the aquatic toxicity of RDP was conducted using the Green Screen process identified in the report '*Evaluating Flame Retardants for TV Enclosures*' issued by Cleaner Production Action.[55] This assessment used additional sources of information which were not included in the Green Screen, including EPA's Ecotoxicology database (ECOTOX), and NIH's Hazardous Substances Database (HSDB).
An evaluation was made of the acute and chronic aquatic toxicity for RDP, another phosphate flame retardant (triphenyl phosphate or TPP), their degradation products, and Deca-, Octa- and Penta-BDE. The specific chemicals subjected to this evaluation are the following:

- RDP (resorcinol bis(diphenyl phosphate))
- TPP (triphenyl phosphate)
- Degradation products:
    - Phenol
    - Resourcinol
    - Diphenyl phosphate
    - Sodium triphosphate
    - Sodium phosphate
- Deca-BDE (deca brominated diphenyl ether)
- Octa-BDE (octabrominated diphenyl ether mixture)
- Penta-BDE (pentabrominated diphenyl ether mixture)

Sodium triphosphate and sodium phosphate were included in the evaluation as the concern was raised about the increased deposition of phosphate from flame retardants upon aquatic bodies. This concern was particularly important given current efforts to limit phosphates in laundry detergents and other consumer products because of the adverse impact phosphates have upon the health of aquatic bodies. This issue is addressed more in Appendix 3.

Seventeen sources were used for this evaluation including many of the reports already cited in this report, risk assessments conducted by the European Union, toxicity databases maintained by EPA, etc.

Aquatic Toxicity Comparison

Based upon the information obtained on aquatic toxicity, a comparison was conducted for each of the individual compounds and degradation products. The Green Screen includes a ranking scheme where each of the toxicity criteria can be assigned a 'low', 'medium' or 'high' value

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[55] Rossi and Heine, '*The Green Screen for Safer Chemicals: Evaluating Flame Retardants for TV Enclosures*', Clean Production Action, March 2007, found at: http://cleanproduction.org/library/Green%20Screen%20Report.pdf

depending upon the numerical values obtained. The full ranking criteria (Table 3 from the report) are included at the end of this Appendix (see page 47)

A ranking was assigned for the numerical values for acute and chronic aquatic toxicity for all chemicals included in this evaluation. The result of this ranking is found below.

Table 5: Summary of Aquatic Toxicity

Chemical	CAS	%	Acute Toxicity	Chronic Toxicity
Flame retardants				
RDP Mixture (mixture of following 3 components)	125997-21-9	NA	Medium	Medium
- **RDP** (Resorcinol bis(diphenylphosphate))	57583-54-7	65-80	Medium	Medium
- Phosphoric acid, bis[3-[(diphenoxyphosphinyl) oxy]phenyl]phenyl ester	98165-92-5	15-30	Low	Low
- **TPP** (Triphenylphosphate)	115-86-6	<5	High	High
Breakdown products:				
- Phenol	108-95-2		Medium	Medium
- Resorcinol	108-46-3		Med-Low	Med-Low
- Diphenylphosphate (DPP)	838-85-7		Insufficient	data
- Sodium triphosphate	7758-29-4		Low	Low
- Sodium phosphate	7558-80-7		Low	Low
Deca-BDE	1163-19-5		High	High
Octa-BDE	32536-52-0		High	High
Penta-BDE	32534-81-9		High	High

Insufficient data was available to determine the impacts of diphenylphosphate as it appears few toxicity evaluations have been done on this chemical. Based upon this evaluation, concerns were identified with the PBDE species and TPP.

An additional concern was identified related to the possible impact phosphates might have upon water quality if all of the brominated flame retardants currently in use were replaced by phosphate containing alternatives. Ecology is concerned about the health of the water resources such as the Puget Sound and the Columbia River. Phosphates in detergents and other consumer products have a long history of negatively impacting water quality. The concern was raised that if Ecology and DOH were to recommend a phosphate alternative to Deca-BDE, it would be important to understand if the decision could negatively impact water quality within the state.

