Recycling and the Need for Information on Chemicals in Products

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Based on the presentations by:
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At the “Chemicals in Products” Workshop in Geneva, Feb 2009

Message from POPs COP4
- Text inserted to Annex A to the Stockholm Convention -

A Party may allow recycling of articles that contain or may contain BDEs, and the use and final disposal of articles manufactured from recycled materials that contain or may contain BDEs, provided that:

(a) The recycling and final disposal is carried out in an environmentally sound manner and does not lead to recovery of BDEs for the purpose of their reuse;

(b) The Party takes steps to prevent this exemption to lead to the export of articles containing levels/concentrations of BDEs that exceed those permitted to be sold within the territory of the Party; and

(c) The Party has notified the Secretariat of its intention to make use of this exemption.
POP COP4 Decision

1. **Parties are requested and observers are invited to provide any information** by July 2010 on newly listed POPs as follows:
   (i) For BDEs found in articles:
       (a) Types and quantities of articles containing DBEs including concentrations of these substances in the articles, including recycled articles;
       (b) Types of articles recycled, the extent of recycling, the types of articles produced from this recycling, the options for the environmental management of the recycling operations and releases resulting from these recycling operations;
       (c) Cost-effectiveness of different management options;
       (d) Options for environmentally sound disposal;
       (e) Methods for identifying the presence and levels of these substances in articles; identification of remediation methods for contaminated site;
       (g) Any other related information...

2. The Secretariat is requested to gather and summarize such information for POPRC6.

3. POPRC5 is requested to develop terms of reference for a technical paper to assess the possible health and environmental impact of recycling and BAT/BEP.

4. The Secretariat is requested to commission a technical paper to be submitted to POPRC6.

5. POPRC is requested to review this information, identify information gaps, and prepare reports and recommendations to COP5 on the elimination of BFRs from the waste stream and on risk reduction for PFOS(F).

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**Importance of information sharing**

- **Information disclosure:** from Producers to Recyclers
  - Safer recycling process
  - Higher recycling rate
  - Less contaminated materials
  - Regulatory framework also needed
  - Economic benefits for recyclers

- **Feedback:** from Recyclers to Producers
  - Improve Design for Environment (DfE)

**Rationale:** With improved knowledge on how products are recycled and how waste is treated, and on hazards related with those operations, producers can improve their product design.
### Hazardous substances and components in WEEE

<table>
<thead>
<tr>
<th>Components</th>
<th>Found in</th>
<th>Substances of concern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cathode ray tubes</td>
<td>Old TV sets, PC monitors, oscilloscopes</td>
<td>Pb in cone glass, Ba in electron gun getter, Cd in phosphors</td>
</tr>
<tr>
<td>Printed circuit boards</td>
<td>Ubiquitous, from beepers to PCs</td>
<td>Pb, Sb in solder, Cd, Be in contacts, Hg in switches, BFRs in plastics</td>
</tr>
<tr>
<td>Batteries</td>
<td>Portable devices</td>
<td>Cd in Ni-Cd batteries, Pb in lead acid batteries, Hg in batteries</td>
</tr>
<tr>
<td>Gas discharge lamps</td>
<td>Backlights of LCDs</td>
<td>Hg</td>
</tr>
<tr>
<td>Plastics</td>
<td>Wire insulation, plastic housing, circuit boards</td>
<td>Brominated flame retardants</td>
</tr>
</tbody>
</table>

### Hazards associated with the recycling chain

**Recycling chain**
- **Disassembly**
- **Size reduction and separation**
- **Metallurgical treatment**
- **Final treatment**

**Hazards**
- **Removal of hazardous components**
  - Hg switches: Hg
  - Batteries: Cd, Pb, Hg
  - Gas discharge lamps: Hg, CRTs: Pb, phosphors

**Hazard stages**
- **Shredding**
  - Formation of dust particles containing plastics, metals, ceramic and silica
- **Smelting**
  - Emission of metal fumes, mixed chlorinated and brominated dioxins and furans (PXDD/Fs)
- **Incineration and landfilling**
  - Emission of metal fumes, PXDD/Fs, Leaching of heavy metals and BFRs

**Risks in the recycling and waste treatment process**
Hazards associated with recycling

Low risk scenario: Hazardous components are removed

- Disassembly
- Shredding and separation
  - Formation of dust containing particles of metals, plastics, ceramic, silica, etc.
  - E.g., PCB shredding → dust of Pb, Cd, Sb, Se, Hg, plastics
- Metallurgical treatment
  - Emissions of metals, Cl/Br dioxins & furans
  - Metals → metal fumes (low temp - Cd, Pb)
  - PVC, BFRs in plastics → PXDD/ Fs

High risk scenario: Hazardous components are not removed

- Hg switches
- Batteries
- Plastics, etc.

