



AIRBAG COMPETENCE in materials technology & pyrotechnics

GWP - Gesellschaft für Werkstoffprüfung mbH
failure analysis | development support | laboratory services

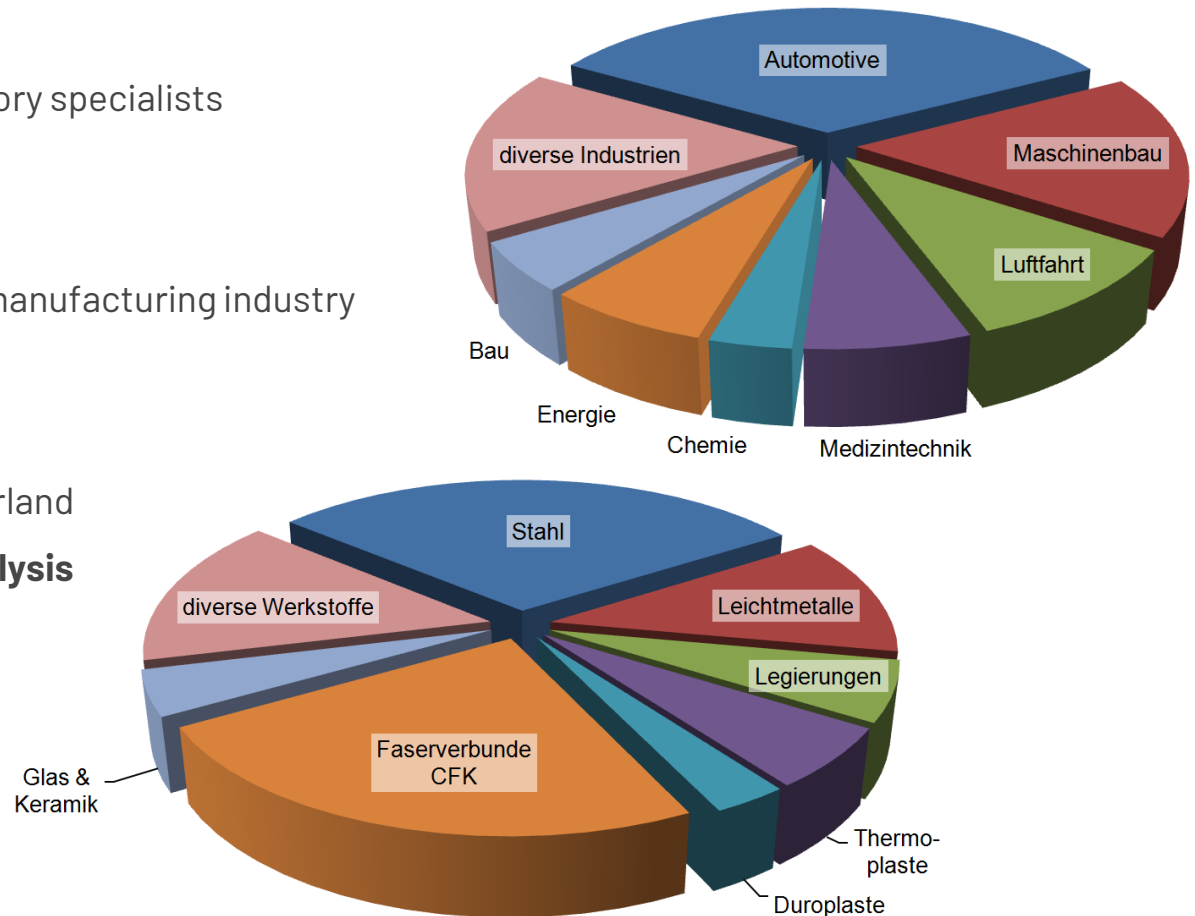
München | Leipzig | Saarland
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FACTS AND FIGURES

- ▶ **6** laboratories and **4** workshops
- ▶ **24** materials experts and laboratory specialists
- ▶ important methods accredited
- ▶ over **40 years of** experience
- ▶ over **2,000** customers from the manufacturing industry
- ▶ over **20,000** orders processed
- ▶ independent, owner-managed
- ▶ Branches in Munich, Leipzig, Saarland
- ▶ Cooperation on **AZT damage analysis**

