Cast Polyurethanes
A Versatile Range of High-Performing Products

Desmodur® VULKOLLAN®

covestro

Providing the industry with versatile cast polyurethane elastomers

Cast polyurethane elastomers are growing in popularity, as enhanced property profiles and processing technologies expand the scope of potential applications. As a polyurethane specialist, Covestro offers a broad variety of Desmodur® systems, Vulkollan® for polyurethane elastomers. Our deep-seated knowledge and onsite expertise – driven by being customer focused and living an entrepreneurial spirit – support our customers with high-quality products, reliable service and innovative solutions.

Covestro offers a variety of technologies for superior casting of polyurethane elastomers with different property profiles. We aim to present in this brochure the variety of solutions we provide. We will focus on the cast polyurethane formulations with our Desmodur® product lines and the Vulkollan® / Desmodur® 15 (NDI) based products, highlighting their characteistics and properties, while informing about the various applications.

A broad portfolio of elastomers

Elastomers for a whole world of applications

Since Otto Bayer's discovery of polyurethane in 1937, this amazingly flexible and durable material has become indispensable in a number of everyday applications. Depending on the chemical formulation, the consistencies and properties of polyurethanes can vary greatly ranging from flexible or rigid foams, binders, integral skin foams, composites to thermoplastic polyurethanes (TPU) and elastomers. Polyurethanes can therefore be used in upholstery, mattresses, car seats, thermal insulation for buildings and the refrigeration chain, wheels, rollers, bodywork parts, coatings, adhesives and many other products.

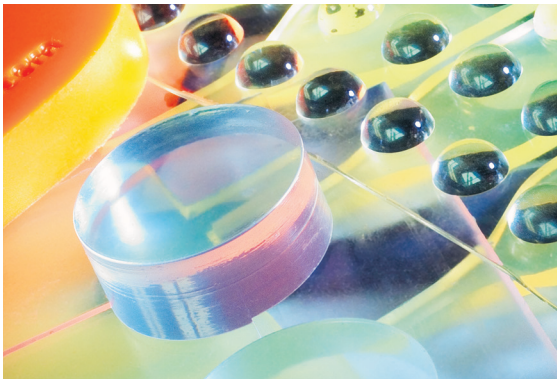
Because of its excellent properties it has also replaced numerous materials. The unique properties of cast polyurethane elastomers make them ideal for a wide range of uses. These include industrial and mechanical parts as well as applications in mining, oil and gas, printing, material handling and many more industries.

Material experts

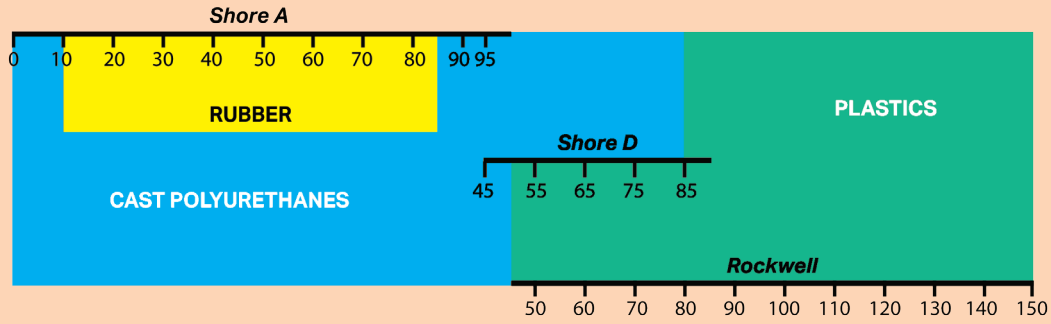
Covestro cast polyurethanes cover a wide spectrum of formulations combining most diisocyanates and polyols available. General purpose systems, specific tailored formulations or high performance specialties are available depending on the final application and molding constraints.

Versatility and high-performance properties

Cast polyurethanes achieve hardnesses on a wider range than any other elastomer and exhibit outstanding physical properties such as: abrasion, by far better than steel; tear resistance, superior to many other elastomers; resilience; load bearing capabilities. Their special properties made them indispensable in many fields, replacing other materials with lower properties.

