What's a Polyurea Elastomer Contractor to Do?

Dudley J. Primeaux II
Primeaux Associates LLC
161 Forest Drive
Elgin, Texas 78621
Dudley@primeauxassociates.com

ABSTRACT: Now that you as a specialty coating / lining contractor have joined the fast growing technology of polyurea elastomeric coating & lining systems, what's the next step? The polyurea technology has grown in use by significant volumes since the initial start in the early 1990's. Applications include concrete coatings / linings, steel coatings, traffic deck systems and specialty coatings. As "polyurea" is a description of a complete technology area, there are a variety of systems / formulations available and this can become very confusing. Add to that the growing list of companies that now offer some form of polyurea system, and it may seem that there are "smoke and mirrors" in the promotion of the system. You as a contractor need to know what questions to ask and what to look for in a polyurea system. With all the various systems that are available, how do you choose the proper system for the application project? Which polyurea supplier company should you as a contractor establish a relationship with? What if you require a specific system that may not be available, are the supplier companies in a position to assist with that special development or at least provide some feedback on the requirements? This paper will focus on the various types of polyurea systems available, the types of polyurea supplier companies and how to choose the proper polyurea system for the desired application area.

INTRODUCTION

The future of the polyurea technology is very promising. Current market sales are approximately 18 – 20 million gallons of system world wide. This is significant considering the world market sales was less than 1,000 gallons in 1990 (1, 2). The advantages of the polyurea technology are well known and published, as compared to other coating / lining technologies. These include:

- Fast reactivity, set and cure: rapid project turn around
- Insensitivity to ambient temperature / weather changes during application
- Contain no solvents, no VOC's and little to no odor
- Flexible, seamless and resilient
- Excellent mechanical properties

To date, the largest market use for the polyurea technology is in concrete coating areas. This includes secondary exposure areas as well as constant immersion applications. The use in steel coating areas is starting to grow, primarily due to the understanding that proper surface preparation is also required for the polyurea technology.

However, the continued growth and success is highly dependant on successful application work. This is enhanced by the presence of credible polyurea system suppliers with complete knowledge of their products and research, development and application support. There is a large investment on the part of the contractor to apply the systems, so one should not skimp on the choice of polyurea system suppliers (3).

The first thing to remember is that not all polyurea systems are created equal. One must select the proper formulation for the specific type of application work to be completed. You can't just use "any old polyurea system." The polyurea system supplier should be able to guide you to the proper system, as well as the application parameters. In doing so, this will insure a successful completion of the project. The system supplier provides the liquid components of the system; the contractor actually prepares the polyurea elastomer in the field via the application equipment.

The overall success will depend on various key elements, including communication between the contractor and polyurea systems supplier. This will include selection of the proper system, knowledge of the type of application, service conditions and surface preparation required.

Formulation Types

There are numerous formulation types, depending on the base chemistry and what elastomer physical properties are desired (4). The main base of the elastomeric polyurea systems are the amine terminated polyether resins. These are then blended with other resin which can either be aromatic or aliphatic in nature. This completed resin blend is then processed with an isocyanate component, either aromatic or aliphatic in nature.

The aromatic based systems are sometimes termed the "work horse systems." These have excellent mechanical properties and performance, but lack color stability when exposed to natural or artificial sunlight. These systems WILL change color! If formulated and applied properly, this color change will be uniform. Also, don't use a white or light color as these will change to beige, or worse.

The aliphatic based systems have similar properties to the aromatic based system. However, the higher thermal exposure limit is not as good as with the aromatic based systems. The unique advantage of the aliphatic systems is that when properly formulated and applied, these will retain color in exposed natural or artificial sunlight. Keep in mind that these systems are higher in cost than the aromatic based formulations due to the type of raw materials used in preparation of the formulation.

Both the aromatic and aliphatic technology has similar chemical resistance properties since they both contain polyether backbones in the polymer chain. The polyurea technology in generally will not withstand exposure to concentrated acidic solutions or strong solvents. The aromatic based systems will be attacked by strong oxidizing agents, so these should not be used in areas of constant exposure to chemicals such as chlorine or sodium hypochlorite.

