Introduction to Rilsan HT
Process flow of high performance PA

Castor plant
- harvesting

Castor seed
- grinding

Castor oil
- monomer
- polymerization

Petroleum base

Aminoundecanoic acid
- Sebacic acid
- Decanediamine
  \[ H_2N-(CH_2)_{10}-COOH \]
  \[ HOOC-(CH_2)_8-COOH \]
  \[ H_2N-(CH_2)_{10}-NH_2 \]

Castor seed harvesting

Petroleum base

Rilsan® XD
- Rigid PA
- PA elastomer PEBAX
- Mid-chain PA PA612
- Mid-long chain PA PA610, 1010, 1012
- Long chain PA PA11
- Long chain PA PA12
- High heat resistance PA
- Amorphous PA

PA elastomer PEBAX

Rilsan® HT - The First Flexible PPA Confidential
Arkema Property – Duplication prohibited
A Breakthrough in Metal Replacement

Rilsan® HT creates opportunities to replace metal in tubing that were previously unthinkable!

- **Metal**
- **Metal & Rubber**
- **Complex solutions (i.e. reinforced Rubber / FKM)**

Cooling:
- PA11
- HPPA MLT solution
- PA12 Special Grade
- Air Intake
  - TEEE, PA6, PA6-Alloy, Rubber

**Flexible Thermoplastic Solution**
What makes Rilsan® HT so different?

High Temperature Resistance.... PLUS:

- **Flexibility**
  
- **Processability:**
  - processing similar to aliphatic polyamides
  - no need for special heating & cooling system
  - excellent thermoforming and fitting insertion

- **Long term heat resistance**
  - (thermooxidation) and chemical resistance at high temperature

- **Integrity of mechanical properties**
  - at high temperature

- **Spin-welding**

- **Low density**

- **Low moisture uptake**

- **Biobased**

Rilsan® HT.....

- is the **first flexible PPA** to replace metal in tubing for high temperature applications

- can be easily manufactured on **standard processing equipment**
  - offers **cost-efficient manufacturing** and system cost reduction
  - features **high design flexibility**

- surpasses other high-temperature thermoplastics with **superior long-term resistance to thermo-oxidative and chemical aging** at high temperatures

- is the **only PPA being spin-weldable** on aliphatic PA

- is a **light-weight PPA resin**

- offers **exceptional dimensional stability**

- **naturally fits into eco-design concepts**
Rilsan® HT – The First Flexible PPA

Rilsan® PA11

**Limitations**
- Temperature resistance up to 150°C

**Key Points:**
- Flexibility
- Excellent Long-Term Aging
- Resistance
- Ease of processing
- BioBased

Classical PPA resins

**Limitations**
- Only available as injection grades due to intrinsic brittleness / stiffness of material
- Poorer Long-Term Aging Resistance
- Difficult overall processing

**Key Points:**
- High melting point
- High temperature resistance

Rilsan® HT: The optimum synergy of both
Rilsan® HT – Unprecedented Flexibility

- Flexural modulus of Rilsan® HT compared to classic HT polymers – a breakthrough amongst HT materials

Rilsan® HT:
- is the only PPA to combine the high-temperature resistance of conventional PPA grades with flexibility
Weight reduction by Rilsan® HT

**Weight savings, through**
- **Metal replacement** and substitution of rubber & other polymeric materials
- **Low density**

**Density of Rilsan® HT compared to metal, rubber and other polymeric materials**

<table>
<thead>
<tr>
<th>Material</th>
<th>Density [g/cm³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brass</td>
<td>8.6</td>
</tr>
<tr>
<td>Steel</td>
<td>7.8</td>
</tr>
<tr>
<td>Zinc</td>
<td>7.1</td>
</tr>
<tr>
<td>PTFE</td>
<td>2.2</td>
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<tr>
<td>ETFE</td>
<td>1.7</td>
</tr>
<tr>
<td>PVDF</td>
<td>1.7</td>
</tr>
<tr>
<td>PPS</td>
<td>1.4</td>
</tr>
<tr>
<td>PEEK</td>
<td>1.3</td>
</tr>
<tr>
<td>PPA 6T</td>
<td>1.2</td>
</tr>
<tr>
<td>PPA 66</td>
<td>1.2</td>
</tr>
<tr>
<td>Nylon 66</td>
<td>1.1</td>
</tr>
<tr>
<td>Nylon 11</td>
<td>1.1</td>
</tr>
<tr>
<td>Polyimide 11</td>
<td>1.0</td>
</tr>
<tr>
<td>Rilsan® HT</td>
<td>1.0</td>
</tr>
<tr>
<td>Rubber</td>
<td>1.15–1.3</td>
</tr>
</tbody>
</table>

**Rilsan® HT:**
- lowers total system weight by min. 50% (factor 2 to 3 vs Al, 6 to 8 vs steel)
- is a light-weight PPA resin
- helps to reduce emissions and fuel consumption

**EGR vacuum tubing @ PSA**
- Alu assembly / 270g → Rilsan® HT / 110g
  - Weight gain: **Rilsan® HT 2.5 times lighter**

**Blow-by @ VW**
- Alu tube w/ Brass QC (280g) resp. w/ Alu QC (110g) --> Rilsan® HT tubing / 50g
  - Weight gain: **Rilsan® HT 2 to 6 times lighter**

**TOC @ Hyundai**
- Metal assembly / 1000g → Rilsan® HT / 350g
  - Weight gain: **Rilsan® HT 3 times lighter**
System Cost reduction by Rilsan® HT

Rilsan® HT vs. metal based tubing assembly:

![Graph showing cost comparison between Metal Tubing Assembly and Rilsan® HT Tubing Assembly. The graph indicates a 50% savings in system costs.]