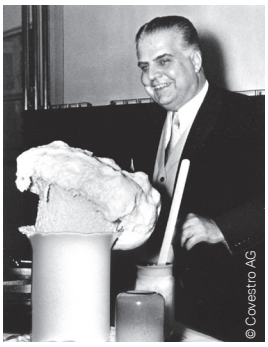


How do hardness ranges compare?



Back to basics

Pioneering polyurethane chemistry



You cannot write the history of polyurethane without Covestro. In 1937, a new category of polymers called polyurethanes was developed by Otto Bayer. The polyisocyanate-polyaddition reaction of a broad variety of raw materials proved a versatile method to produce customized plastics. This discovery was rapidly adapted and modified by many industrial chemists, therefore by the 40s, the possibility to develop polyurethane systems with elastomeric properties was already recognized.

A polyurethane elastomer is thus made up of alternating soft and hard segments resulting from the reaction of at least three basic chemical types: a diisocyanate, a long chain polyol and a short chain extender. Many different polyurethane elastomers can be made by changing the sequence of the reactive components.

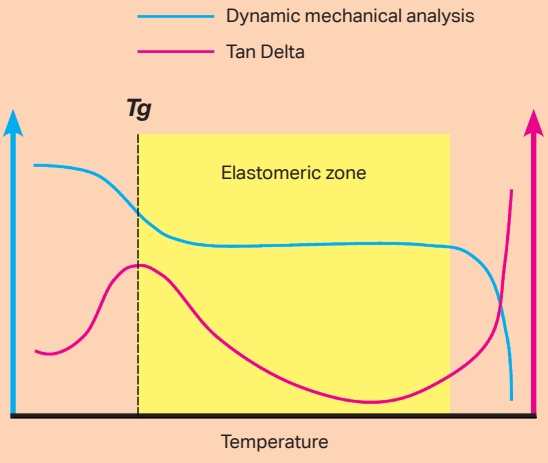
The processing of this new material proved to be a flexible method of producing customized elastomers with adjustable properties. It enables the manufacture by unit or in series of either small or large parts with substantial savings in terms of molds and equipment compared with other plastics. This new material appeared rapidly to be very promising; soon polyurethane parts were manufactured, replacing rubber in many applications.

As the developer of polyurethane lacquers, casting elastomers, adhesives and rigid polyurethane foams, Covestro has been at the forefront of industry innovation and product development for more than 150 years.

What is the glass transition temperature?

Have you ever left a plastic bucket or some other plastic object outside during the winter, and found that it cracks or breaks more easily than it would in the summer time? What you experienced was the phenomenon known as the glass transition. This transition is one of the change that make polymers unique.
Each polymer has its own temperature called the glass transition temperature, or ***Tg***: when the polymer is cooled below this temperature, it becomes hard and brittle, like glass. Some polymers are used below their glass transition temperature, and some are used above.
Hard plastics are used below their Tg's while elastomers are used above; that is where they are soft and flexible. One tries to have an elastomeric zone as long and flat as possible, before the elastomer breaks down.

Depending on the chemical nature of the cast polyurethane components, the glass transition temperature is different and the elastomeric zone is different.



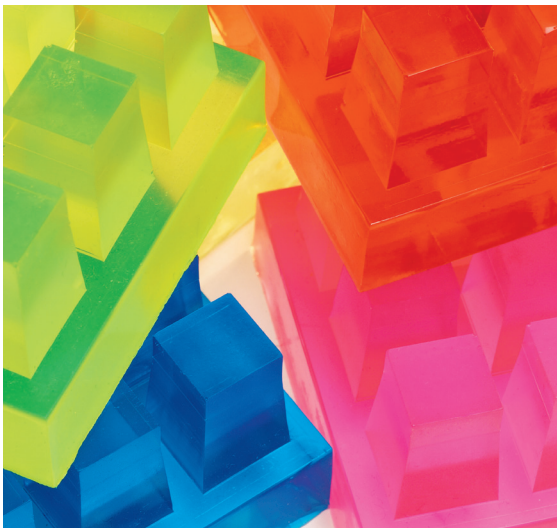
Versatility and outstanding properties

Mechanical and physical properties of cast PU

A wide range of properties can be obtained with polyurethane elastomers by changing the raw materials and formulations. They distinguish themselves from other elastomers by their wide range of hardnesses and their tunable flexibility in terms of physical properties. A polyurethane elastomer is made up from alternating «soft» and «hard» segments. The variation in the nature of the «hard» and «soft» segments gives the elastomer its unique set of properties. This three dimensional matrix mainly determines the modulus and the resistance to solvents, and that gives the elastic properties (compression set, elongation at break...).