The polyurea technology is also known for excellent resistance to high temperature exposure. For the aromatic based systems, a typical high temperature T_g is noted at about 230° to 260°C. For the aliphatic based systems, the high temperature T_g is about 60° to 80°C. This would be the temperature where softening and/or decomposition of the polymer begin to occur.

Recently, there has been some promotion of aliphatic modified polyurea systems. These are basically aromatic based polyurea systems where some additional aliphatic raw material has been used. Well, these still have significant aromatic content and while the color change may not be as great as with the aromatic based systems, they will change colors. In some cases, this color change can actually be worse than the aromatic based formulations. The main reason to possibly use these type systems is for improved wetout and resulting adhesion as these formulations tend to be slower, in most cases, than the aromatic based materials.

In choosing the proper polyurea system for the application, the supplier should guide you on the system to use. Don't just use a polyurea system for a project just because you have some "left over" from a previous application. The formulations are specific for corresponding application areas. A formulation that might work very well for a roofing type application may not be suited for constant immersion in tank lining areas.

Shrinkage

The polyurea technology is a thermoset material. With all thermoset materials there is shrinkage associated with curing of the material. This is common for materials like polyurethanes, epoxies and vinyl esters as well. The degree of shrinkage is directly related to the formulated system, as well as processing conditions.

There are some polyurea systems that have observed linear shrinkage values of up to 5%. Let's think about something for a moment. If I am applying a polyurea system with a 5% shrinkage value to a weak, unsupported substrate like geotextile fabric in a 1000 linear feet run, that equate to 50 feet of shrinkage! You will end up with a liner system that is now a snare drum head. The typical hard fast set aromatic polyurea bedliner systems have linear shrinkage values of 3 – 5%. These are truck bedliner systems and should only be used for that application area.

Most polyurea systems that have been formulated for the coating / lining industry and applications have linear shrinkage values of about 0.5%. Most of this shrinkage will occur within the first 24 hours after application. However, some additional shrinkage has been observed even out to 72 hours. This is all formulation and application equipment dependant.

The faster set, 3 – 10 second gel time systems, that have a high tensile strength and lower elongation (100 – 300%), tend to note higher shrinkage values. The slower gelling spray systems, 15 – 45 seconds, note lower shrinkage values. These systems typically have elongation values of 400% or greater.

Polymer linear shrinkage is also affected by processing conditions. The fast set polyurea systems require heat during processing. If the system is not processed at the recommended heat, set and cure will occur but the resulting polymer will exhibit additional shrinkage. In some cases, the shrinkage forces may be greater than the initial tensile properties of the polymer and cracking may occur when applied to unsupported substrates such as geotextile.

Set and Cure

Polyurea systems are commonly promoted as the fast cure spray applied coating technology. This term, fast cure, is often misused. The reality of it is polyurea systems may "set" very rapidly but the resulting elastomer does not reach full cure for 24 to 48 hours, or longer. This depends on the system formulation, as well as processing conditions. When reporting ASTM tested physical properties as seen on the product Spec Data Sheets, one does not realize that these are based on the fact that the samples are conditioned for 5-days after preparation before testing.

I do not mean to alarm you here, just make you aware of the facts. In most cases, this fast set will allow the application area to be returned to service very quickly. However there have been some major application areas of the polyurea technology where traffic has been allowed to pass over an applied area and some performance issues have resulted. The polyurea system supplier must be able to inform the contractor to the cure properties of their system and when the coated / lined area can be exposed to traffic or service.

From a contractor perspective, the rate of cure is directly related to the type of application equipment used and the processing conditions. Since the technology starts the reaction the moment the two components come in contact within the mixing area of the spray gun the proper gun setup is extremely important. It has been shown that most polyurea spray systems achieve faster green strength and cure when processed through a properly configured mechanical purge gun as opposed to a properly configured air purge gun. However, the properly configured air purge gun may actually show higher resulting elastomer properties after complete cure. The polyurea systems supplier should advise you as to the proper spray gun setup for their specific polyurea systems.

Adhesion

In order to achieve adhesion, the applied coating system must properly wet the surface being applied to. Since earlier polyurea systems had gel times of 3 seconds or less, adhesion was very difficult to achieve. Most polyurea systems of today are properly formulated for coating / linings applications and have gel times, or wet times, of greater than 6 seconds.