**Rilsan® HT:** generates up to 50% cost savings vs. metal tubing assemblies
# Rilsan® HT product line up

<table>
<thead>
<tr>
<th>Grade name</th>
<th>CESV Black P010 TL</th>
<th>CESV Black P010-HP TL</th>
<th>CESV Black P223 TL</th>
<th>CESV Black P123 TL</th>
<th>CZM30 Black TLD</th>
<th>CSR13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (g/cm³)</td>
<td>1.02</td>
<td>1.07</td>
<td>1.05</td>
<td>1.05</td>
<td>1.30</td>
<td>1.15</td>
</tr>
<tr>
<td>Melting point (°C)</td>
<td>255</td>
<td>255</td>
<td>255</td>
<td>270</td>
<td>255</td>
<td>250</td>
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<tr>
<td>Flexural modulus (MPa)</td>
<td>890</td>
<td>1500</td>
<td>410</td>
<td>1100</td>
<td>7300</td>
<td>7600</td>
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<tr>
<td>Color</td>
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<td>Black</td>
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<tr>
<td>Feature</td>
<td>Standard</td>
<td>High pressure resistant</td>
<td>Flexible</td>
<td>Hydrolysis resistant</td>
<td>GF30</td>
<td>conductive</td>
</tr>
<tr>
<td>Process</td>
<td>Extrusion, blow</td>
<td>Extrusion, blow</td>
<td>Extrusion, blow</td>
<td>Extrusion, blow</td>
<td>Injection</td>
<td>Injection</td>
</tr>
</tbody>
</table>

*Note: High pressure resistant and GF30 conductive characteristics are optional features.*
Rilsan® HT – ...

... already been selected by many OEM
Rilsan® HT – with best fit ....
... to Euro 6 & key powertrain technologies
Rilsan® HT Tubing

Grade: Rilsan® HT CESV P010TL

Case study: Powertrain - Aggressive Media Management Blow By Line

Replaced: Aluminium tubing / HPPA with heat shield

Status: Approved and in series prod. since Q3 2010 at VW (PV 3936) / AUDI / SEAT / Porsche / Bentley; Daimler, Mahindra, Ferrari / Maserati / Alfa Romeo, Chrysler

Models:
- **VW groupe**: all diesel engines (having a diesel particle filter, due to new Euro 5/6 regulation), models/platforms starting with 2,0l & 1,6l engines, eg. Golf, Passat, Tiguan, A3, Skoda, …) all new 12 cyl. gasoline engines (e.g. A8, Phaeton, Bentley)
- **Fiat groupe**: e.g. for new V6 engines of Ferrari & Chrysler for Maserati, Alfa Romeo, Chrysler

Example:

Rilsan® HT CESV P010TL

- Exhaust gas
- Combustion Chamber
- Piston
- Connecting rod
- Crankcase
- Crankshaft
- Oil pan

Air Intake

Blow-by tubing

2 temp. classes:
- 160°C
- 180°C
Rilsan® HT Tubing

- **Grades:**
  - Rilsan® HT CESV P010TL
  - Rilsan® HT CESVO P223TL ("ultra-flexible")

- **Case study:**
  - Powertrain – Air / Pressure Management

- **Replaced:**
  - Metal, Rubber

- **Status:**
  - Under development

- **Example:**
  - Rilsan® HT Tubing

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Rilsan® HT CESV P010TL
Rilsan® HT CESVO P223TL ("ultra-flexible")

Powertrain – Air / Pressure Management

Metal, Rubber

Under development

Rilsan® HT Tubing
Rilsan® HT Tubing

- **Grades:**
  - Rilsan® HT CESV P010-HP TL (tubing)
  - Rilsan® HT GF reinforced (QC)
- Connection by spin-welding

- **Case study:**
  - Powertrain - Oil Mngt. / Transport
  - TOC (Transmission Oil Cooling)

- **Replaced:** Metal, Rubber Tubing
- **Status:** Approved at BMW, Greatwall
- **Models:** will be in series for new platforms

- **Example:**
  - Metal, Rubber Tubing
  - replaced by:
  - Rilsan® HT CESV P010-HP TL
  - Rilsan® HT GF reinforced (QC)

**Specification:**
- 3000h oil 150° C / peak 175° C
- Burst resistance: hot oil at 220° C
Rilsan® HT Tubing

**Case: Cooling**

- **Grades:**
  - Rilsan® HT CESV P010 TL (medium temp.)
  - Rilsan® HT CESV black P123 TL (high temp.)

- **Case study:**
  - Powertrain - Aqueous Media Mngt.
  - Cooling lines

- **Replaced:**
  - Aluminium tubing / Rubber

- **Status:**

**Current grade: Rilsan® HT CESV P010 TL**

- **BMW**
  - Mini, series 3, 5, 7 / new Hybride
  - SOP end 2013

- **DAIMLER**
  - e.g. Mercedes Class “C”
  - SOP end 2013

- **VOLVO Truck (US)**

**New grade: CESV black P123 TL**

- Under evaluations
  - (technical feedback from customer to pass VW specification)

125 - 130°C (temp. class rating)
(current grade CESV P010TL)

135 - 145°C (temp. class rating)
(new grade CESV P123L)
**Grade:** Rilsan® HT CESVO P223 TL – “ultra-flexible” Rilsan® HT Grade

**Case study:** Industrial Applications – Air / Vacuum Management

e.g. High Temperature Pneumatic Tubing

**Replaced:** Metal, ETFE, PTFE

**Status:** Under evaluation at customer / OEM

**Example:**

- Temperature class: > 150° C

**Key Benefits:**
- Flexibility (520MPa)!
- “ultra-flexible” Rilsan® HT Grade