Storage-stable NDI Prepolymers - Elastomers with Superior Mechanical & Dynamic Load-bearing Characteristics

Jens Krause, Antonio Alvarez & Ashok Sarpeshkar
Outline

• Why NDI elastomers?
• Established NDI technology
• New stable NDI prepolymers
• Mechanical properties of NDI elastomers
• Dynamic mechanical attributes
• Dynamic load testing of wheels
• Hydrolysis resistance
• NDI vs. PPDI elastomers
• Applications
• Conclusions
Why NDI Elastomers?

- Unrivaled end-use Property profile
- Outstanding mechanical & Dynamic properties
- Performance over wide Temperature range
- High wear resistance
- Excellent load-bearing ability
- Soft Segment
- Hard Segment
- Elastomer of choice when other materials fail
Established NDI Technology

- **Isocyanate**
- **Polyester**

**Prepolymer**
(Mix Ratio = 100:4)
(use within 1 hr.)

**Cast Elastomer**
Stable Prepolymer Technology

Stable NDI Prepolymer

Extender

Meter Mix

(Mix Ratio = 100:4)

Cast Elastomer
# NDI Prepolymer Product Line

<table>
<thead>
<tr>
<th>NDI Prepolymer</th>
<th>Polyol Component</th>
<th>%NCO</th>
<th>Viscosity @ 100°C (mPa.s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ND 3927</td>
<td>Polyester</td>
<td>2.7</td>
<td>2700</td>
</tr>
<tr>
<td>ND 3937</td>
<td>Polyester</td>
<td>3.8</td>
<td>2000</td>
</tr>
<tr>
<td>ND 3941</td>
<td>Polyester</td>
<td>4.1</td>
<td>1500</td>
</tr>
<tr>
<td>NT 3732</td>
<td>Polyether</td>
<td>3.2</td>
<td>1500</td>
</tr>
</tbody>
</table>
Prepolymer processing benefits

- 6–12 months storage stability in sealed drums
- 12 hour stability at 80°C during processing
- BDO extension similar to MbOCA curing of TDI prepolymer
- Pot life of 3-5 min
- Short demold time
- Castings from cold molds possible
## End-use Properties of NDI Prepolymers

<table>
<thead>
<tr>
<th>Properties(^a)</th>
<th>ND 3927</th>
<th>ND 3937</th>
<th>ND 3941</th>
<th>NT 3732</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness</td>
<td>87A</td>
<td>92A</td>
<td>95A</td>
<td>92A</td>
</tr>
<tr>
<td>Ten. Strength</td>
<td>5800 psi</td>
<td>7540</td>
<td>7250</td>
<td>4930</td>
</tr>
<tr>
<td>Elongation</td>
<td>510%</td>
<td>545</td>
<td>560</td>
<td>650</td>
</tr>
<tr>
<td>Die C Tear</td>
<td>171 pli</td>
<td>234</td>
<td>303</td>
<td>303</td>
</tr>
<tr>
<td>Resilience</td>
<td>70%</td>
<td>65</td>
<td>65</td>
<td>70</td>
</tr>
<tr>
<td>Comp. Set @ 70°C/24hr</td>
<td>17%</td>
<td>22</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>Abrasion</td>
<td>40 mg</td>
<td>40</td>
<td>47</td>
<td>35</td>
</tr>
</tbody>
</table>

\(^a\)these are only approximate values and not part of the specifications
Dynamic mechanical attributes

Maintains mechanical properties from -10°C to 130°C
Dynamic mechanical attributes

Tan Delta

Temperature in °C

-50.0 -30.0 -10.0 10.0 30.0 50.0 70.0 90.0 110.0 130.0 150.0 170.0 190.0

0.00 0.01 0.02 0.03 0.04 0.05 0.06

-50.0 0.0 50.0 100.0 150.0 200.0

0.00 0.01 0.02 0.03 0.04 0.05 0.06

-50.0 -30.0 -10.0 10.0 30.0 50.0 70.0 90.0 110.0 130.0 150.0
Summary of DMA Attributes

