INTRODUCTION
FORMULATING A & B SIDES

Formulating Polyurea Coatings & Caulks

Polyurea coating systems were developed back in the 1980’s, when polyurethane RIM technology was new and its future was promising and bright.

Not only were all of the car bumper fascia going to be made from this new elastomer technology, but soon all of the automotive body panels and many non-automotive applications would be using this technology. The world wasn’t going to have enough isocyanate to keep up with all of this new demand. Texaco asked a new young chemist – Dudley J. Primeaux II – to take the mold off of the RIM processing equipment and replace it with a spray nozzle. This certainly over-simplifies it, but this was the start.

Polyureas have been described as the resin from a polyurethane reacted with the curative of an epoxy. This is a good description, as polyurea coatings do seem to take the best from both of these polymer technologies. They have improved chemical and solvent resistance, and higher temperature resistance compared with the polyurethanes. They also have better impact resistance and higher elongation vis-à-vis the epoxy.

A polyurea is formed when amines react (cure) with the isocyanate. This reaction is fast, auto-catalytic (that means it does not need a catalyst to react – even at cold temperatures) and leads to many of the special properties that allow polyureas to distinguish themselves from the other polymers. There are three main properties:

1) Polyurea reactivity is independent of the ambient temperature. Polyurea reacts fast – and it will react at the same speed regardless of the temperature. It can be 100 F or -25 F and the reactivity is almost the same. Polyurethanes can be catalyzed to also react very fast, but a system designed for 70 F, will take forever to cure at -20 F. A polyurethane system that will cure properly (fast) at -20 F will be too
fast to handle at 70 F. Epoxy cannot cure at these very low temperatures.

2) Polyurea reactivity is independent of the ambient humidity. It can be 98% RH and the polyurea coating will spray bubble-free. (Be careful of the dew point – that’s a different story) A polyurethane must have catalysts to complete the reaction. These catalysts are designed to catalyze either the polymer reaction (gelation) or the “blowing” reaction (many polyurethanes use this well known use of water to react with the isocyanate to release CO₂ to use as the blowing agent in polyurethane foams). Unfortunately, either types of catalyst will catalyze BOTH reactions – to some degree. The choice of a good gelation catalyst will still catalyze the ISO/water (from the humid air) reaction – and when it does you WILL have bubbles.

3) Polyurea develop their physical properties FAST. This gives the polyurea “FAST RETURN TO SERVICE”, that is you can drive on the coated floor; use the coated product within 12 hours of application. Polyurethanes take up to 14 days to fully develop their physical properties. Epoxy require several days.

As mentioned before, polyureas have improved chemical and solvent resistance and higher temperature resistance compared with polyurethanes. They have improved impact resistance and elongation compared with epoxies. All of the properties can be impacted by the formulating chemist.

The formulating chemist will always want to know the application for which his polyurea system is intended. The proper selection and amount of raw material components will effect the performance – both processing and physical properties.
The A-Side – Polyisocyanate Prepolymer

The selection of the isocyanate prepolymer will influence most of the properties of the polymer. The %NCO will influence hardness, stiffness, strength properties, speed of reactivity. The “backbone” will influence the type of chemical/solvent resistance, as well as strength properties. The functionality (number of reactive sites per molecule) of the prepolymer will affect the temperature resistance, hardness, stiffness, impact resistance and elongation. The isocyanate can be aliphatic or aromatic. This selection will affect the UV stability, as well as other physical properties. The formulator may add other chemicals to the prepolymer, especially a diluent to lower the viscosity, and slow down the reactivity of the system. The viscosity of the system will greatly affect the processing of the polyurea.

The B-Side – Resin Blend

The Resin blend consists of various amine terminated molecules of varying sizes and types. The choice of which amines to include and the ratio among the amines, will determine the performance and the processing of the polyurea. To be a “pure polyurea” there can be NO (zero) “intentional hydroxyls” added to the system. If there are hydroxyl containing products (polyols) it will be a ‘hybrid’ coating. Hybrid systems have their place. They are good systems for certain applications. There has been significant confusion in the marketplace between a true “Pure” polyurea and a hybrid. A coating system with hydroxyls (hybrid) will require a catalyst to complete the reaction. This catalyst will cause the polymer to have the difficulties sited above.

The choices of amines include: long chain “backbone” polyetheramines like BASF’s PEA D-2000 and PEA T-5000. These are the basis of the system. While PEA T-5000 is tri-functional, it does not act like a traditional cross-linker. This is due to the high chain length between the cross-links, or better in this case – branching. It is important to add some of the PEA T-5000 however because this “branching” will give the polymer a tighter network. All polymers oxidize or
degrade over time. Some, more than others. Polyureas do not have a particular problem with this, but the addition of T-5000 will give the polymer a much longer life. This is especially true in submersion applications.

The short chain curatives may be aliphatic or aromatic. Aliphatic diamines like BASF PEA D-400 are very fast reacting. If cross-linking is desired, BASF’s PEA T-403 is short compact and tri-functional to provide efficient cross-linking. Higher cross-linking will give higher temperature resistance, higher tensile, improved solvent and chemical resistance, but will lower the elongation, tear strength, impact strength. Aromatic diamines like DETDA build in the polymers strength and rigidity.

Secondary diamines like PolyLink 4200 slow down the reaction times and help them process easier. PolyLink 4200 improves the polymer properties with better flexibility, lower water absorption, higher impact strength, better abrasion resistance, better chip resistance, less “orange peel” effect, better flow out, better self-leveling, and less shrinkage. PolyLink 4200 also gives you better substrate wetting and flow, better substrate adhesion, better inter-coat adhesion, and longer “open times” between multiple passes. You will get smaller droplets, less “fingering” and “roping” lower mix viscosity, Less build-up on the gun tip, less nozzle plugging, improved mechanical mixing, greater control on the thickness per pass, and higher productivity with lower down time. The ratio of the PolyLink 4200 to the DETDA will determine the speed of reactivity, the rigidity and hardness of the coating.

Various additives may also be included in the B-Side Resin blend. Adhesion promoters such as PolyGrab ES-187 and PolyGrab AS-1100 will help improve substrate adhesion and should always be used on concrete applications. In applications where UV resistance is important, all aliphatic systems should be used. UV stabilizers, such as PolyStab 100 should also be added to these aliphatic coating systems. In pure polyurea systems, pigments dispersed in BASF PEA D-2000 like those from Rebus Inc. should be used.

In caulk systems, the reaction times need to be much longer than in coating applications. Many of the same chemicals are used but in different ratios. For example, significantly higher levels of PolyLink 4200 will help delay the gel times and give better mixing and flow out at the lower mix pressures usually used for the caulk application.

In all polyurea applications, the coating formulation is only 1/3 of the critical success. Proper substrate preparation is necessary and proper equipment and mixing at proper temperatures and pressures is critical.