To address this issue, Ecology conducted a worst case, rough estimate of the impact phosphate flame retardants would have upon water quality. Full details of this evaluation can be found in Appendix 4. For the purposes of this analysis, Ecology made the following, non-conservative assumptions:

1. All of the Deca-BDE currently used in electronic enclosures was replaced by TPP (the Deca-BDE alternative which has the highest phosphate loading).
2. The amount of TPP used would increase by 20 percent as more TPP is needed to maintain the same level of fire safety as does Deca-BDE.
3. All of the TPP used in electronic enclosures is released within one year (as opposed to the full lifetime of the consumer product.)
4. All of the TPP would be released only to the Puget Sound.

Ecology was able to find enough information on the amount of phosphates currently being added to the Puget Sound and compared this loading with any additional loading based on the above assumptions. Even with these worst case assumptions, it was found that the amount of phosphate loading from phosphate flame retardants was minor and did not pose any additional threat to the waters of the State.

Lastly, the question was raised concerning the long-term impact phosphate flame retardants have upon the environment. Little information was available specifically on RDP although considerable research had been done on TPP in Europe. In summary, phosphate flame retardants were being found in the environment. However, unlike their PBDE alternatives, phosphate alternatives were found to degrade readily while being processed at a waste water treatment plant (WWT). One Swedish study found determined that 56 percent of the incoming TPP was degraded during the treatment process.[56] A similar German study indicated at between 40 to 75 percent of the TPP coming into the WWTP was reduced before discharge.[57] In an early study by Monsanto in the U.S., phosphate esters like TPP were found to exhibit low aqueous solubility, moderate potential for bioconcentration and readily undergo primary and ultimate biodegradation.[58] Therefore phosphate flame retardants have one major advantage over their PBDE equivalents in that they do not persist to the same degree but would be more readily removed from the environment.

We know very little about potential exposure to RDP from use in electronic enclosures; this evaluation focuses on a hazard evaluation of the alternatives compared to Deca-BDE and not on assessing risks from exposures.

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[56] Marklund, et al. '*Organophosphorus Flame Retardants and Plasticizers in Swedish Sewage Treatment Plants*', **Environ. Sci. Tech.**, 39, 2005.

[57] Meyer and Bester, '*Organophosphate flame retardants and plasticizers in wastewater treatment plants*', **J. Environ. Monit.**, 6, 2004.

[58] Saeger et al. '*Environmental Fate of Selected Phosphate Esters*', **Environ. Sci. Technol.**, 1979.

The review of the aquatic toxicity information indicates that RDP as a chemical poses less of a risk to aquatic species for both acute and chronic toxicity than does Deca-BDE. A similar conclusion is reached when all toxicity criteria are evaluated. Therefore the Green Screen process assigned RDP an overall status of 'Benchmark 2: Use but Search for Safer Substitutes.' This does not indicate that RDP is a preferred chemical, only that it poses less of an impact to human health and the environment than Deca-BDE. Ecology and DOH support continued work in the area of flame retardants and support work to identify flame retardants which could be classified as 'Benchmark 4: Safer Chemical' while maintaining fire safety.

RDP has been reviewed by other states and found to be a viable alternative to Deca-BDE. It has been approved by Illinois and Maine as a safer alternative to Deca-BDE. Illinois identified RDP as "potentially unproblematic" and Maine identified RDP as a non-PBT and significantly lower threat.

As identified earlier with RDP, TPP is not a PBT as it readily degrades in the environment. European studies quoted in the section on RDP show that TPP is degraded anywhere between 45 and 70 percent in a POTW while Deca-BDE has been shown to degrade only by about 2 percent. Therefore it does have the added benefit of degrading in the environment unlike deca-BDE and other halogenated flame retardants which persist for much longer periods of time.

As also identified earlier, TPP would have negligible impact on aquatic loading using very non-conservative assumptions. In addition, although RDP and TPP require use of PTFE during formulation as an anti-dripping agent, the amount of PTFE used in this process would have minimal impact on human health and the environment.

