Avoiding safety scandals by controlling the risk of material changes
(SAE Paper # 17M-0168)

Fabian Koark
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A. The Total Recall
Functional materials are a main contribution and challenge for advanced automotive features – small deviations cause big impact

**Ford recalls pickup trucks that could roll while in park**  
April 1\textsuperscript{st} 2017

**Toyota Recalls - Another 2.9 Million Cars Fitted with Airbags**  
Mar 30\textsuperscript{th} 2017

**Mercedes-Benz Recalls One Million Vehicles After 51 Units Catch Fire**  
Mar 7\textsuperscript{th} 2017

**Tesla recalls charging adapters after two reports of plugs overheating**  
Dec 6\textsuperscript{th} 2016
Ammonium nitrate used for airbag inflators already caused over 16 million vehicle recalls

- Since 2009, faulty airbags have led to numerous recall campaigns by renowned car manufacturers, such as Honda and Toyota.
- In 2015 the previous peak of more than 14 million recalled cars was achieved for the NAFTA region alone.

Toyota Recalls - Another 2.9 Million Cars Fitted with Airbags Mar 30th 2017
The history of the Takata airbag case show the difficulties of risk reduction after the system is already deployed.

- **Change from Tetrazole to Ammonium nitrate**
  - Analysis shows no systematic failure
  - FMEA
  - TAKATA settlement 3 Mio. USD

- **Report to NHTSA**
  - No investigation started
  - Investigation terminated

- **Acknowledgement and collaboration with authorities**

- **Production stopped**

- **TAKATA**

- **HONDA**

- **NHTSA**

**Timeline:**
- **2001:** First accident, Honda Accord
- **2005:** Faulty assembly in the USA
- **2007:** First fatality
- **2008:** More accidents
- **2009:** More accidents
- **2010:** Production in Mexico too humid
- **2011:** Wrong assembly in Mexico
- **2012:** More accidents and fatalities
- **2013:** Wrong material, high temperatures, weak design
- **2014:** 200 Mio. fine for Takata
- **2015:** Quit partnership with Takata
- **2016:** Warning for Takata airbags
- **2017:** Incidents
The overall costs of weak technical risk management are hard to estimate – but follow theory with cashflow delay

Theory and effect:

- Change from Tetrazole to Ammonium nitrate
- Analysis shows no systematic failure
- FMEA
- TAKATA settlement 3 Mio. USD

Acknowledgement and collaboration with authorities
- Production stopped
- TAKATA

Year
- '09
- '10
- '11
- '12
- '13
- '14
- '15

Recalled vehicles in thousand
- Mazda
- Chrysler
- Nissan
- BMW
- Toyota
- Honda

Costs of error spotting
B. Law, policy, engineering
Engineering has to contribute to company wide compliance management – with documentation, processes and methods

- Compliance is management challenge in all industries
- Doing nothing, is not an option
- Where the industry executives have to handle all compliance and risk management duties – engineering has a big impact on product liability
- Consistent product engineering data is just a good starting point
Functional material elements are usually not monitored by functional safety management – outside the scope of ISO 26262

ISO 26262 is intended to be applied to safety-related systems that include one or more electrical and/or electronic (E/E) systems...

It does not address hazards related to electric shock, fire,... unless directly caused by malfunctioning behavior of E/E ... systems.
For functional materials, state of research as well as scientific and technical knowledge is blurry.
Better technical documentation and processes assure that state of research and scientific knowledge is used.

**Example:**

**Product:** Airbag Inflator  
**User interaction with:** driver and passenger

**Automation level:** fully automated (no control by driver or passenger)

**Operating temp.:** -13 to +130 °F

**Used functional material:** Tetrazole  
**Chemical structure:** CH₂N₄

**Material risk group:** %): explosive
- H201 (100%): mass explosion hazard

**Re-crystallization temperature (if applicable):** -24° F (volume change)

**Used functional material:** Ammonium nitrate  
**Chemical structure:** NH₄NO₃

**Material risk group:** flammable
- H272 (92.96%): may intensify fire

**Re-crystallization temperature (if applicable):** 90° F (volume change)

**IMPACT?**
Better technical standards for system testing assure that state of research and scientific knowledge is used.

The IEC 60068 for environmental testing clearly requests composite temperature/humidity cyclic and damp head tests. ISO 16750-4 (Road vehicles - Environmental conditions and testing for E/E equipment.) references the IEC 60068-38.

Relevant test scenarios from the IEC standard:

• Damp heat cyclic test:
  up to 131° F, 6 cycles

• Dewing test:
  +77-176° F, 50-100% RH, 5 cycles

• Damp heat test:
  +104° F, 85% RH, 21 days

If long-term testing over a temperature of 90° F and under humidity impact had been performed, it is likely that the functional limitations and problems of the Takata’s PSAN airbag inflators would have been discovered and eliminated much earlier.

PSAN – phase stabilized ammonium nitrate
For material and assembly change, a technical change management process according derived from ISO 26262 controls the risk

The following steps of an impact analysis according to ISO 26262 are highly recommended for a part change:

1. Review all functional contributions allocated to the part
2. If the allocation of functional contribution is not specified re-engineer the functional chain of all safety critical features of the system.
3. (optional) Review the interface requirements of the part.
4. (optional) If the interface requirements of the part are not specified re-engineer the system architecture of the system around the part, finalize the functional allocation and define also mechanical interface characteristics
5. Update the design and system FMEA according to the updated specification of functional contribution and interfaces of the part.
6. Discuss and report identified risks.
7. Define measures to reduce risks.
8. Define tests to assure a reasonable reduction of risks (which means, no safety critical problem shall occur during worst case testing)
C. Company information
INVENSITY assists its clients in analyzing complex challenges and delivers innovative solutions in all aspects of product development

Cross-sector R&D expertise, independent development of methods and rapid request reaction

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<th>8 International Locations</th>
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<td>Offices:</td>
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<td>- Wiesbaden</td>
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<td>- Dusseldorf</td>
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<td>- Stuttgart</td>
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<td>- Munich</td>
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<td>- Detroit (USA)</td>
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<td>Project Offices:</td>
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<td>- Shanghai</td>
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<td>- Shirley</td>
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<th>8 Knowledge Centers</th>
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<td>- Software Engineering</td>
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<td>- Project Management</td>
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<td>Systematic Innovation</td>
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<td>- Organizational Change</td>
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<td>- Data Systems</td>
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<td>- Cyber Security</td>
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<td>- Aerospace</td>
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<td>- Energy and automation engineering</td>
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<td>Medical Technology</td>
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<td>- Communications</td>
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<td>- Defense</td>
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<table>
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<tr>
<th>1 Organization</th>
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<tbody>
<tr>
<td>1 global profit &amp; loss center</td>
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<table>
<thead>
<tr>
<th>30% Growth</th>
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<td>Ø per year, since 2007</td>
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<table>
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<th>220 Consultants</th>
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<td>Full time, no freelancers</td>
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<th>100% Academics</th>
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<td>with technical degrees</td>
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<th>60 Clients</th>
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<td>approx. 70% Automotive</td>
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If you have any questions, please don’t hesitate to contact us

innovation made by talents

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