Alternative Assessment for the Flame Retardant Deca-Brominated Diphenyl Ether

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Polybrominated Diphenyl Ethers (PBDEs)

- Used extensively as flame retardants
- Found to be persistent, bioaccumulative and toxic
- Congeners in Penta-BDE mixture most toxic
- Swedish studies reported PBDEs found in breast milk
- Found in wide range of environmental media
- Concerns about degradation of Octa- and Deca-BDE mixtures into more toxic Penta-BDE congeners
- PBDEs banned in Europe and several states decided to take action limiting use of PBDEs

WA Legislation

- Passed and signed into law in 2007
- Banned the use of Penta- and Octa-BDE mixtures
- Prohibited sale of mattresses containing Deca-BDE (Deca) beginning Jan. 2008
- Prohibited sale of Deca contained in:
  1. Electronic enclosures of TVs or computers
  2. Residential upholstered furniture
     - **IF** Fire Safety Maintained
     - **IF** safer and technically feasible alternative(s) identified
- Alternative Assessment report completed Jan. 2009
- Ban on Deca in electronics and upholstered furniture takes effect Jan. 2011

Alternatives Assessment Approach

Phase I **Chemical Impacts & Uses**	Phase II **Alternatives**	Phase III **Assessment**
Ia. **Identify potential EH&S impacts of chemical** Ib. **Identify uses** Ic. **Prioritize uses for study**	IIa. **Identify Alternatives** IIb. **Screen Alternatives** IIc. **Prioritize Alternatives for study**	IIIa. **Research Alternatives** IIIb. **Contact Experts** IIIc. **Assess Alternatives**

From: Toxics Use Reduction Institute, University of Massachusetts Lowell, Five Chemicals Alternatives Assessment Study

Deca Alternatives

- **Built upon work done in PBDE Chemical Action Plan & subsequent work around the world**

- **Evaluated Current Deca Assessments**
  - What products/plastics included
  - What criteria used to evaluate alternatives
  - What alternatives evaluated
  - Conclusions
  - Strengths/weaknesses

Deca Alternatives Assessment for Electronics

- WA Chemical Action Plan/Syracuse Institute, 2006
- Maine DEP and Maine CDC, 2007
- Illinois EPA, 2007
- Danish EPA, 2007
  - European Commission, 2007
- Clean Production Action, 2007
- Troitzsch Report, 2007
- Karlsruhe Report, 2008

Phase II:

Deca Alternatives

- Many different types of flame retardants (FR) available

- Two main classes evaluated
  1. Halogenated (primarily Br & Cl)
  2. Phosphorous Based

Phase II: (cont.)

Halogenated FRs

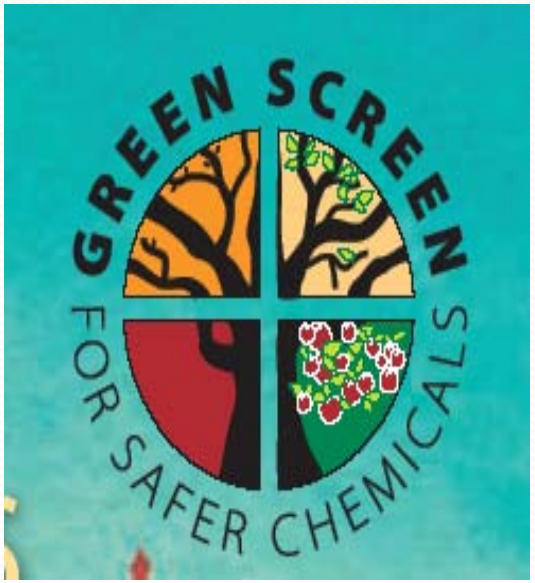
- Several alternatives on WA's PBT list
- Several major manufacturers have established policies which ban the use of halogenated FRs
- Any waste containing more than 100 ppm of halogenated organic compounds (HOCs) is considered a WA state-only dangerous waste

Phase II: (cont.)

