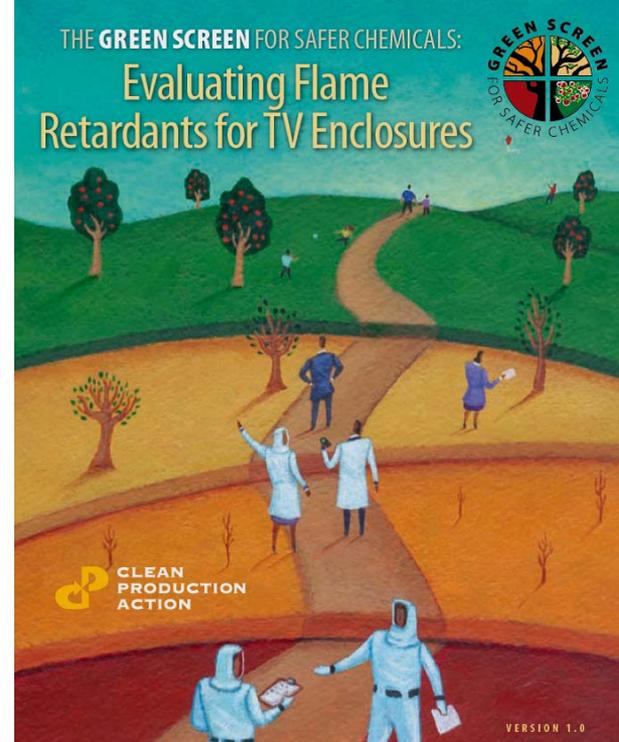


# *The Green Screen for Safer Chemicals*

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## OEHHA-COEH WORKSHOP

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**1. Foundation**

**2. Green Screen Method**

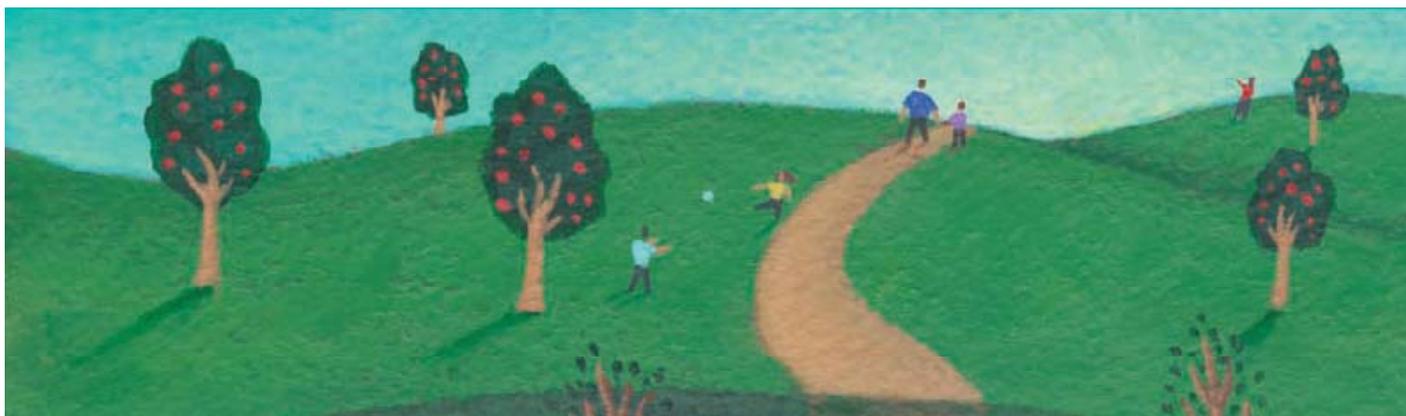
**3. Applying Green Screen to  
Flame Retardants**