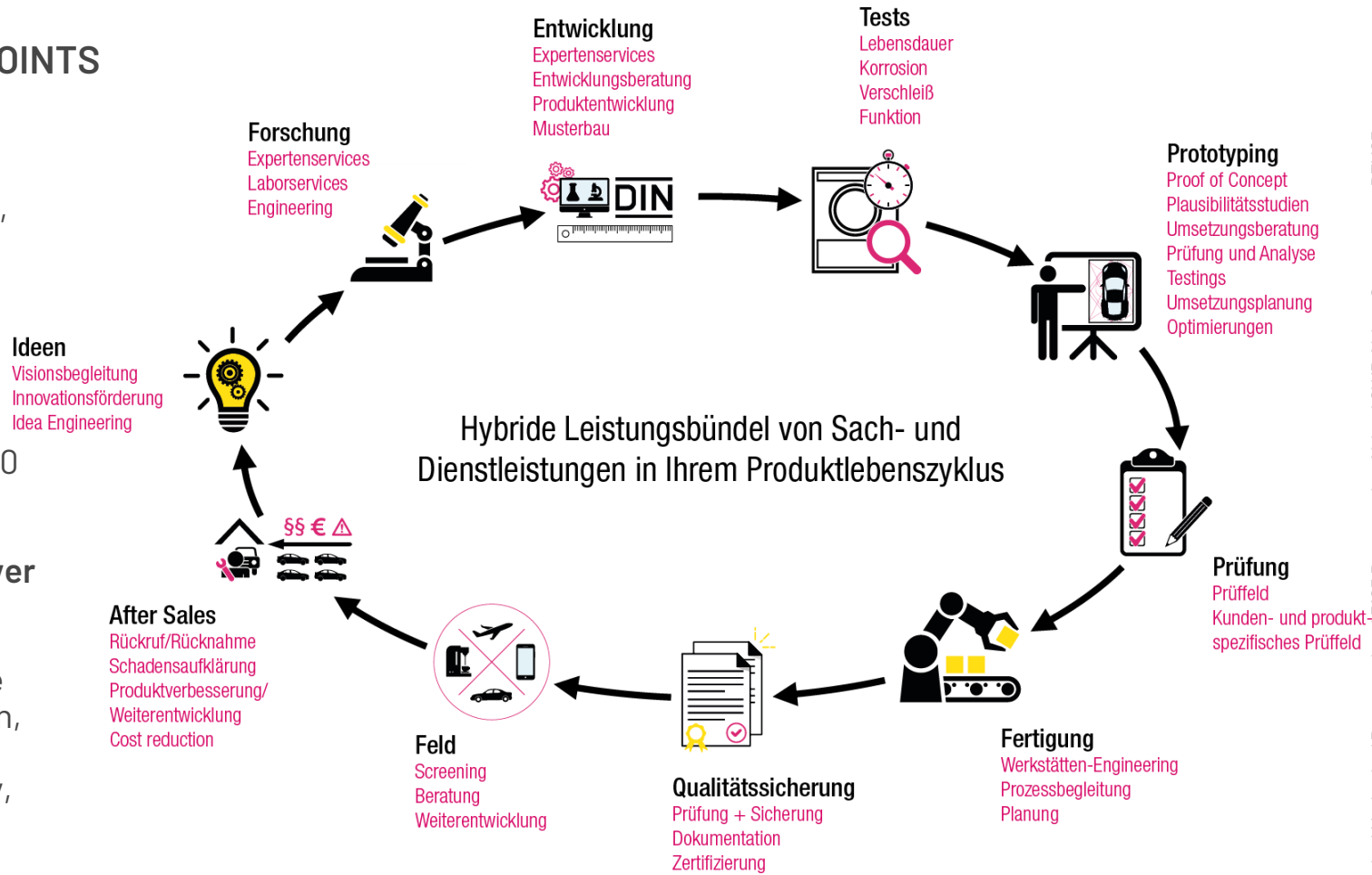


OUR CUSTOMERS AND MATERIALS

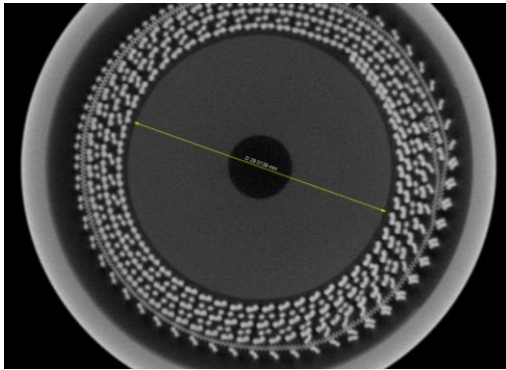


UNIQUE SELLING POINTS

- ▶ **comprehensive materials supplier**
almost all materials,
all components, all industries
- ▶ **highly specialized work flow**
in laboratories and workshops: over 800 services
- ▶ **Experience from over 20,000 orders**
with over 3,000 customers from the automotive, aviation, mechanical engineering, energy, chemical, building materials, medical technology ...



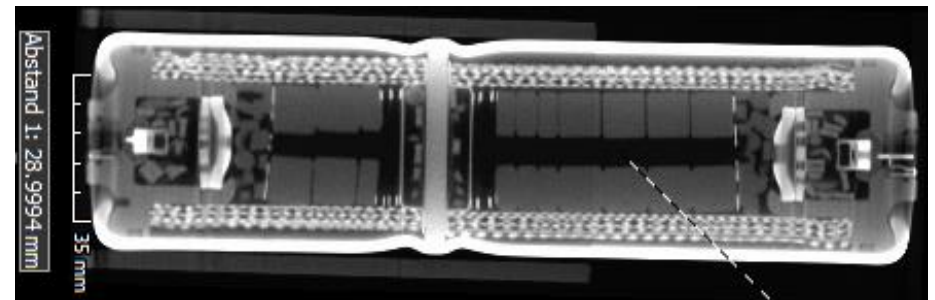
CHALLENGES



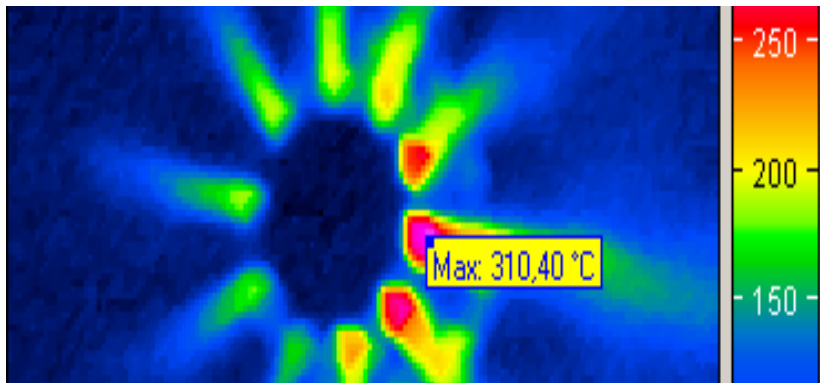
- ▶ Steel housings with high absorption make it difficult to measure the low density pyrotechnics, igniters, seals ... with high accuracy
- ▶ μm resolution for dimensions, fractures, particle distribution and porosity
- ▶ Check joining processes such as welding, flanging ...
- ▶ Location, position and completeness of seals, pyrotechnics, igniters ...

