SUPERIOR COATING, MEMBRANE AND LINING SOLUTIONS

Michael S Osborne-President and CEO

Nukote Coating Systems International

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1 EXECUTIVE SUMMARY

Technological advances in the recent decade have resulted in a new breed of superior polymer coating formulations providing distinct advantages to both contractors and end-users. The development of this new breed of polymer products are the result of a combination of advances in both formulation and equipment technologies, each dependent on the other. The advent of these new product and equipment technologies provide unique solutions for a wide range of application types, limited only by their acceptance in the marketplace. These products are as yet are not widely specified due to the marketing efforts of traditional product manufacturers and the perceptions of personnel involved in the specification process. This situation is not uncommon to new technologies, as a period of time from development to acceptance is a standard obstacle typical to all innovative technologies.

When these products were first introduced, there were many obstacles in place that limited the products wide acceptance. These obstacles included lack of qualified application equipment systems, cost effectiveness of the systems compared to traditional coatings and resistance to the new technology by companies promoting traditional coatings. The principal obstacles have been overcome since production and field application equipment systems are fully developed providing consistent and efficient application of the products, the cost of the products are now extremely attractive to end-users when compared to traditional coating systems, resistance from competing products is being eroded due to a growing acceptance by end-users and qualified product manufacturing, production coating facilities and experienced field applicators are presently available globally. These products will become commonly specified, the question now being not if this will occur but when.

In a few years these new products will replace traditional coating, lining and membrane systems because they; eliminate common weaknesses of the older technologies, provide stronger physical properties, perform at higher levels of abuse and temperature extremes, last longer and can be applied quickly and easily.

Imagine, if you can, polymer products that; can be applied at a rate of 500-1000 square meters per day by a team of three-men without seams or layers, contain no volatile organic compounds, gel in seconds, can be put back in service within hours, use no catalysts or solvents in the curing process, are completely hydrophobic, exhibit physical properties much higher than traditional products, and can be used in coating, lining and membrane applications bonding and conforming to virtually any substrate.

The following document includes; a brief introduction to this new polymer technology, their general chemical compositions, their application flexibility, and summarizes their principal features and benefits over traditional products.

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2 INTRODUCTION

Anti-corrosion, lining and membrane applications represent the largest worldwide volume market for coating products. This market potential naturally draws the focus of every coatings manufacturer, distributor and applicator and for these companies; the successful penetration of these market segments represents large product sales volume increases over an extended period of time. Since large volume sales are the primary goal of every manufacturer, the end-user is bombarded with product marketing information all claiming that their product alone is best suited for these applications. The sheer volume of information available on this subject can be overwhelming, making a decision to select a specific product difficult to reach. The situation is further compounded by typical factors inhibiting new technology acceptance, which include; time required for new technologies to achieve a standardization recognized by end-users, consulting and engineering firms reluctance to try new products prior to lengthy historical performance of the product in field applications, resistance from traditional product manufacturers to adopt new technologies prior to recapturing their initial investments in equipment, and so on.

In addition to the reasons defined above, there are many other non-typical factors that delay the wide acceptance of new coatings technologies. Multi-national oil and gas, construction and engineering companies, which represent the first step in product acceptance, are not only conservative regarding new product technologies, but are also large in structure and require time-consuming product technical approvals and field trials. Due to the size of the investments required for the projects undertaken by these companies, the conservative approach and requirement for field trials is not surprising, but when this lengthy approval process is combined with a plethora of coating companies bombarding the decision makers with marketing data that is based on conjecture, unsubstantiated or even false information regarding the product offerings, reaching a decision can be very difficult.

This document was prepared in an effort to assist in this decision making process. The information contained below was compiled from published data that is readily available to the public and includes information and comparisons of products not manufactured by the company for which the author toils. This document covers all of the aspects critical to the decision making process of coating selection including selection of new coating product technology. As part of this process, an analysis of the specific industries and product lines was required prior to the documents preparation and was accomplished using data published by a variety of sources including product manufacturers, contractors and industry experts.