This is still very fast so it is extremely important to have the proper spray technique and equipment setup that allows for rapid / complete flow of the material into and out of the spray gun. Keep in mind that the reaction is proceeding as the material exist the spray gun and "flies" toward the substrate. So proper gun positioning and distance is very important. Polyurea is not paint, and most failures have been due to uncontrolled over spray and subsequent application over that "dusting."

Primers do play a key role in overall adhesion of polyurea systems to substrates. Some systems are formulated to be used without a primer for certain substrates. Keep in mind though that due to the rapid set time of the polyurea technology, penetration into porous substrates may not occur. The system just sits on the top.

Primers should always be used when applying a polyurea system to porous substrates such as concrete. This will enhance the overall bonding and help eliminate the tendency for pinholing. The primer systems are usually either epoxy or polyurethane based. For most steel coating applications, no primer is used with the

polyurea technology. This of course depends on the proper surface preparation. When used, the primers are typically epoxy based.

Also "*Polyurea*" is not an excuse not to perform the proper surface preparation. It is still used as a coating / lining system and you must have proper surface prep.

"You are only as Good as What you are Sticking To!"

Immersion Service

A question / comment was made by a major coating / lining inspection firm that polyurea systems **could not** be used for immersion applications because they are processed via impingement mix and they contain polyetheramines. Well, this is not the case, numerous applications where polyurea technology has been successfully used for immersion work and many of these have been in service for at least 10 years!

"Polyurea" is a description of a technology and it in itself is not a coating / lining material or system.

Keep that thought in mind for a moment. It all gets back to the basics:

- Use the proper system for the application
- Do the proper / required surface preparation
- PROCESS the systems at the required temperatures / pressures!!!!!

Some are designed for specific application areas, of which one may not be immersion. It has been presented over and over again the importance of the high pressure / high temperature processing requirements to achieve the optimum elastomer physical properties. These properties are directly related to **PERFORMANCE!!**

If you do not process the system at the required optimum conditions; yes, you will still make an elastomer that "gets hard" but ….. the proper mix will not be there and the resulting elastomer may contain significant porosity / voids. This will not work in immersion applications and failures will result.

Polyurea systems that are typically used for immersion service are ones based on a good balance of polymer crosslinking and flexibility. Systems for immersion service must have very low moisture vapor transmission rates, and the supplier should have confirmation data on this (5). Many report MVT values, but these may be based on earlier data from when the technology was first developed. A real MVT value of less than 0.02 perms is typically required for immersion applications.

For steel coating / lining work, a minimum of SSPC SP-10 / NACE No. 2 (near-white metal blast cleaning) is required. A minimum of 3-mil anchor profile has been noted to achieve the optimum performance for the polyurea technology. In coating / lining of concrete follow preparation procedures for SSPC SP-13 / NACE No. 6 and achieve a concrete surface profile of CSP 3 to CSP 6 for optimum performance (6, 7).

AUXILIARY MATERIALS

The polyurea system supplier should also be able to provide auxiliary materials, such as primers, topcoats, etc. These will significantly enhance the overall performance of the polyurea application. Some polyurea system suppliers may actually offer these materials under their formulation / product label. Many will have a suggested source for products such as primers. These should be fully evaluated by the polyurea system supplier to be fully compatible with their polyurea system. The contractor should not be left with "use your best guess and test" (8).

Also, be careful of "add-on" formulations. These are the formulated systems you might be able to purchase at a lower cost, but then if you want adhesion, added color stability, etc, you will need to make a request. Many times this additive package may be shipped to the field for addition to the on-site system by the contractor. It is not advisable for the contractor to "formulate in the field"!

Within auxiliary materials look for system suppliers that continually advance the technology and provide systems that have advanced performance in certain areas (9). This would include higher chemical resistance, improved stability of the products and higher mechanical properties for specific application areas.

APPLICATION EQUIPMENT

Since you the contractor are the one actually making the polyurea elastomer in the field, the polyurea system supplier should have knowledge of the application equipment and what setup is required (10, 11). Some form of training should be made available for the contractor, not just on the equipment but how to use the system supplier's products (12, 13).