Based on the overall evaluation of human and aquatic toxicity, TPP is assigned to the Green Screen 'Benchmark 2: Use but Search for Safer Substitutes.' Because of its aquatic toxicity concerns and the emphasis Ecology and DOH are placing on protecting the waters of the State, Ecology and DOH cannot recommend TPP as a safer alternative to Deca-BDE.

TABLE 3: **Threshold Values for Each Chemical Hazard Included in the Green Screen**

Hazard	Very High (v)	High (H)	Moderate (M)	Low (L)
Environmental Fate				
Persistence—P (half-life in days)[1]	• Soil or sediment >180 days; or • Water >60 days	• Soil or sediment >60 to 180 days; • Water >40 to 60 days; or • Potential for long-range environmental transport	• Soil or sediment 30 to 60 days; or • Water 7 to 40 days	• Soil or sediment <30 days; • Water <7 days; or • Ready bio-degradability
Bioaccumulation Potential—B[1]	• BCF/BAF >5000; or • Absent such data, log K_{ow} >5	• BCF/BAF >1000 to 5000; • Absent such data, log K_{ow} >4.5-5; or • Weight of evidence demonstrates bioaccumulation in humans or wildlife	• BCF/BAF 500 to 1000; • Absent such data, log K_{ow} 4-4.5; or • Suggestive evidence of bioaccumulation in humans or wildlife	• BCF/BAF <500; or • Absent such data, log K_{ow} <4
Ecotoxicity				
Acute Aquatic Toxicity[1]		• $LC_{50}/EC_{50}/IC_{50}$ <1 mg/l; or • GHS Category 1	• $LC_{50}/EC_{50}/IC_{50}$ 1-100 mg/l; or • GHS Category 2 or 3	• $LC_{50}/EC_{50}/IC_{50}$ >100 mg/l
Chronic Aquatic Toxicity[1]		• NOEC <0.1 mg/l; or • GHS Category 1	• NOEC 0.1-10 mg/l; or • GHS Category 2, 3 or 4	• NOEC >10 mg/l
Human Health				
Carcinogenicity*		• Evidence of adverse effects in humans; • Weight of evidence demonstrates potential for adverse effects in humans; • NTP known or reasonably anticipated to be human carcinogen; • OSHA carcinogen; • US EPA known/likely (probable); • California Prop 65; • IARC Group 1 or 2A; • EU Category 1 or 2; or • GHS Category 1A or 1B	• Suggestive animal studies; • Analog data; • Chemical class known to produce toxicity; • US EPA suggested evidence (possible); • IARC Group 2B; • EU Category 3; or • GHS Category 2	• No basis for concern identified or • IARC Group 3 or 4
Mutagenicity/ Genotoxicity*		• Evidence of adverse effects in humans; • Weight of evidence demonstrates potential for adverse effects in humans; • EU Category 1 or 2; or • GHS Category 1A or 1B	• Suggestive animal studies; • Analog data; • Chemical class known to produce toxicity; • EU Category 3; or • GHS Category 2	No basis for concern identified
Reproductive toxicity*		• Evidence of adverse effects in humans; • Weight of evidence demonstrates potential for adverse effects in humans; • NTP Center for the Evaluation of Risks to Human Reproduction; • California Prop 65; • EU Category 1 or 2; or • GHS Category 1A or 1B	• Suggestive animal studies; • Analog data; • Chemical class known to produce toxicity; • EU Category 3; or • GHS Category 2	No basis for concern identified
Developmental toxicity*		• Evidence of adverse effects in humans; • Weight of evidence demonstrates potential for adverse effects in humans; • NTP Center for the Evaluation of Risks to Human Reproduction; or • California Prop 65	• Suggestive animal studies; • Analog data; or • Chemical class known to produce toxicity	No basis for concern identified
Endocrine Disruption*		• Evidence of adverse effects in humans; or • Weight of evidence demonstrates potential for adverse effects in humans	• Suggestive animal studies; • Analog data; • Chemical class known to produce toxicity; • EU Draft List—Category 1 or 2; or • Japanese list	No basis for concern identified