From the information available it is apparent that no traditional coating, lining or membrane product is completely meeting the needs of the end-user. Traditional products are specified because they are deemed to be the “best that are available”. The author contends that this may have been the case 5 or even 10 years ago, but it is not the case now and that use of many traditional products is being maintained due to a failure of the end-users to properly research and investigate the newer technologies available. This situation is exacerbated by many of the larger companies that manufacture or contract for these product applications, which form what are

essentially oligopoly's desiring to maintain the status-quo and recover their significant investment in equipment required to manufacture and/or apply traditional products, prior to changing over to more modern products. Another factor is that the newer technically advanced coatings were historically represented by smaller companies without the technical resources, worldwide representation and financial strengths required to quickly achieve market penetration.

The facts are that newer coating, liner and membrane technologies can provide end-users with better performance, longer design life and faster back in service times for most application types. These products also provide much higher physical properties giving the end-user; higher return on initial investments, reduced costs for maintenance, reduced instance of damage during installation, higher oxidation resistance, higher process temperature ranges, faster installations and above all lower costs. There are companies representing these newer technologies that: are reputable, have invested the time and resources to formulate products specifically for each application type, provide representative product information and are capable of delivering completed coating, liner and membrane systems inclusive of the required technical expertise, production capacity, quality assurance and control required.

Please review the following information carefully and you should reach the same conclusion as that of the author. Time and effort should be expended to carefully review the potential of these newer coating technologies. Manufacturers of these products are driving towards the goal of achieving the testing, application and quality assurance standards required for global acceptance of the products, which are poised for, at minimum, wide acceptance as an alternate system to traditional products.

3 DEVELOPMENT OF POLYURETHANES & POLYUREAS

In today's markets coatings must generally be environmentally friendly, safe during application, durable, provide good chemical resistance and be capable of isolating the substrates they are protecting from oxidation. In addition, qualified coatings should be resistant to mechanical damage during the coating process through installation stages, maintain this durability over the designed service life, and fall within industry standards on a cost basis. Each application type has its own unique performance requirements such as cathodic-disbondment, bend-ability, thermal cycling, permeability, etc. Qualified polyurethane and polyurea coating systems are regarded as a solution that compares well against these requirements and is the fastest growing technology within the coatings industry as a whole.

The acceptance of these technologies as a worldwide standard is a foregone conclusion with the remaining question being when, not if this will occur. A graphic example of where these newer Polyurethane and Polyurea technologies are on a standard technology adoption graph is shown below in Figure 1.

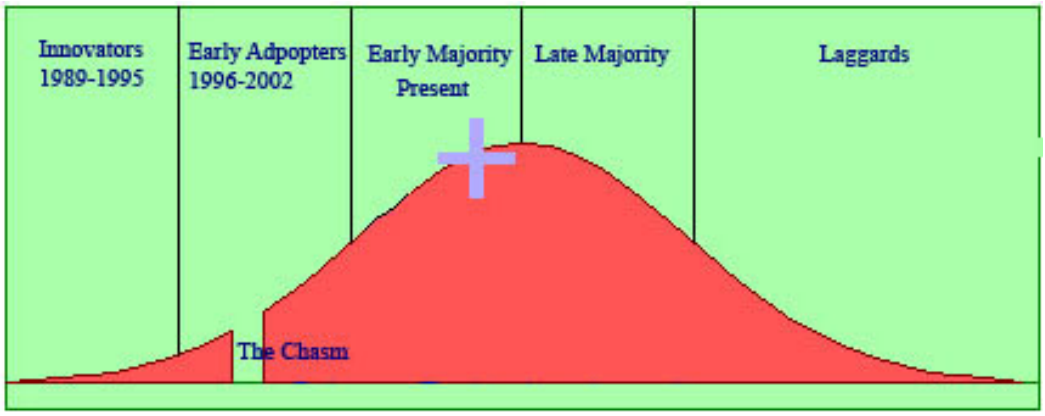


FIGURE 1 ADVANCED POLYMER TECHNOLOGY ACCEPTANCE

Generally this chemical group is broken down into two distinct chemical formulations, polyurethane's and polyureas. Some studies further divide these two groups down into elastomeric and rigid sub-groups. This sub-division is frankly not relevant as the rigidity of either product is determined by formula modification, with degrees of flexibility and rigidity easily modified as part of a specific design to meet specific applications requirements. Polyurethane manufacturers have principally put this sub-division forward as a marketing method to differentiate one product group from another. Rigid polyurethane's display physical properties that are characteristic of formulating towards rigidity and therefore this sub-division grouping will not be utilized for the purposes of this comparison.

