APPLICATION OF 100% SOLIDS, PLURAL COMPONENT ALIPHATIC POLYUREA SPRAY ELASTOMER SYSTEMS

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Abstract: This paper will focus on the 100% solids, plural component aliphatic polyurea spray technology and the processing equipment requirements to achieve successful coating and lining applications.

INTRODUCTION

For decades, coating and lining systems have been used for a variety of applications. These initial systems, though complex in preparation at the time, were fairly simple to install. The common installation technique mainly involved brush / hand application. Newer system developments and the evolution of spray application soon realized enhanced coating and lining performance. This spray technique was mainly single component applied. Excellent atomization could be easily achieved in these systems by introduction of various solvents, which also extended the system "pot life".

With new regulations and the move to higher solids content coating and lining systems, new means of application technique and equipment were required. This gave rise to the plural component application equipment. In the late 1980's, a new coating and lining technology was introduced to the industry, plural component polyurea spray elastomers (1-2). The basis of this technology was aromatic systems, which are very fast in reactivity and cure. Following suit in the early 1990's, 100% solids, plural component aliphatic polyurea spray elastomers were introduced (3-4). Having similar fast reactivities to the aromatic based systems; aliphatic polyurea systems provide optimum performance and color stability.

Due to the extremely fast reactivity and cure of this 100% solids technology, plural component equipment is required. The system must also be heated during processing, not for reactivity control, but for the ability to atomize and spray correctly. High-pressure proportioners are used to properly deliver product to the impingement mix spray gun.

CHEMISTRY and CONCEPT

In order to fully understand the application requirements, we must first define what an aliphatic polyurea spray elastomer system is. The National Association of Corrosion Engineers has recently published a Technical Committee Report, "Introduction to Thick-Film Polyurethanes, Polyureas and Blends", which gives a basic summary of the technologies (5). The aliphatic polyurea spray elastomer systems are defined as having one component, the aliphatic isocyanate quasi-prepolymer and the other component being the resin blend. For polyurea elastomer systems, the resin blend is composed of primary amine terminated resins and amine terminated chain extenders, no polyols or catalysts. Additional additives and fillers may be used so as to enhance performance. These systems are characterized as having extremely fast reactivities and cure properties. The reaction of the two components forms a urea linkage. Typical aliphatic polyurea elastomer physical properties are shown in Table I.

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Table I: Polyurea Spray Typical Elastomer

Properties

Tensile strength, psi	up to 3000
Shore Hardness	A 30 to D 55
Elongation, %	200 to 600
Tear strength, pli	250 to 500
100 % Modulus, psi	500 to 1800
CLTE, mm/mm/°C	4.0 to 13.4 X 10^{-5}
Burst strength, psi	250 to 500

*From a Sprayed Film

The technology has really matured since the initial introduction 9 years ago and use in a broad range of application areas is growing. Specific attributes of the aliphatic polyurea spray elastomer technology, which allows for a wide range of application uses, include:

- Excellent mechanical properties, color stability and extended durability, even in extreme environmental conditions.

- Fast, consistent reactivity that is relatively unaffected by changes in humidity and temperature. No catalysts are required.

- Excellent adhesion to a wide variety of substrates for properly formulated systems, even with the fast system reactivity.

- Readily compliant with regulations limiting the levels of volatile organic compounds. Polyurea spray elastomer systems are able to meet stringent environmental standards due to the 100% solids formulations.

Another mechanical property that is sometimes overlooked is low temperature flexibility. The polyurea spray technology, including the aliphatic-based systems, has excellent low temperature flexibility, even down to -40°C. This is due to the highly amorphous nature of the polymer backbone, unlike the crystalline nature of polyurethane systems. Information on the low temperature characteristics can be found in Table II.