TABLE 3: **Threshold Values for Each Chemical Hazard Included in the Green Screen** continued

Hazard	Very High (v)	High (H)	Moderate (M)	Low (L)
Neurotoxicity*		• Evidence of adverse effects in humans; or • Weight of evidence demonstrates potential for adverse effects in humans	• Suggestive animal studies; • Analog data; or • Chemical class known to produce toxicity	No basis for concern identified
Acute Toxicity (oral, dermal, or inhalation)		• LD_{50} <50 mg/kg bodyweight (oral); • LD_{50} <200 mg/kg bodyweight (dermal); • LC_{50} <500 ppm (gas); • LC_{50} <2.0 mg/l (vapor); • LC_{50} <0.5 mg/l (dust or mist); • US EPA Extremely Hazardous Substance List; or • GHS Category 1 or 2	• LD_{50} 50-2000 mg/kg bodyweight (oral); • LD_{50} 200-2000 mg/kg bodyweight (dermal); • LC_{50} 500-5000 ppm (gas); • LC_{50} 2-20 mg/l (vapor); • LC_{50} 0.5-5 mg/l (dust or mist); or • GHS Category 3 or 4	No basis for concern identified
Corrosion/Irritation of the Skin or Eye		• Evidence of irreversible effects in studies of human populations; • Weight of evidence of irreversible effects in animal studies; or • GHS Category 1 (skin or eye)	• Evidence of reversible effects in humans or animals; • GHS Category 2 or 3—skin irritation; or • GHS Category 2A or 2B —eye	No basis for concern identified
Sensitization of the Skin or Respiratory System		• Evidence of adverse effects in humans; • Weight of evidence demonstrates potential for adverse effects in humans; • GHS Category 1—(skin or respiratory); or • Positive responses in predictive Human Repeat Insult Patch Tests (HRIPT) (skin)	• Suggestive animal studies; • Analog data; or • Chemical class known to produce toxicity	No basis for concern identified
Immune System Effects		• Evidence of adverse effects in humans; or • Weight of evidence demonstrates potential for adverse effects in humans	• Suggestive animal studies; • Analog data; or • Chemical class known to produce toxicity	No basis for concern identified
Systemic Toxicity/Organ Effects (via single or repeated exposure)		• Evidence of adverse effects in humans; • Weight of evidence demonstrates potential for adverse effects in humans; • GHS Category 1—organ/systemic toxicity following single or repeated exposure	• Suggestive animal studies; • Analog data; • Chemical class known to produce toxicity; • GHS Category 2 or 3 single exposure; or • Category 2 repeated exposure	No basis for concern identified
Physical/Chemical Properties				
Explosive		• GHS Category: Unstable explosives or Divisions 1.1, 1.2, or 1.3	• GHS Category: Divisions 1.4 or 1.5	No basis for concern identified
Flammable		• GHS Category 1—Flammable Gases; • GHS Category 1—Flammable Aerosols; or • GHS Category 1 or 2—Flammable Liquids	• GHS Category 2—Flammable Gases; • GHS Category 2—Flammable Aerosols; or • GHS Category 3 or 4 —Flammable Liquids	No basis for concern identified

*=Priority Human Health Effect. [1]= Experimental data are preferred. Absent experimental data, values based on structure activity relationships are sufficient.