METHODS

- ▶ μ-CT with micro focus tubes for μm resolution (research device)
- ▶ μ-CT with 800 W fine focus for massive steel parts (production support)
- ▶ Capacity approx. 20 GG per shift in 3D scan
- ▶ YXLON Application Lab (planned)



CHALLENGES



- ▶ highly dynamic measurements of temperatures in the area of vehicle occupant restraint systems
- ▶ Gas Generators
- ▶ Lighter
- ▶ Light bridges / resistors

METHODS

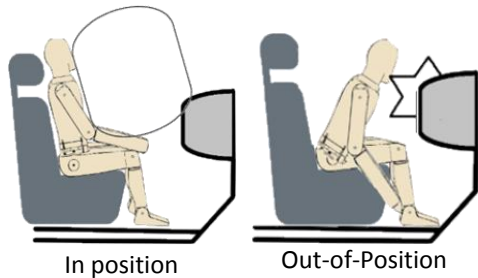
- ▶ IR thermal imaging camera with msec resolution
- ▶ Determination of the bag outside temperature of pyrotechnic and hybrid gas generators
- ▶ Dynamics of glow bridges
- ▶ Monitor outlet openings

Novel alternative METHODS for out-of-position characterization

- ▶ Internal temperature measurement in the gas generator (plenum temperature) by near infrared spectroscopy (7000 spectra/sec)
- ▶ Technology already tested at the Fraunhofer ICT
- ▶ GWP is working on the development of a practicable version of this measurement method.
- ▶ Mass flow determinable by temperature measurements

DEVELOPMENT OF MEASUREMENT METHODS FOR AIRBAG GAS GENERATORS "out of position"

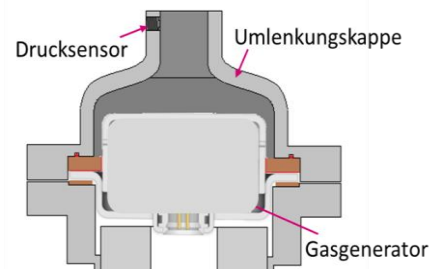
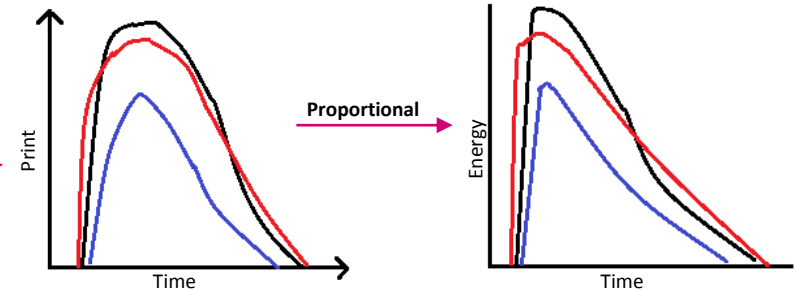
out-of-position issue



- ▶ Automobile manufacturers in the international market who want to obtain a good rating from the many consumer tests (US-NCAP, EURO-NCAP, ADAC, etc.) must ensure that airbag systems meet the requirements of out-of-position (OoP) situations.

The safety of the vehicle occupants comes first!

- ▶ in the early development phase, the design of airbag systems can only be carried out by numerical simulations.
- ▶ Virtual interpretation: Numerical simulation of the performance of restraint systems is becoming increasingly important on a daily basis.
- ▶ The modeling of out-of-position situations (OoP) requires very complex simulation models: Onset is important!
 - ▶ **Detailed gas generator data become necessary with increasing complexity of the simulation**



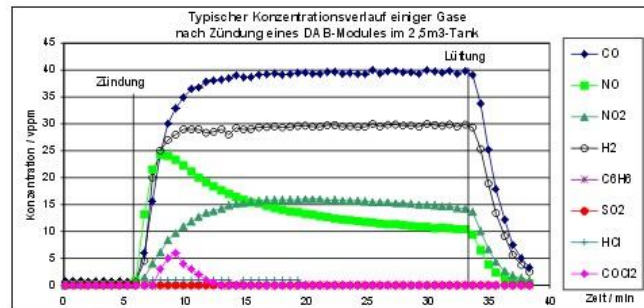
Alternatives

- ▶ Measurement methods based on thrust force or temperature measurements on gas generators
- ▶ Measuring device: Deflection nozzle or thrust nozzles.
- ▶ Better data for OoP modeling
- ▶ GWP aims to develop practicable measurement solutions based on state-of-the-art measurement methods. Focus: qualitative evaluation method is based on "metrologically simple" pressure measurements in thrust force measuring devices.