Storage modulus almost invariant between -10°C & 130°C

- mechanical properties maintained over wide temp. range

Tan Delta below 0.02 between 0°C & 130°C

- excellent damping over temperature range
Dynamic load testing of wheels

Tester Specifications

Wheel Diameter = 9.84 ft
Drum Weight = 16,535 lb
Max Velocity = 37.5 mph

Testing protocol

Starting velocity = 6.25 mph
Starting Load = 2248 lbf
One cycle = 15 min. movement & 2 min. of no movement
Load increase per cycle = 10kN
Break Load* comparison (kN)

*maximum load to break
Applications – *material handling*

- Heavy load wheels
- Drive wheels
Applications – *material handling*

**Wood transporter**
Applications – *material handling*

- high dynamic load bearing capacity
- high traction
- high vibration damping

**Drive unit - mixing drum for recycled goods**
Hydrolysis resistance of NDI Elastomers

Tensile Strength of NDI & TDI Elastomers in 80°C water

**NDI/polyester superior to TDI/PTMG/MbOCA**
Hydrolysis resistance of NDI Elastomers

Shore A hardness of NDI & TDI Elastomers in 80°C water

NDI/polyester superior to TDI/PTMG/MbOCA
Comparison of NDI & PPDI Elastomers

Storage Modulus vs. Temperature

ND 3937 maintains properties over temp range; LFP 2950 softens & loses properties
ND 3937 & LFP 2950 have comparable damping properties
### End-Use properties of NDI & PPDI Elastomers

<table>
<thead>
<tr>
<th>Properties</th>
<th>ND 3941&lt;sup&gt;a&lt;/sup&gt;</th>
<th>LFP 2950</th>
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<tbody>
<tr>
<td>Hardness</td>
<td>95A</td>
<td>95A</td>
</tr>
<tr>
<td>Ten. Strength</td>
<td>7250 psi</td>
<td>5800</td>
</tr>
<tr>
<td>100% Modulus</td>
<td>1813 psi</td>
<td>571</td>
</tr>
<tr>
<td>300% Modulus</td>
<td>2770 psi</td>
<td>1740</td>
</tr>
<tr>
<td>Elongation</td>
<td>560%</td>
<td>620</td>
</tr>
<tr>
<td>Die C Tear</td>
<td>303 pli</td>
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</tr>
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<tr>
<th>Property</th>
<th>NDI</th>
<th>PPDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic load test (break load)</td>
<td>Higher (18kN)</td>
<td>Lower (12kN)</td>
</tr>
<tr>
<td>High load applications</td>
<td>Superior</td>
<td>Inferior</td>
</tr>
<tr>
<td>Modulus over temperature range</td>
<td>Maintains</td>
<td>Decreases</td>
</tr>
<tr>
<td>Higher temperature performance</td>
<td>Superior</td>
<td>Inferior</td>
</tr>
<tr>
<td>Damping</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>
Elastomer benefits

- High dynamic load bearing capacity
- Good resistance against UV-radiation, ozone, & grease
- High wear resistance
- Little dependance on temperature variations
- Excellent damping
- Low permanent set
- High rebound elasticity
- High cut-resistance
Applications - couplings

- High abrasion resistance
- Oil resistance
Applications - *screens*

- Wear resistance
- Noise reducing
Applications - *Elevator/escalator industry*

Guide wheels for lifts
- smooth run
- reliable
- high safety demands
Applications – *Sports & leisure industry*

- fast
- smooth and
- safe runs

Roller coaster wheels
Summary

• Storage-stable NDI prepolymer
• Processed on existing low-pressure equipment
• Reactivity profile similar to TDI/MbOCA processing
• Hydrolysis resistance superior to TDI/PTMG elastomers
• High storage modulus over wide temperature range
• Outstanding load-bearing capabilities
• Excellent damping properties over broad temperature range
• Superior overall end-use properties
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