# **1. Foundation**

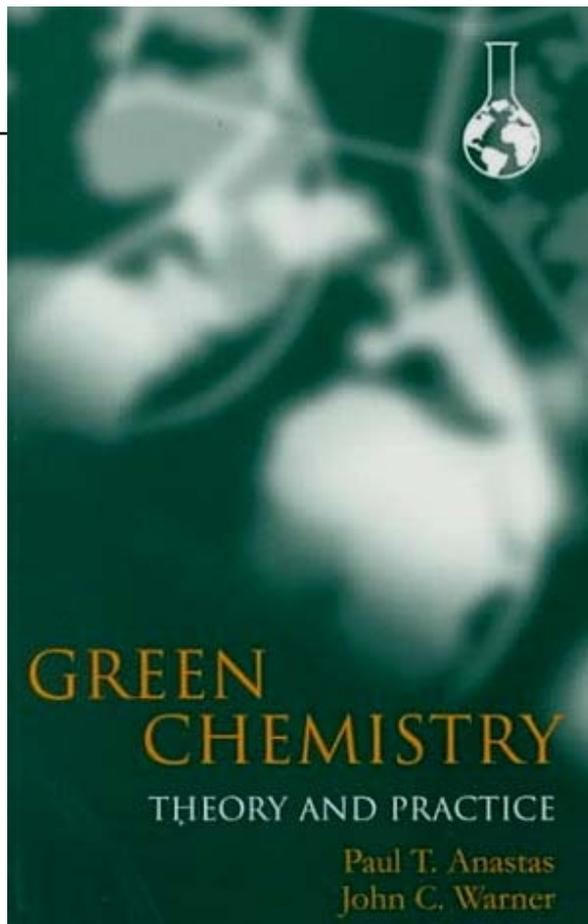
# Why the Green Screen?



- **Defines a path** to greener, safer chemicals
- Builds from :
  - **12 Principles of Green Chemistry**
  - **US EPA DfE Alternatives Assessment model**
- **Open Source:** transparent + publicly available resource
- **Hazards (not risks)**
- **Life cycle thinking**
- Towards agreement on a **method for defining safer, healthier chemicals**



*“the utilization of a set of principles that reduces the use or generation of hazardous substances in the design, manufacture and application of chemical products.”*



**#2. Design safer chemicals and products:** Design chemical products to be fully effective, yet have little or no toxicity.

**#10. Design chemicals and products to degrade after use:** Design chemical products to break down to innocuous substances after use so that they do not accumulate in the environment.

**#12. Minimize the potential for accidents:** Design chemicals and their forms to minimize the potential for chemical accidents including explosions, fires, and releases to the environment.

# Most effective means to reduce risk?



Risk = Hazard + Exposure



**Reduce Hazard**

## Furniture Flame Retardancy Partnership: Environmental Profiles of Chemical Flame-Retardant Alternatives for Low-Density Polyurethane Foam

# US EPA Design for Environment (DfE) Program



*[published  
in 2005]*



[www.epa.gov/dfe](http://www.epa.gov/dfe)

# Identify Priority Endpoints for Screening Level Toxicology (summarized in Table 4-1)

## Human Health Effects

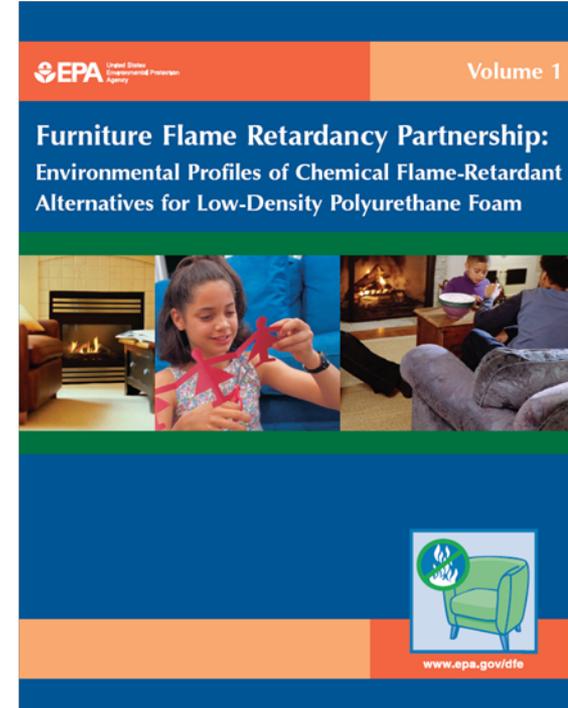
- Cancer
- Reproductive
- Developmental
- Genotoxicity (mutagenicity)
- Neurological
- Systemic
- Skin Sensitizer