These elastic characteristics of the polyurethane elastomers depend on the nature of the «hard» and «soft» segments and especially on their incompatibility, referred to as separation of the phases. This separation is better achieved in a polyether based cast polyurethane than in a polyester: the carbonyls in the ester functions tend to bond with the hard segments and result in a loss of mobility.

Furthermore, the «hard» segments flock together in groups and the cohesion between these groups contributes for a major part to the elastic properties of the polymer. The cohesion of the amine extended elastomers is higher than the cohesion of the alcohol extended ones.



Why to choose cast polyurethanes?

vs. Rubber

- Higher abrasion resistance
- High cut and tear strength
- Superior load bearing capacity
- Oil resistance
- Castable nature
- Processing cost
- Ozone resistance
- Lower mold pressure

vs. Plastics

- High impact resistance
- Elastomeric resistance
- Abrasion resistance
- Noise reduction
- Resilience
- Lower mold cost
- Low temperature resistance

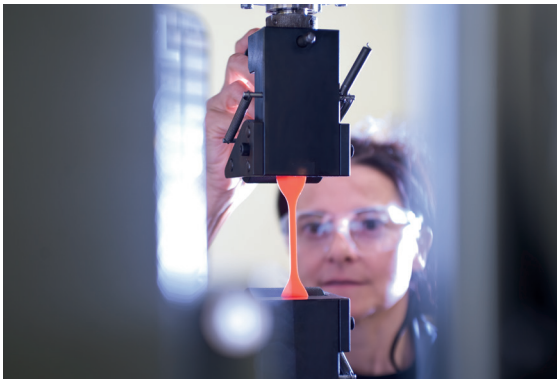
vs. Metal

- Abrasion resistance
- Resilience
- Easily castable
- Corrosion resistance
- Lighter weight
- Noise reduction
- Non conductive

Desmodur® cast PU systems

A plethora of tailored technologies

The large portfolio of polyurethane systems offered by Covestro results from years of constant development. These systems have proven their efficiency through machine or hand casting processes in all kinds of applications worldwide. The Desmodur® based formulations combine most diisocyanates and polyols available and offer a variety of technologies for superior casting of polyurethane elastomers with different property profiles.



Prepolymer technology: a practical mean for the manufacturing of customized elastomers

Desmodur® prepolymer technology from Covestro gives polyurethane elastomer manufacturers the freedom to meet all of their customers' demanding application needs.

The prepolymer technology consists of a reaction between diisocyanates such as:

- Toluene diisocyanate (TDI)
- Diphenylmethane diisocyanate (MDI)
- Aliphatic and unconventional isocyanates

and polyether/polyester polyols such as:

- Polypropylene glycol (PPG)
- Polytetramethylene ether glycol (PTMEG)
- Polyadipate
- Polycaprolactone
- Unconventional polyols

Cast PU elastomers are formed when these prepolymers react with chain extenders followed by curing to generate three-dimensional structures.

How does the isocyanate influence the process?

TDI influence

- Not sensitive to moisture
- Easy to mix
- Processing not very critical
- High hardness grades up to 85 Shore D
- Short curing
- Not very sensitive to curing parameters
- Pot life and demolding time difficult to adjust
- Rather low viscosity increasing slowly during pot life

MDI influence

- Very sensitive to moisture
- Requires an efficient mixing
- Requires a precise processing
- High hardness grades difficult to obtain
- Sometimes long curing
- Sensitive to curing parameters
- Pot life and demolding time easy to adjust
- Viscosity increases quickly during pot life
- Three-component systems allowing a large range of hardnesses

What to expect from TDI-Ether based systems?

