Who/What is MBDC?

- MBDC is McDonough Braungart Design Chemistry
- Product and process design firm founded in 1995 by William McDonough and Michael Braungart
- Core staff of ~15, located in Charlottesville, VA
- Focus on identification of CoCs and alternatives
- Originators of the Cradle to Cradle philosophy, design protocol and certification program
“Design Chemistry”

- True merger of Chemistry and Design
- Achieving the highest standards of design
- Beginning with a scientific understanding of the basic chemistry of materials, products and processes
- Expanding the definition of “Quality”
Agenda

• Cradle to Cradle® Design Protocol
• Cradle to Cradle® Certification Program
• Cradle to Cradle® Alternatives Analysis
Traditional Product Design
Cradle to Grave Product Life Cycle

Cradle → Manufacture → Use → Grave

[Images of a mine, a manufacturing plant, and a recycling facility]

Cradle to Cradle

MBDC
Future Design Paradigm

Cradle

- Materials safe for human and ecological health
- Safely cycled, perpetually
- Manufactured with renewable energy
- Respectful of watershed
- Socially responsible
Design Modeled on Nature

• Nature focuses primarily on *effectiveness* (pursuing the most valuable end)
  - Then it may be *efficient*
  - Abundance, instead of minimization only

• Eco-effectiveness embraces nature’s design principles
Natural Cycles

Biology 101
Emulating Natural Cycles

**Biological Nutrients**
- plants
- soil nutrients
- decomposers
- animals

**Technical Nutrients**
- manufacturing/assembly
- materials
- customer use
- product
Two Metabolisms

Biological Metabolism

Technical Metabolism
Nested, Interdependent Metabolisms

Safe, healthy ingredients

Product design for recyclability / compostability

Reorient design principles

Systems for complete recycling / composting
Waste equals food
Cradle to Cradle Design Principles

Waste equals food

Use current solar income
Waste equals food
Use current solar income
Celebrate diversity
Cradle to Cradle Design Principles

• “Waste equals food”
  - Material life cycles safe for human health & environment
  - Safely cycled, perpetually: recyclable, DfD, recovery system
  - Materials & products continually reused

• “Use current solar income”
  - Power with renewable energy

• “Celebrate diversity”
  - Human rights, including future generations
  - Ecological rights
  - Water use & water quality
  - Not one-size-fits-all solutions
Cradle to Cradle® Certification
Cradle to Cradle Certification

Cradle to Cradle Certified™ is a certification mark of MBDC.
Overview

• Applicable to all industry sectors
• Applicable to materials, sub-assemblies and finished products
• Not binary “pass/fail” – 4 levels of achievement
• Focus is on continuous improvement
• Annual renewal
• Program is moving to GPII
Certification Stats

• Launched in October of 2005
• Over 100 Manufacturers Participating
• ~350 Certified Products
• Grown by ~50% over the past 12 months
• Version 3.0 revision underway
## Certification Criteria

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Materials</td>
</tr>
<tr>
<td>2.0</td>
<td>Material Reutilization/DfE</td>
</tr>
<tr>
<td>3.0</td>
<td>Energy</td>
</tr>
<tr>
<td>4.0</td>
<td>Water</td>
</tr>
<tr>
<td>5.0</td>
<td>Social Responsibility</td>
</tr>
</tbody>
</table>

### Cradle to Cradle Certified™ Product
- Platinum
- Gold
- Silver
- Basic

- Combination of product metrics & company metrics
- Intention: spur innovation & ongoing optimization

Cradle to Cradle Certified™ is a certification mark of MBDC.
1.0 Material Health
Deconstructing the Product

• Break product down into main components, subassemblies, etc.
• Break those down into homogeneous material streams
• Break materials down into chemicals
• Begin evaluation at the chemical level
Chemical Profiling

• A way to rank or score chemicals based on their intrinsic hazards to human/environmental health

• Hazard identification based on:
  – 10 Human Health criteria
  – 8 Environmental Health criteria