Significant marketing efforts have been expended by manufacturers to promote the features and benefits of their specific formulations over others causing a considerable amount of confusion with the end-users. Polyurethane manufacturers direct their efforts towards de-emphasizing the benefits of the newer polyurea technology while polyurea manufacturers emphasize certain aspects of their products to highlight perceived weaknesses of polyurethanes.

For end-users the keys to solving this information quagmire is to determine internally what physical property levels they require and base their product selection on formulations that meet these guidelines, at costs that are acceptable, via manufacturers who have proven formulations specifically designed for the application and installed by applicators experienced in the specific application considered.

3.1 Polyurethane Development

In 1930 Otto Bayer and his associates discovered diisocyanate addition polymerization procedures, which resulted initially in the development of polyurethane foams and coatings. Since its discovery polyurethane products have been widely accepted for use in manufacturing and as coatings on an extremely large scale.

Polyurethane foams were developed during World War II in both flexible and rigid formulations. Since the 1960's, castable polyurethane elastomers have been widely used, particularly in the aviation and automobile manufacturing industries.

Polyurethane adhesives then became accepted in a variety of commercial applications. Finally polyurethane based coatings began to find commercial acceptance but were not mainstream products until the 1980s.

Presently polyurethane foams are the best thermal insulating product on the market, are cost affordable and can be poured, cast or spray applied. Polyurethane based paints are accepted worldwide and comprise a large portion of the paint products industry. Polyurethane paints (aliphatic modified) are the standard automotive paint and are used industry wide. With the historical references available and the continuous development of polyurethane products, available technology is ample and has a history of more than 50-years. Developments in polyurethane coatings are relatively recent, with technical advances being made largely by the coating manufacturers without the help of the resin manufacturers.

3.2 Polyurea Development

Drawing on the wide polyurethane technology available, in 1989 Texaco Chemical Company, now Huntsman ICI developed the chemical concept of 100% solids polyurea spray elastomer coatings, based on the use of Jeffamine polyetheramines. This new chemical composition displayed much higher physical properties than it precursor (polyurethanes), was hydrophobic (allowing for curing in the presence of water) and included much higher temperature stability as well.

Early polyurea formulations required both heat and pressure to combine the two basic components of which it is comprised. When polyureas were first developed, adequate equipment systems were not available to allow for spray application of the products, thus pure polyureas were limited to injection molding processes.

In 1992 application equipment was developed that provided the sprayable capabilities required for the products wide use. Product development within the industry has been ongoing with present formulations allowing for applications without added heat or high-pressure (as original formulations required) resulting in the present formula options of high-pressure spray, low-pressure spray, injection, pour and even brush and roll-grade formulations now widely available.

High-pressure formulations that require heat and pressure to initiate curing remain the product types that provide the highest physical properties of any pure polyurea product and are most often specified in applications where strict compliance with specified properties is required. See Figure 2 for an example of typical high-pressure, plural component equipment used for application of high-pressure formulations.