Main characteristics

- High abrasion resistance
- High resilience
- High hydrolysis resistance
- Excellent behavior at low temperature
- Good tensile strength
- Easy processing
- Low compression set

Typical applications

- General purpose applications
- Caster wheels
- Cushion pads
- Springs
- Industrial rollers
- Seals

Desmodur® TDI-based systems: multi-purpose and easy processing

Conventional TDI-terminated prepolymers for cast polyurethane elastomers are processed using hot casting methods. Desmodur® TDI systems from Covestro include polyether- and polyester-based products. They are designed to be processed with various curatives. Desmodur® TDI-PTMEG systems provide PU elastomers with excellent properties:

- Good abrasion resistance, high tensile strength and high resilience, even at low temperatures
- Good resistance to hydrolysis and microorganisms
- Low viscosities for easy processing
- Large range of hardness : 80 Shore A to 80 Shore D

Desmodur® TDI-ester systems offer a robust set of characteristics:

- High tear resistance
- Excellent dynamic properties
- Good chemical resistance
- A low compression set
- Hardness levels of 80 to 95 ShA

Specialty Desmodur® TDI-ester systems are available with:

- Lower viscosities for easier processing
- Low hardness
- Good resistance to both water and hydrocarbons

Desmodur® MDI-based systems: customized performance systems

Hot cast PU elastomers based on 4,4′-methylene diphenyl diisocyanate (MDI) are available in ether, ester and polycarbonate. They process at high temperature for components and molds.

Desmodur® MDI-ether systems offer the main following properties:

- Good abrasion resistance
- High resistance to hydrolysis and microorganisms
- High resilience
- Potential suitability for food contact

Desmodur® MDI-ester systems possess:

- Good abrasion, tear and chemical resistance
- Excellent dynamic properties and resistance to internal heat build up
- Potential suitability for food contact

Desmodur® aliphatic systems: color-fast and UV-resistant

Producers of cast polyurethane elastomers can turn to Desmodur® aliphatic prepolymers from Covestro when they need to fabricate transparent products or UV-stable elastomers that remain crystal clear over time.

What to expect from TDI-Ester based systems?

Main characteristics

- Excellent abrasion and tear resistance
- Low compression set
- High resistance to chemicals
- Easy processing

Typical applications

- Dynamic applications
- Tires
- Caster wheels
- Pipe Inspection Gauges (PIGs)
- Scrapers
- Cutting pads
- Squeegees

What to expect from MDI-Ether based systems?

Main characteristics

- High abrasion resistance
- High resilience
- Excellent hydrolysis resistance
- Excellent resistance to microorganisms
- Compatible with food contact

Typical applications

- Hydraulic seals
- Hydrocyclones
- Flotation cells
- Timing belts
- Textile rollers
- Dumping pads

Amine cross-linked MDI prepolymers: a unique MDI-based technology

MDI-terminated prepolymers are used to mold high-performance cast polyurethane elastomers with a wide range of properties, but also demand accurate processing. On the other hand, the processing of TDI-based systems is easier and requires less careful handling.

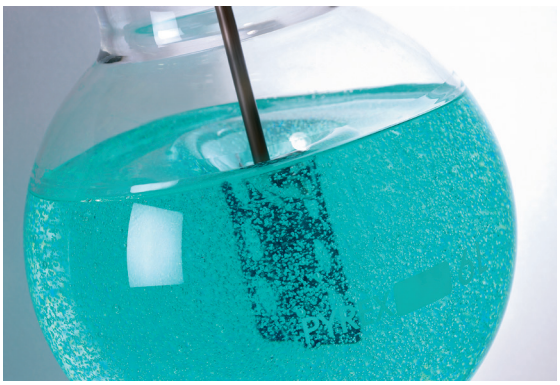
To solve these challenges, Desmodur® MAX systems provide an innovative low-melting two-component amine cross-linked MDI-based solution. Available in both ether and ester series and crosslinked with amines, the resulting polyurethane elastomers possess superior mechanical properties.

