

Polyurea Spray Coating Systems

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The prospects of landing a major coating application loomed before the contractor who could meet the requirements of the job. But how could these areas be efficiently coated/repared in a seven-day-a-week, 10 - 14 hour-a-day, setting without closing some portion of the area use or daily traffic? It was clear that by preparing and installing repairs on a limited area during each work cycle, partial openings could be accomplished. The problem however was in finding a repair material that could be installed during off-hours and would be cured with minimum downtime. The needs of the customer required that the installations be not only tack free, but also have the ability to return the area to normal service.

It was early 1993 and the selection of coating materials, which could meet the needed specifications, was exceedingly meager. Polymer systems based modified polyurethanes, epoxies, methacrylates, polysulfides or silicones might be products to consider except that curing times, which at best, ranged into the 12 hour time zones with many in the 24+ hour zones. None of these products could fully meet the restraints of the project.

During this time, a handful of products were being developed based on a polymer chemistry referred to as polyurea. Cure times of 1 to 3 hours were being touted with product properties for installation and repair that met or exceeded most polyurethane, epoxy and silicone based technologies. What are these new polyurea polymers for coating applications?

Polyurea Chemistry

In the early 1980's, several discoveries and advancements in elastomeric polymer chemistry were made based on reactive amine terminated resins and high performance isocyanate prepolymers. These resulting polymer systems were referred to as polyureas and had certain characteristics suitable for rapid process applications. The major application being Reaction Injection Molding (RIM) for automotive body panel part production. Certain characteristics of this technology could prove useful if utilized in coating applications. Some of these are:

- Fast, consistent reactivity and cure;
- Moisture and temperature insensitivity during processing;
- Excellent physical properties / elastomeric qualities;
- Very low water absorption qualities, hydrolytically stable;
- High thermal stability;
- Auto-catalytic, no solvents.

While this technology became very well suited for RIM applications, applying this concept to coating applications became the task at hand. The typical 2 - 3 sec gel times of these polyurea RIM systems makes for very difficult conventional spray processing techniques. System modifications were required to slow the effective reactivities without compromising the unique characteristics and performance properties of these polyurea elastomer systems.

By 1990, the development of polyurea spray systems had progressed to a point where the possibility of use as coatings and sealants was foreseeable. The prospects of a moisture and temperature insensitive product with extremely rapid curing properties continued to lure formulators into the chemistry.

In 1993, there were several polyurea and hybrid polyurea products on the market, which were generally consistent in application and performance. These products exhibited characteristics such as those set forward previously. The pot life or working times for these coating systems is limited to < 1 minute. This definitely classifies the products as technical but by using proper installation procedures and equipment, polyurea systems can be considered a viable alternative to many coating materials. Cure times ranging from 1 to 3 hours made these types of products the only possibility for the maintenance requirements of many situations. The discovery that product curing will take place in temperatures as low as -40°F without significant changes in developed properties opens many new avenues for efficient repair in cold conditions. The further discovery that the ultimate properties of the products could be varied in a controlled manner through varying the chemical makeup, without loss of the desirable qualities. This has led to the development of products for various uses ranging from high impact to high thermal cycling installations.

Coating Systems

The use of polyurea systems as spray coatings has been made possible through the development of proper application equipment. These polyurea systems must be processed through high pressure, high temperature impingement mix type equipment in order to achieve the optimum atomization and qualities for a coating. These systems are generally much faster in reactivity and are unaffected by changes in humidity and ambient temperature.

For coating applications, the elastomer system must have excellent mechanical properties to insure extended serviceability. These systems must also be stable to their environments. Not only is the performance of the elastomer system important, but the material should be able to be easily applied in a variety of conditions and give comparable performance. The elastomer system should also be free of volatile compounds that could be released into the environment.

The variety of available fast set spray polyurea elastomer coating systems addresses these concerns for many coating applications. These fast set spray materials can be applied as low as -40°F with the ability to open the area to service within 1 hour. Excellent substrate adhesion is also noted. Coated substrate service temperature can easily approach 400°F without any detrimental affect to the coating system. Table I gives an overview of the typical performance of these coating systems.

