Introduction to the GreenScreen™ for Safer Chemicals

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Representing Clean Production Action

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Clean Production Action (CPA) designs and delivers strategic solutions for green chemicals, sustainable materials and environmentally preferable products.

We work with governments, other NGOs and industry leaders to advance green chemistry and safer product design.

www.cleanproduction.org
The GreenScreen for Safer Chemicals

• A Method for Comparative Chemical Hazard Assessment (CCHA)
  • Key Concepts
  • How It Works
  • Case Studies and Applications
Key Concept 1. Green Chemistry
Defined by 12 Principles: focus on reducing risk by reducing inherent hazard

Risk = f(Hazard, Exposure)

Green chemistry is “the design of products and processes that reduce or eliminate the use or generation of hazardous substances.”

#3. Less hazardous chemical syntheses
#4. Design safer chemicals and products
#5 Use safer solvents and auxiliaries
#10 Design chemicals and products to degrade after use
#12. Minimize the potential for accidents
Key Concept 2: Chemical Functionality

- The functionality of a chemical is the job it performs in a formulation, material or product;
  - *Function is related to chemical structure and physical chemical properties*

- Functional use classes for chemicals used in polymers:
  - Plasticizers
  - Colorants
  - Anti-oxidants
  - Stabilizers
  - Processing aids
  - Etc.
Key Concepts 3: Informed Substitution and Hazard Banding (aka Continuum of Improvement)

- Of Concern
  - Characteristics of Ingredient of Concern (HIGH)

- Improved
  - Characteristics of Improved Ingredient (MODERATE)

- Safer
  - Characteristics of Safer Ingredient (LOW)
Origins of the GreenScreen
DfE Alternatives Assessment Partnerships

First DfE AA Partnership: Alternatives to penta-BDE in Furniture Foam

1. Convene stakeholders and evaluate alternatives to chemicals of concern
2. Provide comprehensive chemical hazard profiles and hazard summary table
3. Current Partnerships address EPA Action Plan Chemicals:
   - BPA in thermal paper
   - decaBDE
   - HBCD
   - Phthalates
   - NPEs

*DfE CAA Criteria at: http://www.epa.gov/dfe/alternative_assessments.html*
## DfE Hazard Summary Table 4-1:
Hallmark of Chemical Hazard Assessment (CHA)

*Ongoing studies may result in a change in this endpoint

<table>
<thead>
<tr>
<th>Company</th>
<th>Chemical*</th>
<th>% in Formulation</th>
<th>Cancer Hazard</th>
<th>Skin Sensitizer</th>
<th>Reproductive</th>
<th>Developmental</th>
<th>Neuronal</th>
<th>Systemic</th>
<th>Gene Toxicity</th>
<th>Acute</th>
<th>Chronic</th>
<th>Persistence</th>
<th>Bioaccumulation</th>
<th>Potential Routes of Exposure</th>
<th>Worker</th>
<th>General Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albemara</td>
<td>ANTI BLAZE 180 and ANTI BLAZE 195</td>
<td>95%</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>L</td>
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<td>Y</td>
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<tr>
<td></td>
<td>Triethyl(1,3-dichloro-2-propyl)Phosphate CAS # 13374-67-8</td>
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<td>M*</td>
<td>M*</td>
<td>M*</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>L</td>
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<td></td>
<td>ANTIBLAZE 182 and ANTI BLAZE 201</td>
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<td>M</td>
<td>M</td>
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<td>M</td>
<td>M</td>
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<td>Proprietary A</td>
<td>Chloroalkyl phosphate (1)</td>
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<td>M*</td>
<td>M*</td>
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<td>L</td>
<td>H</td>
<td>H</td>
<td>L</td>
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<td>Y</td>
<td>Y</td>
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<tr>
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<td>Aryl phosphate</td>
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<td>L</td>
<td>M</td>
<td>M*</td>
<td>M*</td>
<td>L</td>
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<tr>
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<td>L</td>
<td>L</td>
<td>M</td>
<td>H</td>
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<td>Y</td>
<td>Y</td>
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<td>Y</td>
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<td>Proprietary C</td>
<td>Chloroalkyl phosphate (2)</td>
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<td>M*</td>
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<td>Y</td>
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<tr>
<td>Proprietary B</td>
<td>Aryl phosphate</td>
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<td>M</td>
<td>M*</td>
<td>M*</td>
<td>L</td>
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<td>N</td>
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<tr>
<td>Triphenyl Phosphate</td>
<td>CAS # 115-86-6</td>
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<td>L</td>
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<td>Y</td>
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<td>Y</td>
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<td>SAYTEX RX-8500</td>
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<td>L</td>
<td>L</td>
<td>M*</td>
<td>M*</td>
<td>M*</td>
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<td>L*</td>
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<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
</tbody>
</table>