In addition, long pot-lives and short demolding times with Desmodur® Max systems make these prepolymers suitable for the molding of very large components.

Covestro offers Desmodur® Max prepolymers with a wide range of cross-linking amines, including commonly used MOCA (2,2′ dichloro-4,4′-methylene dianiline) and other alternatives.

Desmodur® MAX amine cross-linked MDI ester and ether combines the performance of MDI-based systems with easy processing and good flowability. Desmodur® MAX provides superior mechanical properties:

- High elongation
- High resilience
- Excellent tear and tear propagation resistance
- Exceptional abrasion resistance
- Outstanding hydrolytic stability
- Low compression set



What to expect from MDI-Ester based systems?

Main characteristics

- Excellent abrasion and tear resistance
- Good chemical resistance
- Excellent dynamic properties
- Excellent resistance to internal heat build up

Typical applications

- Scrapers
- Couplings
- Doffers
- Squeegees,
- Wheels and castors

Quasi-prepolymer technology: flexibility, easy processing and high performance

Cast polyurethane elastomer molders looking for a flexible while H&S friendly solution to produce parts may turn to Desmodur® quasi-MDI systems from Covestro. These Desmodur® systems provide ultra-high performing polyurethane elastomers in a wide range of hardness levels.

Like MDI full prepolymers, Desmodur® quasi-MDI prepolymers from Covestro are prepared from MDI and various polyether and polyester polyols. These low-viscosity products do not require extensive heating and can be mixed at low temperature with an additional polyol, a chain extender and catalyst to produce final elastomers with excellent mechanical properties. Varying these three components provides access to elastomers with a wide range of hardness values.

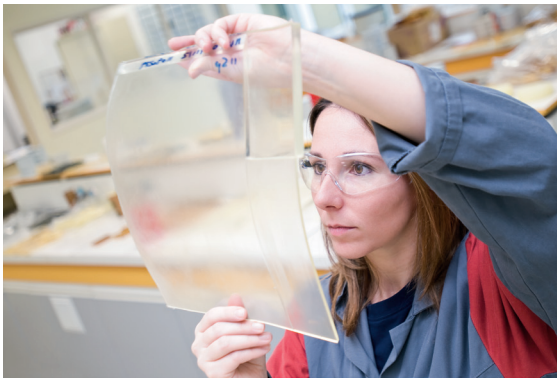
There are several advantages of Desmodur® quasi-MDI prepolymer technology:

- Low viscosity products process at low temperature
- Ability to achieve a wide range of hardness levels with the same three components
- Excellent mechanical properties
- Adjustable reactivity through catalyst choice and ratio
- Use in casting of very large parts
- Alternatives to systems facing regulatory restrictions
- Reduced energy consumption

Desmodur® Quasi-MDI-based systems: flexibility and wear resistant systems

Quasi-MDI systems provide flexibility through a broad hardness range with excellent wear resistance, including abrasion and tear resistance.

In wet, warm surroundings, MDI-ether systems are necessary to prevent hydrolysis damage from water or acids. Depending on the level of performance required, Covestro has formulated PTMEG and PPG versions. The PTMEG series is appropriate for applications such as hydraulic seals, hydrocyclones and timing belts. The PPG series offers a very low compression set. These systems are intended, i.e., for uses at low temperatures and for the manufacturing of fenders or concrete molds. Some systems of the series are also suitable for food contact applications.



The MDI-ester quasi systems offer superior abrasion and tear resistance with excellent resistance to chemicals such as hydrocarbons, oils and solvents. It is an ideal choice for applications such as screens, scrapers, PIGs, concrete blades, sheets and vibratory bowls. The series outstanding resistance to solvents also satisfies requirements for squeegee applications.

We also offer Desmodur® quasi-MDI-caprolactone-based series with excellent fatigue resistance. It is used for flip-flop screens among other applications.

What to expect from Quasi MDI-Ether systems?