Table II: Low Temperature Properties

Low Temperature T_g	-50°C
1/8 Inch Mandrel bend, -20°C	Pass
Gardner Impact, -20°C, 160 in-lbs	
Direct*	Pass
Indirect*	Pass

*Applied to 1/32 inch metal coupon

In addition to the excellent mechanical properties of the aliphatic polyurea spray technology, the main performance advantage is UV or color stability. Earlier work has shown that the UV – color stability of this technology is such that it is suitable as an interior skin material for automotive applications (6-7). Table III gives the retention of elastomer physical properties after 3000 hours of exposure using a QUV Weatherometer. Given this performance data, the technology is well suited for conventional coating and lining applications.

Table III: UV Weatherability Characteristics
Retention of Physical Properties

Tensile strength	> 95%
Elongation	100%
Tear strength	> 98%
Shore D Hardness	100%
Chalking / cracking	none
Gloss retention	> 90%

ASTM G-53, UVB-313 Bulbs, 3000 hours

One of the limitations of the technology is in regard to chemical resistance. Unfortunately, the technology is not a cure-all system. While the systems do show excellent resistance to moderately alkali conditions, strong acidic or solvent environments will pose some problems. That is not to suggest that this technology does not have any application potential. Typical chemical resistance would be comparable to that of conventional polyurethane or epoxy systems.

When the aliphatic technology was first introduced, systems reactivities were typically

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within the 1 – 5 second gel time area. Recent developments in slower reacting amine terminated chain extenders have allowed the formulation of systems with gel times in excess of 45 seconds, making for somewhat easier processing characteristics (8-10). Impingement mix spray equipment is still required though for spray application.

APPLICATION EQUIPMENT

In order to process this exciting new technology, considerations must be given to the processing equipment (11). The key to processing is within the proportioning pump and the spray gun. This is the "life support" system for proper installation and application. There are 2 types of proportioning pumps, vertical and opposed horizontal. These can either be air operated or hydraulically driven. For the spray guns, only the impingement mix types are appropriate for the fast cure, 100% solids aliphatic polyurea spray systems.

Ideally, one would like to see comparable viscosities between each component. This aids in the mechanical delivery of equal volumes of material to the spray gun. Most systems are processed at a 1:1 volume ratio.   For proper proportioning and application of aliphatic polyurea spray elastomer systems, you must have the following:

- Pressure,
- Temperature,
- and Volume material flow.

Proportioning Unit Vertical proportioning pumps have been the common place in the industry for delivering plural component coating systems. For high solids coatings systems though, the vertical pumps will not fill components of different viscosity materials at the same time and rate of speed. For higher viscosity systems, the use of positive flow drum pumps for material supply will help overcome this. However, both drum pumps will be working at the same time in this configuration, both being typically fed off the same air supply line.

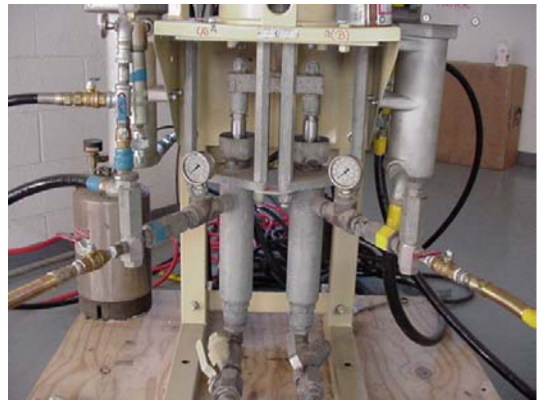

Figure 1: Vertical Proportioning Pump

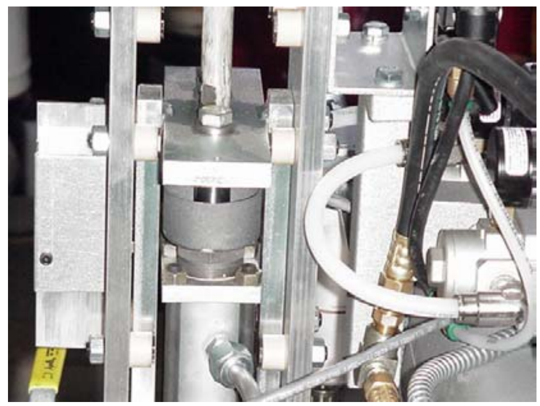

Figure 2: Vertical Proportioning Pump, Lube Reservoir

The pump systems closest to the air supply source will receive higher pressure and flow than the pumps father down the same air supply line. With twin pumps filling at the same time, the drive mechanism can not "feel" or notice if one side is not filling exactly like the other side.