ABBREVIATIONS:
BAF=bioaccumulation factor; **BCF**=bioconcentration factor; **EC_{50}**=median effective concentration; **EU**= European Union; **GHS**=Globally Harmonized System of Classification and Labelling of Chemicals; **IARC**=International Agency for Research on Cancer; **IC_{50}**=mean inhibitory concentration; **LC_{50}**=median lethal concentration: the concentration at which 50% of test animals died after exposure; **LD_{50}**=median lethal dose: the dose at which 50% of test animals died during exposure; **log K_{ow}**=log-octanol water partition coefficient; **NOEC**=no observed effect concentration; **NTP**=National Toxicology Program; **OSHA**=Occupation Safety and Health Administration

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Appendix 3: Impact to Water Quality of Potential Deca-BDE Replacement with Phosphate Alternatives

Summary

Based on a series of worst case assumptions, replacement of Deca-BDE with phosphate alternatives would increase the amount of phosphate loading to Puget Sound by slightly less than 2 percent. In actuality, the increase of phosphates to the Sound would be only a fraction of this amount and likely to be several orders of magnitude lower. Since the amount of phosphate from this source is so small given other sources and the conservative nature of the assumptions used, further research to quantify this source is not needed.

Amount of Phosphate Involved

In 2001, 24,500 metric tons of Deca-BDE was used in products sold in North America (WA PBDE Chemical Action Plan, Table 1, page 6). If one were to assume that all of these products were used only within the U.S. and that Washington State received a proportionate share based on its population, 490 metric tons of Deca-BDE was sold in products in Washington State. Four hundred ninety metric tons is equal to 490,000 kilograms of Deca-BDE.

Several reports have indicated that a higher concentration of phosphate flame retardants are needed compared with their brominated alternatives in order to maintain fire safety. If one assumes 20 percent more RDP is needed than Deca-BDE, this converts into 588,000 kilograms of RDP which would equal the Deca-BDE used in 2001. RDP is used instead of other phosphate flame retardants like TPP because the amount of phosphate in the RDP is higher and therefore would lead to the higher total phosphorus loading.

RDP has the structural formal of $C_{30}H_{24}O_8P_2$ and a molecular weight of 574.47. Phosphorus has a molecular weight of 30.1. Therefore the amount of total phosphorus in RDP is 10.97 percent of the total weight of RDP (2 x 20.1/574.47). Based on this ratio, the amount of total phosphorus in RDP sold in WA in 2001 is 63,460 kilograms (588,000 x 0.1097).

If one makes the following conservative assumptions:

- All of the phosphorus in RDP is released within 1 year.
- The release rate is constant over that period.
- All of the RDP is released only to the Puget Sound, i.e. no releases elsewhere within the state.

The amount of phosphorus loading from RDP to the Puget Sound would equal about 175 kg/d (63,460 kilograms/365 days).

Phosphate Loading to the Puget Sound

Information on phosphate loading to Puget Sound is incomplete. Ecology conducted one study which evaluated phosphate loading to the Puget Sound below Edmonds. This information can be found in the report *South Puget Sound Water Quality Study, Phase 2: Dissolved Oxygen-Interim Data Report, June 2008'*. Another study looked at toxic chemical loading to all of Puget Sound but did not include phosphate as one of its chemicals of concern. This information can be found in *'Control of Toxic Chemicals in Puget Sound Phase 1: Initial Estimate of Loadings'*. Data can be combined from the two reports to give an estimate of total phosphate loading to the Sound.

For this evaluation, only two sources of total phosphate, 1) discharge from Waste Water Treatment Plants (WWTPs) and 2) input from stream flows, were considered. Several other inputs to the Sound were not included in this evaluation such as:

- Industrial discharges.
- Combined sewer overflows.
- Storm water.
- Fertilizer run-off and run-off from exposed soil.
- Etc.

Many of these sources contribute considerable additional phosphate loading to the Sound. Therefore the estimate of total phosphorus loading to the Sound provided here is appreciably lower than the actual loading but it does allow the reader to evaluate the difference in scale between these inputs. It is important though to remember that the amount of phosphate from flame retardants is overestimated while phosphate loading to the Sound from other sources is underestimated.

<u>Loading from WWTPs:</u>

Page 95 of the South Puget Sound report identifies the **total phosphorus loading from WWTPs as 2,900 kg/day** (see info below).

Figure 62 presents phosphorus loads from wastewater treatment plants by region. South Puget Sound produces an average of 283 kg/d. Commencement Bay and South Sound produce an average of 493 kg/d, accounting for 17% of the total 2,900 kg/d of total phosphorus discharged from wastewater treatment plants south of Edmonds.

