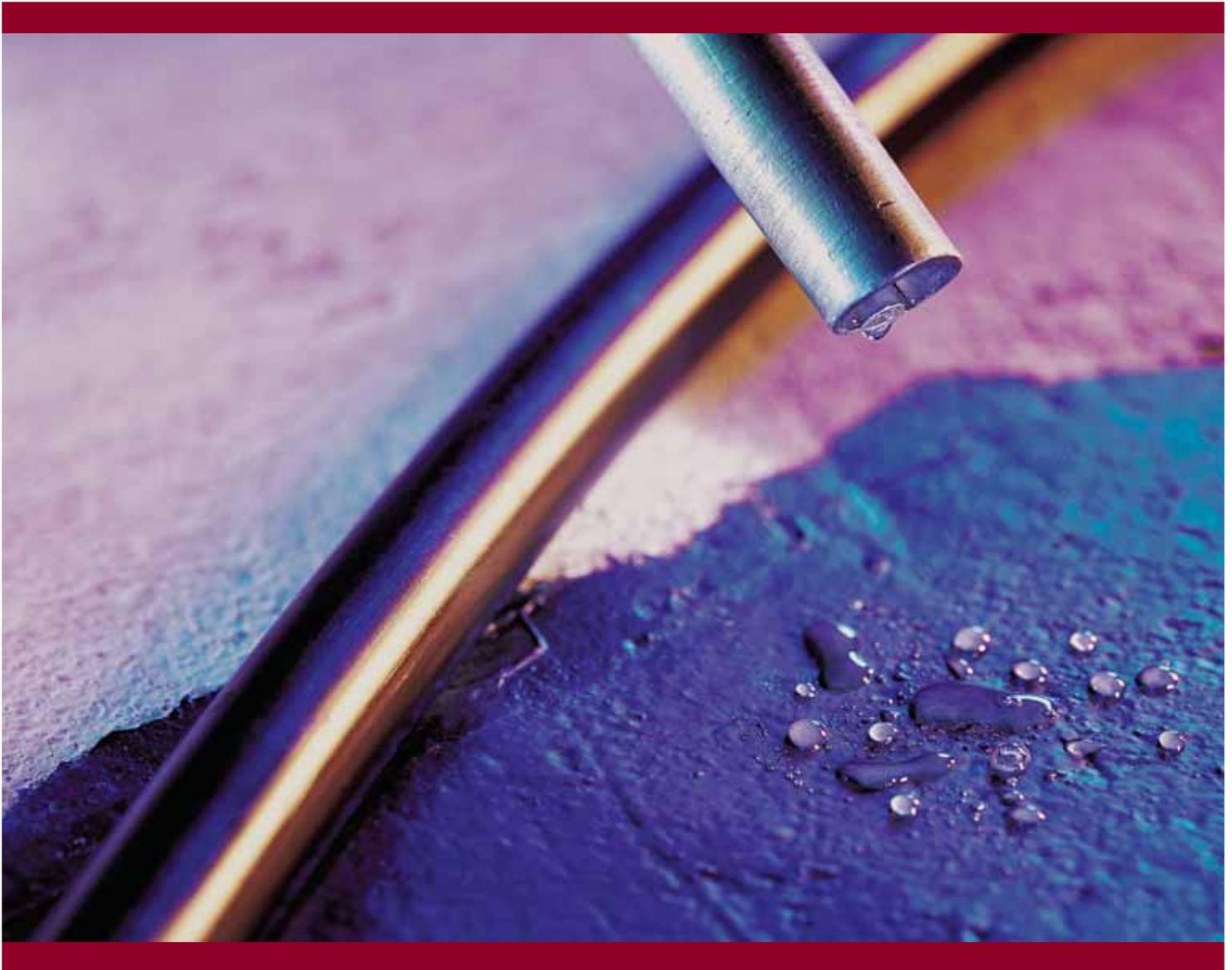


HUNTSMAN

Enriching lives through innovation

 **COATINGS**
Polyurea Spray



SUPRASEC® MDI
FOR PROTECTIVE SYSTEMS



PART 1

The concept of polyurea spray elastomer technology was introduced about 20 years ago by chemists at Texaco Chemical Company (now Huntsman Corporation) in Austin, Texas. This new application was based on the reaction of an isocyanate component with an amine blend to produce a polyurea elastomer system.