There are several options when it comes to the type of application equipment to use. The equipment suppliers have done an excellent job in providing various setups and spray gun configurations. But keep in mind that not all configurations will perform properly with the polyurea technology. Some setups may not give the complete mix required for this fast reacting technology. Yes, it sprays and comes out the gun but all may not be right. This could lead to off-ratio / off-mix areas in the applied polyurea system and subsequent failure of the application.

The application equipment for the fast set polyurea technology must be plural component, heated and capable of high flow / pressure. The material delivery pumps must be capable of delivering the component to the proportioner at a rate of twice (2X) the overall output of the proportioner. The spray gun must be configured to an overall output capability not to exceed the output capacity of the proportioning unit. The proportioning units can be of pneumatic, hydraulic or electrical function. The electrical being the most efficient, followed by hydraulic and then pneumatic.

For the spray gun used, these must be impingement mix design and can either be air purge or mechanical purge. For either, a good supply of clean, dry air is required. It has been shown that for the fast set polyurea technology, the mechanical purge spray guns do provide for improved mixing over typical air purge spray guns. The air purge spray guns may be easier to maintain.

The contractor needs to seek guidance from the polyurea system supplier as to the proper equipment setup for their polyurea systems. In addition, the polyurea system supplier needs to promptly inform the contractor if they do not have the proper / required application equipment

We all need to preserve the abilities of the polyurea technology and stop compromising the work. This will hurt us all. Use the proper systems for the application; discuss your needs with the system supplier. Use the proper application equipment, equipment should be matched to the application area / work you are doing. Don't use a small "bedliner rig" to coat / line a major municipality's water treatment facility.

CONCLUSION

After all this, it may seem like a very complex mess. You might be asking yourself "why do I want to be in this business?" It really is quite simple though, know what to ask and develop a good working relationship with your supplier. If they are unable to guide you to the proper systems to use, and just want to supply you with "polyurea", look for another supplier. Don't use a system just because it is the least expensive system on the market. Remember, you get what you pay for!

References

(1) The Polyurea Development Association, Kansas City, MO.

(2) ***Polyurethanes, V***, A Multiple-Client Study. Skeist Incorporated, New Jersey, 2004.

(3) Courier, John, "Key to Polyurea Success: Choose Your Manufacturer Carefully," ***CoatingsPro***, May 2004, pp 20 – 22.

(4) Primeaux II, D. J., "Polyurea vs Polyurethane & Polyurethane/Polyurea: What's the Difference?", Polyurea Coatings: That Was Then, This Is Now, 2004 PDA Annual Conference, Tampa, Florida, March 2 – 4, 2004, pp. 1 – 20.

(5) ASTM E-96 (latest version); Test Method for Water Vapor Transmission of Materials, American Society for Testing and Materials, West Conshohocken, PA.

(6) ICRI Guideline No. 03732, International Concrete Repair Institute, Des Plaines, IL.

(7) Design, Installation, and Maintenance of Protective Polymer Flooring Systems for Concrete, SSPC-TR 5, SSPC: The Society for Protective Coatings, Pittsburgh, PA, 2003.

(8) Helton, Dan "Picking the Right Primer," ***CoatingsPro***, July 2002, pp 12 – 13.

(9) Primeaux II, D.J., Scott, Ray and Hanson, Lee, "Recent Advances in Polyurea Technology: Higher Performance Raw Materials for Improved Polyurea Properties," *Infinite Possibilities,* API 2005 Polyurethanes Technical Conference & Trade Fair, Hilton Americas, Houston, Texas, October 17 – 19, 2005.

(10) Primeaux II, D. J., "Application of 100% Solids, Plural-Component Aliphatic Polyurea Spray Elastomer Systems," SSPC 2000, Nashville, Tennessee, November 2000, pp. 95 – 102.

(11) Primeaux II, D. J. and J. P. Courier, "Equipment and Organization for Application of Polyurea Elastomer Systems," Polyurea, The Future is Now, PDA 2nd Annual Meeting, Orlando, Florida, November, 2001, pp. 1 – 20.

(12) Polyurea Applicator Spray Course, Polyurea Development Association, Kansas City, Missouri.

(13) "The Fundamentals of Polyurea Technology," The Polyurea Training Group, training seminar.