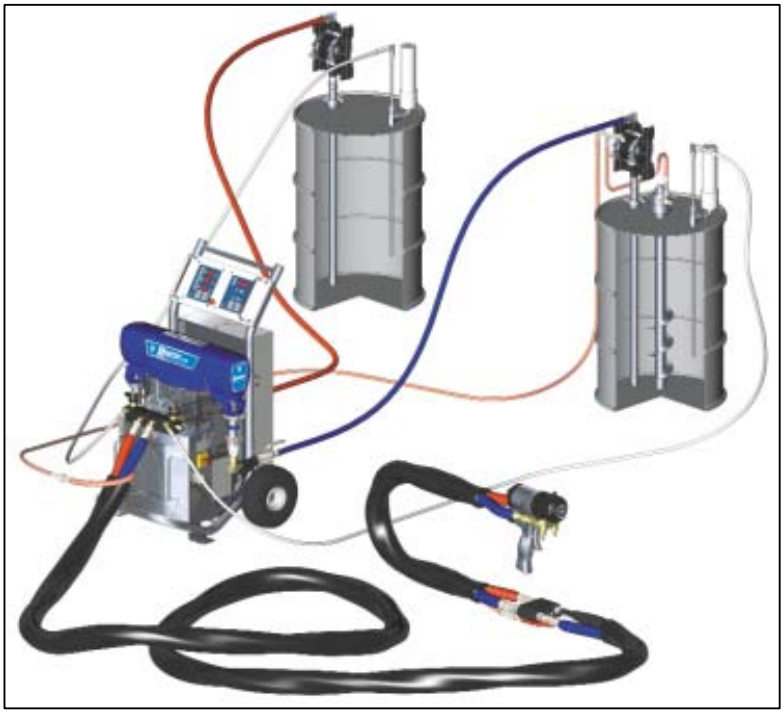
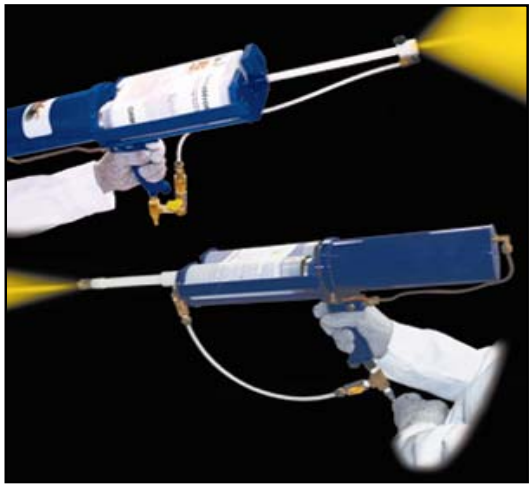


FIGURE 2 HIGH PRESSURE EQUIPMENT

FIGURE 3 LOW PRESSURE EQUIPMENT

Formulations that require minimal application pressure and do not require added heat allow for the use of less complex and less expensive equipment in the application process. These formulations typically exhibit slightly reduced physical properties than the high-pressure formulations but still maintain much higher physicals than traditional coatings and create a wider range of contractors worldwide that are capable of applying the products correctly.



Low-pressure formulations can also be applied using portable, hand-held cartridge equipment allowing for ease of repair, cost effective remote access, etc. This equipment uses twin-cartridge low-pressure slow gel products requiring no electrical supply. 125-psi constant air is all that is required for operation. The development of this hand-held cartridge application equipment has solved the problems surrounding repair and maintenance, which previously required mobilization of entire equipment systems regardless of project size.

FIGURE 4 HAND HELD GUNS

Brush and roll-grade formulations are similar to low-pressure formulations, displaying slightly lower physical properties, taking longer to gel, tack and cure and are principally used as architectural finishes or in areas where spray application is not feasible. These products are simply mixed and then applied using squeegees, rollers, brushes or standard cup sprayers.

FIGURE 5: ROLLER APPLICATION

3.3 Polyaspartic Development

New polyaspartic aliphatic polyurea formulations have emerged with these products displaying features such as low dft requirements, high color and gloss stability, lower permeability and self priming features. This product group does not require heated high-pressure equipment to apply and is typically installed using standard cup sprayers, airless sprayers, brushers or rollers. These products are more expensive and essentially aesthetic in nature but can be combined with aromatic formulations to provide durable color fast applications in a variety of market segments. This product group is protected by global patents held by Bayer.

