AIR PRODUCTS

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AirMail

TIMELY TECH TIPS AND HOT NEWS FOR OUR GLOBAL POLYURETHANE CAST ELASTOMER CUSTOMERS

PSP OFFERINGS

- Airthane® Prepolymers
- Versathane® Prepolymers
- Versalink® Polyurethane Curatives
- Lonzacure® MCDEA Curative
- Versalink Oligomeric Diamines

Comparing Polyether and Polyester Urethanes

Castable urethane prepolymers can be separated into two general types: polyether and polyester.

Polyether type prepolymers typically use PTMEG (polytetramethylene ether glycol) or PPG (polypropylene glycol) as the soft segment. Polyester type prepolymers generally use PEA (polyethylene adipate), often blended with other polyesters to get specific desirable properties such as the soft segment.

Air Products' materials of both types are TDI (toluene diisocyanates) and are typically cured with MOCA [methylene bis(ortho-chloroaniline)] to provide their hard segment. However, a number of other diamine and polyol curatives—Lonzacure® MCDEA, Versalink® 740M, Versalink P650, Versalink P1000, etc.—are routinely used.

Main features

Polyether prepolymers (Airthane® PET, PHP and PPT series products; Versathane® CP 1090, 1160, and 2070 series)

- Superior dynamic performance
- Superior resistance to hydrolysis
- Higher Bashore rebound (vs. similar polyesters)
- Generally liquid at room temperature*
- Low viscosity at working temperatures.

Polyester prepolymers (Airthane PST series; Versathane A,D series; Versathane QM series)

- Superior oil resistance.
- Superior physical properties, particularly below 90 Shore A.
- Higher split tear strength.
- Generally tougher.
- Lower Bashore rebound (vs. similar polyethers).
- Superior thermal stability of the vulcanizates.

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Table 1: Viscosities of Selected Airthane and Versathane Prepolymers

Prepolymer	Description	Elastomer Durometer Diamine-Cured	Viscosity Max. (cPs @ 70 °C)
PTMEG AIRTHANE PREPOLYMERS			
PET-95A	TDI-Polyether	95A	500
PET-90A	TDI-Polyether	88A	1400
PET-85A	TDI-Polyether	85A	1500
PPG AIRTHANE PREPOLYMERS			
PPT-95A	TDI-PPG	95A	400
PPT-80A	TDI-PPG	80A	300
PPT-65D	TDI-Polyether	65D	700
AIRTHANE POLYESTER PREPOLYMERS			
PST-90A	TDI-Polyester	90A	2100
PST-95A	TDI-Polyester	95A	~1800
PST-85A	TDI-Polyester	85A	~2200
PST-80A	TDI-Polyester	80A	3100

Prepolymer	Description	Elastomer Durometer Diamine-Cured	Viscosity Max. (cPs @ 70 °C)
VERSATHANE POLYESTER PREPOLYMER			
A-8	TDI-Polyester	80A	3500
A-85	TDI-Polyester	85A	3400
A-9	TDI-Polyester	90A	3300
VERSATHANE "QM" POLYESTER PREPOLYMERS			
A-8QM	TDI-Polyester	80A	5000
A-85QM	TDI-Polyester	85A	4500
A-9QM	TDI-Polyester	90A	4100

*Some of the low %NCO products, are low melting solids.

Comparing Polyether and Polyester Urethanes

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PSP
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- *Airthane® Prepolymers*
- *Versathane® Prepolymers*
- *Versalink® Polyurethane Curatives*
- *Lonzacure® MCDEA Curative*
- *Versalink Oligomeric Diamines*

prepolymers

Table 2: Environmental Resistance of Polyurethane Elastomers

Environment	Polyether Polyurethane Elastomers	Polyester Polyurethane Elastomers
Heat	F	G
Cold	G	G
Weather	E	E
Ozone resistance	E	E
ASTM No. 1 oil	F	E
ASTM No. 3 oil	P	E
Aliphatic solvents, e.g. heptane	F	E
Chlorinated solvents, e.g. trichloroethane	P	F-G
Aromatic solvents, e.g. toluene	P	F
Dilute acids, e.g. 5% HNO_3	F	P-F
Dilute alkalines, e.g. 5% NaOH	F	P-F

E=Excellent G=Good F=Fair P=Poor

1.) Resistance to hydrolysis:

Polyurethanes are subject to attack by hydrolysis, which can limit their use in water contact applications. Hydrolysis is accelerated by temperature and acidic or alkaline conditions. Elastomers prepared using polyether prepolymers have greater resistance to this form of decay. They are recommended for continuous use applications up to 150 ºF in a pH range of 5 to 9. Polyurethanes prepared using polyester prepolymers are generally not recommended for continuous water contact applications.