Phosphate Based FRs

- Are not persistent and have limited bioaccumulation potential
- Have been and are being used in TV enclosures and similar applications
- Are the most studied alternatives to Deca

Phase III: Assess Toxicity of Alternatives



Used Green Screen developed by Clean Production Action (CPA)

- Non-profit NGO
- Promotes the use of products that are safer and cleaner across their life cycle for consumer, workers and communities
- Publications on green chemistry, healthy business strategies and consumer information

Criteria Evaluated using Green Screen

Human Health

- Acute mammalian toxicity
- Carcinogenicity
- Reproductive/Developmental/ Neuro-developmental toxicity
- Genotoxicity/Mutagenicity
- Endocrine disruption
- Neurotoxicity
- Respiratory sensitization
- Skin sensitization
- Systemic/organ effects toxicity
- Immune system toxicity

Environmental Fate

- Acute aquatic toxicity
- Chronic aquatic toxicity
- Persistence
- Bioaccumulation

Physical/Chemical Properties

- Explosivity
- Flammability

Degradation Products

Green Screen Benchmarks

- Alternatives are designated as 1 of 4 benchmarks

Benchmarks
4 - Prefer: Safer Chemical
3 - Use but still opportunity for improvement
2 - Use but search for safer substitutes
1 - Avoid: Chemical of High Concern

Green Screen Conclusions

Adapted from: Tables 6 and 7 of the Green Screen for Safer Chemicals, 2007

Chemical	Benchmark Achieved
Deca-BDE and its breakdown products	**Benchmark 1: Avoid - Chemical of High Concern**
BPADP / BAPP and its breakdown products	**Benchmark 1: Avoid - Chemical of High Concern**
RDP and its breakdown products	**Benchmark 2: Use but search for safer substitutes**
TPP and its breakdown products	**Benchmark 2: Use but search for safer substitutes**

WA Alternatives Assessment

- Updated and re-evaluated toxicity concerns
  - Human Health
  - Ecological
- Reassessed benchmarks based upon updated data
- Reached different conclusion for one of the flame retardants which caused it to move into Benchmark 1 (avoid) category

Updated Green Screen Evaluation

Table 5: Summary of Aquatic Toxicity

Chemical	Acute Toxicity	Chronic Toxicity
Flame retardants		
RDP Mixture (mixture of following 3 components)	**Medium**	**Medium**
- **RDP** (Resorcinol bis(diphenylphosphate))	**Medium**	**Medium**
- Phosphoric acid, bis[3-[(diphenoxyphosphinyl) oxy]phenyl]phenyl ester	**Low**	**Low**
- **TPP** (Triphenylphosphate)	**High**	**High**
Breakdown products:		
- Phenol	**Medium**	**Medium**
- Resorcinol	**Med-Low**	**Med-Low**
- Diphenylphosphate (DPP)	**Insufficient**	**data**
- Sodium triphosphate	**Low**	**Low**
- Sodium phosphate	**Low**	**Low**
Deca-BDE	**High**	**High**
Octa-BDE	**High**	**High**
Penta-BDE	**High**	**High**

Updated Green Screen Conclusions

Adapted from: Tables 6 and 7 of the Green Screen for Safer Chemicals, 2007

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BPADP / BAPP and its breakdown products	**Benchmark 1: Avoid - Chemical of High Concern**
RDP and its breakdown products	**Benchmark 2: Use but search for safer substitutes**
TPP and its breakdown products	**Benchmark 1: Use but search for safer substitutes**

Manufacturing Alternatives for Electronic Enclosures

1. Use a different flame retardant
2. Change plastic and flame retardant
3. Redesign product to eliminate need for flame retardant

Use a different Flame Retardant

- Traditionally, High Impact Polystyrene (HIPS) used most often in electronic enclosures
- Deca and other brominated flame retardants used in HIPS
- Non-brominated flame retardants cannot be used in place of Deca in HIPS

Change Plastic and Flame Retardant

- Deca alternatives can be used in other plastic blends
  - HIPS/PPE (polyphenylene ether)
  - PC (polycarbonate)/ABS (acrylonitrile butadiene styrene)
- Fire safety maintained
- Confirmed by flame retardant manufacturers

