What Polyurethane Where?
Selecting the Right Polyurethane Elastomer for the Application
Overview

Types of Polyurethane Materials
  • Cast urethane examples and applications

Cast Urethane Elastomers
  • Benefits
  • Comparison with Rubber, Metal, Plastic

Selecting a Urethane for an Application
  • The Urethane Toolbox
Types of Polyurethane Materials

- Castable Elastomers
- Thermoplastics
- Foams
  - Flexible
  - Rigid
- Adhesives and Sealants
- Coatings
Cast Urethanes - Major Applications

- Wheels
- Mining Parts
- Oil and Gas Pipelining
- Rolls - Papermaking, Printing, Industrial
- Golf Balls
- Abrasives
- Marine Applications
- Bushings, Bearings, Seals
Recreational Parts
Lift Truck Wheels
Flexible Coupling
Pipeline Cleaning Pigs
Why Use Cast Urethane Elastomers?

- **Performance**
  - Abrasion Resistance
  - Toughness and Tear Resistance
  - Hardness and Elasticity
  - Dynamic Performance

- **Cost Effective**
  - Large improvement in performance vs “rubber”
  - High value applications
  - Lower tooling and equipment costs for small production runs
Advantages vs. Rubber

- Abrasion resistance
- Cut and tear resistance
- Oil resistance
- Higher load bearing
- Harder durometer range
- Clarity; translucence
- Non-marking
- Pourable; castable
- Ozone resistance
- Microorganism resistance
# Advantages vs. Rubber

## General Comparison of Polyurethane Elastomers with Various Rubbers

<table>
<thead>
<tr>
<th>Property</th>
<th>Polyurethane</th>
<th>Nitrile</th>
<th>Neoprene</th>
<th>Natural</th>
<th>SBR</th>
<th>Butyl</th>
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<tbody>
<tr>
<td>Tensile Strength (MPa) Durometer</td>
<td>20.7 to 65.5</td>
<td>13.8+/-</td>
<td>20.7+/-</td>
<td>20.7+/-</td>
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<td>Specific Gravity</td>
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<td>40 to 95A</td>
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<td>Tear Resistance</td>
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<td>Good</td>
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<td>Excellent</td>
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<td>Compression Set</td>
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<td>High</td>
<td>Low</td>
<td>Very High</td>
<td>Medium</td>
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<tr>
<td>Rebound</td>
<td>Very High to Very Low</td>
<td>Fair</td>
<td>Low</td>
<td>Fair</td>
<td>Very High</td>
<td>Medium</td>
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<td>Gas Permeability</td>
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<td>Good</td>
<td>Excellent</td>
<td>Good</td>
<td>Good</td>
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<tr>
<td>Acid Resistance</td>
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<td>Good</td>
<td>Excellent</td>
<td>Poor</td>
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<td>Aliphatic Hydrocarbons</td>
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<td>Aromatic Hydrocarbons</td>
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<td>Fair</td>
<td>Poor</td>
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<td>Oil and Gas Resistance</td>
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<td>Good</td>
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<td>Oxidation Resistance</td>
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<td>Ozone Resistance</td>
<td>Outstanding</td>
<td>Fair</td>
<td>Excellent</td>
<td>Fair</td>
<td>Fair</td>
<td>Excellent</td>
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<tr>
<td>Low Temperature Resistance</td>
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<td>Good</td>
<td>Good</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
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</tbody>
</table>
Advantages vs. Metal

• Lighter weight
• Less noise
• Better wear
• Corrosion resistance
• Cheaper fabrication
• Non-sparking
• Non-conductive
• Impact resistance
Advantages vs. Plastics

- Non-brittle
- Abrasion resistance
- Elastomeric memory
HARDNESS RANGES
Various Elastomers and Plastics

DUROMETER A

20 30 40 50 60 70 80 90 95

Rubber Band
Auto Tire Tread
Mens' Shoe Heel

DUROMETER D

45 55 65 75 85

Fluorocarbons
Polypropylene
Polystyrene
Nylons
Acrylcs
Phenolics

ROCKWELL R

50 70 90 100 110 120 130 140 150

CAST
POLYURETHANE
ELASTOMERS

CAST
POLYURETHANE
PLASTICS

RUBBERS
Limitations of Polyurethane

- High temperature applications
- Moist, hot environments
- Certain chemical environments
Selecting the Right Cast Urethane for an Application

• Identify properties needed
  • Durometer
  • Physical properties
  • Dynamic performance
  • Chemical resistance

• Identify processing window
  • Pot life
  • Viscosity
  • Cure temperatures
  • Demold time
The Polyurethane Toolbox

Polyol:
- PTMEG
- PPG
- Esters
- PCL
- PC

Isocyanate:
- TDI
- MDI
- PPDI
- HDI

Curative:
- Diamines
- Diols
- Triols

Additives:
- Antioxidants
- Plasticizers
- Fillers

Properties:

Processing:
- Curative Ratio
- Cure Temperature
- Postcure
Polyurethane Elastomer Structure
Selecting an Isocyanate

- **MDI**
  - Least health hazards
  - FDA Wet and Dry Food Approvals
  - Dimerization
- **TDI**
  - Better moisture resistance
  - Wide durometer range
- **PPDI**
  - Best dynamic performance
  - High temperature applications
  - Hydrolysis and chemical resistance
- **Aliphatic Isocyanates (HDI)**
  - Oxidation resistance, non-yellowing
Selecting an Isocyanate