**Note**: The above table is not based on the new DfE Alternatives Assessment for Hazard Criteria
Need a Structured Decision Logic

Don’t just count H’s (or M’s or L’s) ….
What is the Green Screen?

- Comparative Chemical Hazard Assessment approach (CCHA) developed by Clean Production Action
- Builds on the DfE Approach (Chemical Alternatives Assessment and Safer Product Criteria)
  - Considers 18 environmental and human health endpoints;
  - Addresses constituents and breakdown products
- Evaluates chemical hazards for an overall chemical score (Benchmark 1 - 4)
- GreenScreen v 1.0 (2007); GreenScreen v 1.2 launched October 2011
Publicly Accessible, Transparent, Peer-Reviewed and Reproducible

Welcome to the GreenScreen™ for Safer Chemicals v 1.2
We would like to thank the GreenScreen™ Technical Advisory Committee and the GreenScreen™ Steering Committee for all of their helpful feedback and input in helping us realize our goal of continual improvement and development of a robust, scientifically based method that is practical and protective of human health and the environment.

At this site you may download all of the supporting resources and documentation for performing a GreenScreen™ assessment using GreenScreen™ v1.2. We have also provided example assessments.

GreenScreen™ v 1.2 Hazard Criteria
There are 18 hazard endpoints addressed by GreenScreen™ Hazard Criteria:

<table>
<thead>
<tr>
<th>ENVIRONMENTAL HEALTH</th>
<th>HUMAN HEALTH GROUP I</th>
<th>HUMAN HEALTH GROUP II</th>
<th>PHYSICAL HAZARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistence</td>
<td>Acute Aquatic Toxicity</td>
<td>Carcinogenicity</td>
<td>Acute Mammalian Reactivity</td>
</tr>
<tr>
<td>Bioaccumulation</td>
<td>Chronic Aquatic Toxicity</td>
<td>Mutagenicity &amp; Genotoxicity</td>
<td>Systemic Toxicity &amp; Organ Effects (incl. Immunotoxicity)</td>
</tr>
<tr>
<td>Other Ecotoxicity Studies when available</td>
<td>Reproductive Toxicity</td>
<td>Neurotoxicity</td>
<td></td>
</tr>
<tr>
<td>Developmental Toxicity (incl. Developmental Neurotoxicity)</td>
<td>Sensitization 1. Skin 2. Respiratory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endocrine Activity</td>
<td>Irritation / Corrosivity 1. Skin 2. Eye</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Click here to download the GreenScreen™ hazard criteria (PDF, 115KB)

All supporting resources at:  http://www.cleanproduction.org/Greenscreen.v1-2.php
How It Works

1. Assess and Classify Hazards
2. Apply the Benchmarks
3. Make Informed Decisions
## Step 1: Assess & Classify the Hazards

