Regulation on Recyclability and Recycling

EVE Meeting Brussels Nov. 28/29, 2014

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Adam Opel AG
RECYCLABILITY
An innovative concept
Recyclability in Vehicle Type Approval

- Type Approval **Recyclability** is dealing with the theoretical **reusability**, **recyclability** and **recoverability** of the **WHOLE VEHICLE** based on its material composition.
  - Legislation on type approval recyclability is addressing the automobile industry (OEMs and suppliers)
- In Europe, Type Approval Recyclability has been regulated in Directive 2005/64/EC, amended by Dir. 2009/01/EC.
- At WP29 meeting Nov. 2013, a UNECE regulation on recyclability of motor vehicle has been approved ensuring GLOBAL ALIGNMENT.
Recyclability in the context of EU End-of-Life Regulation

- T +

RRR Directive 2005/64/EC
UNECE Reg.

Type Approval

Directive on Waste 2008/98/EC

Sector/Product Specific Regulation

ELV Directive 2000/53/EC
WEEE Directive 2012/19/EC
Battery Directive 2006/66/EC
Packaging Directive 94/62/EC

Treatment Specific Regulation

Landfill-Directive
Shipment of Waste
Thermal Treatment of Waste

Unecea Reg.

- t +
Two Aspects of Vehicle Recycling

- Type Approval – New Vehicle Types
  - End of Life Vehicles
  - Recyclability Rate
  - Waste Treatment
  - Theoretical Approach

- End of Life Vehicles – Treatment
  - Waste Treatment of Vehicle fluids & components (incl. Battery)
  - Real Life

ELV Directive 2000/53/EC

Battery Directive 2006/66/EC
Recyclability a Visionary Concept! Why we needed it!

- Inauguration of ELV Directive 2000/53/EC required OEMs to achieve RECYCLING QUOTAS:

<table>
<thead>
<tr>
<th>Year</th>
<th>Reuse &amp; Recycling</th>
<th>Reuse &amp; Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006 onwards</td>
<td>80%</td>
<td>85%</td>
</tr>
<tr>
<td>2015 onward</td>
<td>85%</td>
<td>95%</td>
</tr>
</tbody>
</table>

- Recyclability was introduced into regulation as early as 2001 as a bridge instrument to attain recycling performance 14 years later!

- Both RECYCLABILITY and RECYCLING QUOTA are product specific performance measurements!
Battery Directive 2006/66/EC – A Regulatory Summary

Collection
- Portable
- Automotive
- Industrial

Financing
- Producer need to finance any net cost for public information campaigns
- Producer need to finance any net cost arising for collection, treatment & recycling:
  - Waste portables
  - Waste automotive

Information
- End-user information on:
  - Impact on health and environment
  - Collection schemes
  - Producer contribution for recycling of batteries
  - Product labeling (crossed-out wheeled bin, substance symbol (Hg, Cd, Pb))

Performance
- Collection Target for Portable Batteries:
  - > 25% by 2012
  - > 45% by 2016
- Recycling Efficiency Requirements:
  - > 65% Lead acid Batt.
  - > 75% NiCd
  - > 50% all other Batt.

Material Ban
- Mercury < 0.0005%
- Cadmium < 0.002%
- Exemptions for:
  - Button Cells (Hg)
  - Applications (Cd)

Recycling Efficiency is **NO PRODUCT** specific performance criteria! It is a **RECYCLING PROCESS** oriented performance measurement.

Battery Directive has no product specific recycling performance mandate!
BATTERY RECYCLING
How it is done?
Origin of HV Batteries or Battery Components for Recycling

Introduction of Vehicle

Captive Volume

Limited Volume

Regular Volume

End-of-Life Vehicles

Secondary Use

Battery Recycling

Refurbishment

Aftersales Service

Time 15+ yrs
## Battery Recycling Volumes

Traction Battery Volume dependent on:
1. Vehicle Registrations
2. Battery System Durability
3. Battery System Reparability
4. (Innovative Secondary Use Applications)