- LF Prepolymers (MDI, TDI, PPDI)
  - Health and Safety Advantage
  - Processing
    - Lower viscosity
    - Longer pot life
  - End-Use Performance
    - Improved physical properties
    - Improved dynamic performance
Selecting a Polyol

• Ethers
  • Hydrolysis resistant
  • High rebound
  • Low durometer formulations

• Esters
  • Physical properties
  • Low rebound, good impact absorption
  • Hydrolyze when exposed to moisture

• PCL
  • Fatigue strength

• PC
  • Chemical resistance
Selecting a Curative

- Aromatic diamines
  - Generally used with TDIs
- Diols
  - Least health hazards
  - Molecular weight range can be used to modify hardness
  - Generally used with MDIs
- Triols
  - Used for cross-linking
Ways to Mold Polyurethane Parts

- **Open Casting** (Most common, easiest, cheapest)
- **Compression Molding** (Precision parts)
- **Centrifugal Molding** (Pipelining, Multi-cavity Molds)
- Liquid Injection Molding
- Reaction Injection Molding
- Ribbon Flow ® Moldless Casting
- Spraying
- Rotational Molding
- Vacuum Casting
- Transfer Molding
- B-Staging
- Pressure Casting
- Solvent Casting
- Trowelling
Polyurethane Prepolymer Processing

- Prepolymer
  - (Melting), Warming & Degassing

- Metering

- Mixing

- Curative
  - Melting or Warming (Degassing)

- Dispensing

- Molding

- Curing

- Demold

- Post-Cure

- Finishing
Lined Steel Pipe- Centrifugal Cast
## Selection Guidelines

<table>
<thead>
<tr>
<th>Property</th>
<th>Greatest</th>
<th>Least</th>
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<tbody>
<tr>
<td>Hardness</td>
<td>~</td>
<td>~</td>
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<tr>
<td>Tensile Strength</td>
<td>Ester</td>
<td>Ether</td>
</tr>
<tr>
<td>Elongation</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td>Modulus</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td>Tear Strength</td>
<td>Ester</td>
<td>PPG Ether</td>
</tr>
<tr>
<td>Compression Set</td>
<td>TDI</td>
<td>MDI</td>
</tr>
<tr>
<td>Rebound</td>
<td>MDI Ether</td>
<td>PPG Ether / Ester</td>
</tr>
<tr>
<td>Low Temperatures</td>
<td>MDI Ether</td>
<td>TDI Ester</td>
</tr>
<tr>
<td>High Temperatures</td>
<td>TDI</td>
<td>MDI</td>
</tr>
<tr>
<td>Abrasion Resistance:</td>
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<td></td>
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<tr>
<td>-Sliding</td>
<td>Ester</td>
<td>PPG Ether</td>
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<tr>
<td>-Impingement</td>
<td>MDI Ether</td>
<td>PPG Ether</td>
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<tr>
<td>Heat Buildup</td>
<td>Ether</td>
<td>Ester</td>
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<tr>
<td>Hydrolysis Resistance</td>
<td>MDI Ether</td>
<td>TDI Ester</td>
</tr>
<tr>
<td>Oil Resistance</td>
<td>Ester</td>
<td>Ether</td>
</tr>
<tr>
<td>Heat Aging</td>
<td>Ester</td>
<td>PPG Ether</td>
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## Specific Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Urethane Type</th>
<th>Basis of Choice</th>
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</thead>
<tbody>
<tr>
<td>Roller Skate Wheels</td>
<td>MDI Ether</td>
<td>High Resilience</td>
</tr>
<tr>
<td>Printing &amp; Coating Rolls</td>
<td>TDI Ester</td>
<td>Solvent Resistance, Good Physicals at Low Durometers</td>
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<tr>
<td>Oil Pipeline Pigs</td>
<td>TDI/MDI Ester</td>
<td>Oil &amp; Abrasion resistance</td>
</tr>
<tr>
<td>Grain Handling Equipment</td>
<td>MDI Ester</td>
<td>Abrasion resistance, FDA Approval</td>
</tr>
<tr>
<td>Fork Lift tires</td>
<td>TDI Ether (LFTDI Ester)</td>
<td>Low Heat Buildup</td>
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<tr>
<td>Hammers</td>
<td>TDI Ester</td>
<td>Tear Resistance, Low Resilience</td>
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<tr>
<td>Sandblast Curtains</td>
<td>MDI Ether</td>
<td>High Resilience-Impingement Abrasion resistance</td>
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<tr>
<td>Laundry Equipment</td>
<td>MDI Ether</td>
<td>Hydrolysis Resistance</td>
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<tr>
<td>Paper Mill Rolls</td>
<td>TDI Ether</td>
<td>Hydrolysis Resistance, Hardness Stability, Dynamics</td>
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<tr>
<td>Meat Processing Equipment</td>
<td>MDI Ester (Special)</td>
<td>FDA Wet Food Approval</td>
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</table>
Selecting a Urethane

• Decide which properties are of key importance
  • Physical properties
  • Chemical or environmental resistance
• Review your capabilities: heating for ovens and molds, mixing equipment
• Select a prepolymer/curative system
• Consult your suppliers for recommendations and further information
Questions?