Since this seminal work, a number of advances in both the chemistry and application equipment for polyurea have enabled polyurea elastomer coatings to compete with (and often displace) their traditional counterparts in the commercial arena. Legislation regarding volatile organic compounds (VOC) in coatings has further heightened market interest in polyurea coatings.

This brochure provides the coatings expert and novice alike with background starting-point formulation and application information for these unique polymer systems.

The concept

The catalyst-free isocyanate/amine reaction is normally rapid, proceeding to completion within a few seconds. Working times (“gel times”) generally fall within the sub-five-second range, thus requiring specialised mixing and application equipment. High pressure two-component spray machines equipped with impingement mixing have proven efficient and entirely adequate for sufficient blending and rapid dispensing of the polyurea raw materials. It is chiefly this equipment that allows polyurea technology to venture outside of the realm of Reaction Injection Molding (RIM).

Definition

A polyurea coating/elastomer is derived from a reaction of an isocyanate component and a resin blend component. The isocyanate can be aromatic or aliphatic in composition. It can be a monomer, polymer, or any variant reaction of isocyanates quasi-pre-polymer, or a pre-polymer. The pre-polymer or quasi-pre-polymer can be made of an amine-terminated polymer resin, or hydroxyl-terminated polymer resin. The resin blend must be made up of amine-terminated polymer resins, and/or amine-terminated chain extenders. The amine-terminated polymer resins will not have any intentional hydroxyl moieties. Any hydroxyls are the result of incomplete conversion to the amine-terminated polymer resin. The resin blend may also contain additives, or non-primary components. These additives may contain hydroxyls, such as pre-dispersed pigments in a polyol carrier. For clarification purposes, a polyurethane/polyurea hybrid is a reaction of an isocyanate with a resin blend. The resin blend will contain an amine-terminated polymer resin and a hydroxyl containing polyol. It may or may not contain catalysts.

Technology

Polyurea spray elastomers can be formulated from ingredients which produce either conventional or light-stable products. Conventional polyureas use JEFFAMINE® polyetheramines with aromatic SUPRASEC® isocyanates and

chain extenders, and therefore will develop the characteristic amber or yellow colour when exposed to sunlight. However, unlike with polyurethanes, no chalking or cracking is observed in polyureas. Pigmentation, for example carbon black, improves the resistance to discoloration and masks its effects.

Polyurea spray elastomers based on JEFFAMINE® polyetheramines, aliphatic isocyanates and amine chain extenders are light stable and do not change colour or chalk in sunlight. As would be expected, light-stable polyureas are more expensive than those based on conventional products, due to higher costs of raw materials.

The “Polyurea advantage”

Polyurea elastomer coatings offer many advantages over their traditional counterparts (i.e. polyurethanes, polyurethane-urea hybrids). The following list highlights a number of polyurea’s advantages.

1. **Fast cure.** Polyurea can be sprayed on sloped (and even vertical) surfaces without drip or run formation. Foot traffic can resume on coatings applied to horizontal surfaces within 30 seconds.
2. **Water insensitivity.** Relative moisture and temperature insensitivity during application. Little effect is encountered on adhesion or coating performance due to weather variations (i.e. high humidity, temperature and residual moisture).
3. **100 % solids.** Two-component, one-coat system can be sprayed and poured at 1:1 volume ratio. Eliminates the need for multi-coat applications. It is environmentally friendly.
4. **Excellent physical properties,** including tensile strength, tear strength and elongation. (See page 8)
5. **Thermal stability.** Stable up to 150°C.
6. **Pigment compatible.** Colorants can be added to change appearance and light-stability.
7. **Formulation flexibility.** Can be formulated into products ranging from soft to hard elastomer.
8. **Reinforcible** fibres and fillers can be incorporated during application.