3.4 Water Catalyzed Polymer Development

Recent developments in polyurethane technologies have resulted in single component, water catalyzed polymers that can be used in a wide range of applications including coating, lining and membrane applications covering, concrete repair, coving and crack and joint filling on vertical surfaces, intumescent and fire proofing applications among others. This product group provides seamless films requiring no special equipment and resolves many issues within the industry including environmental

restrictions in some markets that do not allow the spray application of any product containing isocyanate. This product group is protected by global patents held by Nukote Coating Systems and/or its affiliated group companies.

3.5 Expanded Polymer Development

Recent developments in equipment system technologies have resulted in an expansion process that uses gas and other injected materials providing a variety of features and benefits including; high abrasion resistant coatings, liners and membranes (using gas and sand injection), lower permeability rated coatings, liners and membranes (using gas injection only), higher chemically resistant coatings, liners and membranes (using gas and chemical injection), and higher cathodic protection rated coating for metal substrates (using gas and chemical injection). This new technology utilizes common polymer formulations, expanding these product and reducing the consumption of material from 50% to 300% while providing the same dft levels as when using the same product when not expanded. This technology is protected by global patents held by Nukote Coating Systems and/or its affiliated group companies.

3.6 Hybrid or Modified Polymers

The polyurea and polyurethane Industries loosely classify polyurethane formulations as those that contain hydroyl polyol content ≥ 80% and polyurea formulations as those that contain an amine or polyetheramines content of ≥ 80%. Between these two parameters, a system can be considered a polyurea/polyurethane hybrid or blended system. A better method of differentiating between the two systems is simply to qualify the products by having the manufacturer state whether the product is a pure polyurea or pure polyurethane, designating products that are less than 100% pure as modified or hybrid. Nukote Coating Systems differentiates products manufactured in this way as pure polyureas, pure polyurethanes or modified polymers. Modified polymers are those products that are not 100% amine or polyetheramines content formulations. This is the only method that we are aware of that clearly indicates to the end-user exactly which formulation type they are purchasing. The industry definitions mentioned above do not clearly indicate this and are, in fact, marketing tactics that are both confusing and misleading to the end-user.

Manufacturers typically develop modified elastomers, meaning both modified polyureas and modified polyurethanes, for specific purposes. Polyureas are typically modified by reduction of the Jeffamine content to reduce the cost of producing the products. These modifications commonly display lower physical properties, temperature resistance, etc. Polyurethanes are typically modified to resolve perceived deficiencies of pure polyurethanes and change physical properties to more closely resemble those of polyureas. These modifications are often not disclosed to the end-user and further confuse the procurement/decision making process.

Some modifications are made to create formulations that exhibit increases in specific physical properties beneficial for specific application requirements. These modifications usually increase raw material costs and thus the market price of the

modified product. This type of modification is typical of polyurethane manufacturers developing higher quality rigid polyurethane products that are higher priced and higher performing. These modified products are beneficial to the end-user and are typically fully disclosed on the product data sheets. Nukote Coating Systems has developed several modified polymers for specific applications to achieve increases in specific properties. Nukote XT is a typical example and the product displays much higher physical properties than pure-polyurea or pure polyurethane formulations including, temperature resistance, abrasion resistance and chemical resistance; and the price reflects the additional costs to achieve this.

3.7 Product Development Summary

In summary polyurethane was developed initially more than 50-years ago. Over the past 50-years research and development have made this product group a widely accepted product in a variety of application types. Polyurethane products have never reached a wide acceptance as an industrial coating for the simple reason that they fail to provide the physical properties required in many applications.

Polyurea was developed 16-years ago by utilization of polyurethane technology combined with newly developed chemical components. Over the past 16-years research and development have increased formulation variations and equipment technologies making the product suitable for a wider variety of applications than that of its precursor. Polyurea is ideally suited for specific applications where polyurethanes are not suitable and vice-versa.

Hybrid or Modified polymers fill the gaps in the application spectrum that neither pure polyureas nor pure polyurethanes can fill, providing the correct range of properties for the specific applications needs.

New technologies in polyaspartic aliphatic polyureas and single component water catalyzed polyurethanes fill the final gaps in application types giving the end-user a complete solution for virtually any application type encountered.