Additionally, an imbalance of pressure is always noted between the up and down stroke with any vertical twin pump set up due to dynamic and mechanical flow characteristics. On the up stroke, or proportioning pump fill stroke, the drum pumps supply additional material pressure. This can never be fully compensated for to balance the flow pressures. Replacement of the air drive motor with a hydraulic motor will give a significant improvement in operation.

It has also been noted that on vertical proportioning pumps that the pumps will move faster in one direction than in the other, fill stroke verses dispense stroke. This results in a pulsating flow of material to the spray gun and affects the spray pattern as well as the consistency of applied coating thickness. The air driven, vertical pumps also tend to "float" more due to the compressibility of air and moisture in that air. High flow rate air compressors, minimum 100 scfm are a must for using this type of proportioning pump.

Opposed horizontal proportioning pumps work in reciprocal of each other. When one component pump is in the fill stroke, the other pump is in the dispense or discharge stroke. This allows for improved equal fill and pressures. With this configuration, the drum pumps meter material individually and therefore receive the same air pressure. One drum pump is not starving the other drum pump. This will give a more positive fill for the proportioning pumps.

Figure 3: Opposed Horizontal Pump, Hydraulic

With this opposing action, each proportioning pump helps the other side maintain very even pressures no matter which direction the pump is moving. Provided the check valves are working properly, you will never have a difference in pump or spray pressure from left to right because everything is balanced from a pressure and flow standpoint.

These opposed horizontal proportioning pumps can either be air or hydraulically driven. For the air drive system, a large flow rate of supplied air is required much like the vertical proportioning pumps. The hydraulic drive units will keep a more even flow / pressure on the system. Unique to the opposed horizontal proportioning systems is that the hydraulic motor actually feels the strain on each pump independently and yet moves both simultaneously allowing the independent fill cycles to work more accurately.

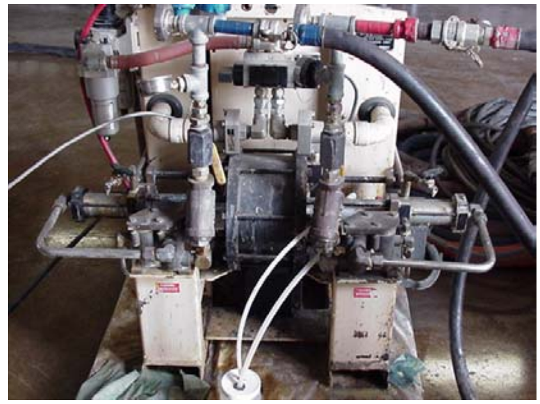

Figure 4: Opposed Horizontal Pump, Pneumatic

Regardless of the type of proportioning pump used, these pumps must also have the capability of heating the 2 components of the polyurea spray elastomer system. Heat is not required so as to promote the reaction of the system. That is built into the formulation. Heat is required to lower the mix viscosity of the 2 components as the reaction is initiated inside the mixing chamber of the spray gun. This initiation reaction causes a rapid viscosity build in the mixed system. The heat allows for proper atomization and sprayability of the polyurea system. This is much like heating high solids, conventional coating systems such that they properly atomize and spray. Heating output should be such that the delta T is a minimum of 70°F at full operation. Preheaters can be installed to aid in this for cooler climate conditions.

It has been shown that the optimum spray pressure for proper application of polyurea spray systems is at or above 2000 psi, coupled with high flow rate and heat (11).

Flow Rate Capabilities Whether one uses vertical or horizontal opposed proportioning pumps, material flow rate is essential. Many utilize a proportioning unit that will develop high pressure but lacks material output capacity to properly feed the spray gun. This is the same scenario when one uses a low-cost household pressure washer. Sure, you have "high" pressure but without volume water flow, you are not going to get the job done.