CHALLENGES

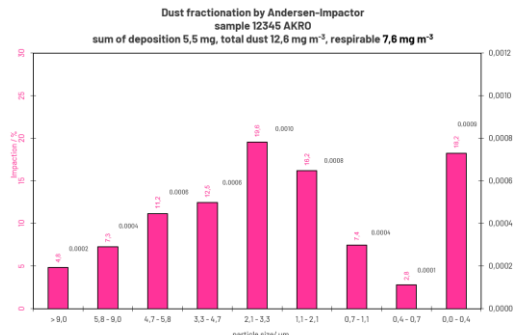


- ▶ Measurement of emissions in the field of vehicle occupant restraint systems

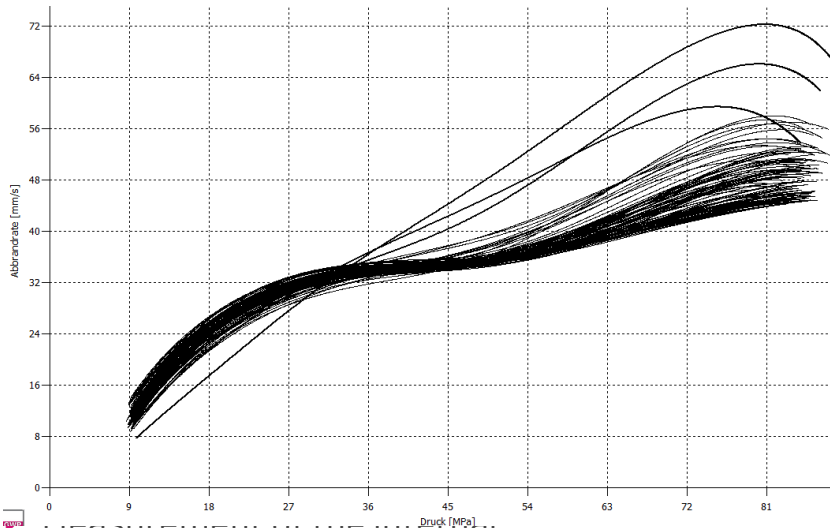


METHODS

- ▶ Determination of up to 21 relevant gases according to AK-ZV or SAE standards
- ▶ Determination also of inert gases (Ar, He) in hybrid and cold gas generators
- ▶ Continuous measurement of the emission course: storage of the development over 20 (SAE J1794) or 31 minutes (AK-ZV01) instead of integral measurements
- ▶ Measurements with sensitive process gas mass spectrometer and process gas FTIR spectrometer
- ▶ nitrogen oxides (NO, NO₂) with a chemiluminescence spectrophotometer (CLD)



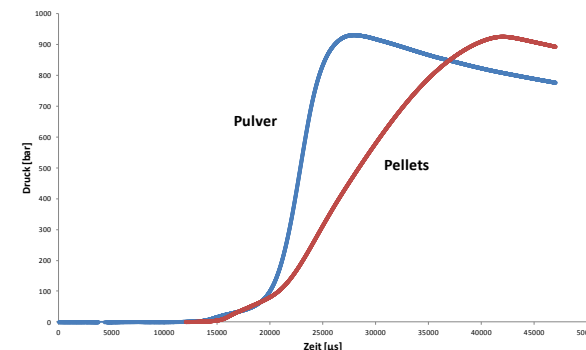
CHALLENGES



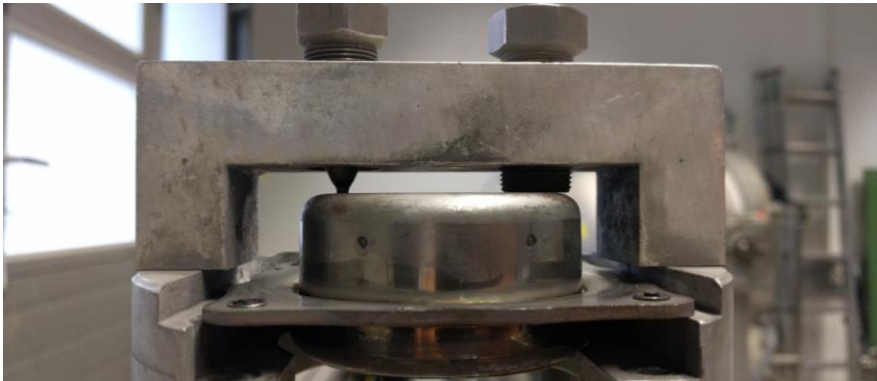
- ▶ Measurement of the internal pressures in the gas generator
- ▶ Measurement at high/low temperatures

METHODS

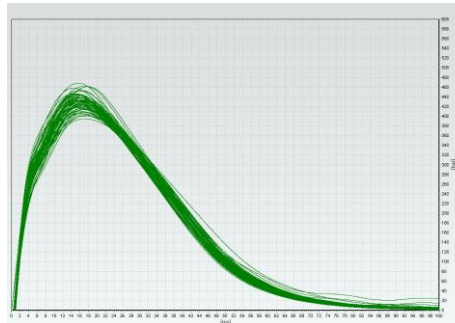
- ▶ Pressure curves in the 60L jug
- ▶ Attaching pressure sensors directly to the GG
- ▶ Measurement of several chambers simultaneously
- ▶ Monitoring of ignition current/voltage
- ▶ Variable ignition delay



CHALLENGES

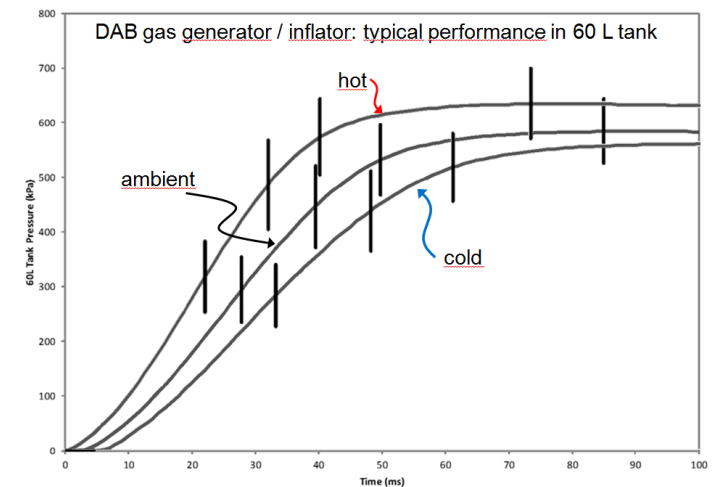


- ▶ Messung der Kannendrücke
- ▶ Messung der Innendrücke im Gasgenerator
- ▶ Messung bei hohen/tiefen Temperaturen