New equipment system technologies provide expanded films (only with fast setting polymers) that reduce the material consumption considerably, providing lower cost of applications and at the same time providing desirable physical properties for specific application types.

Many manufacturers, to protect their core business product lines, lower the costs of their products by reducing percentages of critical raw material components and specify a generic formulation in applications that are in fact not suitable for the product type. Some manufacturers only market polyurethanes or polyureas and modify these products to correct perceived deficiencies when compared to competitive products, when they should be producing and marketing the correct formulation for the application not a single product type. Good manufacturers will offer formulations from both product types specifying the correct product formulation for the specific applications requirements.

Some modified products are developed for specific applications with targeted increases of specific physical properties driving the modification. The manufacturers

should indicate on the products data sheets whether the product is a 100% pure-polyurea or polyurethane, or if it has been modified. Some Modified products are of a higher quality, in some aspects, than many pure product formulations, but these modifications are normally tied to higher price points than the original or pure products. If the product type is unclear the end-user should request clarification from the manufacturer.

4 SIMILARITIES AND DIFFERENCES

4.1 Formulation Basics

Polyurethane chemistry is based on the exothermic reaction between di, or, poly-isocyanates and compounds with hydroxyl end-groups such as polyols is illustrated in Figure 1. It is the exothermic nature of this reaction that provides polyurethane's with the fast-setting, cold-temperature curing and unlimited film builds of 100% solids pure polyurethane coatings. See Figure 6.

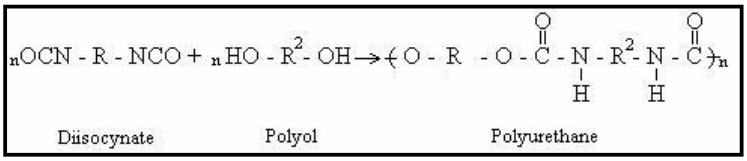


FIGURE 6 POLYURETHANE CHEMISTRY

Polyurea chemistry is based on a similar exothermic reaction between di, or poly-isocyanates with the key difference being that the polyurea utilizes active hydrogen groups (amines) to form polyurea (See Figure 7) instead of polyurethane. This chemical difference causes a much faster reaction period giving the polyurea group the faster gel, tack and cure times critical to pipeline coatings, while providing the desirable cold-temperature applicability and unlimited film builds similar to polyurethane. The basic chemical difference also explains the reason that polyureas resolve the known weaknesses of polyurethanes those being; curing problems in the presence of moisture or high-humidity, low chemical resistance, etc. See Figure 7.

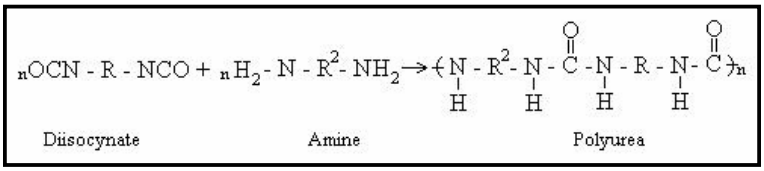


FIGURE 7 POLYUREA CHEMISTRY

ASTM has grouped six different polyurethane coating types in the ASTM D16 standard. This standard summarizes the characteristics and properties of the six ASTM coating types. Type I are one-package pre-reacted products, Type II are one-package moisture cured products, Type III are one-package heat cured products, Type

IV are two-package catalyst reacted products, Type V are two-package polyol products and Type VI are one-package non-reactive lacquers. Most 100% solids Elastomeric and rigid polyurethane products used in anti-corrosion use the ASTM D16 Type V plural component format.