Main characteristics

- High abrasion resistance
- Low compression set
- High resilience
- Excellent resistance to hydrolysis
- Lower toxicity
- Easy processing

Typical applications

- Screens
- Seals
- Inline skate wheels
- Hydrocyclones

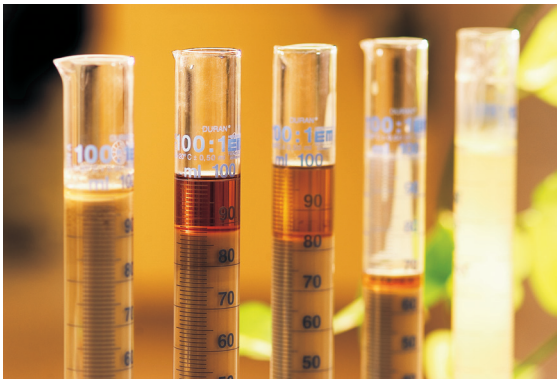
Low unreacted TDI prepolymers: low viscosity and high performance

Desmodur® low unreacted TDI prepolymers from Covestro allow an easier and safer processing with improved dynamical properties.

These systems provide high resilience and load bearing ability. The ordered structure of Desmodur® low unreacted TDI-based prepolymers allows the formation of polyurethane cast elastomers with morphologies that provide higher performance, particularly in extreme environments.

Compared with conventional TDI prepolymers, Desmodur® low unreacted TDI prepolymers benefit from:

- Low free TDI content
- Low viscosity
- Long pot-life
- Outstanding dynamical properties



From a health and safety point of view, our Desmodur® low unreacted TDI prepolymers further protect operators with free monomer content less than 0.1%. These products reduce worker exposure and limit health and safety issues.

The processing assets of low viscosity and long pot-life allow an easy final elastomers process.

Cold cast systems: easy processing at room temperature

With no need to pre-heat molds or post-cure formed parts in ovens, the cold cast process is simpler and faster than hot casting of polyurethane elastomers and requires less of an initial investment. These systems are used to fabricate simple to complex parts with a wide range of hardness values. Cold cast elastomers based on Desmodur® prepolymers are particularly appropriate for the manufacture of prototypes and concrete molds because they experience low shrinkage and high elongation.

What to expect from Quasi MDI-Ester systems?

Main characteristics

- Excellent abrasion resistance
- High resistance to chemicals
- Low processing temperature
- Easy processing

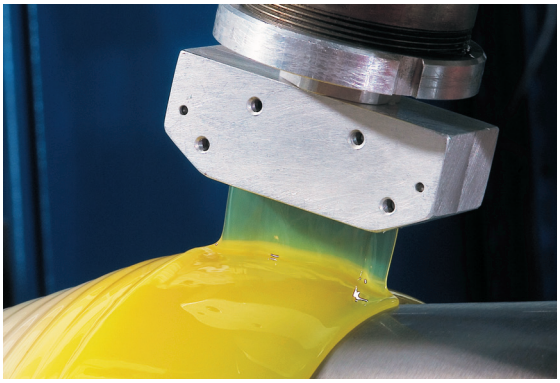
Typical applications

- Screens
- Scrapers
- PIGs
- Concrete blades
- Sheets
- Vibratory bowls

Rotational Casting technology: advanced roller casting technology

The unique properties of cast polyurethane elastomers make them attractive to the roller industry to meet stringent requirements. Rotational Casting, an innovative technique that eliminates molds and ovens and creates new possibilities.

When it debuted in the 1980s, the Rotational Casting method offered an alternative to open mold casting, the traditional polyurethane roll covering technique. The rotational casting process utilizes MDI ester-based or MDI ether-based systems.



During rotational casting, a very fast-reacting polyurethane mixture is dispensed directly onto a rotating roll. The production of roll coverings using Rotational Casting requires a dedicated machine that heats, meters and mixes every component of the formulation. Rotational Casting requires a mastery and compatibility of machines and systems. Covestro offers machinery designed specifically for this processing method.

Additional advantages of Rotational Casting are:

- Energy savings: no preheating of the core required
- No mold required: time and energy savings
- Less waste
- Coverage of rollers of various sizes and shapes
- Coverage with several layers of different systems
- No risk of contamination of the core by release agent
- Coverage of up to 40 mm on a single pass

The Rotational Casting method for processing cast polyurethane elastomers is well-suited for applications in the steel, pulp and paper industries. Applying its extensive expertise in polyurethane technology, Covestro has developed a broad portfolio of Desmodur® systems specifically for Rotational Casting of industrial rollers with a wide range of hardness values suitable for paper and steel mill rollers. The range of systems available contains cast polyurethane systems in both ether and ester series.