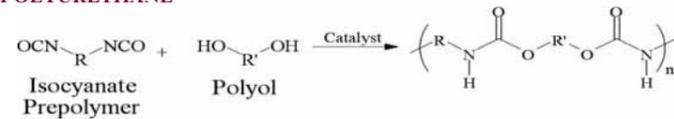
Sprayed polyurea elastomers have exhibited excellent adhesion to clean substrates such as concrete, wood, asphalt and fresh blasted steel. However, as with other rapid cure coatings, the rapid cure of polyurea systems can sometimes limit surface wetting and penetration of substrate surfaces for mechanical bonding. For this reason the end users are advised to test the adhesion of the sprayed elastomer films on target substrates to assess bonding of the coating, Surface primers and adhesion promoters may be necessary. In addition, because the polyurea film exhibits such robust physical properties and remains intact as it is pulled from the substrate's surface, greater adhesion may be necessary for specific applications.

Basic chemistry

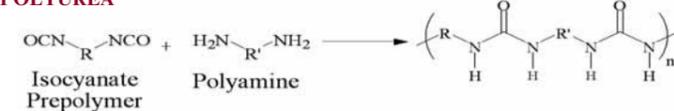
Polyurea systems have been defined as the reaction of an isocyanate or isocyanate pre-polymer with a resin blend that consists of amine functional species.

A key advantage of polyurea spray coatings is that the amine/isocyanate reaction is very fast, predictable and consistent. In contrast, polyurethane elastomers require high levels of catalyst packages which can cause degradation of the elastomer and usually possess tight processing parameters such as temperature and humidity ranges. The following figure offers a structural comparison of generic polyurethanes and polyureas.

POLYURETHANE



POLYUREA



While polyols are often utilised in the construction of isocyanate pre-polymers used in polyurea spray systems, these specialty pre-polymers, such as Huntsman's line of SUPRASEC® isocyanates, are produced without the catalysts that are usually required to promote the reaction of isocyanates and polyols. Polyols are not to be added into the amine resin blend if the elastomer is considered to be a true polyurea. Polymer systems that do incorporate polyols into the resin blend are commonly referred to as "hybrid systems". The term hybrid refers to the presence of both polyurea and polyurethane linkages within the system, and it should be noted that on many occasions these materials do not offer the same performance or processing profiles as true polyureas.

Typically, aromatic SUPRASEC® isocyanates are reacted with JEFFAMINE® amines and diethyltoluene diamine (DETDA).

The SUPRASEC® isocyanate component functions as the system's rigid "hard block" while the JEFFAMINE® amine segments are commonly referred to as the system's "soft block".



These specialty amines generally possess soft, flexible polyoxypropylene backbones that significantly contribute to the hydrophobic/waterproof nature of the respective polyurea coatings. These alternating hard block/soft block polymer units are linked by DETDA, which is commonly referred to as the "chain extender" of the system.

Spray equipment

Processing of spray polyurea coatings requires specialised, high pressure/high temperature impingement mix equipment. The capability of heating the components prior to mixing is a key attribute of the spray equipment, as it was found that heating of the materials prior to spray was necessary to reduce system viscosity (i.e. the isocyanate amine resin blend components). Viscosity reduction improves the mix, flow, and leveling of the applied material and leads to significant improvements in the performance and appearance of the coating. To ensure proper mixing, it was found that the use of a high-pressure proportioner and a spray or pour gun are essential.

Application areas

The concept of instant, high-performance coatings has attracted the interest of many who possess an entrepreneurial spirit, as well as those with vivid imaginations. In the infancy of this new polyurea technology, spray applications of structures and objects too numerous to fully list, were attempted. As already mentioned, the reaction of the isocyanate component with the amine blend is generally a very rapid, predictable reaction. The fast reactivity allows for rapid return to service for coating application work.

The current polyurea technology allows the preparation of both aromatic and aliphatic (light stable) elastomer systems. By selecting the appropriate isocyanate component and amine blend, a variety of system reactivities is possible. Slower systems can be utilised for a variety of sealant/caulk-type applications.

Given these attributes, polyurea elastomer systems are well-suited for a myriad of application areas including pipeline coatings, secondary containment, synthetic stucco coatings, concrete coatings, railcar coatings, foam and EPS coatings, tank linings, part production, truck bed liners, various waterproofing applications and floor joint/seam sealants. In addition to these uses, polyurea continues to be evaluated for use in numerous niche applications that require high performance coatings with near-immediate return to service.