4.2 Physical Properties Basics

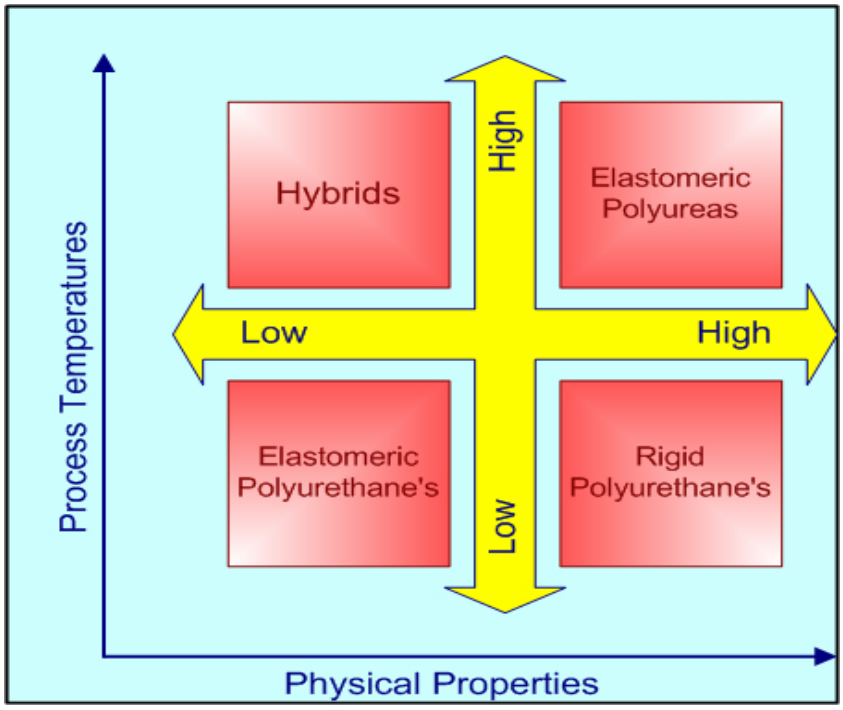


FIGURE 8 POLYMERS PROPERTY CHART

The principal properties common to all pure polyureas include: Hydrophobic properties that are able to react and cure in the presence of moisture, or, in fact, on water or ice and can be applied to cold substrates without pre-heating. These formulations also provide; high chemical resistance, high mechanical abuse resistance, high physical properties including tensile, elongation, abrasion, etc. Pure-polyureas set up very quickly, within seconds or minutes of application, reach a 75% cure in 1-2 hours and reach full cure within 24-hours.

Pure polyurethanes are; not hydrophobic, reacting negatively with curing compromised in the presence of moisture or even high humidity; are not applicable on cold substrates without pre-heating; do not exhibit high chemical resistance; cannot withstand high mechanical abuse; typically exhibit lower physical properties than pure-polyureas; typically exhibit poor adhesion always requiring the use of primers; do not meet cathodic disbondment requirements; set up in minutes to hours, reaching 75% of cure in 3-6 hours and full cure within 24-hours.

Hybrid or modified products can exhibit a range of properties dependent on formulation and objective of the manufacturer.

Some modified products can exhibit all of the benefits of polyurea while eliminating the deficiencies (and even exhibit higher physical properties in some aspects) than those common to polyurethanes. These modified products will not be hydrophobic and will have some negative reactions with moisture present and will not perform well on cold substrates. These modified products typically cost more than pure polyurea or pure polyurethane formulations

Some modified polyurea products can exhibit the fast set-up times typical to both polyurea and polyurethane but have significantly reduced physical properties, react negatively to the presence of moisture and cannot be applied to cold substrates. These hybrid products typically cost less than standard polyurea or polyurethane formulations.