• Scoring is done using a “stoplight” approach
Chemical Profile Colors

• **Green**
  - Little or no hazard

• **Yellow**
  - Low to moderate hazard

• **Red**
  - High hazard

• **Grey**
  - Incomplete HH or EH data
Human Health Criteria

- Carcinogenicity
- Disruption of Endocrine System
- Mutagenicity
- Reproductive Toxicity
- Teratogenicity

- Acute Toxicity
- Chronic Toxicity
- Irritation of Skin/Mucous Membranes
- Sensitization
- Other (e.g., skin penetration potential, flammability, etc.)
Environmental Health Criteria

- Aquatic toxicity
  - Fish toxicity
  - Daphnia toxicity
  - Algae toxicity
- Bioaccumulation (BCF, log Kow)
- Climatic Relevance/Ozone Depletion Potential
- Persistence/Biodegradation
- Organohalogen content
- Other (e.g., Water Danger Score, Toxicity to Soil Organisms, etc.)
# Human Health Cut Off Values

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Green</th>
<th>Yellow</th>
<th>Red</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcinogenicity</td>
<td>Not known or suspected of being carcinogenic</td>
<td>Not classifiable as a human carcinogen</td>
<td>Known or suspected carcinogen</td>
</tr>
<tr>
<td>Disruption of Endocrine System</td>
<td>Not known or suspected of being an endocrine disruptor</td>
<td></td>
<td>Listed as a known/suspected endocrine disruptor supported by peer reviewed science</td>
</tr>
<tr>
<td>Mutagenicity</td>
<td>Product has been tested and is not mutagenic to eukaryotes</td>
<td>Product has been tested in prokaryotes only and is negative</td>
<td>Product has confirmed positive mutagenicity test(s)</td>
</tr>
<tr>
<td>Reproductive Toxicity</td>
<td>Not known or suspected of being a reproductive toxin</td>
<td></td>
<td>Substance has positive test results or is listed as a reproductive toxin</td>
</tr>
<tr>
<td>Teratogenicity</td>
<td>Not a known or suspected teratogen</td>
<td>Not teratogenic as long as MAK value observed</td>
<td>Positive teratogenic test results or listed as a known or suspected teratogen</td>
</tr>
<tr>
<td>Acute Toxicity (oral)</td>
<td>Oral LD50 &gt; 2000 mg/kg</td>
<td>2000 mg/kg &gt; Oral LD50 &gt; 200 mg/kg</td>
<td>Oral LD50 &lt; 200 mg/kg</td>
</tr>
<tr>
<td>Acute Toxicity (inhalative)</td>
<td>LC50 &gt; 4000 mg/m3</td>
<td>4000 mg/m3 &gt; LC50 &gt; 400 mg/m3</td>
<td>LC50 &lt; 400 mg/m3</td>
</tr>
<tr>
<td>Chronic Toxicity</td>
<td>Low chronic toxicity (e.g., NOAEL &gt; 100 mg/kg)</td>
<td>Moderate chronic toxicity</td>
<td>High chronic toxicity</td>
</tr>
<tr>
<td>Sensitization</td>
<td>Not sensitizing to skin or airways (either proven via experience or test)</td>
<td>Equivocal sensitization data</td>
<td>Listed as a skin or airway sensitizer or has tested positive in sensitization test(s)</td>
</tr>
<tr>
<td>Irritation of Skin/Mucous membranes</td>
<td>Mild or no irritation</td>
<td>Mild to moderate irritation</td>
<td>Severe irritation, risk of severe burns or serious damage to eyes</td>
</tr>
</tbody>
</table>
## Environmental Health Cut Off Values