METHODS

- ▶ Druckverläufe in der 60L Kanne
- ▶ Anbringen von Drucksensoren direkt am GG
- ▶ Messen von mehreren Kammern gleichzeitig
- ▶ Überwachung von Zündstrom/Spannung
- ▶ Variable Zündverzögerungen



CHALLENGES



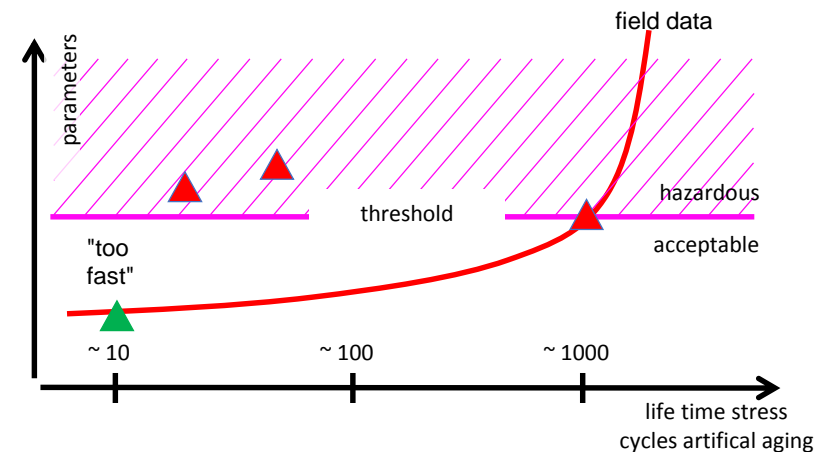
- ▶ Ageing of gas generators and propellants through climatic aging or hydrothermal aging
- ▶ Ageing of entire gas generators or individual pellets
- ▶ Clarification of failure mechanisms through targeted stress
- ▶ Basics for lifetime considerations of the parts in the field
- ▶ Aging according to standard or customer-specific / root cause related

METHODS

Environmental simulation tests
AK-LV01 on bags, modules, GG, e.g.

- ▶ Temperature shock
- ▶ Climate change test
- ▶ Salt spray test
- ▶ Can pressure at -35 and $+85^{\circ}\text{C}$
- ▶ Mech. shock test, drop test, vibration load

Ultra-ruffled temperature and climate storage
(ATC, AHC)





PRODUCT ACCOMPANYING QUALITY ASSURANCE

CHALLENGES

- ▶ Product safety of gas generators and modules over the entire life cycle
- ▶ Long-term stability of new propellants and propellant components

Guideline RL 12 (EN)

Qualification of Airbags
Test Design

Created/Revised:	2019-01-31	Lead Author:	Dr. X. Steemann
Inspected:	2019-02-01	Inspector:	Dr. S. Loibl
Approved/Validated:	2019-03-11	Management:	Dr. Julius Nickl
Installation:	2019-03-11	QM:	A. de Marné

Preface

The analytical as well as conceptual competence of GWP have already been proven in the

METHODS

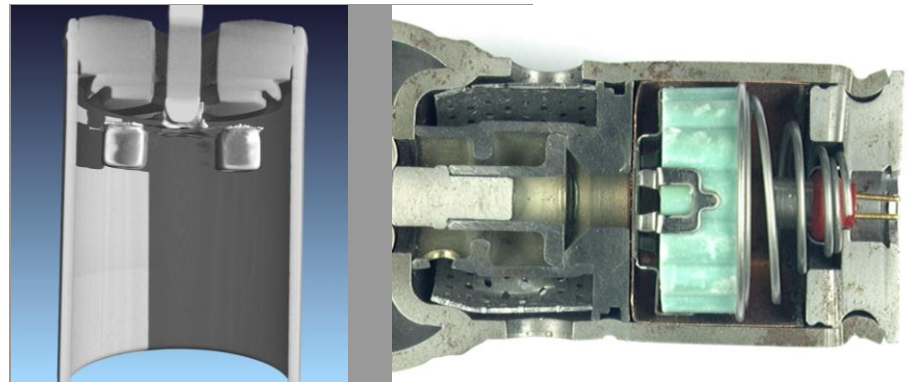
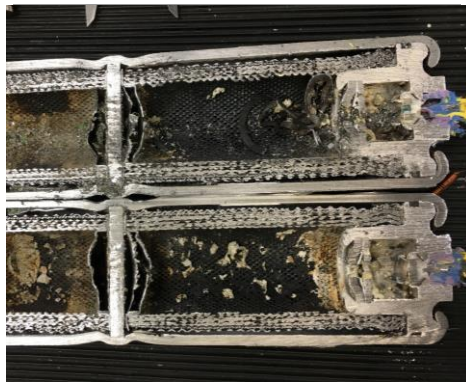
qualification of modules and generators:

- ▶ USCAR 24-2 (design verification, product validation)
- ▶ AKLV01 ff.
- ▶ GWP RL 12-1(EN)
- ▶ ...

