DuPont™ Viton®
Introduction to Our Next Generation DiPolymers (NGDP)

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Outline

Background: Why Develop the Next Generation Dipolymer (NGDP) Product Line

NGDP Product Line

NGDP for Increased Productivity

NGDP for Improved Part Performance

Summary
Technology Evolution of Viton®

APA delivered breakthrough technology in specialty fluoroelastomers in 2002.

NGDP balances the Viton® portfolio by advancing the state of the art in dipolymer fluoroelastomers.
Why Develop A Next Generation Dipolymer Product Line?

Key Objective:
Create A Superior Fluoroelastomer Dipolymer (66%F) Offering

• Improved flow in injection and transfer molding
• Improved compression set resistance
• Fast cure rate

Resulting In

• Increased productivity
• Improved final part performance
NGDP - Polymer Line

• 20 ML VTX-7619 & 70 ML VTX-7620 gum polymer sheets
  • Bisphenol curable
  
  • VTX-7619 has (ML@121°C) of 20
  • VTX-7619 useful for injection and transfer molding

  • VTX-7620 has (ML@121°C) of 70
  • VTX-7620 targeted at compression molding

• Can be compounded with VC50/VC30
• Can be blended with precompounds (PCs)
• Can be blended to make polymers ranging from 20ML to 70ML
NGDP - Precompound Line

- precompounds forming NGDP triangle
  - 60 Mooney – standard cure rate – VTR-7621
  - 20 Mooney – standard cure rate – VTR-7622
  - 20 Mooney – slower cure rate – VTX-7624

- Other precompound developed
  - 35 Mooney – precompound (for bonded parts) – VTX-7625
NGDP – Compound Data with Gums VTX-7619 & VTX-7620

<table>
<thead>
<tr>
<th>E113064 - Compound #</th>
<th>A72-06</th>
<th>A72-07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VTX-7620 sheet</td>
<td>97.3</td>
<td>-</td>
</tr>
<tr>
<td>VTX-7619 sheet</td>
<td>-</td>
<td>97.3</td>
</tr>
<tr>
<td>VC50</td>
<td>2.2</td>
<td>2.2</td>
</tr>
<tr>
<td>VC30</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>ELASTOMAG 170</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>N990</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Ca(OH)2 HP-XL</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Mooney Scorch @ 121°C
Minimum: 56, 20
5 Pt. Rise (min): 23.4, >30
10 Pt. Rise (min): >30, -

MDR @ 177°C, 0.5 Degree Arc, 100 Range, 6 Minute Clock
M-L (dNm): 2.6, 0.6
ts-2 (min): 1.0, 1.2
t'50 (min): 1.3, 1.3
t'90 (min): 1.9, 2.1
t'95 (min): 2.3, 2.6
M-H (dNm): 32.7, 26.7

In typical compounds, NGDP gums yield fast, square cure curves while retaining excellent scorch safety.
Product Offer - NGDP Precompound “Triangle”

**Benefits:**
- Blending options:
  - to vary compound viscosity
  - to vary compound ts2 & tc90 cure speed
- Increased compounding flexibility
- Reduced inventory levels
Product Offer - NGDP Precompound “Triangle”:
Increased Compounding Flexibility with Precompounds and Gums

Blends can be made to modify viscosity, cure speed or both. Blends can be done with VTR-7619 and 7620 as well.
## Product Construction with NGDP Precompound Triangle

<table>
<thead>
<tr>
<th>Compound #</th>
<th>Descr</th>
<th>A401C control</th>
<th>NGDP blend like A401C</th>
<th>VTR-9160</th>
<th>NGDP blend like VTR-9160</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viton® A401C</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VTR-9190</td>
<td>-</td>
<td>-</td>
<td>100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VTX-7521 (NGDP)</td>
<td>-</td>
<td>75</td>
<td>-</td>
<td>35</td>
<td>-</td>
</tr>
<tr>
<td>VTX-7522 (NGDP)</td>
<td>-</td>
<td>25</td>
<td>-</td>
<td>65</td>
<td>-</td>
</tr>
<tr>
<td>Elastomag 170</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>N990 (MT Black)</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Process aid</td>
<td>-</td>
<td>-</td>
<td>0.8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ca(OH)2 HP-XL</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Total phr lab</td>
<td>139</td>
<td>139</td>
<td>139</td>
<td>139.8</td>
<td>139.8</td>
</tr>
</tbody>
</table>