Recent European projects cover applications such as trading hall flooring, secondary containment in harbour areas, anti-abrasion coatings on sieves, pipeline coatings, road marking, truck bed lining.



PART 2 RAW MATERIALS

Polyurea elastomer systems are based on formulations that can be finely tuned for an application. Just as in a complex cooking recipe, a number of chemical ingredients (raw materials) are incorporated into this two-component system. It is not uncommon to utilise 5 or 10 function-specific additives in addition to the isocyanate component and amine blend. Below is a brief summary of the types of reagents that are commonly incorporated into polyurea formulations. In part 3, entitled "Polyurea Physical Properties", specific admixtures are presented and the impact of their varying constitutions on coating performance and properties discussed.

Resin blend

The amine blends used in the application of polyurea elastomer systems are often referred to as the resin blend. As mentioned in part I, the resin blend's multi-functional, amine terminated-polyethers and chain extenders are used in conjunction with the quasi-isocyanate pre-polymers. At the heart of the resin blend mixture are Huntsman's JEFFAMINE® polyetheramines and JEFFLINK® chain extender. JEFFAMINE® polyetheramines are amine-terminated ethylene oxide and propylene oxide-based polyethers exhibiting molecular weights from ~ 200-5000 g/mole. JEFFLINK® products are cycloaliphatic amine products that have been designed to give slower reaction times in elastomer/coating systems. Suitable JEFFAMINE® amines and JEFFLINK® diamine products for polyurea elastomer technology include:

Product	Approx. molecular weight	Approx functionality amine group
JEFFAMINE® T-5000 amine	5000	3
JEFFAMINE® D-2000 amine	2000	2
JEFFAMINE® T-403 amine	400	3
JEFFAMINE® D-400 amine	400	2
JEFFAMINE® D-230 amine	230	2
JEFFLINK® 754 diamine	250	2

Resin components' viscosities range from about 800 to 1000 mPa.s at 25°C and 140 to 170 mPa.s at 65°C.

Because of their backbone and structure type, JEFFAMINE® polyetheramines are largely responsible for the low moisture vapor transmission rates in the corresponding polyurea systems. The primary amine groups in these molecules react rapidly and consistently with the isocyanate components, obviating the need for catalysts.

New JEFFAMINE® SD-secondary polyetheramines.

Product	Approx. molecular weight	Approx functionality amine group
JEFFAMINE® SD-231 amine	315	2
JEFFAMINE® SD-401 amine	515	2
JEFFAMINE® SD-2001 amine	2050	2

JEFFAMINE® SD-231 amine, JEFFAMINE® SD-401 amine and JEFFAMINE® SD-2001 amine are high content, secondary aliphatic, liquid polyether-diamines. The secondary amine functional groups provide a slower reaction compared to primary amines, capable of slowing down the cure speed of polyurea/polyurethane elastomeric coating systems. Designed to be used in conjunction with aromatic or aliphatic chain extenders, or to partially replace existing primary polyether amines, they can improve the flexibility and colour of aromatic formulations, while reducing the overall cost of development. As low viscosity liquids, these new secondary aliphatic diamines allow the efficient formation of much lower viscosity isocyanate prepolymers, with properties equivalent to primary polyetheramines or polyols used. The products are stable and there is no off-gassing of reversible blocking agents. They can also expand the formulation capabilities of aspartic esters and aromatic formulations at a lower cost, with equivalent performance properties.

Secondary aliphatic polyetheramines also enable the formation of high hardness aromatic and aliphatic systems while maintaining flexibility and good cure speeds at a reasonable cost.

Isocyanate component

The isocyanate component is a soft block quasi-pre-polymer based on commercially available isocyanates, such as MDI for aromatic systems and IPDI for aliphatic systems. Viscosities of the isocyanate quasi-pre-polymer components vary with the formulations employed and are typically under 3000 mPa.s at room temperature (25°C) and under 500 mPa.s at normal processing temperatures of 65°C.