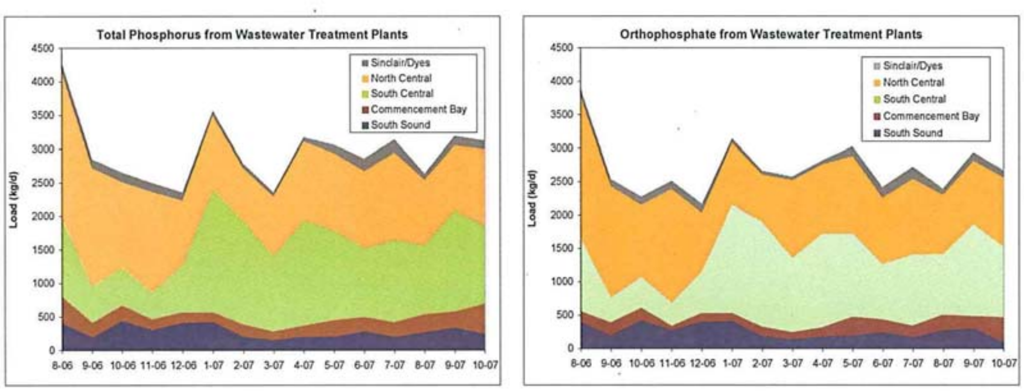

Figure 62. Phosphorus loads (kg/d) from wastewater treatment plants by region.

Loading from Stream Runoff:

This estimate requires the combination of information from the two reports. The Control of Toxic Chemicals in Puget Sound report includes an estimate of the amount of stream water reaching the Sound. Table 3 on page 59 indicates that the total stream runoff to the Puget Sound equal 1,717 m^3/sec. This translates into 148,348,800,000 liters per day.

Table 3 - Study Unit Runoff Rates

Study Unit	Mean Runoff Rate (cubic meters per second)					
	January	February	March	April	May	June
Main Basin	743	442	343	323	480	595
South Sound	458	327	292	226	204	197
Hood Canal	343	198	199	148	163	151
Whidbey Basin	836	625	599	598	691	733
Bellingham	198	170	148	150	181	192
Olympic Peninsula	202	171	136	123	166	190
TOTAL	**2,780**	**1,934**	**1,717**	**1,567**	**1,885**	**2,058**

Study Unit	Mean Runoff Rate (cubic meters per second)						
	July	August	September	October	November	December	Average Annual
Main Basin	368	128	119	195	571	550	**405**
South Sound	137	98	89	137	269	372	**234**
Hood Canal	91	51	43	119	251	306	**172**
Whidbey Basin	574	357	314	472	736	777	**609**
Bellingham	138	83	74	111	200	206	**154**
Olympic Peninsula	130	71	52	93	175	211	**143**
TOTAL	**1,437**	**789**	**690**	**1,128**	**2,202**	**2,423**	**1,717**

The South Puget Sound report contains information on the concentration of total phosphorus for 30 streams within the boundaries of the study. Many of these are major inputs of runoff to the Puget Sound. Based on the information found in Figure 50 on page 86 (below), a value of 0.05 mg/L is selected for an average runoff total phosphorous concentration.