### GreenScreen v1.2 Hazard Endpoints

<table>
<thead>
<tr>
<th>Human Health Group I</th>
<th>Human Health Group II</th>
<th>Environmental Toxicity &amp; Fate</th>
<th>Physical Hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcinogenicity</td>
<td>Acute Toxicity</td>
<td>Acute Aquatic Toxicity</td>
<td>Reactivity</td>
</tr>
<tr>
<td>Mutagenicity &amp; Genotoxicity</td>
<td>Systemic Toxicity &amp; Organ Effects</td>
<td>Chronic Aquatic Toxicity</td>
<td>Flammability</td>
</tr>
<tr>
<td>Reproductive Toxicity</td>
<td>Neurotoxicity</td>
<td>Other Ecotoxicity Studies when available</td>
<td></td>
</tr>
<tr>
<td>Developmental Toxicity</td>
<td>Skin Sensitization</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Respiratory Sensitization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endocrine Activity</td>
<td>Skin Irritation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eye Irritation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# GreenScreen v 1.2 Hazard Criteria

**Example: Acute Mammalian Toxicity (AT)**

<table>
<thead>
<tr>
<th>Information Type</th>
<th>Information Source</th>
<th>List Type</th>
<th>Very High (vH)</th>
<th>High (H)</th>
<th>Moderate (M)</th>
<th>Low (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data</strong></td>
<td>GHS Criteria &amp; Guidance</td>
<td></td>
<td>GHS Category 1 or 2 for any route of exposure</td>
<td>GHS Category 3 for any route of exposure</td>
<td>GHS Category 4 for any route of exposure</td>
<td>GHS Category 5 or adequate data available, and negative studies, no structural alerts, and GHS not classified.</td>
</tr>
<tr>
<td><strong>Guidance Values for Animal Data (see GHS for further information)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral LD&lt;sub&gt;50&lt;/sub&gt; (mg/kg)</td>
<td></td>
<td></td>
<td>≤50</td>
<td>&gt;50-300</td>
<td>&gt;300-2000</td>
<td>&gt;2000</td>
</tr>
<tr>
<td>Dermal LD&lt;sub&gt;50&lt;/sub&gt; (mg/kg)</td>
<td></td>
<td></td>
<td>≤200</td>
<td>&gt;200-1000</td>
<td>&gt;100-2000</td>
<td>&gt;2000</td>
</tr>
<tr>
<td>Inhalation-Gas or Vapor LD&lt;sub&gt;50&lt;/sub&gt; (mg/L)</td>
<td></td>
<td></td>
<td>≤2</td>
<td>&gt;2-10</td>
<td>&gt;10-20</td>
<td>&gt;20</td>
</tr>
<tr>
<td>Inhalation-Dust/Mist/Fumes LD&lt;sub&gt;50&lt;/sub&gt; (mg/L)</td>
<td></td>
<td></td>
<td>≤0.5</td>
<td>&gt;0.5-1.0</td>
<td>&gt;1-5</td>
<td>&gt;5</td>
</tr>
</tbody>
</table>

**A Lists**

- **DOT** Authoritative: Class 2.3 Group A, or Class 6.1 Group 1 or Group 2
- **EU H-statements** Authoritative: H300, H310, or H330
- **H301, H311, or H331**
- **EU R-phrases** Authoritative: R26, R27, or R28

**B Lists**

- **DOT** Authoritative: Class 2.3 Group B
- **EPA-AVT** Authoritative: Extremely Hazardous Substance
- **H111**
- **EU H-statements** Authoritative: H302, H312, or H332
- **H303, H313, or H333**
- **EU R-phrases** Authoritative: R20, R21, or R22
- **WHMIS** Screening: R23, R24, or R25
- **D1A Toxic**
- **D1B Toxic**
Step 1: Classify the Hazards

- **Data Sources**
  - Scientific literature
  - Test data
  - Models
  - Analogs, read-across and expert judgment

---

<table>
<thead>
<tr>
<th>Group I Human</th>
<th>Group II Human</th>
<th>Ecotox</th>
<th>Fate</th>
<th>Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>dx</td>
</tr>
<tr>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>dx</td>
</tr>
<tr>
<td>M</td>
<td>M</td>
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<td>M</td>
<td>dx</td>
</tr>
<tr>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>dx</td>
</tr>
</tbody>
</table>