Methods for assessing the long-term stability of propellants according to GWP RL 12-1(EN)

Rev: 01

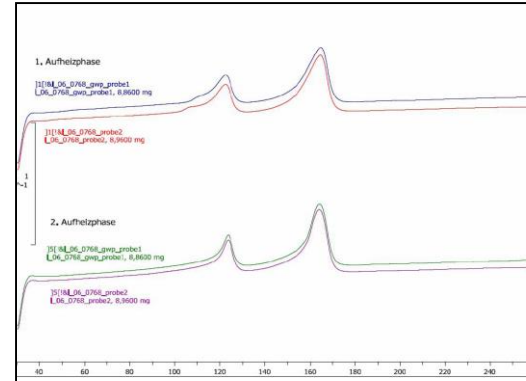
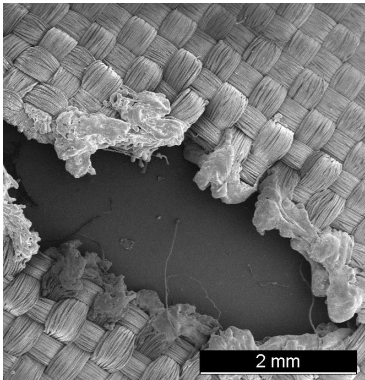




PRESSURE VESSELS

- ▶ Materialography, CT and 2D radiography, microstructure, hardness measurement...
- ▶ Burst tests, fracture tests, cold brittleness, ...
- ▶ chemical characterization, optimization of joining processes...





COVER

- ▶ Determination of the strength and damage behaviour of airbag covers, split lines, etc. under various load conditions or in the event of damage
- ▶ Break edge examination by means of REM
- ▶ Characterization of the plastic: tensile strength and elongation at break, material classification, Shore hardness, volume flow index, filler content

TISSUE

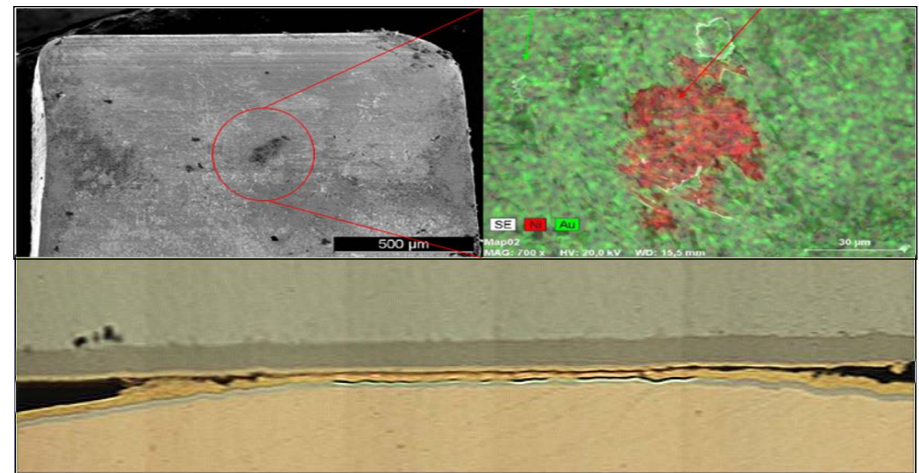
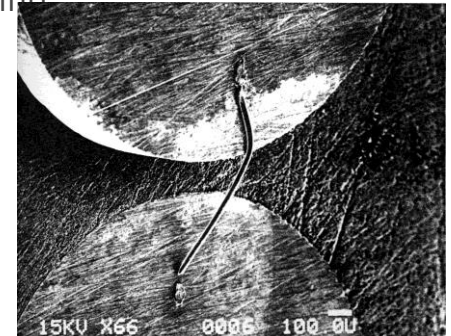
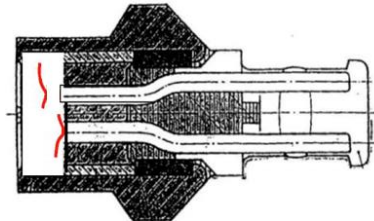
- ▶ Determination of the strength and damage behaviour of airbag fabric under various load conditions
- ▶ root cause analysis in the event of damage

CHALLENGE

- ▶ gas & diffusion tight cap by welding, crimping or soldering
- ▶ well-defined predetermined breaking points of the cap (embossing depth) with homogeneous metal sheet,
- ▶ Corrosion protection especially of the surface of the cap
- ▶ gas-tight and friction-locked metal glazing of the pins
- ▶ the gilding must not be "cauliflower-like"
- ▶ Quality of contact of the filament (thin fibre on solid pin) by squeezing, soldering, welding, ...
- ▶ Incandescent bridge with missing contact to pyrotechnics and quality of pyrotechnics (moisture, fissures, bubbles, crumbs, particle size distribution)
- ▶ Moisture must be excluded inside the squibs
Risk of corrosion

EXAMPLES OF DAMAGE CASES

- ▶ Lighter root cause "mobile pin"
- ▶ Connectors & Electroplating
"variable resistance"



PROJECT EXAMPLES

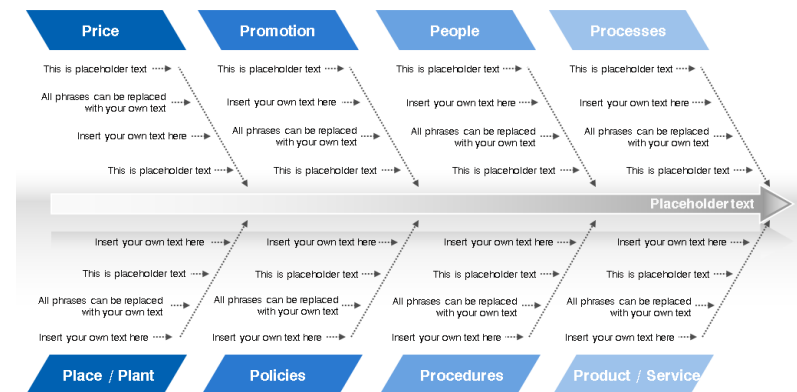
- ▶ TAKATA recall: Lifetime model
- ▶ Airbag of the accident vehicle of Lady Diana investigated on behalf of Scotland Yard
- ▶ "Shaped charge" identified in detonator
- ▶ separating emblems
- ▶ Cold embrittlement of the pressure vessel
- ▶ Gas composition
- ▶ Detection of installed inert components
- ▶ novel tube-pipe welds
- ▶ retarded ignition
- ▶ Bursting Pressure Outflow
- ▶ Sedimentation in the set
- ▶ changing resistances clarified by electroplating audit
- ▶ uvam.