Isocyanates	Description	%NCO	Viscosity at 25°C mPa.s	Average functionality
SUPRASEC®2008	Low-functional pre-polymer	10.2	1800	2.0
SUPRASEC®2054	Low-functional pre-polymer	15.0	775	2.0
SUPRASEC®2058	Low-functional pre-polymer	15.4	850	2.0
SUPRASEC®2067	Higher-functional pre-polymer	19.3	610	2.2

The SUPRASEC® MDI grades are designed to be used in polyurea applications, ensuring extremely good miscibility with the resin blends and therefore provide a constant reactivity profile.

Isocyanate analysis in polyurea spray applications

The following examples are all performed at below-process parameter:

Processing	Index	Value
	Ratio isocyanate/resin	1.00 v/v
	Application temperature	75-80 °C
	Application pressure	150-180 bar

Standard base formulation

Isocyanate	SUPRASEC® 2054	100 pbw
Resin blend	JEFFAMINE® D-2000 amine DETDA	74.0 pbw 26.0 pbw
Typical properties	Gel time	3 sec.
	Tack free time	7 sec.
	Tensile @break	15.6 MPa
	Elongation @break	349 %
	Angle tear	63 N/mm
	Trouser tear	34 N/mm
	Hardness	96 Shore A 50 Shore D

- Advantages:**
- very high flexibility
 - relatively high strength
 - very low shrinkage

- Advantages:**
- relative high flexibility combined with high strength
 - good tear resistance
 - good chemical resistance

Soft flexible system

Such soft formulations are used to produce for example elastomeric truck bed linings, roof coatings and flexible membranes.

Isocyanate	SUPRASEC® 2008	100 pbw
Resin blend	JEFFAMINE® T-5000 amine JEFFAMINE® D-2000 amine DETDA Pigment	16.0 pbw 59.5 pbw 14.5 pbw 10.0 pbw
Typical properties	Gel time	13 sec.
	Tack free time	25 sec.
	Tensile @break	13 MPa
	Elongation @break	638 %
	Angle tear	46 N/mm
	Trouser tear	20 N/mm
	Hardness	75 Shore A 25 Shore D

Standard high strength system

Similar formulations are used to produce secondary containment coatings, floor coatings, waterproofing membranes and truck bed lining.

Isocyanate	SUPRASEC® 2054	100 pbw
Resin blend	JEFFAMINE® T-5000 amine JEFFAMINE® D-2000 amine DETDA Chain extender Adhesion promoter Pigment UV-stabiliser	6.0 pbw 53.5 pbw 20.5 pbw 8.0 pbw 1.0 pbw 10.0 pbw 1.0 pbw
Typical properties	Gel time	5 sec.
	Tack free time	7 sec.
	Tensile @break	21 MPa
	Elongation @break	312 %
	Angle tear	71 N/mm
	Trouser tear	41 N/mm
	Hardness	94 Shore A 47 Shore D

High hardness system

Such a system is required and used for corrosion protection and abrasion resistance.

Isocyanate	SUPRASEC 2067	100 pbw
Resin blend	JEFFAMINE® T-5000 amine	8.0 pbw
	JEFFAMINE® D-2000 amine	25.0 pbw
	DETDA	8.0 pbw
	JEFFAMINE® D-400 amine	20.0 pbw
	Chain extender	32.0 pbw
	Pigment	6.0 pbw
	Adhesion promoter	1.0 pbw
	Typical properties	Gel time
Tack free time		18 sec.
Tensile @break		16 MPa
Elongation @break		171 %
Angle tear		117 N/mm
Trouser tear		35 N/mm
Hardness		97 Shore A

Advantages:

- very high hardness
- moderate flexibility combined with strength
- very high tear resistance
- good chemical resistance
- very low water uptake

Chain extenders

A second set of amine reagents, referred to as “chain extenders” play a key role in both processing time and the ultimate properties of the respective coatings. As with isocyanate components, chain extenders can be either aliphatic or aromatic in nature. Aliphatic species are utilised in applications where light stability is a high priority. However these chain extenders are significantly more expensive. Listed are common chain extenders used in polyurea elastomer systems: ETHACURE® 100, LONZACURE® 80, UNILINK® 4200, ETHACURE® 300, CLEARLINK® 1000, JEFFLINK® 754 Diamine.