**MDR @ 177°C, 0.5 Degree Arc, 100 Range, 12 Minute Clock**

- M-L (dNm) | 1.7 | 1.9 | 1.3 | 1.2 |
- ts-2 (min) | 1.1 | 1.1 | 0.9 | 1.1 |
- t50 (min) | 1.4 | 1.4 | 1.1 | 1.3 |
- t90 (min) | 2.1 | 2.1 | 1.8 | 1.9 |
- M-H (dNm) | 32.1 | 30.6 | 29.5 | 27.3 |

**Physical Properties @ R.T. - Original** (Cure 7' @ 177°C, PC 16 hrs @ 232°C)

- M-100, MPa | 6.3 | 6.2 | 8.0 | 6.7 |
- Tensile, MPa | 13.0 | 14.4 | 13.4 | 14.0 |
- (Tb, psi) | 1878 | 2092 | 1937 | 2026 |
- Elongation, % | 204 | 229 | 163 | 187 |
- Hardness, A, pts | 76 | 76 | 77 | 76 |

**Compression Set, 336 hrs @ 200°C, Method B , O-Rings**

- PC, 4 hr @ 250°C | 32 | 32 | - | - |
- PC, 18 hr @ 232°C | 30 | 29 | 45 | 36 |

- NGDP triangle precompounds can be blended with one another to replicate the nominal viscosity & cure characteristics of current commercial precompounds.

- In this example
  1. A NGDP blend for compression molding like A401C
  2. A second NGDP blend is made for injection molding like VTR-9160
NGDP: Increased Productivity
Through Broader Operating Window

<table>
<thead>
<tr>
<th>Starting Pcmpd Mooney @ 121°C</th>
<th>~20 Mooney Pcmpd</th>
<th>~35 Mooney Pcmpds</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGDP pcmpd blend</td>
<td>16</td>
<td>35</td>
</tr>
<tr>
<td>Current technology VTR-9160</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>NGDP blend</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Full compound Mooney after black and metal oxides added</td>
<td>31</td>
<td>71</td>
</tr>
<tr>
<td>Mooney viscosity rise when compounded</td>
<td>15</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>36</td>
</tr>
</tbody>
</table>

In a 35 Mooney viscosity (MV) precompound comparison, a NGDP black loaded compound shows a 16 point lower Mooney viscosity rise than current standard Viton® VTR-9160

**Benefits:**
- Option to reduce process aid levels -> further improved compression set resistance
- Option to increase filler levels and reduce curative level while maintaining equal final viscosity, compression set resistance, and hardness
- *Injection molding flow improved – NEXT SLIDE*
NGDP: Increased Productivity Through Better Injection Molding (IM) Flow

Benefits:
- faster IM fill times - shorter cycle times
- option to use more cavities tool at a given press tonnage
- option to use smaller runners resulting in less scrap

- 35 Mooney NGDP PC blend shows superior flow by filling the mold much faster than current standard 35 Mooney VTR-9160
- 20 Mooney NGDP PC blend can lower mold fill times even further, or can be injected at lower pressures
Lab data confirms: Excellent Injection Molding (IM) Flow of NGDP Precompounds

40 cavity D-214 O-ring, injection molding

- Same precompound viscosity
- Lower compound viscosity with NGDP
**NGDP: Increased Productivity Through Fast Cure Rates**