## Ecotoxicity

- Acute
- Chronic

## Environmental

- Persistence
- Bioaccumulation



 United States Environmental Protection Agency

Volume 1

**Furniture Flame Retardancy Partnership:  
Environmental Profiles of Chemical Flame-Retardant  
Alternatives for Low-Density Polyurethane Foam**



[www.epa.gov/dfo](http://www.epa.gov/dfo)

# Define Levels of Concern, Collect Data and Apply to Each Endpoint

## Levels of Concern

- High
- Moderate
- Low
- ▲ = Persistent degradation products expected



# **2. Green Screen for Safer Chemicals – Method**

# Green Screen – Overview



- **Benchmarks** – defines 4 benchmarks
- **Hazard Criteria** – each benchmark consists of a set of hazard criteria
- **Hazard Endpoints + Levels of Concern** – each hazard criterion consists of these
- **Threshold Values** – defines the levels of concern

## Benchmark 4

**Prefer – Safer Chemical**



## Benchmark 3

**Use but Still Opportunity  
for Improvement**



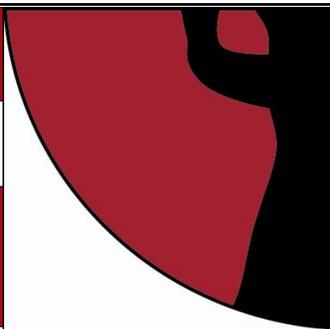
## Benchmark 2

**Use but Search for Safer  
Substitutes**



## Benchmark 1

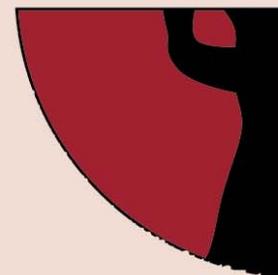
**Avoid – Chemical of  
High Concern**



# Hazard Criteria -- Hazard Endpoint(s) + Level of Concern

## BENCHMARK 1

- a. PBT: high P + high B + high T<sup>1</sup> (high Human Toxicity<sup>2</sup> or high Ecotoxicity)
- b. vPvB: very high P + very high B
- c. vPT (vP + high T) or vBT (vB + high T)
- d. high Human Toxicity for any priority effect<sup>3</sup>



If this chemical and its breakdown products pass all of these criteria, then move on to Benchmark 2

**Avoid—Chemical of High Concern**

- a. **PBT** = high Persistence + high Bioaccumulation + high Toxicity
- b. **vPvB** = very Persistent + very Bioaccumulative
- c. **vPT** or **vBT** = (very Persistent or very Bioaccumulative) + Toxic
- d. **high Human Toxicity** for any “priority effect”

(four hazard criteria for Benchmark 1)

# “Priority Effects” – Human Health

- **Cancer**   
- **Reproductive/ Developmental Toxicity**   
- **Genotoxicity / Mutagenicity**   
- **Endocrine Disruption**  
- **Neurotoxicity**  

 = EU, REACH, Article 57

 = US EPA, 40 CFR Part 372, PBT Final Rule (1999)

# Hazard Endpoints

## Human Health Effects

- \*\*\* Cancer
- \*\*\* Reproductive
- \*\*\* Developmental
- \*\*\* Genotoxicity (mutagenicity)
- \*\*\* Neurological
- Systemic
- Skin Sensitizer
- \*\*\* Endocrine disruption
- Acute toxicity
- Corrosion/irritation skin/eye
- Immune system