JEFFLINK® 754 diamine, available from Huntsman, was originally developed for use as UV stable chain extender in aliphatic polyurea, but it may also be used as partial or complete replacement for aromatic chain extenders such as UNLINK® 4200. By replacing aromatic chain extenders with JEFFLINK® 754 diamine, or with the new secondary polyetheramines, it is possible to formulate aromatic systems with high hardness while maintaining good flexibility, and good cure speed at a reasonable cost. It also improves initial coating color. More information is available on request.

Replacement of UNILINK® 4200 additive with secondary amines in aromatics. All formulations based on US-origin aromatic isocyanate RUBINATE® 9480

Reference No.	8276-72	8314-12	8276-92
JEFFAMINE® D-2000 amine	53	55	53
JEFFAMINE® T-5000 amine	10	10	10
DETDA	22	22	22
JEFFAMINE® SD-231 amine	0	0	10
JEFFLINK® 754 curing agent	0	8	0
UNILINK® 4200 additive	10	0	0
TiO2	5	5	5
Tensile strength, MPa	20.0	18.4	17.7
Max Elongation, %	637	606	653
100% Modulus, MPa	7.7	7.3	6.9
300% Modulus, MPa	11.3	10.8	10.0
Tear strength, N/mm	88.6	83.3	83.7
Shore D, 0 sec/10 sec	50/41	51/43	52/41
Spray, Gel Time, sec	6	7	7
Tack Free, sec	12	11	11,5

- Secondary aliphatic amines can partially replace UNILINK® 4200 additive.
- Reduces cost and improves the initial coating color.

Slower amines may be used to fine-tune the reactivity of spray systems to control surface appearance and improve physical properties.

Other additives

The resin blend mixture can contain a host of other additives that serve a variety of functions in the ultimate polyurea elastomer system. When needed by certain difficult substrates, silane based adhesion promoters can be used. For applications where a good rough morphology is desired (e.g. truckbed liners), texturing agents such as washed sand or calcium carbonate can be incorporated. For caulk applications a thixotrope such as fumed silica is required to maintain dispersion of the other resin blends. A variety of UV-stabilisers and anti-oxidants are also formulated into coatings by adding the resin blend side. Polyurea elastomer technology is also amenable to the use of pigments and colorants.

A number of JEFFAMINE® polyetheramine-based pigments dispersions are available. These offer a wide range of possible coating colours.

Polyurea system availability

Huntsman manufactures and sells the family of JEFFAMINE® polyetheramines, JEFFLINK® chain extenders and SUPRASEC® methyl-diisocyanates (MDI) that are key ingredients in polyurea.

Formulators can supply the technical service support and work with their applicator customers, supplying materials designed to meet the specific needs of the applications.



PART 3 POLYUREA PHYSICAL PROPERTIES

Chemical resistance testing for polyurea spray elastomers

Polyurea spray elastomer systems are 100 % solids, two-component spray systems which have extremely fast reactivities and cure times. This technology is similar to the high-performance polyurethane systems currently used, except in several key areas. In the polyurea spray technology, JEFFAMINE® polyoxyalkylene diamines and triamines have replaced the polyols, amine chain extenders are utilised, and catalysts have been eliminated.

Elastomer systems based on polyurea technology are good candidates for coating and non-coating applications. In each application type, the chemical resistance of the material could be of major importance

There are many factors which affect the chemical resistance of elastomer systems including:

- Elastomer system formulation
- Service conditions
- Chemicals/impurities present in the system components

Tables 1 and 2 describe the chemical resistance of polyurea polymers. The polyurea systems utilised are standard spray elastomer systems, including both aromatic and aliphatic based elastomers. It is believed that these systems give a good representation of each particular type technology. For testing purposes, both ASTM D1308 and ASTM D3912 methods were utilised. These tests were performed at 25°C with visual observations being noted at the end of the test procedures. Because of the simplicity of these tests and due to the factors listed above - which are beyond the control of Huntsman - no guarantee or warranty concerning the use of these elastomer systems is either intended or implied, thus the chemical resistance should be determined on actual polyurea elastomers that are to be used. These test results are reported to serve as a guide to the applicability of polyurea spray elasto-

mers in a variety of applications. It is the responsibility of each system supplier and/or end user to assess the suitability of polyurea spray elastomers for specific applications.