**Compounds**
identical BpAF and accelerator = to standard A-type Viton® VTR-9129 recipe 30phr N990 black

<table>
<thead>
<tr>
<th>Compounds</th>
<th>6 Ca(OH)2, 3 MgO</th>
<th>9 MgO</th>
</tr>
</thead>
<tbody>
<tr>
<td>177 C</td>
<td>NGDP</td>
<td>Standard</td>
</tr>
<tr>
<td>Torque (dN-m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time (min)</td>
<td>0 1 2 3 4 5 6</td>
<td>0 1 2 3 4 5 6</td>
</tr>
<tr>
<td>Standard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t95 (min)</td>
<td>3.1</td>
<td>2.5</td>
</tr>
<tr>
<td>MH (dN-m)</td>
<td>30.3</td>
<td>30.2</td>
</tr>
<tr>
<td>NGDP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t95 (min)</td>
<td>2.5</td>
<td>3.8</td>
</tr>
<tr>
<td>MH (dN-m)</td>
<td>30.2</td>
<td>22.9</td>
</tr>
</tbody>
</table>

**Benefits**
- Shorter mold closed time  \(\rightarrow\) shorter cycle times
Lab data confirms: Faster Cure Rates for NGDP Precompounds

Benefits
- Lower accelerator levels reduce gas generation that can lead to dieseling or voids -> higher quality parts -> less scrap
- Reduced gas generation also permits higher mold temperature for faster cycles

NGDP gums cure faster than current standard Viton®

Example: 70 Mooney NDGP precompound made with VTX-7620 gum has similar cure rate as A-601C with 12% less accelerator!
Lab Data Demonstrates: Operating Flexibility Provides Increased Productivity ... 

40 cavity D-214 O-ring, injection molding

- Injection time to fill in a 40 cavity D-214 o-ring mold
- Even with 45% process aids of the standard Viton®, NGDP flow is better
- Less process aids for better end use properties with no processing compromise
- With lower levels of process aids, NGDP flows better than standard Viton®....
... AND Improved Performance

**Compression set of injection moulded D-214 o-rings (200 °C / 70 Hr)**

- NGDP allows shorter post cure times to develop the same compression set of standard Viton® post cured with much longer cycles

- … for further better compression set & less surface defects like welding lines
… while maintaining excellent release properties
% of self release at steady state

- NGDP 1.10 phr
- NGDP, 0.90 phr
- NGDP, 0.70 phr
- NGDP, 0.50 phr
- Standard, 1.10 phr

% self release
NGDP: Improved Performance
Through Excellent Compression Set

Benefits:
• Option for short post cure cycle resulting in faster production cycles
• High quality sealing
• Meet demanding end users specifications

30-35 Mooney injection molding stocks

40-60 Mooney compression molding stocks

• 336 hr comp set of low Mooney NGDP blend with process aids is improved – 10% better than current VTR-9160 & VTR-9180
• High Mooney NGDP comp set best in class. Low C/S with 4 hr PC
NGDP: Improved Performance
Through Excellent Sealing Property

Stress relaxation @ 175°C, air

% retained sealing force

hours

A601C Control
VTR-7621
VTR-7622
VTX-7623
VTX-7624
A201C
NGDP: Lab Data Confirms Good Low Temperature Performance

Benefits:
• Equivalent or slightly better low temperature sealing

• NGDP does not compromise low temperature Glass Transition (Tg) and TR-10 properties. Same to slight improvement
NGDP: Lab Data Confirms Good Physical Properties

<table>
<thead>
<tr>
<th>Descr.</th>
<th>NGDP precompounds</th>
<th>Stand. A201C control</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>VTR-7621</td>
<td>VTR-7622</td>
</tr>
<tr>
<td>Viton® A 601C</td>
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<td>VTR-7621</td>
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<td>VTR-7622</td>
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<td>VTX-7624</td>
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<tr>
<td>Viton® A 201C</td>
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<tr>
<td>ELASTOMAG 170</td>
<td>3</td>
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<tr>
<td>N990</td>
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<tr>
<td>Ca(OH)2 HP-XL</td>
<td>6</td>
<td>6</td>
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</table>