## Ecotoxicity

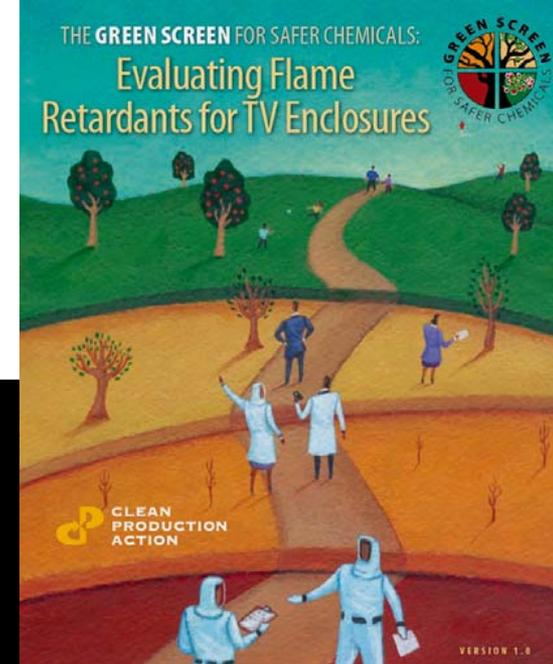
- Acute
- Chronic

## Environmental

- Persistence
- Bioaccumulation

## Physical/Chemical

- Explodability
- Flammability



\*\*\* = Priority Human Health Effect

“Green” endpoints are in Green Screen, not US EPA DfE summary table.

# Levels of Concern Defined by Threshold Values

**vH = very High**

**H = High**

**M = Moderate**

**L = Low**

*Threshold values define level of concern for each hazard endpoint:*

- *Environmental fate: persistence + bioaccumulation*
- *Ecotoxicity: acute + chronic*
- *Human Health*
- *Physical/Chemical Properties*

# Levels of Concern: Environmental Fate & Ecotoxicity

Hazard	Very High (v)	High (H)	Moderate (M)	Low (L)
<b>Environmental Fate</b>				
<b>Persistence</b> (half-life in days)	<ul style="list-style-type: none"> <li>• Soil or sediment &gt; 180 days; or</li> <li>• Water &gt; 60 days</li> </ul>	<ul style="list-style-type: none"> <li>• Soil or sediment &gt; 60 to 180 days;</li> <li>• Water &gt; 40 to 60 days; or</li> <li>• Potential for long-range environmental transport</li> </ul>	<ul style="list-style-type: none"> <li>• Soil or sediment 30-60 days; or</li> <li>• Water 7-40 days</li> </ul>	<ul style="list-style-type: none"> <li>• Soil or sediment &lt; 30 days;</li> <li>• Water &lt; 7 days; or</li> <li>• Ready biodegradability</li> </ul>
<b>Bioaccumulation Potential</b>	<ul style="list-style-type: none"> <li>• BCF/BAF &gt; 5000; or</li> <li>• <math>\log K_{ow} &gt; 5</math></li> </ul>	<ul style="list-style-type: none"> <li>• BCF/BAF &gt; 1000 to 5000;</li> <li>• <math>\log K_{ow} &gt; 4.5-5</math>; or</li> <li>• Weight of evidence demonstrates bioaccumulation</li> </ul>	<ul style="list-style-type: none"> <li>• BCF/BAF 500 to 1000;</li> <li>• <math>\log K_{ow} &gt; 4-4.5</math>; or</li> <li>• Suggestive evidence of bioaccumulation</li> </ul>	<ul style="list-style-type: none"> <li>• BCF/BAF &lt; 500; or</li> <li>• <math>\log K_{ow} &lt; 4</math></li> </ul>
<b>Ecotoxicity</b>				
<b>Acute Aquatic Toxicity</b>		<ul style="list-style-type: none"> <li>• <math>LC_{50}/EC_{50}/IC_{50} &lt; 1</math> mg/l; or</li> <li>• GHS Category 1</li> </ul>	<ul style="list-style-type: none"> <li>• <math>LC_{50}/EC_{50}/IC_{50} 1-100</math> mg/l; or</li> <li>• GHS 2 or 3</li> </ul>	<ul style="list-style-type: none"> <li>• <math>LC_{50}/EC_{50}/IC_{50} &gt; 100</math> mg/l</li> </ul>
<b>Chronic Aquatic Toxicity</b>		<ul style="list-style-type: none"> <li>• NOEC &lt; 0.1 mg/l; or</li> <li>• GHS Category 1</li> </ul>	<ul style="list-style-type: none"> <li>• NOEC 0.1-10 mg/l; or</li> <li>• GHS 2, 3, or 4</li> </ul>	<ul style="list-style-type: none"> <li>• NOEC &gt; 10 mg/l</li> </ul>