ASTM D 1308: Effect of household chemicals on clear and pigmented organic finishes.

This test describes the “spot test” or “watch glass” method to simulate exposure of the coating through possible spillage. Each chemical was in contact with the elastomer system for a period of seven days, except where noted. Daily visual observations were made on the elastomer and additional chemical was added as needed. The tested area was covered with a watch glass to inhibit evaporation and /or contamination of the chemicals.

Table 1: Chemical resistance ASTM D 1308		
Chemical	Aromatic polyurea	Aliphatic polyurea
Acetone	A	A
Brake Fluid	B	C
CLOROX®, 10 %	NR1	A
Dimethyl formamide	NR	NR
Gasoline, unleaded	A	A
Hexane	A	A
Hot tub water 2	B	A
Hydraulic oil	A	C
JEFFAMINE® D-400	NR	NR
Methanol	A	C
5% Methanol/gasoline	A	C
Motor oil	B1	B1
Propylene carbonate	C	C
Sodium hydroxide 5%	A	A
10%	A	A
25%	A	A
50%	B'	B'

Sulfuric acid, 5%	A	B
10%	B	B
50%	NR	NR
conc.	NR3	NR3
Vinegar, 5% acetic acid	A	B
Water	A	A

A	No visible damage
B	Little visible damage
C	Some effect-swelling, discolouration, cracking
NR	Not recommended
E	Swelling, <24 hrs
1	Some discolouration only
2	Brominated water
3	Less than 24 hour exposure

ASTM D 3912 :
Chemical resistance of coating used in light-water nuclear power plants.

This test method describes the immersion method of exposure for a coating system to chemicals. In this testing procedure, a black pigmented aromatic polyurea spray elastomer system was used. This system was spray-applied to 2 mm blast profile steel panels, giving total encapsulation. These coated panels were then immersed half way into individual chemicals for a period of 1 year at 25°C, except were noted. The panels were then removed and inspected.

Table 2 Chemical resistance ASTM D 3912			
Methanol	D	Sulphuric acid/5 %	A
Gasoline	C	Sulphuric acid/10 %	A
Diesel fuel	A	Hydrochloric acid/5 %	A
Toluene	E	Hydrochloric acid/10 %	A
MTBE	B	Phosphoric acid/10 %	A
5% MTBE/gasoline	B	Ammonium hydroxide/10 %	A
Motor Oil	C	Ammonium hydroxide/20 %	A
Hydraulic fluid	A	Sodium hydroxide/10 %	A
2-Methylbutane	A	Sodium hydroxide/ 20 %	A
Water/Room temperature	A	Sodium hydroxide/50 %	C
Water/82°C, 14 days	A	Sodium hydroxide/1%,50°C, 14 days	C
10% NaCL/water/room temp	A	Potassium hydroxide/10 %	A
10% NaCL/water/50°C, 14 days	A	Potassium hydroxide/20%	C
10 % Sugar/water	A	Acetic acid/10%	A

A	No visible damage
B	Slight surface change
C	Slight surface discolour, no hardness loss
D	Swelling, <48 hrs
E	Swelling, <24 hrs

In addition to the chemical resistance chart above, we have included a comparative polymer guide (Table 3) to familiarise customers with the relative performance ranking of the polyurea chemistry with other available polymer systems. The information described here, along with Table 2, can be regarded as a general guide to the chemical and performance benefits of polyureas.

