POLYURETHANE CAST ELASTOMERS
A NATURAL EXTENSION FOR RUBBER MOULDERS

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DOW FORMULATED SYSTEMS

• An industry leader with experience in the development, formulation and manufacture/application of fully formulated polyurethane and epoxy systems

• Experience of over 40 years in polyurethane system development and 65 years in polyurethane chemistry.

• Focused on providing customers worldwide with innovative tailor-made solutions in targeted markets:
  - Alternative Energy
  - Energy Efficiency
  - Infrastructure Life Preservation
  - Leisure & Lifestyle
  - Industrial Castings & Adhesives

• Industrial Castings & Adhesives is a sector within Dow Formulated Systems created to help meet customers’ needs and bring their ideas to life through fully formulated systems.
Polyurethane Elastomers were Invented to Replace Rubber

But polyurethanes offer the rubber compounder the opportunity to extend their product application portfolio

Pros
- Abrasion resistance
- Cut and tear resistance
- Higher load bearing ability
- Ozone resistance
- Microbial resistance
- Oil and petroleum resistance
- Non-marking, non-staining
- Versatility
- Superior dynamic performance

Cons
- Relatively lower melting temperature
Polyurethane Elastomer Applications

Concrete mould liners 25 to 60A

Auto suspension Components 65A

Membranes 85-90A

PU Spray coated Marine Fenders 90A

Pipeline Cleaning Pigs 65 to 85A

Aggregate separation screens 85 to 95A

Medical training model 10A

Material handling rollers 70A to 70D

Percussion tool body 60D
Two-step PU Elastomer Synthesis

\[
2OCN-R-NCO + HO-R' OH \rightarrow \text{Prepolymer}
\]

\[
\begin{align*}
OCN-R-N-C-O-R' & \quad O-C-N-R-NCO \\
\text{Diol} & \quad \text{Diamine} \\
\end{align*}
\]

\[
\begin{align*}
\text{Polyurethane} & \quad \text{Polyurethane-urea}
\end{align*}
\]
Microphase-separated Morphology in Polyurethane Elastomers

- **Soft Segments** — Flexible chains with low glass transition temperature imparting elastomeric properties (Polyols).

- **Hard Segments** — Highly polar, relatively rigid blocks producing regions of hydrogen-bonded domains that act as cross-linking points for the soft segments (isocyanates and chain extenders).

- The superstructure of the PU elastomers strongly depends on the molecular weight of soft segment, hard segment content, preparation conditions, and chemical structure of raw materials.

- Characteristic properties of the polyurethanes depend on chemical structure and superstructure originated from hydrogen bond and microphase-separated structure.
Wide Range of Processing Techniques

- Open casting (most common, easiest, cost effective)
- Compression moulding (precision parts)
- Centrifugal moulding (pipelining, sheet goods, multi-cavity moulds)
- Direct Pour casting (rollers)
- Liquid injection moulding (low pressure)
- Transfer moulding (multiple precision parts)
- Rotational moulding (for hollow castings)
- Vacuum casting (wire or fiber inserts)
- Pressure casting (pressure chamber)
- Reaction injection moulding (high pressure impingement mixing)
- Spraying
- Solvent casting (low pressure for fabric penetration)
- Trowelling (repairs and special applications)
- Dipping (long pot-life and heat activated)
- Multi and single component
Simple Schematic of Dispensing Machinery Requires Minimum Investments Up-front
## Engineering Properties - PU versus Rubber

<table>
<thead>
<tr>
<th>Samples</th>
<th>HYPERLAST™ 101</th>
<th>DIPRANE™ 530</th>
<th>VORASTAR™ HB 6544</th>
<th>Rubber #1</th>
<th>Rubber #2</th>
<th>Rubber #3</th>
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</table>

The properties shown are typical but should not be construed as specifications.
PU Elastomer versus Rubber—Dynamic Visco-elastic Properties

Critical to Wheel, Roller and Tyre Applications

-100 -50 0 50 100 150 200 250

G' (Pa)

Temperature (°C)

TDI-ether
MDI-ether
TDI-ester
Rubber 1
Rubber 2

 Ability to carry a load

Working Temperature Range

Enhanced capability to maintain constant modulus values between 0°C-150°C
PU Elastomer versus Rubber—Dynamic Visco-elastic Properties

Critical to Wheel, Roller and Tyre Applications

- Similar T<sub>g</sub>
- Lower Tan δ Between 0ºC-150ºC
Marine & Offshore Applications

HYPERLAST™ Elastomers

- Resistant to hydrolysis, abrasion and microbial attack
- Capable of withstanding low temperature and extremely high pressure in deep water
- Acoustically transparent with no interference with the signal strength of sonar equipment
- Reduces strain caused to pipes and cables by flexing in the marine environment
- Suitable for encapsulating electrical components, protecting pipes and cables and protecting foam buoys and fenders
Urethane elastomers have been widely used in many phases of the mining process, such as extraction, transportation, processing and storage.

Typical applications include mining screens, pump impellors, pipe linings, cross-over pads, conveyors, hydro-cyclones as well as rollers and wheels.