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This high pressure, low volume flow will result in poor mix, atomization and installation of the material due to the fluid pressure drop at the spray gun. The gun output / proportioner capacity ratio must be less than 0.75 for proper operation and application.

Careful consideration must also be given to the spray hoses. These must be heated hoses also. Depending on the overall length, the setup should include a "step-down" so as to minimize pressure drop at the spray gun. The hoses may have an "accumulator" affect so have a larger ID hose at the proportioning pump with a smaller ID section near the spray gun.

Spray Gun Now that we have the pump basics described, forget the conventional mix block, static mix application for polyurea spray elastomer systems. An impingement mix gun is required. There are 2 types of impingement mix spray guns, those with a fixed mixing chamber with moving valving rod and those with a moving mix chamber/valving rod combination.

For the moving mix chamber/valving rod combination spray guns, purge air is required at detriggering to flush out the mixing chamber. These guns are hence referred to air purge guns. In many cases, the air purge guns allow for free flow of mixed material out of the mixing chamber. While the material does experience some mixing, it is very poor due to the fast reaction and viscosity build of the aliphatic technology. A spray tip is required to hold backpressure in the mixing chamber and control the formation of the spray pattern.

Figure 5: Moving mix chamber / valving rod diagram

Since air is being used to purge the mixing chamber at detriggering, the pressure and flow must be consistently high to completely flush the chamber. If not, the mixing chamber / tip will become plugged. Because of this high airflow, one may also introduce contaminants such as oil and water onto the substrate at the detriggering stage. This may cause blistering and delamination of the polyurea coating system.

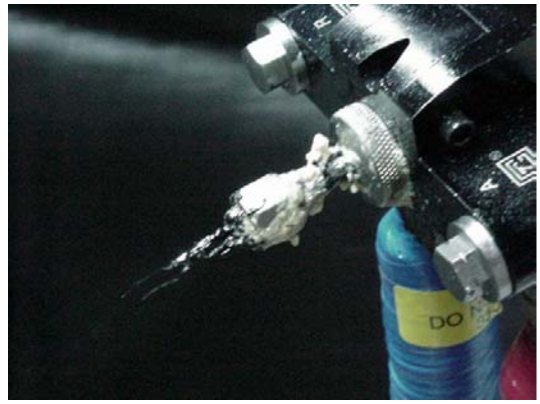

Figure 6: Plugged air purge spray gun; moving mixing chamber / valving rod

For the fixed mixing chamber, single valving rod spray gun, the return of the valving rod at detriggering seals off and flushes out the mixing chamber area. The material enters the mixing chamber under high pressure like that of the air purge spray guns. The material mixes and is then squeezed out of the restricted orifice area of the spray tip. This is then what makes the difference in thoroughly finishing the mix of the materials by breaking the mix into finer droplets to form the optimally mixed aliphatic polyurea spray elastomer system.

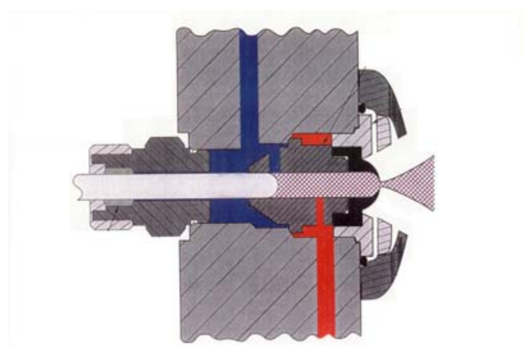

Figure 7: Fixed mixing chamber / Moving valving rod diagram

The basic concept for the mix gun is that the material must enter, mix and then leave the mixing chamber of the spray gun as quickly as possible. Flow should not be restricted into the

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chamber with respect to overall volume of the mixing chamber of the spray gun. A spray tip is a must, even on the fixed mixing chamber, single valving rod spray guns so as to hold back pressure and finish off the mixing. No free flow of material.

