This presentation is courtesy of ADHESIVES.ORG
THE BENEFITS OF SILICONE FOAMS FOR USE IN THE AUTOMOTIVE INDUSTRY

CREATING TOMORROW'S SOLUTIONS
AGENDA

• Properties of silicone rubber
• Seal methods
• RTV-2 chemistries
  • Condensation / addition systems
• Silicone foams
• LIS (Liquid Injected Silicone)
• Applications
• Summary
VERSATILE PROPERTIES OF SILICONE

• Wide variety of achievable mechanical properties
• Mechanical properties virtually constant between –50 to +200°C
• Excellent resistance to weathering and UV radiation
• Low moisture absorption
• Resistance to many chemicals
• Water repellency
**STATIC SEAL FUNCTION MECHANISMS**

- **Compression Sealing**: Elastomer rebound force, conformity and friction to mating surface.
- **Adhesion Sealing**: Elastomer adhesion to mating surfaces.
- **Expansion Sealing**: Elastomer expansion from fluid absorption and/or thermal expansion.
### STATIC SEAL FAILURE MODES

<table>
<thead>
<tr>
<th>Seal Types</th>
<th>Compression Seals</th>
<th>Adhesion Seals</th>
<th>Expansion Seals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preformed, CIPG</td>
<td>FIPG, Anaerobics</td>
<td>Liquid Injection Sealing</td>
<td></td>
</tr>
<tr>
<td>FIPFG, MIP</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Durability Failure Modes

- **Compression Seals**
  - Chemical Degradation
  - Loss of adhesion to substrate

- **Adhesion Seals**
  - Chemical Degradation
  - Loss of adhesion to substrate

- **Expansion Seals**
  - Chemical Degradation

RTV-2 SILICONE RUBBER

• 2-component, pourable to non-slump compounds
  • Condensation-curing
  • Addition-curing
RTV-2 SILICONE RUBBER
CONDENSATION - CURING

• Polymer: OH- (Hydroxy-) functional

• Crosslinker: Ethoxy or propoxyfunctional silanes

• Catalyst: Organo-tin compound

• Co-Catalyst: Moisture
RTV-2 SILICONE RUBBER
CONDENSATION-CURING

The Benefits of Silicone Foams for use in the Automotive Industry

© 2006 Wacker Chemical Corporation
RTV-2 SILICONE RUBBER CONDENSATION-CURING

• Characteristics:

• Volatile alcohol is formed during curing
• Weight loss and shrinkage (0.2 - 2 % linear)
• Reversion of the crosslinking at temperatures above 90°C
• Lack of moisture can interfere with the curing process
• **Polymer:** $\text{CH}_2 = \text{CH}$- (vinyl-) functional

• **Crosslinker:** H- (hydride-) functional

• **Catalyst:** Organo-platinum compound

• **Co-Catalyst:** None
RTV-2 SILICONE RUBBER ADDITION-CURING

• Characteristics:

• No volatile by-product
• No weight loss and very low shrinkage (< 0.1 %)
• No reversion of the crosslinking reaction
• Problems with curing caused by inhibition of the organo-platinum compound by a number of substances
SILICONE FOAM

• Same chemistries as conventional RTV-1 and RTV-2 systems

• Condensation reaction between SiH + SiOH

• Two mixed together, blowing and curing occur

• Hydrogen gas is generated which forms a bubble large amounts of bubbles together make a foam
RTV-2 SILICONE FOAM REACTION

Reaction scheme:

- **X** + **Y** → **Z**
- **Pt catalyst**

The Benefits of Silicone Foams for use in the Automotive Industry

© 2006 Wacker Chemical Corporation
• 2-part systems are supplied for 1:1 mixing

• 2-part systems require dynamic mixing

• 2-part system is fully foamed and cured in 15 minutes

• Thermally cured 1-part system requires no mixing
• Grooved design is preferable for foamed gaskets is preferable to maximize adhesion
• The groove should have a rectangular shape and the increase in height due to expansion must be taken into account
ADVANTAGES OF SILICONE FOAM

• Density lower than that of other silicones
• Soft, compliant seal
• Good sound and heat insulation
• Flame resistance
• No release of toxic gasses on thermal decomposition
• Open-cell or closed-cell foam structure
ADVANTAGES OF SILICONE FOAM CONT’D