*Hazard levels (vH, H, M, L, vL) in *italics* reflect a lower level of confidence (See Guidance).
Step 2: Apply the Benchmarks

Aligned with Regulatory Drivers
Step 2: Apply the Benchmarks

Chemical Structure(s):

\[
\begin{array}{c}
\text{O} \\
\text{H}_3\text{C} \\
\text{O} \\
\text{CH}_2
\end{array}
\]

Identify Applications/Functional Uses:
(e.g., Cleaning product, TV casing)
Vinyl acetate is used in the manufacture of polyvinyl and vinyl acetate copolymers, which are used in water-based paints, adhesives, paper coatings, and applications not requiring service at extreme temperatures. Additionally, it is used in safety glass and hairspray (HSDB 2009).

**Green Screen Rating**: Vinyl acetate was assigned a Benchmark Score of 2 based on several hazard ratings, including: Moderate classifications for Carcinogenicity (C), Mutagenicity (M), Reproductive (R) and Developmental (D) Toxicity; High classification for Systemic Toxicity (S) and Reactivity (R); and Very High classification for Skin Irritation/Corrosion (IrS) and Flammability (F). *NOTE:* Data gaps (dg) exist for Endocrine Activity (E) (not listed, but not tested), Neurotoxicity (N), and Skin Sensitization (SnS). In a worst-case scenario, if vinyl acetate was assigned a High score for E it would be assigned a Benchmark Score of 1.

<table>
<thead>
<tr>
<th>Group I Human</th>
<th>Group II Human</th>
<th>Ecotox</th>
<th>Fate</th>
<th>Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>M</td>
<td>M</td>
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<td>dg</td>
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<tr>
<td>M</td>
<td>F</td>
<td></td>
<td>F</td>
<td>F</td>
</tr>
</tbody>
</table>

*Hazard levels (vH, H, M, L, vL) in *italics* reflect a lower level of confidence (See Guidance).

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1 For inorganic chemicals with low human and ecotoxicity across all hazard endpoints and low bioaccumulation potential, persistence alone will not be deemed problematic. Inorganic chemicals that are only persistent will be evaluated under the criteria for Benchmark 4.
Step 3: Make Informed Decisions

- Compare results by functional use (e.g. flame retardants, plasticizers, etc.)
- Hazard table allows users to consider specific concerns (exposure to workers or other users based on functional use)
- Scores can be applied by those without toxicology expertise (e.g. engineers, purchasers)
- Drives wider adoption of preferred materials
  - Preferred material lists
  - New product development
Step 3: Make Informed Decisions

GreenScreen™
Application Highlights
HP is the world’s leading practitioner of the GreenScreen™ tool.

“HP has committed to replace restricted substances only with materials that are better for the environment and human health, and when there is sufficient assurance of required volumes and we have enough time to design and qualify the new material into the product. To assess alternative replacement materials we now use the GreenScreen, a hazard-based assessment framework developed by the nongovernmental organization Clean Production Action.”

HP’s Global Citizens Report
ROHS – And More Regulations Are Coming

- Substance restrictions are now a major class of regulation for finished electronic and other products
  - More substances
  - More jurisdictions
  - More reporting
  - Alternatives assessments being specified in state legislation

ROHS
EU Directive 2002/95/EC on the Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment
How Many Companies Implement RoHS Restrictions

• Look for substances that are legal
  – All unregulated substitutes equally acceptable

• Base material selection only on:
  – Cost
  – Function
  – Reliability
  – Manufacturability
Business Case for Choosing Low Hazard Materials

• Replacing materials is expensive
  – Want to select alternatives that will not be restricted in the future

• Replacements should have lower environmental impact
  – Avoid unintended consequences
  – Identify preferable materials (not just minimally acceptable)
1. HP started GreenScreen™ program as a small pilot to learn what works