Physical Properties @ R.T. - Original (Cure 7' @ 177°C, Postcure 4 hrs @ 250°C)

<table>
<thead>
<tr>
<th></th>
<th>M-25, MPa</th>
<th>M-100, MPa</th>
<th>Tensile, MPa</th>
<th>Elongation , %</th>
<th>Hardness, A, pts</th>
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<tbody>
<tr>
<td>VTR-7621</td>
<td>2.0</td>
<td>6.4</td>
<td>14.2</td>
<td>218</td>
<td>75</td>
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<tr>
<td>VTR-7622</td>
<td>2.1</td>
<td>5.2</td>
<td>13.4</td>
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<td>80</td>
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<tr>
<td>VTX-7624</td>
<td>1.9</td>
<td>5.1</td>
<td>13.1</td>
<td>216</td>
<td>74</td>
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<tr>
<td>A201C</td>
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<td>6.3</td>
<td>14.3</td>
<td>215</td>
<td>76</td>
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</table>

Physical Properties @ R.T. - Original (Cure 7' @ 177°C, Postcure 16 hrs @ 232°C)

<table>
<thead>
<tr>
<th></th>
<th>M-25, MPa</th>
<th>M-100, MPa</th>
<th>Tensile, MPa</th>
<th>Elongation , %</th>
<th>Hardness, A, pts</th>
</tr>
</thead>
<tbody>
<tr>
<td>VTR-7621</td>
<td>2.2</td>
<td>6.6</td>
<td>14.8</td>
<td>220</td>
<td>76</td>
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<tr>
<td>VTR-7622</td>
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<td>5.6</td>
<td>13.5</td>
<td>231</td>
<td>80</td>
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<tr>
<td>VTX-7624</td>
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<tr>
<td>A201C</td>
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<td>75</td>
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</table>

Compression Set , Method B , O-Rings

<table>
<thead>
<tr>
<th></th>
<th>70 Hrs @ 200°C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- PC, 4 hr @ 250°C</td>
</tr>
<tr>
<td></td>
<td>- PC, 16 hr @ 232°C</td>
</tr>
</tbody>
</table>

Volume swell - % increase , 7700 Fluid , 70 hr @ 200°C , %

<table>
<thead>
<tr>
<th></th>
<th>70 Hrs @ 200°C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- PC1, 4 hr @ 250°C</td>
</tr>
<tr>
<td></td>
<td>- PC2, 16 hr @ 232°C</td>
</tr>
</tbody>
</table>

- NGDP O-ring precompounds are formulated like standard 66%F bisphenol curable FKM – like Viton® A201C run as a control in the table to the left
- NGDP shows similar tensile and elongation to A201C
- Physicals & compression set are good with a short 4 hr postcure and optimal with a 16 hr PC
- Fluids resistance to 7700 fluid is similar to A201C
**Product Offer - NGDP Availability**

- VTX-7619 & 7620 gums available now
  - Can be compounded with VC50/VC30
  - Can be blended with precompounds

- **precompounds forming NGDP triangle available**
  - 60 Mooney – standard cure rate **VTR-7621**
  - 20 Mooney – standard cure rate **VTR-7622**
  - 20 Mooney – slower cure rate **VTX-7624**

- **Other precompounds developed**
  - 35 Mooney oil seal precompound (for bonded parts) – **VTX-7625**

- **Sampling quantities available in 2Q 2010**
Key Messages for NGDP

• increased productivity
  • shorter injection molding fill times
  • faster cure rates leading to shorter cycle times
  • shorter post cure times
  • Lower process aid levels leading to higher quality yield (fewer parts with defects like flowmarks or knitlines)

• enhanced part performance
  • through better compression set resistance

• additional flexibility with available gums and precompounds
  • through blend options within in the precompound triangle to develop customized formulas for specific applications
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