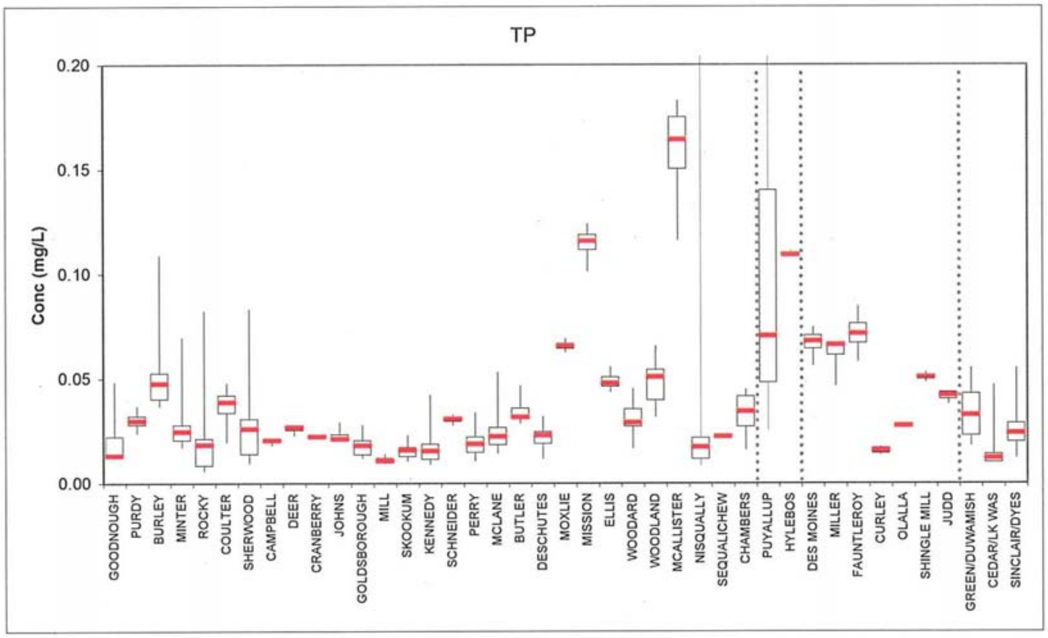

Figure 50. Total phosphorus concentrations in rivers and tributaries. Boxes represent the 25th and 75th percentile concentrations, thick red lines indicate the 50th percentile (median) concentrations, and lines extend to the minimum and maximum values.

Given an average concentration of 0.05 mg/L and an average runoff of 148,348,800,000 liters per day, the mass of total phosphorus can be calculated and determined to be 7,417 kg/d.[59]

Combining these two phosphorus sources, a total loading of 10,317 kg/d is identified.

<u>Comparison of existing sources with RDP</u>

Based on the information above, the total phosphorus loading can be identified:

1. Loading from RDP = 173.86 kg/d
2. Loading from WWTP and stream runoff = 10,317 kg/d

Therefore as a worst-case evaluation, the potential loading from RDP would constitute an increase of 1.69 percent.

[59] Note: In order to compare the impact of selecting 0.05 mg/L as the stream loading, the calculation was also done using the lower value of 0.025 mg/L. The phosphorus loading decreased to 3,709 kg/d and the overall percentage increased to 2.63%. Therefore the final result does not alter appreciably if lower stream concentrations levels are used.

Appendix 4: Marketing Information from a Manufacturer of Flame Retardants

A major manufacturer of Deca-BDE also markets phosphate alternatives and provides information on the types of products in which these phosphate alternatives can be used. The following is a copy of the table from the manufacturer's website. It is meant to demonstrate the range of products for which phosphate flame retardants are feasible.

Phosphorous-Based Products by Application View phosphorous-based products by polymer

Phosphorous-Based	BUILDING & CONSTRUCTION	Adhesives & Coatings	Furniture	Insulation	Mattresses	Roofing	Textiles	Transportation	Wall/Floor Covering	ELECTRICAL COMPONENTS	Circuit Boards	Connectors, Relays & Switches	CONSUMER PRODUCTS	Appliance Housings	Battery Casings	Business Machines	Consumer Electronics	TV Housings	WIRE & CABLE	Conduit	Plenum Cable	Transport Cable	Power Cable	Building Cable	Appliance Cable
Reogard® 1000 new		III	III	III		III		III						III	III		III			III					
Reogard® 2000 new		III	III	III		III		III						III	III		III			III					
Reofos® 35		III		III		III	III		III		III														
Reofos® 50		III	III	III	III	III	III	III	III																
Reofos® 65		III	III	III	III	III	III	III	III													III	III	III	III
Reofos® 95		III	III	III	III	III	III	III														III	III	III	III
Kronitex® CDP		III	III	III	III		III	III	III		III														
Kronitex® TCP		III	III	III	III		III	III	III													III	III	III	III
Kronitex® TXP		III	III	III	III		III	III														III	III	III	III
Reofos® TPP											III			III		III	III	III							
Reofos® 507														III		III	III	III							
Reofos® RDP				III	III			III						III		III	III	III							
Reofos® NHP new			III		III			III																	
Reofos® BAPP new														III		III	III	III							