### EBRA Recycling Statistics:

**Comparison 2011-2012 (Tons)**

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2012</th>
<th>Var % 11-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary ZnC, Alkaine, Zn-Air</td>
<td>25529</td>
<td>26660</td>
<td>4%</td>
</tr>
<tr>
<td>Button cells (all types)</td>
<td>11</td>
<td>101</td>
<td>817%</td>
</tr>
<tr>
<td>NiCd (consumer, sealed)</td>
<td>3488</td>
<td>3254</td>
<td>-6%</td>
</tr>
<tr>
<td>NiCd (industrial)</td>
<td>3116</td>
<td>3367</td>
<td>8%</td>
</tr>
<tr>
<td>Subtotal NiCd</td>
<td>6604</td>
<td>6632</td>
<td>0%</td>
</tr>
<tr>
<td>NiMH (portable/consumer)</td>
<td>581</td>
<td>954</td>
<td>66%</td>
</tr>
<tr>
<td>NiMH (ind., non-E-mobility)</td>
<td>19</td>
<td>72</td>
<td>462%</td>
</tr>
<tr>
<td>NiMH (E-mobility)</td>
<td>9</td>
<td>48</td>
<td>436%</td>
</tr>
<tr>
<td>Subtotal NiMH</td>
<td>603</td>
<td>1085</td>
<td>80%</td>
</tr>
<tr>
<td>Li-primary (other than button cells)</td>
<td>90</td>
<td>581</td>
<td>545%</td>
</tr>
<tr>
<td>Li-secondary (portable)</td>
<td>2047</td>
<td>3386</td>
<td>65%</td>
</tr>
<tr>
<td>Li-secondary (ind., non-E mobility)</td>
<td>62</td>
<td>0</td>
<td>-100%</td>
</tr>
<tr>
<td>Li-secondary (E-mobility)</td>
<td>24</td>
<td>127</td>
<td>428%</td>
</tr>
<tr>
<td>Subtotal Li-secondary</td>
<td>2135</td>
<td>3512</td>
<td>65%</td>
</tr>
<tr>
<td>Production / Operation waste</td>
<td>26</td>
<td>21</td>
<td>-21%</td>
</tr>
<tr>
<td><strong>Total recycled:</strong></td>
<td><strong>34996</strong></td>
<td><strong>38591</strong></td>
<td><strong>10%</strong></td>
</tr>
</tbody>
</table>

NB: EBRA Members only

Source: EBRA
HV Battery System Design

Major design elements
- Casing
- Cell
- Cooling (depending on cell chemistry)
- Electronics
- Wiring
## Battery System Materials

### Breakdown of Materials by Weight

- **Light Metals**: 19.80%
- **Steel**: 16.50%
- **Non-Ferrous Metals**: 24.10%
- **Other Materials**: 0.30%
- **Process Polymers (Adhesives, Lacquers) Polymers**: 20.50%
- **Other Materials**: 19.80%

### Material Weight per KWh

<table>
<thead>
<tr>
<th>Material</th>
<th>Kg / KWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>1.50 - 5.00</td>
</tr>
<tr>
<td>Copper</td>
<td>1.50 - 4.20</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.00 - 1.20</td>
</tr>
<tr>
<td>Cobalt</td>
<td>0.20 - 0.30</td>
</tr>
<tr>
<td>Lithium</td>
<td>0.07 - 0.01</td>
</tr>
<tr>
<td>Steel</td>
<td>1.00 - 2.00</td>
</tr>
<tr>
<td>Carbon</td>
<td>1.00 - 1.80</td>
</tr>
<tr>
<td>Organic Electrolyte</td>
<td>1.00 - 2.00</td>
</tr>
<tr>
<td>Plastic</td>
<td>1.00 - 3.00</td>
</tr>
</tbody>
</table>

### Non-Metal Share

- **Non-Metal Share**: 41% - 35%

### Percentage of Battery System

<table>
<thead>
<tr>
<th>Item</th>
<th>% of Battery System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals</td>
<td>60% - 70%</td>
</tr>
<tr>
<td>Cell Weight</td>
<td>~ 60%</td>
</tr>
</tbody>
</table>

*Source: ZVEI*
Global Landscape of Battery Recycling Facilities

★ = Battery Recycling Facility
? = Tbd.
Battery Recycling Flow

End-of-Life Battery

Depowering / Deactivation

Mechanical Pre-Treatment

Battery Cells

Electronics

Casing, Wiring, other

Pyrometallurgy

Hydrometallurgy

Combination

Metal / Plastic Recycling
Characteristica of hydro- and pyrometallurgical routes

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Hydrometallurgy</th>
<th>Pyrometallurgy</th>
</tr>
</thead>
</table>
| • High selectivity   | • 
| • Extraction of ignoble metals is possible | • ignoble metals, organics and carbon used for reduction and as energy carrier |
| • Carbon remains as product | • direct recovery of metals |
| • Low off-gas volumes | • potential for zero-waste process |
| • Small plant size feasible | • high productivity |
| | • Low space requirements |

<table>
<thead>
<tr>
<th>Disadvantages</th>
<th>Hydrometallurgy</th>
<th>Pyrometallurgy</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Using of chemical reagents</td>
<td>• intensive requirement of energy emission control needed slag – commercial risk large volume of scale</td>
<td></td>
</tr>
<tr>
<td>• Water requirement, Waste water treatment</td>
<td>• low productivity</td>
<td></td>
</tr>
<tr>
<td>• Low productivity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: RWTH Aachen
Example: UMICORE Battery Recycling Process

Conclusions

- EV-battery recycling is technically feasible, beneficial for the environment and is imposed by law.

5 years of experience;
2011: new, improved smelter

Source: Umicore
Battery Recycling Conclusions

➢ Today’s recycling processes are capable to recycle all types of batteries
➢ Battery recycling efficiency determined by process configuration
➢ Process up-scaling to suit automotive traction battery systems
  ▪ Process innovation to facilitate handling of large scale automotive traction batteries for recycling
Impact Assessment: Recyclability

Influence of battery recyclability requirements on:
- Battery regulation
- Vehicle recyclability process
- Innovation to further develop competitive battery systems
- Innovation to industrialize automotive battery pre-treatment for recycling
- Implementation of today’s best practices likely to inhibit innovation in battery recycling processes / technology
- Increase of battery system complexity

- Incremental environmental benefit
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