Magna Steyr Discussion on xEV Battery Pack Designs
November 12, 2012
Agenda

• Magna Steyr Fuel and Battery System Introduction
• Four main areas of xEV Li-ion Battery design consideration:
  – Li-ion Cell
  – Mechanical/structural
  – Electrical
  – Thermal
• RESS Safety – A Systems Perspective
Worldwide Presence MAGNA Int.
(Status Q3 2012)

- ~ 115,000 employees  |  26 countries
- 296 manufacturing operations
- 88 product development / engineering / sales centers

$28.7 billions (Sales 2011)

Canada
19,075
Aurora
(Headquarters)

Mexico
20,000

USA
19,450

South America
4,975
Brazil
Argentina

Westeuropa
32.325
Austria
Belgium
England
France
Germany
Ireland
Italy
Schweden
Spain

Osteuropa
10,450
Czech Republic
Hungary
Poland
Russia
Slovak
Republic
Turkey

Asia
9,050
China
Korea
Japan
India
Thailand

Africa
100
South Africa

Osteuropa
33
South Africa

Westeuropa
81
34

Osteuropa
32
3
Fuel & Battery Systems – Worldwide Presence

(Status Q3 2012)

1,500 employees | 7 locations in Europe
1 location in Asia
1 location in North America

- North America
  - Auburn Hills

- Germany
  - Grevenbroich
  - Neumark
  - Potsdam
  - Schwäb. Gmünd

- Austria
  - Graz
  - Sinabelkirchen
  - Weiz

- China
  - Changchun

Filler Pipes (plastic and steel)
- Fuel and Oil Caps
- Water-Carrying Components
- Steel Compressed-Air Tanks
- Steel Fuel Tanks
- Aluminum Fuel Tanks
- Battery Systems
- Plastic Fuel Tanks
- Steel Compressed-Air Tanks
We offer …

- Engineering services including complete vehicle engineering
- Flexible solutions from niche to volume production
- Innovative fuel & battery systems
- Entire range of roof systems
Innovative Battery Systems

- Battery pack development & production based on state-of-the-art lithium-ion cell technology
- Cell, module and battery pack testing
- Material testing
- Truck/Bus HEV Battery Packs
- HEV Battery Packs
- PHEV / REX Battery Packs
- EV Battery Packs

- Excellence in automotive engineering and production
- Deep knowledge of international safety standards
- Integrated thermal and electronic management
- Customizable solutions due to modular design
- Leading Li-ion battery provider for commercial vehicle segment
Battery Pack Portfolio

Current & Future Products

Truck/Bus HEV Battery Pack
- Energy Content: 2 - 18 kWh
- Power: up to 180 kW
- Nom. Voltage: 360V / 650V
- Battery Weight: 60 to 150 kg
- Cooling: air or liquid
- SOP: 2009
- Next Generation: 2011

EV Battery Pack
- Energy Content EV: up to 36 kWh
- Power: up to 200 kW
- Battery Weight: <10 kg/kWh
- Cooling: air / liquid
- SOP: Q4/2010
- Flexible Modular Concept
- Passenger Car & Commercial Applications

PHEV / REX Battery Pack
- Energy Content PHEV: 6-16 kWh
- Power: 50-120 kW
- Battery Weight: < 10 kg/kWh
- Cooling: air / liquid
- SOP PHEV: 2013

HEV Battery Pack
- Energy Content: 0.2 -3 kWh
- Power: 15 -60 kW
- Battery Weight: 10 -40 kg
- Cooling: air / liquid
- SOP: 2014 (2nd Gen.)

Battery Development Timeline

<table>
<thead>
<tr>
<th>Year</th>
<th>1st Generation Li-Ion Battery Systems</th>
<th>2nd Generation Li-Ion Battery Systems</th>
<th>Serial Production Truck/Bus HEV Gen 1</th>
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xEV Battery Design Considerations
Li-ion Cell

- **Cell type**
  - Cylindrical
  - Prismatic
  - Pouch (Laminate)

- **Chemistry**
  - LFP, NMC, NCA

- **Safety Features**
  - Vents
  - Current Interrupt Devices
  - Safety Separator
Mechanical / Structural

- Single or multiple packs
- Pack mounting location
  - Inside vehicle cabin
  - Exterior to cabin
- Permanent or Removable
  - Battery Swapping
- Module type and concept
  - Different module types for different cells
Electrical

• BMS
  – Centralized
  – Distributed
  – Modular
• Cell Balancing
  – Active
  – Passive
• Safety systems
  – High Voltage Interlock Loop
  – Manual Service Disconnect
• HV Switches, Contactors and Fuses
• Charging
  – Fast Charge
  – Standard Charging
Thermal

- Liquid / Air
- Active / Passive
- Closed / Open system
- Cooling / Heating
- Phase Change materials
RESS Safety – A Systems Perspective

**Li-ion Cells**
- Chemistry
- Separators
- Electrolyte
- OC protection
- Short protection

**Thermal**
- Cell temperature
- Leak protection
- Cell to cell temperature variation

**Mechanical / Structural**
- Dust and Liquid intrusion
- Crash protection
- Penetration

**Electrical**
- MSD
- HVIL
- Contactors
- Separate modules?
- Convert energy?

**RESS System Safety**
The future is ours to make.