*These products not registered in Europe

Appendix 5: Determination of the Washington State Fire Marshal

CHRISTINE O. GREGOIRE
Governor

JOHN R. BATISTE
Chief

STATE OF WASHINGTON
WASHINGTON STATE PATROL
General Administration Building, PO Box 42600 • Olympia, WA 98504-2600 • (360) 753-6540 • www.wsp.wa.gov

RECEIVED
NOV 19 2008
DEPARTMENT OF ECOLOGY
OFFICE OF DIRECTOR

November 18, 2008

Mr. Jay Manning, Director
Department of Ecology
PO Box 47600
Olympia WA 98504-7006

Dear Director Manning:

As required by RCW 70.76, the Department of Ecology (DOE) and the Department of Health (DOH) convened the members of Governor Gregoire's Fire Safety Committee on November 7, 2008. The departments presented information on safer and technically feasible alternatives to the flame retardant known as Deca-Brominated Diphenyl Ether (Deca-BDE). Alternatives were presented for two types of products: residential upholstered furniture and electronics. The departments reviewed their approach to identification of alternatives and went on to present information on the performance of these alternatives in providing for fire safety. The alternatives assessment conducted by DOE and DOH considered only those chemicals or technologies currently on the market and available to replace Deca-BDE in current products, while still maintaining fire protection.

Electronic Enclosures for TVs and Computers

Ecology and DOH identified one alternative to Deca-BDE for use in TVs and computers. Resorcinol bis(diphenyl phosphate) or RDP is less toxic than Deca-BDE and is technically feasible for use in these applications.

Rating of the flammability of plastic enclosures is a voluntary standard identified by the National Fire Protection Association (NFPA) in conjunction with the Underwriter's Laboratory (UL) which defines the specific method. The departments presented information to the Fire Safety Committee on the performance of RDP compared with Deca-BDE when used in electronic enclosures. RDP performs as well as Deca-BDE, although a different type of plastic has to be used. RCW 70.76 established that a simple majority vote of the Fire Safety Committee would be used to make a finding as to whether or not the alternative identified by the agencies meets applicable fire safety standards. **The committee unanimously found that RDP meets applicable fire safety standards.**

Residential Upholstered Furniture

For residential upholstered furniture, DOE and DOH relied on information from the Consumer Product Safety Commission (CPSC) indicating the availability of furniture design options that do not require the addition of chemical flame retardants. DOE and

DOH decided that achieving fire safety by redesign without the use of flame retardants is the best possible way to replace Deca-BDE.
Under the CPSC's proposed standard, fire safety in upholstered furniture can be achieved through the use of cover materials or barrier layers. The use of internal barrier materials may require the use of chemical flame retardants. The CPSC estimates that barriers would be used in only about 5 percent of upholstered furniture to meet the standard. Internal barriers are not required if compliant cover fabrics are used. Although the CPSC flammability standard for residential furniture has not been finalized, it is expected that design options will be available to meet any additional requirements in a final standard. **Again the committee unanimously found that design alternatives meet applicable fire safety standards.**

CONCLUSIONS
Based upon my review of the materials presented by the agencies and the findings of the Fire Safety Committee, I have determined that RDP, as an alternative to Deca-BDE in electronic enclosures, meets applicable fire safety standards. I have also determined, based on the information presented by the agencies and the findings of the Fire Safety Committee, that the design options for residential upholstered furniture meet applicable fire safety standards.

Sincerely,

Michael G. Matlick

State Fire Marshal Michael G. Matlick
Fire Protection Bureau

MGM:can
cc: Ms. Carol Kraege, Department of Ecoloty