Lower risk of pollution and occupational exposure

Formation of dust containing particles of metals, plastics, ceramic, silica, etc.
E.g., PCB shredding → dust of Pb, Cd, Sb, Se, Hg, plastics

Emissions of metals, Cl/Br dioxins & furans
Metals → metal fumes (low temp - Cd, Pb)
PVC, BFRs in plastics → PXDD/Fs

Investigated facility:
- Dismantling and shredding of waste TVs.
- Dismantling approximately 600 TVs/day.
- New dust collection apparatuses were introduced.

Survey:
- Sampled air in working place before and after introduction of the apparatus.
- Difference of BFRs and PBDD/DFs concentrations and patterns in air samples was evaluated.

Schematic diagram of the investigated TV dismantling process
( ■: introduced apparatus for dust collection)

H. Takigami; Organohalogen Compounds, 68, 2190-2193 (2006)
### Behavior and emission control at recycling/waste treatment stage

#### BFRs and PBDD/Fs in recycling plant of waste home appliances

**Before improvement**

- PBDEs: 510,000 pg/m³
- PBDD/DFs: 2,400 pg/m³

**After improvement**

- One order magnitude lower

- The patterns and concentrations of PBDEs in the airborne dust were quite similar to those of the TV inside dust.

- Emission control of dust is effective for reducing the concentration of BFRs and PBDD/DFs.

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### Recent initiatives on treatment of end-of-life products and hazardous chemicals in products

**Globalizing movement**

- Many policy initiatives, mainly originating from the EU
- Fewer and less hazardous substances used
- Improved availability of information on hazardous substances used in products
- Regional initiatives have global impact

**Domestic initiatives in Japan**

- Revision of the Chemical Substances Control Law
- Recycling-related laws (e.g. Electronic Home appliances, PCs)
- JAMP (industry response to REACH)
- Waste Data Sheet
- Marking and Labelling
- J-moss (Japanese RoHS labeling)

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Adapted from: Yoshiaki Ichikawa (Hitachi), "Eco-conscious design and the 3Rs" - IGES K- FACE Global Environmental Seminar Economic Globalization and the 3Rs, January 31, 2007
# Current situation in Japan

## Collection and recycling of e-waste

<table>
<thead>
<tr>
<th>Products</th>
<th>Collection scheme</th>
</tr>
</thead>
</table>
| Refrigerators, Washing machines, TVs, PCs, Air conditioners | • Producer responsible for recycling  
• Consumers pay recycling fee at disposal |
| Mobile phones | Network operators run a joint initiative to collect and recycle |
| Other large household electronics (Stereos, Microwave ovens etc.) | • Some municipalities collect as "large waste" on designated days  
• Sold to recyclers |
| Small electronics (Cameras, MP3s etc.) | • A few pilot projects to collect  
• Often public-private partnerships |

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## Current situation in Japan

**JAMP (Joint Article Management Promotion-consortium)** is an industry initiative to manage information on chemicals in products (response to REACH)

**JAMP MSDSplus**: supplemental MSDS regarding substance/preparation. MSDSplus focuses on materials and the amount.

**JAMP AIS (Article Information Sheet)**: Information format for conveying chemical information

- Information sharing from up-stream to down-stream in the supply chain
- Producers of articles can receive "complete" chemical information

Waste Data Sheets contain information of industrial waste to assure proper disposal and to prevent accidents.

1. Date
2. Name of Waste
3. Name and Contact of Waste Provider
4. Class of Waste (check lists)
5. Type of Packing
6. Amount of Waste
7. Hazardous information
   1) Hazardous Characteristics
   2) Stability
8. Physical/Chemical Property
9. Composition/Component Information
10. Remarks
    1) Measure for Safety
    2) Accident Response (Emergency Treatment, Treatment for Leaking, and Treatment for fire)
11. Special Note.
12. Others.

- Information from waste generators to recycling and treatment
- Only industrial waste and focus on physical hazards

Current situation in Japan

Marking and Labeling

1. Identification of plastic parts
2. Symbols to make manual disassembly easier
3. Marking for presence or absence of selected chemical substances
4. Labeling of equipment containing rechargeable batteries

- Mostly voluntary systems
- Developed for large household appliances
- Introduced over the last few years