2.) Bashore rebound:

This is a measure of resiliency—the higher the Bashore rebound, the greater the resiliency. A material with a Bashore rebound of 100 percent has perfect resiliency since it reflects or returns all energy imparted to it. Such a product would provide perpetual motion and would make a good super ball. Unfortunately, no such rubber exists.

A material with a 50 percent Bashore rebound would reflect one-half of the energy imparted to it, absorbing the remainder. A material with 0 percent rebound would absorb all of the energy imparted to it and be ideal for low-frequency energy absorption.

Thus, a higher Bashore resiliency returns energy while a lower one means greater energy absorption. Since absorbed energy is converted to heat, high resiliency is desired for dynamic applications.

Polyurethane elastomers based on polyethers generally have higher Bashore rebound than those elastomers based on polyesters.

A material with a lower Bashore resiliency is capable of absorbing more energy. In applications requiring energy absorption, lower Bashore resiliency is desired.

Many engineering applications require energy absorption. Dynamic engineering applications involving rapid cyclic stress favor higher resiliency to reduce heat buildup, which can cause premature polyurethane failure.

Polyester prepolymers are superior for energy absorption, while polyethers perform better in dynamic applications, i.e., polyether prepolymers (45-55 Bashore) and polyester prepolymers (14-40 Bashore).

pumping, degassing, and mixing. Versathane QM series versions are formulated specifically to be faster melting. In the same hardness range, Airthane and Versathane ester prepolymers generally provide elastomers with higher tensile strength than corresponding ether prepolymers. The QM series provide faster melting prepolymers with similar physical properties at the expense of somewhat higher processing viscosity.

The practical difference between the two types is the time needed to prepare one 55-gallon drum for mixing:

- Airthane PST, Versathane A, D series—2 1/2 days; one day with a drum roller.
- Versathane QM series—Half-day.
- Liquid polyether—Half-day.

“In comparing elastomer properties of polyurethanes, evaluate them at the same hardness. Three hardness points can make a significant difference in modulus, elongation, and other properties.”

3.) Liquid at room temperature:

Polyether prepolymers are viscous materials at room temperature. Some are fluid enough so that they can be poured slowly from their containers, but most require heating to reduce their viscosities sufficiently for pumping, degassing, and mixing. Airthane polyether prepolymers are the lowest viscosity prepolymer class in typical cast elastomer processing.

Polyester prepolymers are either solid or high-viscosity liquids at room temperature. The solid prepolymers require heat to melt; all polyester prepolymers need heat to reduce their viscosities for

4.) Low viscosity:

Lower viscosities permit pumping and mixing at lower temperatures and allow easier molding.

5.) Oil resistance:

Polyester prepolymers have superior resistance to oils. Polyurethanes prepared using polyester prepolymers are heavily used in industrial applications where oil exposure is commonly encountered. Polyester prepolymers demonstrate oil resistance similar to that of nitrile rubbers, while polyether prepolymers have a lower resistance, similar to that of neoprene rubber.

6.) Physical properties:

Modulus, tensile, elongation, and tear strength are typical characteristic physical properties of polyurethane elastomers. At a given hardness, polyester prepolymers generally provide elastomers with improved physical properties vs. polyether-based elastomers. Within the general classification of polyether polyurethane elastomers, PTMEG-based prepolymers provide elastomers with improved physical properties vs. PPG-based polyether prepolymers.

7.) Split tear strength:

Split tear strength is a measure of the ability of an elastomer to resist tearing, gouging, and abrasion. Polyester prepolymers are several times stronger than polyether prepolymers in tear strength, For example, PST 90A comes in at 145 pounds per linear inch (pli) versus PET 90A at 65 pli using the ASTM D470 method. PTMEG-based prepolymers provide elastomers with improved tear strengths vs. PPG-based prepolymers.

8.) Toughness:

Toughness is one reason why urethanes are used. Toughness reflects a mix of properties including tear strength, abrasion resistance, and the ability to absorb energy.