**Hostile Environments**
- Impact and abrasion challenges posed by aggregates
- Moisture, chemicals and sometimes heat in the environment

**Advantages of PU Solutions**
- A wide range of hardnesses
- Excellent mechanical, solvent and heat resistance
- Excellent hydrolysis resistance, low temperature flexibility and resilience
- Resistant to both sliding and impingement abrasions
- Capable of outlasting steel and many other materials
- FRAS capability
Mould Making

DURAMOULD™ Systems

- Flexible materials capable of producing seamless moulds of numerous shapes at various hardinesses
- Capable of reproducing proud, recessed and textured profiles in the finest of detail
- Great flexibility and excellent durability
- Great impact, abrasion and weather resistance
- Easy room temperature processing
Rotationally Cast Polyurethane Rollers

ROTAKOTE™ Elastomers

Conventional Mould Process
- Preparation of the mould, such as cleaning, mould releasing and heating
- Cure the roller in an oven, demould the roller, and post-cure the roller in an oven
- Significant investment up front and additional production costs (labour, cycle time and energy)

ROTAKOTE™
- Fast reacting urethane elastomers with excellent physical and dynamic properties
- Convenient and flexible production with no need for a mould, preparation of the mould, demould and post-cure
- Helps to improve productivity by reducing labour and cycle time
- Available from 65 Shore A to 70 Shore D
MONOTHANE™ – One Component Technology

- Used for over 35 years in the manufacture of rollers and other engineering components
- Intended as a simple entry into polyurethane for the rubber processor
- Easy, heat, pour, cure process
- No component weighing
- No degassing required
- Hardness 20 to 90A
- Solvent resistance
- Applications include printing rollers, iso-static bags etc.
Wheels and Tyres

HYPERLAST™, DIPRANE™ and VORASTAR™ Elastomers

Subjected to repeated deformations of varying magnitude and frequency

Conversion of Mechanical Energy to Heat = Temperature Rise

- Affects durability, wear resistance, handling and traction, as well as rolling resistance
- Causes thermal degradation in rubber wheels and tyres
- Leads to fatigue cracking, bond failure, and blow out

HYPERLAST™ and VORASTAR™ elastomers have demonstrated reduced heat build-up and improved load bearing capability when compared to other rubbers, thus are widely used in these applications.
Furniture Edging

DURELAST™ Elastomers

- Seamless, hygienic, moisture-resistant seals
- Excellent adhesion to wood and laminates
- Impact and abrasion resistant edging
- Flexibility of design – Can be moulded in any profile, colour, texture and hardness
- Easy room temperature processing
- Suitable for moulding onto a wide variety of furnishings such as desks, work-stations, and counter tops
CONCLUSIONS

- Polyurethane chemistry can offer considerable possibilities in customizing and engineering elastomers. The versatility of polyurethane elastomers can not easily be matched by rubber or any other elastomers.

- Polyurethane elastomers possess great advantages over rubber in abrasion resistance, cut and tear resistance, ozone resistance, microbial resistance and chemical resistance.

- Polyurethane elastomers also demonstrated improved dynamic performance (over rubber) with reduced heat build-up and enhanced load bearing capability.

- Polyurethane elastomers can be processed by a wide range of processing techniques. Many of the techniques are easy to use and require minimum up-front investment.

- The Dow Chemical Company offers a wide-range of tailor-made elastomer solutions based on HYPERLAST™, DIPRANE™ and VORASTAR™. These systems have been successfully employed in a variety of consumer and industrial applications.
THANK YOU
## Engineering Properties of Elastomers Based on HYPERLAST™ 101

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<th>150</th>
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<th>103</th>
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* parts by weight

The properties shown are typical but should not be construed as specifications

- Excellent resilience
- Good stress-strain properties
- Excellent hydrolytic stability
- Great low temperature flexibility
# Engineering Properties of Elastomers Based on DIPRANE™ 530

<table>
<thead>
<tr>
<th>Property</th>
<th>DIPRANE™ C530/45 Polyol*</th>
<th>DIPRANE™ C*</th>
<th>DIPRANE™ 530 Prepolymer*</th>
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<th>Tensile Strength (MN/m²)</th>
<th>Elongation at Break (%)</th>
<th>Angle Tear Strength (KN/m)</th>
<th>Compression Set at 70 °C (%)</th>
<th>Resilience (%)</th>
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<td>&lt;30 &lt;30 &lt;30 &lt;30 &lt;30 &lt;30 &lt;30 &lt;30 &lt;30 &lt;30 &lt;30</td>
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<td>* parts by weight</td>
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- Greater tear resistance
- Excellent wear resistance
- Enhanced stress-strain properties
- Excellent solvent resistance

The properties shown are typical but should not be construed as specifications.
# Mechanical Properties of Elastomers Based on VORASTAR™ HB 6544 Isocyanate

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</table>

* parts by weight

- Great stress-strain properties
- Remarkable wear and tear resistance
- Excellent resilience and compression set

The properties shown are typical but should not be construed as specifications.
An elastomer is a polymer with the property of viscoelasticity (or simply "elasticity"). Elastomers generally have low Young's modulus and high yield strain compared with other materials. Elastomers are similar to Synthetic & Natural rubbers in character – but usually offer significant benefits around environmental stability (UV/Ozone etc), abrasion resistance & ease of processing.

In customer applications, most solid elastomers are unlikely to see & withstand continually repeated strains greater than 50%. Typically they are likely to be less than 10% for the majority of their service life (Wheels, rollers, conveyor belts, bend stiffeners, etc)

Energy absorbing foamed elastomers can, and do see strains of between 50-80% in typical applications (lift buffers, suspension components, filter seals, etc) – but they are especially good at energy absorption & isolation.