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Green</th>
<th>Yellow</th>
<th>Red</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish Toxicity</td>
<td>LC50 &gt; 100 mg/L (96 hr)</td>
<td>100 mg/L &gt; LC50 &gt; 10 mg/L</td>
<td>LC50 &lt; 10 mg/L</td>
</tr>
<tr>
<td>Daphnia Toxicity</td>
<td>LC50 &gt; 100 mg/L (96 hr)</td>
<td>100 mg/L &gt; LC50 &gt; 10 mg/L</td>
<td>LC50 &lt; 10 mg/L</td>
</tr>
<tr>
<td>Algae Toxicity</td>
<td>EC50 &gt; 100 mg/L (96 hr)</td>
<td>100 mg/L &gt; EC50 &gt; 10 mg/L</td>
<td>EC50 &lt; 10 mg/L</td>
</tr>
<tr>
<td>Persistence/Biodegradation</td>
<td>T1/2 &lt; 10 days</td>
<td>10 days &lt; T1/2 &lt; 30 days in air, 50 days in soil</td>
<td>Not biodegradable</td>
</tr>
<tr>
<td></td>
<td>Readily biodegradable (based on OECD tests)</td>
<td>Ultimately biodegradable but not readily</td>
<td></td>
</tr>
<tr>
<td>Bioaccumulation</td>
<td>BCF &lt; 100</td>
<td>100 &lt; BCF &lt; 1000</td>
<td>BCF &gt; 1000</td>
</tr>
<tr>
<td>Content of Halogenated Organic Compounds</td>
<td>Substance does not contain any organohalogens in concentrations &gt; 0.01%</td>
<td></td>
<td>Substance contains organohalogens in concentrations &gt; 0.01%</td>
</tr>
<tr>
<td>Climatic Relevance/Ozone Depletion</td>
<td>Not listed as a class 1 or 2 ozone depletor</td>
<td></td>
<td>Listed as a class one or two ozone depletor</td>
</tr>
</tbody>
</table>
Rolling Chemical Profiles up to Material Assessments

- Identify all ingredients and their functions
- Complete Chemical Profile for each ingredient
- Understand end state of each ingredient
- Apply “Contextual Filter” to each input to determine hazard relevance
- Assess and score material/mixture using same “stoplight” approach
# Nylon 6 Assessment

## Nylon 6 Material Assessment Report

### MATERIAL ASSESSMENT SUMMARY

<table>
<thead>
<tr>
<th>Material Name</th>
<th>Comments</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nylon 6</td>
<td>The potential routes of exposure of carbon black as it exists in a polymeric material do not pose a risk to the user or recycler of the material. Therefore the red flag for this ingredient is changed to a yellow assessment as used in this material. While there is very little recycled content in this material, glass filled Nylon 6 can be mechanically, or chemically recycled and therefore is positioned to be a true technical nutrient.</td>
<td>GREEN</td>
</tr>
</tbody>
</table>

### INGREDIENT ASSESSMENT SUMMARY

<table>
<thead>
<tr>
<th>Ingredient Name</th>
<th>CAS No.</th>
<th>Function</th>
<th>Concentration</th>
<th>Profile</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nylon 6</td>
<td>25038-54-4</td>
<td>Base resin</td>
<td>&gt;80%</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Chopped Strand Fiberglass</td>
<td>65997-17-3</td>
<td>Reinforcement</td>
<td>15%</td>
<td>Yellow</td>
<td>Green</td>
</tr>
<tr>
<td>Sodium Stearate</td>
<td>822-16-2</td>
<td>Lubricant</td>
<td>&lt;1%</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Potassium Bromide</td>
<td>7758-02-3</td>
<td>Stabilizer</td>
<td>&lt;1%</td>
<td>Yellow</td>
<td>Yellow</td>
</tr>
<tr>
<td>Copper Iodine</td>
<td>7681-65-4</td>
<td>Stabilizer</td>
<td>&lt;1%</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Carbon Black</td>
<td>1333-86-4</td>
<td>Pigment</td>
<td>&lt;1%</td>
<td>Red</td>
<td>Yellow(1)</td>
</tr>
</tbody>
</table>

### FOOTNOTES

1. Carbon Black - The potential routes of exposure for carbon black as it exists in a polymeric material does not pose a risk to the user or recycler of the material.
# Product Overview