# Levels of Concern: Human Health – for example, Cancer

High	Moderate	Low
<ul style="list-style-type: none"> <li>• Evidence of adverse effects in humans</li> <li>• Weight of evidence demonstrates potential for adverse effects in humans</li> <li>• US EPA known/probable</li> <li>• NTP or OSHA</li> <li>• IARC Group 1 or 2A</li> <li>• California Prop 65</li> <li>• EU Category 1 or 2</li> <li>• GHS Category 1A or 1B</li> </ul>	<ul style="list-style-type: none"> <li>• Suggestive animal studies</li> <li>• Analog data</li> <li>• Chemical class known to produce toxicity</li> <li>• US EPA possible</li> <li>• IARC Group 2B</li> <li>• EU Category 3</li> <li>• GHS Category 2</li> </ul>	<p>No basis for concern</p>

GHS = Globally Harmonized System for the Classification and Labeling of Chemicals

# “Breakdown Products”



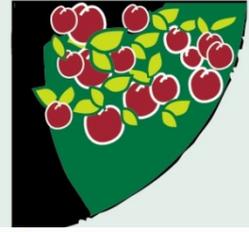
If this chemical and its breakdown products pass all of these criteria, then move on to Benchmark 2

This chemical passes all of the criteria.

## BENCHMARK 4

ready biodegradability (low P) + low B + low Human Toxicity + low Ecotoxicity (+ additional ecotoxicity endpoints when available)

**Prefer—Safer Chemical**



## BENCHMARK 3

- moderate P or moderate B
- moderate Ecotoxicity
- moderate Human Toxicity
- moderate Flammability or moderate Explosiveness

**Use but Still Opportunity for Improvement**



If this chemical and its break-down products pass all of these criteria, then move on to Benchmark 4

## BENCHMARK 2

- moderate P + moderate B + moderate T (moderate Human Toxicity or moderate Ecotoxicity)
- high P + high B
- (high P + moderate T) or (high B + moderate T)
- moderate Human Toxicity for any priority effect or high Human Toxicity
- high Flammability or high Explosiveness



If this chemical and its break-down products pass all of these criteria, then move on to Benchmark 3

**Use but Search for Safer Substitutes**

## BENCHMARK 1

- PBT: high P + high B + high T<sup>1</sup> (high Human Toxicity<sup>2</sup> or high Ecotoxicity)
- vPvB: very high P + very high B
- vPT (vP + high T) or vBT (vB + high T)
- high Human Toxicity for any priority effect<sup>3</sup>



If this chemical and its break-down products pass all of these criteria, then move on to Benchmark 2

**Avoid—Chemical of High Concern**

# **3. Applying the Green Screen to Flame Retardants**

# Applying the Green Screen



1. Gather data – no small task!
2. Assign level of concern to each endpoint for each chemical & its breakdown product(s)
3. Run each chemical through the Green Screen to determine chemical Benchmark achieved
4. Benchmark achieved by a chemical & its breakdown products is the lowest Benchmark achieved by either the chemical or a breakdown product