<table>
<thead>
<tr>
<th>Contents</th>
<th>Example of Marks</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Info.</td>
<td>&gt;PC&lt;+ABS-CF FR(40)&lt;</td>
<td>2007</td>
</tr>
<tr>
<td>No Flame Retardants</td>
<td>&gt;ABS&lt; FR0</td>
<td></td>
</tr>
<tr>
<td>Contents Recycled Plastic</td>
<td>&gt;PP&lt; CR30</td>
<td></td>
</tr>
<tr>
<td>Label and Seal</td>
<td>&gt;PET&lt; / &gt;PS&lt;</td>
<td></td>
</tr>
<tr>
<td>Metal Info.</td>
<td>-Fe-</td>
<td>2008</td>
</tr>
<tr>
<td>Metal has been inserted into the plastic parts</td>
<td></td>
<td>2004</td>
</tr>
<tr>
<td>Hole puncture location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symbols to show the direction of the compressor’s refrigerant enclosing pipe</td>
<td><img src="image" alt="Symbol" /></td>
<td></td>
</tr>
<tr>
<td>J-Moss Red mark</td>
<td></td>
<td>2006</td>
</tr>
<tr>
<td>Marking presence of specific chemical substances in mounted boards</td>
<td><img src="image" alt="Symbols" /></td>
<td>2005</td>
</tr>
<tr>
<td>Rechargeable battery</td>
<td><img src="image" alt="Symbol" /></td>
<td>2001</td>
</tr>
</tbody>
</table>

Reference: MOEJ, WDS guideline

Reference: http://www.aeha.or.jp/
Overview of information systems in Japan

Currently no comprehensive information system for the recycling chain

Chemicals in products/articles

Analysis of chemicals in new products/articles

Samples:
- Liquid crystal display (LCD) TV, Laptop PC, Power supply unit
- Wallpaper, Curtain, Heat insulation material

Analyzed chemicals:
- Organobromine compounds (PBPhs, TBBPA, HBCDs, PBDEs)
- Phosphoester plasticizers and flame retardants (TMP, TEP, TPrP, TBP, TCIPP, TCEP, TBEP, TDCPP, TOP, TPhP, TCP)

Analysis method:
- Samples were pulverized by frost shattering using liquid N₂.
- HRGC/HRMS and LC/MS methods.
### Chemicals in products/articles

#### BFRs and PFRs in new model LCD TVs

**LCD TV (containing BFRs in its casings, SONY Bravia)**

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Rear cover</th>
<th>Front cover</th>
<th>LCD panel</th>
<th>Printed circuit board</th>
<th>Printed circuit board (power supply unit)</th>
<th>Printed circuit board (LCD panel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBPhs</td>
<td>5,700</td>
<td>4,600</td>
<td>33</td>
<td>730</td>
<td>980</td>
<td>1,200</td>
</tr>
<tr>
<td>TBBPA</td>
<td>68</td>
<td>92</td>
<td>7</td>
<td>87</td>
<td>90</td>
<td>890</td>
</tr>
<tr>
<td>HBCDs</td>
<td>&lt; 0.5</td>
<td>6</td>
<td>2</td>
<td>&lt; 0.5</td>
<td>130</td>
<td>680</td>
</tr>
<tr>
<td>PBDEs</td>
<td>14,000</td>
<td>14,000</td>
<td>2</td>
<td>59</td>
<td>15</td>
<td>54</td>
</tr>
<tr>
<td>DBDPE</td>
<td>130,000</td>
<td>92,000</td>
<td>NA</td>
<td>36</td>
<td>1,100</td>
<td>770</td>
</tr>
<tr>
<td>T-Br (XRF)</td>
<td>136,000,000</td>
<td>125,000,000</td>
<td>ND</td>
<td>23,900,000</td>
<td>133,000</td>
<td>22,600,000</td>
</tr>
<tr>
<td>TMP</td>
<td>&lt; 0.3</td>
<td>&lt; 0.3</td>
<td>&lt; 0.3</td>
<td>&lt; 0.3</td>
<td>&lt; 0.3</td>
<td>&lt; 0.3</td>
</tr>
<tr>
<td>TEP</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>TpP</td>
<td>&lt; 0.5</td>
<td>&lt; 0.5</td>
<td>&lt; 0.5</td>
<td>&lt; 0.5</td>
<td>&lt; 0.5</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>TPP</td>
<td>16</td>
<td>11</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>TCIpP</td>
<td>10</td>
<td>14</td>
<td>4</td>
<td>23</td>
<td>52</td>
<td>16</td>
</tr>
<tr>
<td>TCPE</td>
<td>7</td>
<td>4</td>
<td>&lt; 4</td>
<td>9</td>
<td>&lt; 4</td>
<td>4</td>
</tr>
<tr>
<td>TBPE</td>
<td>&lt; 80</td>
<td>&lt; 80</td>
<td>&lt; 80</td>
<td>&lt; 80</td>
<td>&lt; 80</td>
<td>&lt; 80</td>
</tr>
<tr>
<td>TDCPP</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>TOP</td>
<td>3</td>
<td>17</td>
<td>&lt; 0.9</td>
<td>&lt; 0.9</td>
<td>&lt; 0.9</td>
<td>&lt; 0.9</td>
</tr>
<tr>
<td>TPEP</td>
<td>1,100</td>
<td>2,400</td>
<td>1,200,000</td>
<td>1,600,000</td>
<td>6,700,000</td>
<td>320,000</td>
</tr>
<tr>
<td>TCP</td>
<td>180</td>
<td>370</td>
<td>84</td>
<td>480</td>
<td>4,500,000</td>
<td>140,000</td>
</tr>
<tr>
<td>T-P (XRF)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