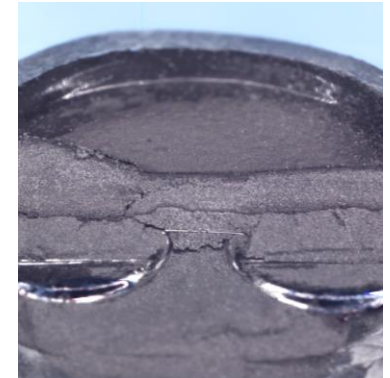
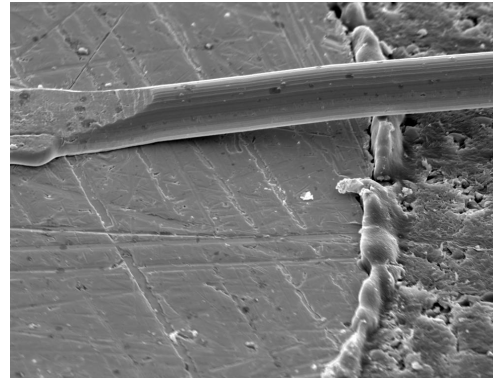
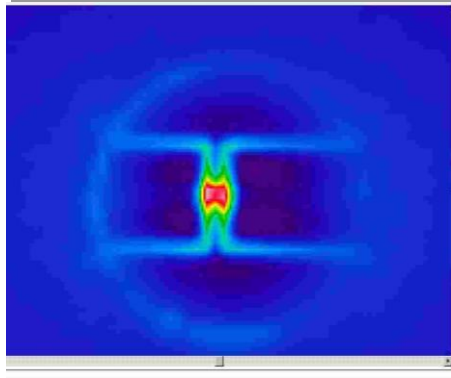
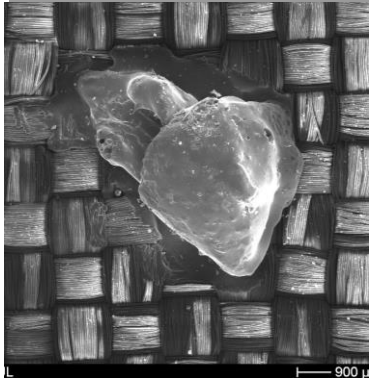
METHODS

- ▶ Error or damage analysis Automotive 6M's, 8M's
- ▶ FMEA of the DGQ, Six-Sigma
- ▶ mind maps, fishbone analysis
- ▶ VDI 3822

CUSTOMER BENEFITS

- ▶ Structured planning of measures to clarify the cause of damage
- ▶ Quick adoption of measures to minimize and hedge risks