Deca-BDE Alternatives

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

Great Lakes FLAME RETARDANTS

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	II							
Reofos® 507														III		III	III	I							
Reofos® RDP																III	III	III							
Reofos® NHP new			III		III			III																	
Reofos® BAPP new														III		III	III	III							

*These products not registered in Europe

Redesign product to eliminate need for flame retardant

Options are being explored:

- Some success in Europe separating power supply from display thereby decreasing need for flame retardants in enclosures
- Evaluating options for more inherently flame resistant plastics and/or using other, non-plastic enclosures

Electronic Fire Standards

Two Questions:

1. How does a TV or computer manufacturer prove that his product meets the fire standard?

2. How does Ecology and Health know that Deca alternatives meet this standard?

Information Evaluated

- National Fire Standards
- Lowell Institute Report
- Danish EPA Report
- Karlsruhe Report

Electronic Fire Standards (cont.)

- Established by the National Fire Protection Association (NFPA) and developed by Underwriters Laboratories (UL)
  - Although not a law, often mandated by federal & state regs
  - Product liability concerns
- The standard for electronic enclosures is rating V-O in UL method 94
  - Products using Deca meet this standard
  - Products with any other flame retardant which meet this requirement 'meet applicable fire standards'

Karlsruhe Report

Evaluated alternatives to Deca using various criteria:

- Processability
- Thermal stability
- Mechanical Properties
- Hydrolytic stability
- Recyclability
- RoHS and WEE directives

Karlsruhe Report (cont.)

Evaluated:

- PC/ABS
- HIPS/PPO

Tested plastics to evaluate fire safety rating

Various results about TPP, RDP and BDP in PC/ABS blends are presented in Table 4 to Table 6.

PC/ABS 4/1	% FR Additive	UL 94* (1.6 mm)
RDP	9.0	V0 (1.5)
BDP	12.3	V0 (1.5)
TPP	14.0	V0 (1.7)

* avg. flame time

Table 4: UL 94 flammability in FR-PC/ABS (4/1)

Cost Effectiveness

Not specifically called out in WA legislation but did consider it to some extent.

Alternative was considered cost effective if it:

1. Has been used
2. Is currently used
3. Is being marketed for the application
4. Meets manufacturers' requirements

Overall Electronic Conclusions:

1. Alternatives to Deca are readily available & being used
2. Plastic blends and alternative flame retardants are available for most applications
3. Fire safety can be maintained without the use of Deca

Alternatives to Deca in Residential Upholstered Furniture

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Proposed Standard

- In March 2008 the US Consumer Product Safety Commission (CPSC) proposed a flammability standard for residential upholstered furniture
- Standard is performance based, i.e. there are no requirements for how manufacturers comply. Manufacturers can choose one of several alternatives as long as fire safety maintained.

Expected use of flame retardants

The CPSC proposed standard does not rely on the use of flame retardants

- Many choices of compliant cover materials exist that do not require the addition of flame retardants; CPSC predicts that 14% of existing fabrics would not comply
- Inherently flame retardant barriers can be used. Barriers estimated to be used in a small percentage (<10%) of furniture
- Deca reportedly not used in furniture in U.S.; has been used in fabric back-coating to meet UK open flame standard

Conclusions

- Meeting the proposed flammability standard for residential upholstered furniture does not require the use of chemical flame retardants
  - Redesign alternatives are available
- Manufacturers have expressed an intent to avoid use of flame retardants in fabrics, filling materials and barriers because of consumer concerns

Final remarks on Deca

- Our task was to identify if there was at least one viable alternative to Deca. Our report states we believe there is.
- Neither Ecology nor Health has the authority to dictate what flame retardant is used in place of Deca.
- Green Screen provided scientific method to evaluate toxicity of chemicals
- If a safer alternative exists, a toxic chemical should be removed from use regardless of exposure potential