- Only 0.1% of total-Br was detected in rear and front cover as MS-measured BFRs.
- Other BFR compounds may be used in this TV. (TBBPA epoxyoligomer and carbonate oligomer)
- Both BFRs and PFRs were used in liquid crystal and printed circuit board.
Most of the units contained approx. 1-1.5 % of TPhP, which may be used as plasticizer and flame retardant. Other PFR compounds, such as condensed phosphate, may be used in this TV. These results show use of flame retardants is changing from BFRs (e.g., PBDEs) to other BFRs and PFRs in accordance with some regulations such as RoHS and REACH.

<table>
<thead>
<tr>
<th>Chemicals in products/articles</th>
<th>BFRs and PFRs in new model LCD TVs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LCD TV (containing PFRs in its casings, SHARP Aquos)</strong></td>
<td><strong>Concentration (ng/g-unit)</strong></td>
</tr>
<tr>
<td>Rear cover Front cover LCD panel Printed circuit board Printed circuit board (power supply unit) Printed circuit board (LCD panel)</td>
<td></td>
</tr>
<tr>
<td>PBFs</td>
<td>41</td>
</tr>
<tr>
<td>TBBPA</td>
<td>15</td>
</tr>
<tr>
<td>HBCDs</td>
<td>53</td>
</tr>
<tr>
<td>PBDEs</td>
<td>32</td>
</tr>
<tr>
<td>DBDPENA</td>
<td>NA</td>
</tr>
<tr>
<td>T-Br (XRF)</td>
<td>ND</td>
</tr>
<tr>
<td>TMM</td>
<td>&lt;0.3</td>
</tr>
<tr>
<td>TEP</td>
<td>0</td>
</tr>
<tr>
<td>TCPP</td>
<td>2</td>
</tr>
<tr>
<td>TCEP</td>
<td>4</td>
</tr>
<tr>
<td>TDEP</td>
<td>6</td>
</tr>
<tr>
<td>TCP</td>
<td>47</td>
</tr>
<tr>
<td>T-P (XRF)</td>
<td>527,000</td>
</tr>
</tbody>
</table>

- Most of the units contained approx. 1-1.5 % of TPhP, which may be used as plasticizer and flame retardant. Other PFR compounds, such as condensed phosphate, may be used in this TV. These results show use of flame retardants is changing from BFRs (e.g., PBDEs) to other BFRs and PFRs in accordance with some regulations such as RoHS and REACH.

Chemicals in products/articles

**BFRs and other chemicals in video tape (mg/kg)**

<table>
<thead>
<tr>
<th>Country of production</th>
<th>PBDEs</th>
<th>TBBP-A</th>
<th>HBCD</th>
<th>DeBDEthane</th>
<th>TBr</th>
<th>Sb</th>
<th>Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>0.54</td>
<td>0.0030</td>
<td>&lt;0.01</td>
<td>&lt;0.07</td>
<td>170</td>
<td>170</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>4700</td>
<td>340</td>
<td>15</td>
<td>na</td>
<td>4400</td>
<td>1700</td>
<td></td>
</tr>
<tr>
<td>Korea</td>
<td>2400</td>
<td>280</td>
<td>30</td>
<td>na</td>
<td>2500</td>
<td>1100</td>
<td></td>
</tr>
<tr>
<td>Korea</td>
<td>1600</td>
<td>34</td>
<td>1.1</td>
<td>na</td>
<td>1500</td>
<td>650</td>
<td></td>
</tr>
<tr>
<td>Korea</td>
<td>1300</td>
<td>46</td>
<td>1.6</td>
<td>260</td>
<td>1600</td>
<td>780</td>
<td></td>
</tr>
<tr>
<td>Korea</td>
<td>1000</td>
<td>9.5</td>
<td>0.31</td>
<td>na</td>
<td>610</td>
<td>270</td>
<td></td>
</tr>
</tbody>
</table>

- BFRs are usually added by around 10 wt% of plastics for flame resistance.
- Recycled products could be contaminated with BFRs by using waste flame retarded plastics (e.g., TV casing).
- PBDEs contained in video tapes is mainly DeBDE

Y. Hirai; Organohalogen Compounds, 68, 2190-2193 (2006)