2. For PVC alternatives, screening was made mandatory, in addition to all standard and regulatory requirements

   • 100% of PVC-free power cords screened by suppliers and HP
     • Requires full disclosure under CDA
     • Several approved (> Benchmark 1)
   • CHA used as a feature along with cost, performance, risk assessment, LCA, etc.
• Supplier of halogen and phthalate-free products that meet performance and regulatory requirements
• PolyOne GLS engaged with GreenScreen via relationship with HP
• Learned from it, and will continue to use the GreenScreen process to develop cleaner, greener products going forward as part of their corporate responsibility

“The more you know about what you are putting into your products, the more likely you are to make better choices in product development”

Jonathan Plisco, PolyOne
Concluding Thoughts

• Comparative chemical hazard assessment (CCHA) is increasingly important for identifying safer chemicals and materials for business and regulatory purposes
  – Chemical/material selection is not just about cost and performance
  – Chemical hazard is being perceived as a quality feature
  – The presence of hazardous chemicals in a material or product can be considered a defect – especially if it leads to regulatory risk
• CCHA is necessary but not sufficient
  – Used with risk assessment, life-cycle assessment, carbon foot-printing, etc;
• The GreenScreen is a leading method for CCHA
  – Science-based, publicly accessible, transparent, comprehensive, reproducible and based on best national and international precedents such as the USEPA DfE approach, GHS and more.
  – Future developments to include:
    • Public repository of GreenScreen assessments
    • Software for initial screening (GreenScreen LiTe in collaboration with GreenWERCS)
GreenScreen Training

• Date: Tuesday, May 8\textsuperscript{th}, 2012
• Time: 8:00 AM – 5:30 PM
• Location: Ann Arbor, MI
• Registration: [http://greenscreen-annarbor.eventbrite.com/](http://greenscreen-annarbor.eventbrite.com/)
• Sponsors:
  • US EPA Region 5 Great Lakes Restoration Initiative; partners
    o National Pollution Prevention Roundtable
    o Great Lakes Regional Pollution Prevention Roundtable
    o Great Lakes Green Chemistry Network
  • NSF International
  • Green Chemistry and Commerce Council
GreenScreen Training
Speakers

- Lauren Heine, Clean Production Action
- Helen Holder, Hewlett-Packard
- Emma Lavoie, USEPA Design for the Environment
- Alex Stone, Washington State Department of Ecology
- Teresa McGrath, NSF International
- Margaret Whittaker, Chris Schlosser and Kristin Schaefer, ToxServices
- Ann Blake, Environmental & Public Health Consulting
- Shari Franjevic, Transform to Green
GreenScreen Training Agenda

• 8:00 - 8:30  Registration
• 8:30 – 8:40  Welcome & Introductions
• 8:40 - 9:10  Session I: GreenScreen Introduction
• 9:10 - 9:55  Session II: Assigning Benchmarks
• 10:05 – 10:50 Session III: Benchmarking with Special Scenarios
• 10:50 – 11:50 Session IV: Hazard Overview
• 12:50 – 2:20  Session V: Assessing & Classifying Hazards
• 2:20 - 2:50  Session VI: Classifying Hazards with Special Scenarios
• 2:50 - 3:00  Conclusion: Hazard Assessment Strategies
• 3:15 – 3:45  VII: Making Informed Decisions
• 3:45 – 5:00  Discussion - Implementing the GreenScreen in Your Organization
• 5:00 - 5:30  Review and Closure
GreenScreen Training Schedule

• 6 GreenScreen Trainings in the Great Lakes 2012-2014
• Next Training
  – November 15, 2012 in Chicago, IL
  – Green Chemistry Conference November 16-17, 2012
• Future Trainings
  – Dates and locations TBD
  – Projected Timeline:
    • 2 Trainings in 2013; Spring & Fall
    • 2 Trainings in 2014; Winter & Spring
GreenScreen Training Information

1. Watch Clean Production Action Spotlight
   http://www.cleanproduction.org/Home.php

2. Sign up for GreenScreen listserv
   http://www.cleanproduction.org/Green.php

*** See Lower left side of page