# Run Each Chemical through the Green Screen

Chemical	Reason for Benchmark	Stopped by Benchmark ...	
<b>RDP Constituents and Breakdown Products</b>			
<b>CAS# 57583-54-7</b>	<ul style="list-style-type: none"> <li>• H - bioaccumulation</li> <li>• H - chronic ecotox.</li> </ul>	<ul style="list-style-type: none"> <li>• M - persistence</li> <li>• M - systemic + irritation eyes</li> </ul>	Benchmark 2(a), 2(c)
<b>CAS# 98165-92-5</b>	<ul style="list-style-type: none"> <li>• H - persistence</li> </ul>	<ul style="list-style-type: none"> <li>• M - systemic + irritation eyes</li> </ul>	Benchmark 2(c)
<b>CAS# 115-86-6</b> (triphenyl phosphate)	<ul style="list-style-type: none"> <li>• M - bioaccumulation</li> <li>• M - systemic + irritation/corrosion eyes</li> </ul>	<ul style="list-style-type: none"> <li>• H - acute + chronic ecotoxicity</li> </ul>	Benchmark 3(a), 3(b), 3(c)
<b>CAS# 108-95-2</b> (phenol)	<ul style="list-style-type: none"> <li>• H - systemic + irritation/corrosion eyes/skin</li> </ul>		Benchmark 2(d)
<b>CAS# 108-46-3</b> (resorcinol)	<ul style="list-style-type: none"> <li>• M - acute and chronic ecotoxicity</li> <li>• M - endocrine, neurotox., acute, skin sen., irritation/corrosion</li> </ul>		Benchmark 3(a), 3(b), 3(c)
<b>CAS# 838-85-7</b>	<i>(diphenyl phosphate) insufficient data for evaluation</i>		
<b>BPADP (BAPP) Constituents and Breakdown Products</b>			
<b>CAS# 5945-33-5</b>	<ul style="list-style-type: none"> <li>• H - persistence</li> </ul>	<ul style="list-style-type: none"> <li>• M - systemic + irritation eyes</li> </ul>	Benchmark 2(c)
<b>CAS# 83029-72-5</b>	<ul style="list-style-type: none"> <li>• vH - persistence</li> </ul>	<ul style="list-style-type: none"> <li>• M - systemic + irritation eyes</li> </ul>	Benchmark 2(c)
<b>CAS# 115-86-6</b> (triphenyl phosphate)	<ul style="list-style-type: none"> <li>• M - bioaccumulation</li> <li>• M - systemic + irritation/corrosion eyes</li> </ul>	<ul style="list-style-type: none"> <li>• H - acute + chronic ecotoxicity</li> </ul>	Benchmark 3(a), 3(b), 3(c)
<b>CAS# 108-95-2</b> (phenol)	<ul style="list-style-type: none"> <li>• H - systemic + irritation/corrosion eyes/skin</li> </ul>		Benchmark 2(d)
<b>CAS# 80-05-7</b> (BPA)	<ul style="list-style-type: none"> <li>• H - endocrine disruption (emerging: H - repro. + dev.)</li> </ul>		Benchmark 1(d)
<b>CAS# 838-85-7</b>	<i>(diphenyl phosphate) insufficient data for evaluation</i>		
<b>DecaBDE and Breakdown Products</b>			
<b>CAS# 1163-19-5</b> (decaBDE)	<ul style="list-style-type: none"> <li>• vH - persistence</li> <li>• M - cancer, repro., dev., neurological, systemic, endocrine</li> </ul>	<ul style="list-style-type: none"> <li>• M - bioaccumulation</li> </ul>	Benchmark 2(a), 2(c), 2(d)
<b>CAS# 32536-52-0</b> (octaBDE)	<ul style="list-style-type: none"> <li>• vH - persistence</li> </ul>	<ul style="list-style-type: none"> <li>• H - reproductive effects</li> </ul>	Benchmark 1(c)
<b>CAS# 32536-52-0</b> (pentaBDE)	<ul style="list-style-type: none"> <li>• vH - persistence + bioaccumulation</li> <li>• H - acute + chronic ecotox.</li> </ul>	<ul style="list-style-type: none"> <li>• H - systemic organ effects</li> </ul>	Benchmark 1(a), 1(b), 1(c)

# Final Benchmarks for Three Flame Retardant Chemicals (& their breakdown products)

Chemical	Reason for Benchmark	Final Benchmark
<b>DecaBDE</b> and its breakdown products	<u>Breakdown products:</u> <ul style="list-style-type: none"> <li>• <b>pentaBDE</b> = PBT, vPvB, vPT, vBT, + H-endocrine -- Benchmarks 1(a),(b),(c)</li> <li>• <b>octaBDE</b> = vPT + H-developmental -- Benchmark 1(c)</li> </ul>	Benchmark 1: Avoid - Chemical of High Concern
<b>BPADP (or BAPP)</b> and its breakdown products	<u>Breakdown product (and formulation contaminant):</u> <b>bisphenol A</b> -- high concern for endocrine disruption -- Benchmark 1(d)	Benchmark 1: Avoid - Chemical of High Concern
<b>RDP</b> and its breakdown products	<ul style="list-style-type: none"> <li>• <u>Chemical constituents:</u> high persistence or bioaccumulation and moderate or high toxicity (but not for priority effects) -- Benchmarks 2(a), 2(c)</li> <li>• <u>Breakdown product:</u> <b>phenol</b> -- high toxicity (but not for priority effects) -- Benchmark 2(d)</li> </ul>	Benchmark 2: Use <u>but</u> Search for Safer Substitutes

# For Copies of the Green Screen...

[www.cleanproduction.org/Green.GreenScreen.php](http://www.cleanproduction.org/Green.GreenScreen.php)

