TPV Seal Geometry Effects On Compression Set (CSet) and Compression Load Deflection (CLD)

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Outline

• Background
• Study objectives
• Approach
• Sample production
  – Materials
  – Process
• Results
• Conclusions
Background

• Primary and secondary automotive weatherseals are complex, multifunctional profiles that:
  – Control or affect:
    • Water ingestion
    • Wind noise
    • Door closing effort
    • Aesthetics at vehicle entry
  – Typically consist of:
    • Sponge sealing section
    • Mounting section
    – Dense polymer
    – Metal reinforcement
    • Trim
    – Secondary lip
    – Skin coat
Background

• Performance requirements for weatherseal sponge
  – Surface contact area for sealing
  – Conform to sealing surface imperfections and build tolerances
  – Low compression force
  – Withstand high deformations
  – Provide rapid, elastic deformation recovery
  – Operate over a wide temperature range
  – Maintain properties with cyclical deformations
  – Provide consistent properties over long product life
Meeting weatherseal performance needs requires:

- **Materials**
  - Designed for performance
  - Foamability
  - Surface aspect
  - Low CLD
  - Low CSet
  - Elongation

- **Process**
  - Trexel MuCell™ process
  - Closed cellular structure

- **Part Design**
  - Geometry
  - Dimensions
  - Sponge specific gravity
Background

- EPDM material properties ≠ TPV material properties
  - Current weatherseal designs based on EPDM properties
    - Historical material of choice
    - Seal designer and manufacturer experiences
  - Different design rules anticipated for optimal seal performance with TPV
Objective

• The objective of this investigation was to quantify the effects of varying TPV profile design on key weatherseal performance criteria to define TPV sponge designs for optimal weatherseal performance.
  – Study variables
    • Profile shape
    • Profile wall thickness
    • Sponge density
  – Measured results
    • CSet
      – Short term
      – Long term
    • CLD
Approach

- Produce “D” shaped profiles of equal height varying:
  - Shape
  - Wall thickness 1.5 and 2.0 mm
  - Sponge density 0.55 to 0.65 gm/cc

- Assess performance differences
Sample Preparation

• Process
  – MuCell™ foam extrusion process
    • Physical foaming technology
    • Direct injection of supercritical N₂ or CO₂
  – Equipment
    • Trexel extrusion system 63 mm diameter, 32:1 L/D
    • Throughput 45 kg/hr (100 lb/hr)
Sample Preparation

• Materials
  – Santoprene™ X121-60F150 polymer
    typ. properties
    • Specific gravity 0.97 g/cc
    • Hardness 60 Shore A
    • Ultimate tensile str. 4.5 MPa (650 psi)
    • Elongation @ break 390%
    test method
    TPE-0105/1
    TPE-0104
    TPE-0153
    TPE-0153
  – SCF
    • Type $N_2$
    • Delivery pressure 172 bar (2,500 psi)
Results

• Samples Produced
  – Actual optical comparator tracings

-2° Profile

22° Profile

57° Profile
Results

Short Term Cset - 22hr @ 70°C
Santoprene™ X121-60F150, Sponge S.g. 0.54 - 0.60 g/cc, Test Method TPE 0016
Results

CLD - 50% and 25% Compression
Santoprene™ X121-60F150, Sponge S.g. 0.54 - 0.60 g/cc, Test Method ASTM D 1667
Results

50% Compression CLD vs. Short Term CSet
Santoprene™ X121-60F150, Sponge S.g. 0.54 - 0.60 g/cc, Test Methods ASTM D 1667 & TPE 0016

Wall Thickness (mm)

CLD (N/100 mm)

CSet (%)

-2° Profile
22° Profile
57° Profile

-2° Profile
22° Profile
57° Profile
Results

Long Term Cset - 1,000 hours @ 70°C
Santoprene™ X121-60F150, Sponge S.g. 0.54 - 0.60 g/cc, Test Method TPE 0016
Results Summary
Santoprene™ X121-60F150 Sponge 0.54 – 0.60 g/cc

- Anticipated CLD and CSet range:

<table>
<thead>
<tr>
<th></th>
<th>Min.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLD (25% compression)</td>
<td>2.6</td>
<td>10.8</td>
<td>N/100 mm</td>
</tr>
<tr>
<td>CLD (50% compression)</td>
<td>7.0</td>
<td>34.5</td>
<td>N/100 mm</td>
</tr>
<tr>
<td>CSet</td>
<td>32</td>
<td>48</td>
<td>%</td>
</tr>
</tbody>
</table>

Shape and wall thickness changes from 1.4 to 2.2 mm.

- Sponge density changes did not affect CSet or CLD.

- Short term CSet is reduced with:
  - Shape change parallel to load ≈ 5% points at fixed wall thickness.
  - Wall thickness increase ≈ 1.4% points/0.1 mm increase.
  - A total of 16% points with both shape and wall thickness changes.
Results Summary
Santoprene™ X121-60F150 Sponge 0.54 – 0.60 g/cc

• CLD is reduced with:
  – Shape change to more round profiles at fixed wall thickness
    • ≈ 11 to 12 N/100 mm (50% compression)
    • ≈ 1.7 to 3.8 N/100 mm (25% compression)
  – Decreased wall thickness
    • ≈ 2 N/100 mm for a 0.1 mm wall thickness reduction (50% compression)
    • ≈ 1.7 N/100 mm for 0.1 mm wall thickness reduction (25% compression)
Conclusions

• Profile shape has a large effect on TPV sponge CSet and CLD.

• Profile shape for TPV can be optimised for CSet and CLD independently of sponge specific gravity.

• TPV CSet is consistent over time.

• TPV sponge CSet ≤ EPDM sponge CSet after 700 hours (29 days).
THANK YOU FOR YOUR ATTENTION!

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