How does the Polyol influence the properties?

Property	Ester influence	Ether influence
Hydrolysis resistance	-	+
Microorganism resistance	-	+
Solvent resistance	+	-
Behavior at low temperature	-	+
Behavior at high temperature	+	-
Easy processing	-	+
Resilience	-	+

Vulkollan® elastomers

Ultimate solid and cellular solution

Vulkollan® is one of the most powerful elastomers in the market, combining highest mechanical load-bearing characteristics with highest dynamic load-bearing capacity. Therefore, Vulkollan® is preferably used for superior tasks in many technical fields.

Vulkollan® / Desmodur® 15 (NDI) : superior material for demanding applications

In a multistage process developed by Covestro, solid Vulkollan® is produced through chemical reactions between polyester polyols of the high-quality Vulkollan® range, Desmodur® 15 and glycols. Desmodur® 15 is the trade name for 1,5-naphthylene diisocyanate (NDI) from Covestro. The ultra-high-performance elastomer covers a hardness range from approx. 65 Shore A up to 60 Shore D. Vulkollan® can only be manufactured by licensed processors. They produce wheels and castors to deal with the highest dynamic loads, technical and semi-finished parts.

Cellular Vulkollan® is produced from Vulkollan® polyols, Desmodur® 15 and water. It covers a density range from approx. 300 up to 850 kg/m3 and combines high volume compressibility with minimal transverse expansion. Cellular Vulkollan® is used for the manufacture of superior damping elements, such as bumpers, springs and NVH (noise, vibration, harshness) elements.

What to expect from Vulkollan®?

Vulkollan® main characteristics

- Highest mechanical and dynamic load capacity
- Low damping behavior (low tan delta)
- High and constant shear modulus (stiffness) -10 to 120 °C
- Excellent wear resistance, even at high temperatures
- High resilience, even at high stiffness
- Low pressure deformation behavior and rapid recovery behavior after deformation

How do elastomers made of stable NDI-prepolymers compare with classic Vulkollan®?

Elastomers made of stable NDI-prepolymers exhibit similar outstanding characteristics as classic Vulkollan®. Several individual properties stick out:

- Improved hydrolytic and microbial stability
- Improved resilience
- Reduced heat build-up
- Reduced flat spot behavior
- Improved low temperature behavior

NDI-based cast polyurethane elastomers

NDI-based cast polyurethane elastomers can have a solid or a cellular structure. In a multistage process these ultra-high-performance elastomers are produced through chemical reactions between polyols, NDI and glycols or water.

In the first step prepolymers are produced from polyols and NDI. In the second step prepolymers are reacted with glycols (solid elastomers) or water (cellular elastomers) by mixing, and these mixtures are poured into open molds.

Solid elastomers are produced by casting at temperatures exceeding 100 °C; cellular elastomers require temperatures around 90°C. The reaction mixtures cure in open/closed molds to form solid/cellular elastomers. After demolding, the elastomers are subject to a special maturing process that is essential to achieve exceptional mechanical and dynamic properties.

Besides the classic multistage process, solid and cellular NDI-based cast polyurethane elastomers can also be manufactured from stable NDI-prepolymers offered by Covestro. These products are recommended especially for small- and mid-scale production.

When Desmodur® 15 and Vulkollan® polyols from Covestro are used, the manufactured solid and cellular elastomers can be marketed as Vulkollan®, provided that processing guidelines are implemented and a trademark license is granted by Covestro.

How do conventional TDI and MDI based systems compare with Vulkollan®?

TDI and MDI based systems

- Designed for various different applications
- Various dedicated systems with different strengths and weaknesses
- Dynamic performance far below Vulkollan®

Vulkollan®

- All relevant mechanical properties on a high level
- Constant properties across a wide temperature range
- Excellent dynamic performance

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