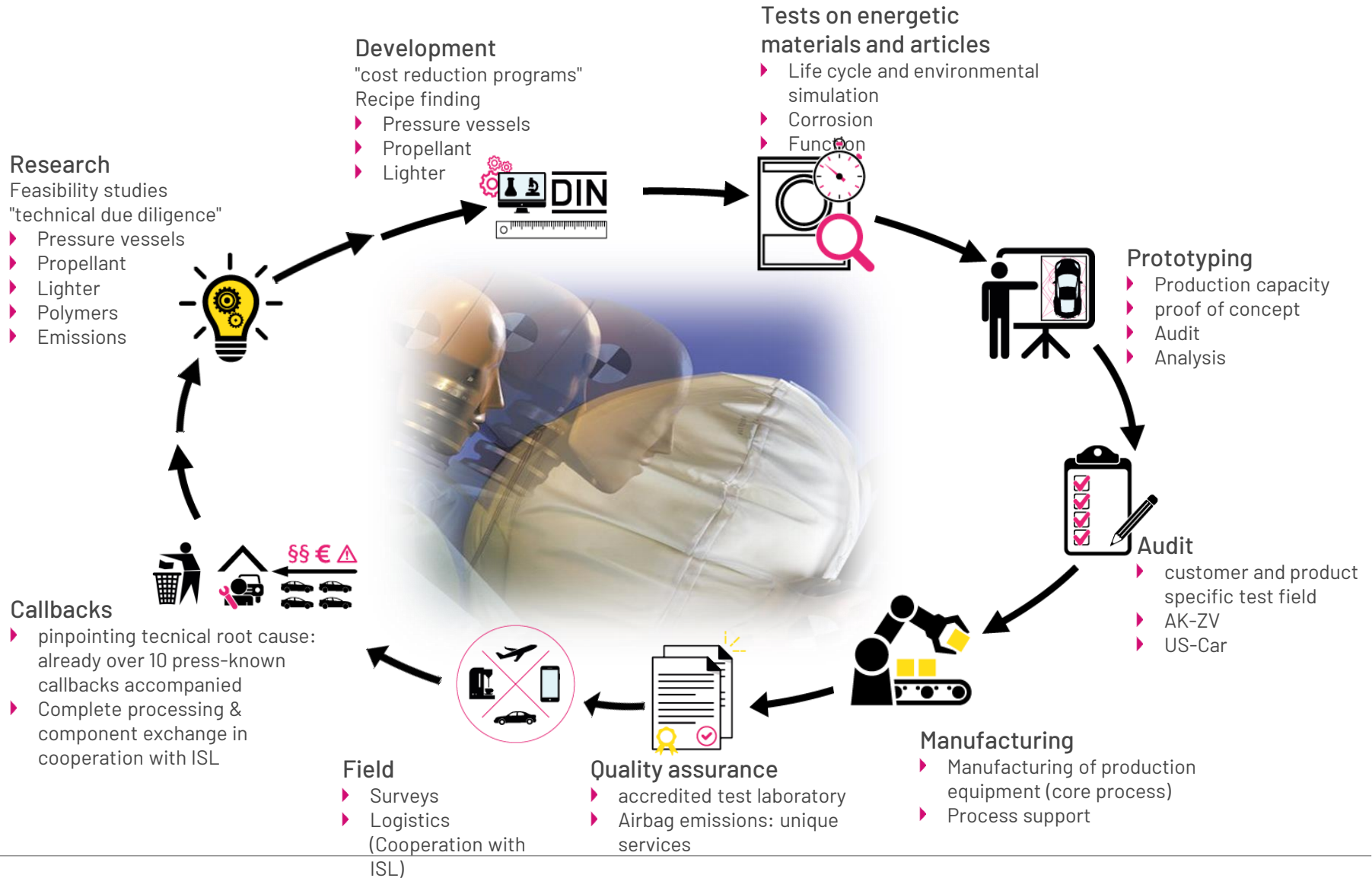
DEVELOPMENT & PRODUCTION

- ▶ Pressure vessels, igniters, light bridges, fabrics, airbag covers, split lines, clips, transport damage, glass breakage etc.
- ▶ Fractography using LIM & REM
- ▶ Characterization of metals, plastics
- ▶ component testing
- ▶ Joining processes




FIELD PARTS

- ▶ Determination of the *technical root cause*
- ▶ Establishing and safeguarding life cycle models
- ▶ Presentation to authorities
- ▶ Verify remedial action

HYBRID SERVICE PACKAGE: AIRBAG



ORGANIZATION CHART

Labor-Services 1000 M. Diederich (S. Löhe)			Experten 3000 Dr. Nickl (LoS)	academy 5000 JAN (DM)
LabS M 1100 S. Löhe (LoS)	LabS L 1200 Dr. Schurig (ScS)	LabS S 1300 K. Trenz (PS)		
Airbag-Emission 1105 Dr. J. Nickl (DoM)	-	-	Aluminium 3103 Dr. Kühlein/ext.	Office 5110 B. Schinzel
Analytikum Dr. S. Loibl (ReT)	-	-	Airbag 3105 Drs. J. Nickl, LoS, SX	Ausbildung 5130 N.N.
Chem./Korrosion Dr. S. Loibl (SX)	-	-	Batterien 3110 Dr. J. Nickl	Symposien 5140 N.N.
Brandlabor 1170 Dr. S. Loibl (SX)	Brandlabor 1270 S. Korzak (-)	-	Baustoffe 3115 Dr. J. Nickl	Seminare 5150 Dr. J. Nickl
Elektroniklabor N.N. (-)	-	-	Brand 3170 Dr. S. Loibl	 TZM 5160 S. Löhe
Ex-Labor 1122 Dr. X. Steemann (ReT)	-	-	Composites 3120 Dr. S. Loibl	 Kolloquien 5180 Dr. J. Stoiber AZT
Katalyse-Labor Dr. J. Nickl (-)	-	-	energ. Materialien 3122 Dr. X. Steemann, Dr. T. Reith	Vorträge 5170 Dr. J. Nickl
Kunststoff-Labor Dr. M. Ziegler (-)	-	-	Fraktografie 3125 M. Diederich	
Materialografie S. Löhe (KF)	Materialografie M. Diederich (N.N.)	Materialografie K. Trenz (DM)	industr. Prozesse 3135 Dr. J. Nickl	
Mikroskopie S. Löhe (KF)	Mikroskopie S. Korzak (-)	-	Katalyse 3140 Dr. J. Nickl	
µ-CT 1195 N.N. (-)	-	-	Kunststofftechnik 3155 Dr. M. Ziegler	
 C. v. Laverne (-)	-	-	metall. Gefüge 3175 S. Löhe	
Umweltsimulation Dr. S. Loibl (SX)	Umweltsimulation S. Schindler (KS)	-	Kleben 3147 Dr. M. Ziegler	
Werkstatt 1145 F. Pribil (ScT)	Werkstatt 1245 T. Roemer (N.N.)	Werkstatt S. Trenz (-)	µ-Computer-Tomografie S. Löhe	
Werkstoffprüfung F. Kronpass (-)	Werkstoffprüfung S. Korzak (-)	Werkstoffprüfung K. Trenz (-)	Schweißen 3387 G. Scharloh/ext.	
ZfP S. Loibl (ScV)	-	-	Umweltsimulation Dr. Schurig	
			zerstörungsfr. Prüf. 3195 Dr. Loibl	



Our expertise

Dr. Xaver Steemann	Dipl.Chem	10 years of experience	Expert for energetic materials
Dr. Stefan Loibl	Dipl.Chem	5 years of experience	Expert for applied chemistry
Dr. Julius Nickl	Dipl.Chem	30 years of experience	Senior expert for industrial processes & products
Dr. Thomas Reith	MSc Chem.	5 years of experience	Junior expert for energetic materials
Dr.-Ing. M. Ziegltrum	chartered engineer	30 years of experience	Senior Expert Plastics & Process Development
Pedro Yurrita	chartered engineer	10 years of experience	Junior Expert Airbag Performance
Dr. Christian Schurig	MSc Chem.	15 years of experience	Expert for environmental simulation & analytics