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>xxxx</td>
<td>893446503</td>
<td>CYLINDER - BALL END</td>
<td>ACETAL</td>
<td>DELRIN 500 AL</td>
<td></td>
<td></td>
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<tr>
<td>xxxx.1</td>
<td>801846511</td>
<td>SIDE RAIL, LH</td>
<td>ALUMINUM</td>
<td>A380 ALUMINIUM</td>
<td></td>
<td>PLASTIC MEDIA VIBRATORY FINISH</td>
</tr>
<tr>
<td>xxxx.2</td>
<td>860046501</td>
<td>AXLE</td>
<td>STL_CARBON</td>
<td>1008 CARBON STEEL</td>
<td></td>
<td></td>
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<tr>
<td>xxxx.3</td>
<td>883046506</td>
<td>LINK AND BUSHING ASSEMBLY, SMM</td>
<td>MULTIPLE</td>
<td>N/A</td>
<td></td>
<td></td>
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<tr>
<td>xxxx.3.1</td>
<td>892146505</td>
<td>BEARING - SHOULDER</td>
<td>ACETAL</td>
<td>DELRIN 500 AL</td>
<td></td>
<td>NATURAL</td>
</tr>
<tr>
<td>xxxx.3.2</td>
<td>860046500</td>
<td>AXLE</td>
<td>STL_CARBON</td>
<td>CARBON STEEL CASE HARDENED TO RC 60</td>
<td></td>
<td>COMMERCIAL ZINC TRIVALENT</td>
</tr>
<tr>
<td>xxxx.4</td>
<td>893246506</td>
<td>BLOCK - HINGE, RH</td>
<td>RESIN</td>
<td>LUBRIBLEND PA 6/6 GF 50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.0 Material Reutilization

- Design with the end in mind
  - Design that is truly reusable
  - Biological nutrients – safely returned to the earth
  - Technical nutrients – unending reuse
  - Truly closed loops
3.0 Energy

- What is the energy intensity of a material’s or product’s creation?

- What is the quality of energy required for its creation?

- What energy sources are used in its creation, distribution, use, and value recovery processes? (Renewables vs. non-renewables.)

- What is your plan for supplying all production energy needs from renewables?
4.0 Water

• Water stewardship
• Recognize water flows
• Water conservation initiatives
• Improve the quality of water discharges
5.0 Social Fairness

- Corporate ethics
- Fair labor
- Self assessment
- Making a difference
Summary of Certification Levels

BASIC

• All materials inventoried and assessed
• No “Black List” substances present
• Must be developing strategy to phase out problematic substances
• Defining product for BN/TN
Summary of Certification Levels

SILVER

• Does NOT mean material chemistry fully optimized
• Must have strategy/timeline for optimizing problematic chemicals
• Beginning to develop strategy for recovering/cycling product
• Understand energy footprint and have strategy to increase % of renewables
• Water stewardship and social fairness policies publicly available
Summary of Certification Levels

GOLD

• Product chemistry optimized
• Manufacturer playing larger role in product recovery/cycling
• Energy for final assembly/manufacturer at least 50% renewable
• Water audit done on manufacturing facility(ies)
• Fair labor self audit
Summary of Certification Levels

PLATINUM

• Material chemistry fully optimized
• Product recovered and recycled/remanufactured into product of equal or higher value
• Total energy footprint of product at least 50% renewable
• Innovations around water use/quality of discharge
• Third party social accreditation – all suppliers meet Silver level social equity criteria
Cradle to Cradle AA Process

• Required under the product certification program for all products with one or more RED assessed materials

• Collaborative process with manufacturer and supplier chain

• Flexible timeline for implementation

• Continuous improvement, NOT perfection, is the goal
Cradle to Cradle AA (cont.)

PRIORITIES:

• Toxicity

• Nutrient reuse potential of material
AA Example - MechoShade
• Original fabric RED due to PVC coextrusion over PET core
• Original fabric not recyclable due to PVC contamination

• New fabric TPO over PP core but still RED due to non-PBDE based BFR
• New fabric 100% recyclable
Initial carpet tile
• N 6.6 face fiber
• PVC backing with Sb2O3 FR synergist

Optimized version of same carpet tile
• N6 face fiber
• TPO backing with mineral based FR
We do not inherit the earth from our ancestors, we borrow it from our children.