Polyester prepolymers demonstrate superior toughness, a property that can often be demonstrated only by actual performance testing. Frequently, tough applications are handled best by soft and more elastic elastomers in the 70 to 90 Shore A range.

Many applications in this range employ polyester vs. polyether elastomers.

9.) Thermal stability of the vulcanizates:

The polyethers are more susceptible to thermo-oxidative attack than are the polyesters. Consequently, polyesters are recommended for use at higher operating temperatures, at least in the absence of moist conditions. Under moist conditions, one must balance the oxidative stability vs. the hydrolytic stability of the polyurethanes (polyether vs. polyester).

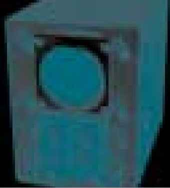
Oxidative stabilizers are frequently added to polyether elastomers used in high-temperature service.

A final word

In comparing elastomer properties of polyurethanes, evaluate them at the same hardness. Three hardness points can make a significant difference in modulus, elongation, and other properties.

Remember, too, that properties such as hardness, stress/strain, Bashore rebound, tear strength, compression set, and compression modulus are rather reproducible and can be related to end-use applications.

Other properties such as DeMattia flex endurance and abrasion are not always reproducible or easily related to end-use applications. Suppliers often do not publish “typical” DeMattia flex and “typical” abrasion properties. They merely describe these properties as being excellent, good, or failing. ▲



Trouble Shooting Guide for Field Failures: Swelling

OVERVIEW

Polyurethane elastomers will swell when exposed to certain solvents. This swelling can range from a few percentages in mild cases to several hundred percentages in severe cases.

POTENTIAL CAUSE

The overwhelming cause of swelling is exposure to solvents, materials which are incompatible with the polyurethane system. In addition, solvents used at elevated temperatures further accelerate the problem. The proper specification of polyurethane for the specific solvent is critical.

SOLUTIONS

1.) Choose the Proper Elastomer

Generally, polyether-based elastomers are the proper choice for high humidity and water applications. Polyesters, on the other hand, are generally used for applications where there is the potential for exposure to oil-based solvents.

2.) Shield the Elastomer from the Solvent

In cases where the elastomer is being splashed by the solvent, it may be possible to mechanically shield the part from the solvent.

3.) Test the Elastomer Before Field Exposure

Testing the elastomer with the correct solvent before field application is recommended. It is a simple test—simply immerse a known weight of elastomer into a container filled with the desired solvent at the desired temperature for an extended period of time. At the conclusion of the test, reweigh the elastomer to determine the uptake of solvent. If plaques of the proper thickness are used, standard ASTM tensile and tear tests can also be performed. ▲

Airthane® PHP-70A and Airthane® PST-70A Prepolymers

Excellent Choices for Soft Applications

In response to several customer questions, we recommend that you use Air Products' Airthane PHP-70A (polyether) and Airthane PST-70A (polyester) prepolymers for soft applications (70 Shore A). Plus, neither requires additives.

For example, Airthane PHP-70A prepolymer is a cost-effective, high-performance soft polyether. PHP-70A prepolymer has excellent dynamic performance and compression set.

In addition, elastomers made with Airthane PHP-70A prepolymer remain soft at lower use temperatures and offer easier processability due to a decreased melting point and dramatically lower viscosity. See the above table for typical properties for both prepolymers.

For more information on Airthane PHP-70A and PST-70A prepolymers, visit our website, www.airproducts.com/psp. ▲

Table 3: Typical Properties for Airthane® PHP-70A and Airthane PST-70A Prepolymers

TYPICAL PREPOLYMER PROPERTIES	AIRTHANE PHP-70A	AIRTHANE PST-70A
NCO%	2.1	2.1 to 2.6
Viscosity (cPs) @ 70 °C	1000	4500
TARGET ELASTOMER PROPERTIES (MBOCA-CURED AT 95% STOICHIOMETRY)	AIRTHANE PHP-70A	AIRTHANE PST-70A
Hardness, Shore A	70	72
Tensile modulus, psi		
100%	350	400
300%	550	600
Elongation, %	650	800
Ultimate tensile, %	1300	6000
Rebound, %	60	40
Die C tear resistance	200	280
Split tear resistance	30	70
Compression set, %	25	40

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