Table I
Polyurea Spray Elastomer Systems

<u><i>ASTM Test</i></u>	<u><i>Typical Physical Properties</i></u>
Shore Hardness	Shore A 30 to Shore D 65
Elongation, %	Up to 800
Tensile strength, psi	Up to 4000
Tear strength, pli	250 - 600
100% Modulus, psi	900 - 2000
300% Modulus, psi	1000 - 3000
Taber Abrasion, mg loss (1000 gms, 1000 revs, H-18 wheels)	< 200
Flexibility / Crack Bridging, -26°C	> 1/8 inch, pass
Moisture Vapor Transmission, perms @ 30 mils	0.025
CLTE	4 - 13.4 X 10 ⁻⁵ mm/mm/ ° C
Dielectric constant, 1Mhz	3.5 - 4.5
Gel time, sec	2 - 15
Tack free, sec	10 - 60
Open to traffic, hours	1
Elcometer Adhesion, psi	
concrete, dry	400
concrete, primed	> 400
steel, 2 mil blast	> 2000

As one can see, this new technology of polyurea coating systems has high potential for limitless degrees of application and versatility in concrete, metal and wood coating applications. Other applications include flooring, decking, secondary containment, corrosion protection and moisture barrier systems. Given the fast reactivity and cure as well as the 100% solids nature of the polyurea elastomer technology, repairs can be made in food contact applications. No fugitive materials are present in the technology that would contaminate foodstuffs. USDA self-approval is possible for these incidental food contact applications.

The drawback? Well, polyurea system should not be used as the sole coating / lining system in areas where there is a highly acidic environment or strong solvents. This is due to the polyether backbone structure of the polymer. Strong oxidizing environments should also be avoided as this will cause breakdown of the system, especially aromatic based products. This would include swimming pool applications where high content of chlorinated or brominated water.

The Polyurea Advantage

One may ask, why use the polyurea elastomer technology over conventional coating technologies? There are several reasons as mentioned in the previous text. The most important being that this technology is 100% solids, **NO Volatile Organic Compounds (VOC's)**. During application and once the material is applied, no vapors, fumes or chemicals are released. This makes the technology applicable for confined space application as well as coating in food processing/ handling applications.

With respect to 100% solids, polyurea elastomer systems contain no catalyst for cure development even down to ambient temperatures of at least -20°C. System which require a type of catalyst for cure, i.e. polyurethanes and some epoxies, are adversely affected by low ambient temperatures. Polyurea elastomer systems cure readily at a broad range of ambient temperature conditions.

The lack of a catalyst also gives improved performance when exposed to UV light. The catalyst in a system will promote polymer degradation when the system is exposed to high temperatures or UV light. Polyurea elastomer systems exhibit exceptional performance with only slight color changes being noted in accelerated weatherometer testing. Elastomer physical property retention is excellent.

Polyurea elastomer systems are amorphous in nature, not crystalline like polyurethane systems. This amorphous nature is similar to that of epoxy type systems except that polyurea system do not have a true glass transition temperature. Instead, 2 distinct T_g 's can be noted, one corresponding to the melting point of the soft block in the polymer and the other corresponding to the melting point of the hard block in the polymer. From Dynamic Mechanical Spectroscopy evaluations of typical polyurea elastomer systems, a low temperature T_g is noted at about -50°C with a high temperature T_g of about 230°C to 260°C. The response curve between these two points remains relatively flat. This would be the performance range, temperature wise, for a polyurea elastomer system. In lay terms, the polyurea elastomer systems would tend to show some significant stiffening at temperatures less than -50°C with some polymer softening, or possible decomposition, at temperatures above 230°C to 260°C.

The following Table II gives general comparisons of polyurea elastomer systems to conventional technologies used in most coating applications:

Table II
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-High	Low-High	Mid-High	Low-Mid	Low-Mid
Oxygenated solvents	Low-Mid	Low-Mid	Low-High	Low-High	Mid-High	Low-Mid	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