Table 3: Comparative polymer performance							
Performance type	Polyurea	Polyurethane	Polyester	Epoxy	Vinyl ester	Acrylic	Polysulfide
Physical strength	Low-High	Low-Mid	High	High	High	Mid-High	Low-Mid
Elongation	High	High	Low	Low	Low	Low-Mid	High
Impact resistance	High	Mid-High	Mid	Mid	Mid	Mid-High	Mid-High
Abrasion resistance	High	Mid-High	Mid-High	Mid-High	Mid-High	Mid-High	Mid
Adhesion to concrete	Low-High	Low-Mid	Mid	High	Mid	Low-Mid	Low-Mid
Cure shrinkage	Low	Low	High	Low	High	High	Low
Permeability	Low	Mid-High	Low	Low	Low	Low-Mid	Mid-High
UV resistance	Mid-High	Low-High	Mid-High	Low	Mid	High	High
Creep	Low	High	Low-Mid	Low-Mid	Low-Mid	Low-Mid	High
Temperature limit	Low-High	Mid	Low-Mid	Mid-High	Mid-High	Mid	Low-Mid
Chemical resistance							
Mineral acids	Low-Mid	Low-Mid	Mid-High	Mid-High	Mid-High	Mid	Low-Mid
Organic acids	Mid	Low-Mid	High	Mid	High	Mid	Low-Mid
Alkalis	Mid-High	Low-Mid	Mid	High	High	High	Low-Mid
Chlorinated solvents	Low-Mid	Low-Mid	Low-Mid	Low-Mid	Mid-High	Low-Mid	Low-Mid
Oxygenated solvents	Low-Mid	Low-Mid	Low-High	Low-High	Mid-High	Low-High	Low-Mid
Hydrocarbon solvents	Low-Mid	Low-Mid	Mid-High	Mid-High	Mid-High	Low-High	Low-Mid
Salts	High	Mid-High	High	High	High	High	Mid-High
Water	High	Low-High	Mid-High	Mid-High	Mid-High	Mid-High	Low-High

Health and safety

Potential health and safety hazards associated with the spray application described in this bulletin may arise from both the toxicological properties of the chemical components and from the mechanical aspects of the high pressure equipment involved. Before undertaking any spray work, the applicator should be thoroughly familiar with the safe operation of the equipment and should follow all instructions and safety precautions provided by the manufacturer of the equipment. Particular care should be taken that the spray nozzle is never directed towards anyone's face or body during operation. Under normal equipment operating conditions, the isocyanate component and the resin component of the polyurea spray system react almost instantaneously so that there is no excess of either isocyanate or amine exiting from the spray nozzle. However, even under ideal operating conditions, very small amounts of unreacted MDI (4, 4'-diphenylmethane diisocyanate), or IPDI (isophorone diisocyanate) – depending on the formulation of the isocyanate component, or DETDA (diethyltoluene diamine) or IPDA (isophorone diamine) – depending on the formulation of the resin component, may be present as an aerosol or vapour. Prior to handling or using any component of a polyurea spray system or engaging in polyurea spray work, the manufacturer's Material Safety Data Sheet (MSDS) for both the isocyanate component and the resin component should be reviewed for their recommendations for appropriate respiratory and dermal protection measures when handling, using or spraying their products. Additional information available from Huntsman about safe handling of the different components should be consulted as well. To minimise any risk due to exposure to chemicals used or the particulate matter created in polyurea spray applications, spraying should be done only in a well-ventilated location (either outdoors or by use of mechanical fans), or in a properly ventilated spray booth. Applicators should wear the appropriate personal protective clothing and equipment. In areas with poor ventilation, or where oxygen supply is at risk, supplied air breathing equipment must be worn.

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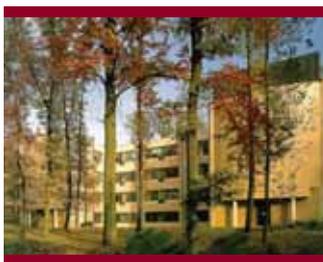
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The Huntsman story

Global resources for local needs

Huntsman Polyurethanes is a business division of Huntsman Corporation. Huntsman is a global manufacturer and marketer of differentiated chemicals. Its operating companies manufacture products for a variety of global industries including chemicals, plastics, automotive, aviation, textiles, footwear, paints and coatings, construction, technology, agriculture, health care, detergent, personal care, furniture, appliances and packaging. Originally known for pioneering innovations in packaging, and later rapid and integrated growth in petrochemicals, Huntsman today has 14,000 employees and 78 operations in 24 countries. The company had 2006 revenues of over \$ 13 billion.

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