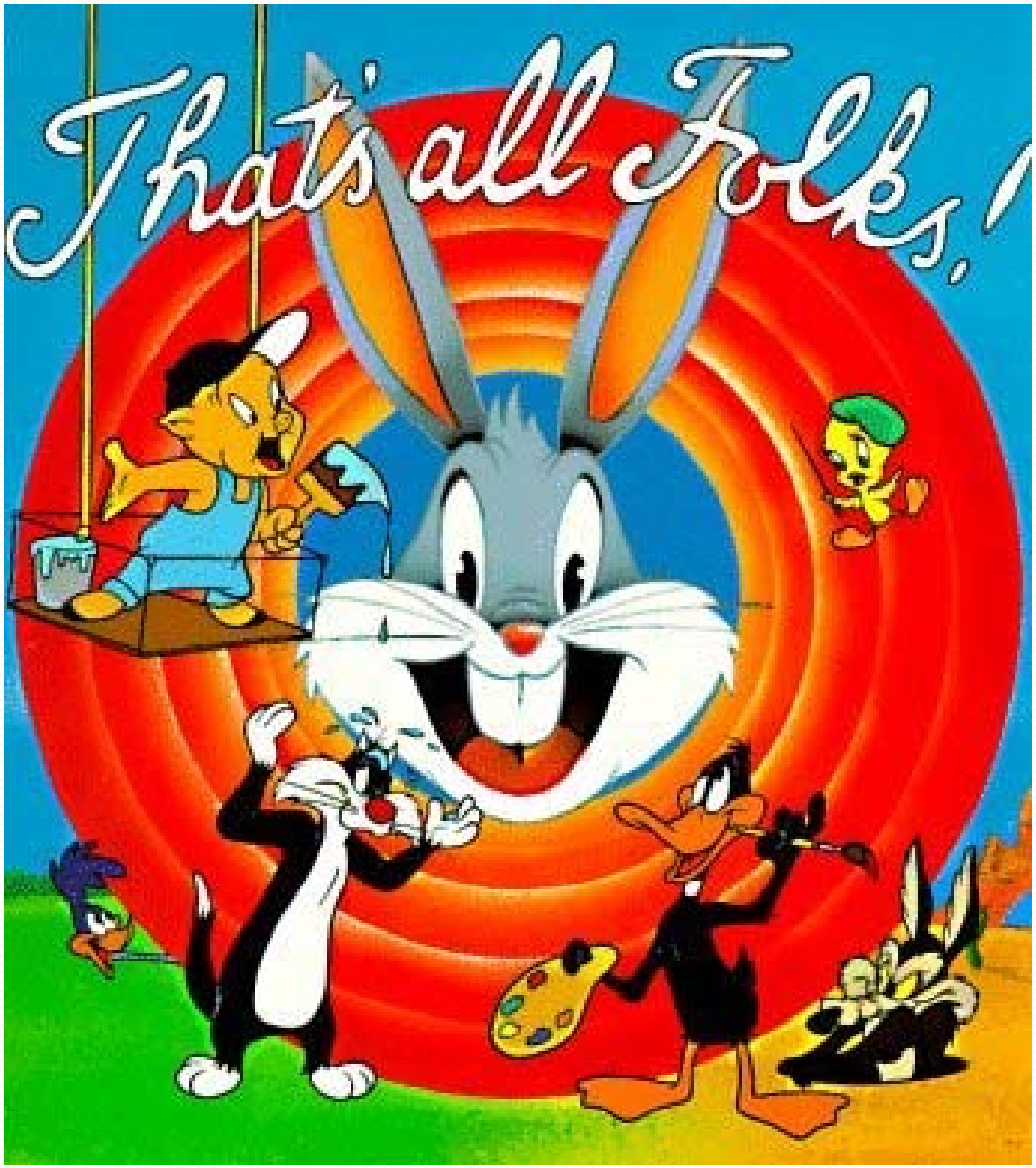
Lessons Learned from Assessment Process

Positive:

1. Alternative Assessments are feasible
2. Procedures have been developed by TURI, Clean Product Action (the Green Screen), DfE, etc. to assist
3. Methodologies are comprehensive and based upon the most recent science and assessment methodologies

Negative:

1. Time and resource intensive
2. Requires expertise in chemistry, toxicology, process engineering, etc.
3. Does not look at full life cycle impacts
4. Always a risk that new data will alter conclusions


That's all Folks!

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