• Low compression set

• Compressible seals with high, UV, chemical and weathering resistance

• Processing viscosities ranging from flowable to non-sag
TYPES OF SILICONE FOAM

• Open cell
• Closed cell
• Syntactic foam
  • Foam where the cells are present in the uncured material - usually as a composite sphere
• Slab stock or laminated foam
  • Foam molded as sheets of cured material
RTV-2 SILICONE FOAM PROCESSING

• Metering
  • Insure that components are at the correct ratio

• Mixing
  • Insure that there is enough mixing to enhance nucleation of bubbles

• Dispensing
  • Use the best method for placing foam where it is needed
INDUSTRIAL APPLICATIONS

- Automotive
  - HVAC components, dash board panels
  - Air filters/ fuse boxes/grommets
- Electrical
  - Dust and vapor seals/vibration insulation of power units
- Aerospace
  - Thermal insulation/sound and vibration insulation
LIQUID INJECTION SEALING

The Benefits of Silicone Foams for use in the Automotive Industry

© 2006 Wacker Chemical Corporation
INNOVATIVE method to install custom “Inject-in-Place” static seals in component parts. The seal is formed by injecting a liquid sealant through a port into a groove of a fully-assembled part.

• **Unique to LIS:**
  - Sealing function
  - Material
  - Installation methodology
  - Application equipment?
  - Control systems

• **Major Characteristics:**
  - Requires a cast-in or machined groove
  - Injected sealant displaces air through the part flange
  - Forms a seamless seal
  - Injection pressure and volume monitored for “real-time” QC
LIQUID INJECTION SEALING
PROCESS DEVELOPMENT BACKGROUND

Liquid Seals
- Form-In-Place
- Cure-In-Place
- Form-In-Place Foam
- Mold-In-Place

Molded Seals
- Compression
- Transfer
- Injection
- Liquid Injection

Liquid Injection Sealing

The Benefits of Silicone Foams for use in the Automotive Industry

© 2006 Wacker Chemical Corporation
<table>
<thead>
<tr>
<th></th>
<th>Compression</th>
<th>Adhesion</th>
<th>Expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
<td>Excellent¹</td>
<td>Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Temperature</td>
<td>Good</td>
<td>Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Vibration/Part movement</td>
<td>Excellent</td>
<td>Good to Excellent²</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

¹ Material cost generally increases as chemical resistance requirements increase.
² Requires application and/or installation sensitive design for optimal performance.
<table>
<thead>
<tr>
<th></th>
<th>Compression</th>
<th>Adhesive</th>
<th>Expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seals</td>
<td>Seals</td>
<td>Seals</td>
</tr>
<tr>
<td>Debris</td>
<td>High</td>
<td>Very low</td>
<td>None</td>
</tr>
<tr>
<td>Fluid</td>
<td>Low</td>
<td>High</td>
<td>Very low</td>
</tr>
<tr>
<td>Surface Finish</td>
<td>Narrow</td>
<td>Wide Range</td>
<td>Wide Range</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Component Part Gaps</td>
<td>High</td>
<td>Very low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(FIPG) to High (anaerobic)</td>
<td></td>
</tr>
<tr>
<td>Nicks/Scratches</td>
<td>High</td>
<td>Low</td>
<td>Very low</td>
</tr>
</tbody>
</table>
LIQUID INJECTION SEALING PRODUCT BENEFITS

• Substantial seal material cost reduction (up to 85%)
• Reduction in seal warranty
• Custom fit expansive seal for each component
• Improved component structure
  • Retention of fastener preload
  • Reduction in vibration from metal-to-metal joint
• Wide latitude in surface finish requirements
LIQUID INJECTION SEALING SERVICE BENEFITS

• Easily removed from substrate

• Can be injected into a fully assembled part or a bead can be placed in the groove prior to assembly

• Reduced inventory

• Reduced service part management complexity

• Reduction in labor requirements
LIQUID INJECTION SEALING
SUMMARY

Liquid Injection Sealing is a new, innovative static sealing process that can provide the benefits of both preformed and liquid seals, in a single, automated installation process.
THANK YOU FOR YOUR ATTENTION!