The ideal spray gun for proper application of the 100% solids, plural component aliphatic polyurea technology is the fixed mixing chamber, single valving rod spray guns. This is the same concept used by the automotive industry for Reaction Injection Molding of polyurea automotive body parts. The aftermixer in the RIM mold functions much like that of the spray tip on the spray gun. Keep in mind also that correct gun setup is crucial to successful installation, as with conventional spray guns.

COMMERCIAL APPLICATIONS

Now that we have addressed an understanding of the basic chemistry and the equipment required, we can have a look at typical commercial applications. Due to the mechanical properties and UV stability of the aliphatic polyurea spray technology, most application areas involve the coating of cementicious substrates. The speed of the technology often allows for installation during a normal shutdown procedure.

The fast cure, excellent flexibility at low temperatures, substrate adhesion characteristics and color stability allow the aliphatic polyurea spray elastomer systems to be an optimum choice for clean room / food processing facility wall coating applications. Here, the technology is replacing some type of paint system that will not hold up to the impact abuse and rigorous cleaning procedures often utilizing steam cleaning. Substrates are normally concrete or brick but may also be fiberglass panels. The use of the aliphatic polyurea system allows for a seamless installation, Figure 8. Numerous applications of this type are in use at facilities such as Kraft Foods, Jennie-O Foods and Frito-Lay.

Figure 8: Wall & Ceiling Coating Application

In addition to wall coating applications, the technology may also be used as a ceiling coating system. In food and beverage facilities, it becomes very difficult to maintain a clean ceiling area. Wash-down usually involves high pressure, hot water and most paint systems are not able to withstand this aggressive wash-down procedure. In some cases, repainting may be required after wash-down.

Figure 9 is an installation at Cavendish Farms, a french fry facility. The aliphatic polyurea spray elastomer coating system was applied at a thickness of 40 mils (1 mm) to the asbestos insulated ceiling. The ceiling is now very easy to maintain, color stable and seamless as well as encapsulating the asbestos.

Figure 9:Ceiling Coating over Asbestos

Due to the fast cure and high durability, the aliphatic polyurea spray elastomer systems are good candidates for some floor coating applications. Following recommended substrate preparation, the system can be readily applied at

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the recommended thickness. A stipple or fog coat is then introduced for some nonskid characteristics. Figure 10 shows a floor coating application at a Goodyear Tire & Rubber, Specialty Polymers Plant. The aliphatic system was specified due to the durability / performance and color stability of the system.

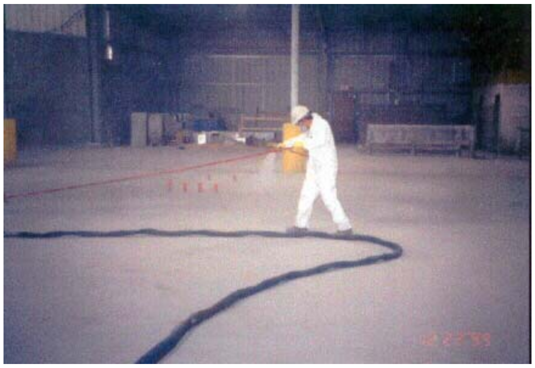

Figure 10: Floor Coating System

SUMMARY

The aliphatic polyurea spray technology provides for an extremely good cost and time effective solution for a variety of coating issues. The fast, consistent reactivity, coupled with an excellent performance record, is pushing the technology to levels exceeding conventional epoxy and polyurethane coating systems. The 100% solids nature allows for easy compliance with EPA rulings such as the Architectural and Industrial Maintenance (AIM) coating rule of 1998.

The fast, consistent reaction rate of the technology can be an advantage to the application, but a major disadvantage for the application equipment. High pressure, high temperature plural component equipment is a must. Selection of the proper mixing configuration in the spray gun that gives good, high flow rate and material atomization is the key.

Understanding and accepting the fact that the reaction characteristics of the aliphatic polyurea spray technology are far different than polyurethane or epoxy systems; successful applications can readily be made. It should be noted though that proper substrate preparation is always required so as to insure a successful coating and lining application.

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