4.3 Common Misconceptions

1. "Pure-polyureas have the same shortcomings as pure polyurethanes." As described above the chemical differences in polyureas resolve the shortcomings of polyurethanes. Polyureas are typically a more elastomeric product than polyurethanes.
2. "All polyurethane products are not chemically resistant, not stable over the long term and react negatively to moisture presence." Modified polyurethanes can be formulated to resolve the known shortcomings of the pure versions and be modified to achieve near hydrophobic status (will have less of a negative reaction to moisture).
3. "Modified polyureas are less expensive than pure-polyureas and perform just as well." Modified polyureas that are less expensive are typically formulated with less Jeffamine content to reduce the cost period. Reduction of Jeffamine content without costly additives will not produce a superior product.
4. "Polyureas and polyurethanes always require primers." Most pure-polyurethane and modified polyurea products require primers due to formulation modifications to enhance physical properties, which in turn can reduce adhesion properties. Many pure-polyurea formulations do not require primers and provide excellent adhesion to steel and concrete without any primers. The requirement of a primer on non-immersed applications is dependent on the application type and the formulation utilized. Primers should always be required in immersed applications.
5. "Polyureas are all the same and one is as good as another." There are a variety of resin and isocyanate compounds available, enough in fact to make the combinations literally unlimited. Each manufacturer's product formulations are quite different and none are exactly alike. Formulations can be modified to have higher or lower physical properties and increasing one property affects

the other. Good manufacturers tailor formulas for specific application types. Poor manufacturers make standard formulations and sell them for every application type. Polyurea can be tailored to fit specific needs if the manufacturer has a solid research and development team and incorporates laboratory and field testing prior to marketing each individual formulation for specific uses.

6. "Polyurethanes are old technology and can not compete with the physical properties of polyurea." Polyurethane is an older technology but there are several manufacturers that have developed modified or hybrid products that compare well to polyureas and provide features and benefits that are beneficial in some specific application types.

4.4 Similarities and Differences Summary

Polyurea or polyurethane coating products are similar to normal paint products in that there is a wide variety of types and manufacturers. All paint products are not the same and pricing ranges across the board depending on the specific application type, life expectancy, budget, etc. Polyurea and polyurethane products are exactly the same in that there is a wide variety of types and manufacturers with different formulations for different application types and budgets. Polyureas are a development of older polyurethane technology. As with all technologies improvements are made from one generation to the next. Polyurea resolved the common deficiencies of polyurethane products and increased physical properties and temperature resistance at the same time however Polyurethane products have specific uses in some application types. Some modified polyurethanes are of very high quality and price and offer specific benefits in some application types. Some modified polyureas are formulated to provide higher properties and benefits than pure polyureas. Modified polyureas or polyurethanes always cost more if they are superior to the pure versions. Modified polyureas and polyurethanes cost less if they are inferior to the pure versions.

5 QUALIFYING THE PRODUCT

For the specified or end-user, selecting the correct product is a difficult process requiring careful review and verification of physical properties, process properties, historical references and contractor qualifications. The selection of advance polymer products is no different and with careful consideration the right product, its manufacturer and the correct application contractor can be determined.

5.1 Qualifying the Manufacturer

Manufacturing process controls are the key to consistency. The manufacturer's capabilities should always be reviewed as a first step in qualifying a product for use. For established technologies this is a fairly simple process as proven performance of a single manufacturer with an established historical track record can be verified by the

end-user electronically. For cutting edge technologies the verification process is not so simple, but with care can be achieved.

Polyurethane product manufacturers represent older established technologies, many of them having been in operation for decades. There are many well-established companies with proven production methods and controls in place. Polyurea manufacturers represent a newer technology and thus are not as easy to qualify. There are few established polyurethane manufacturers producing polyureas and the few that do produce both have recently entered the market and only after losing market share to polyurea manufacturers, not as a result of embracing newer technology from the outset.

Smaller companies, comprised of the new technology innovators, primarily represent polyurea manufacturing worldwide. This is typical of new technologies regardless of product type (See figure 1). These companies should be admired for their initiative and drive, but at the same time carefully researched to determine their ability to produce qualified products consistently. In recent years several successful small polyurea manufacturers have been purchased or merged with larger established coating companies, which does not imply that these entities are better manufacturers than othrt qualified polyurea manufacturers, but does indicate that polyurea market acceptance has reached the point where established coating manufacturers have decided to participate in polyureas and are adding polyurea lines to compete.

Any polymer manufacturer should be qualified based on the quality of the products they produce, the level of success that their products have reached (in the application type being researched) and their methods of manufacturing quality control. As with any coating system, bulk manufacturing is a pre-requisite for consistency. A qualified manufacturer should be capable of blending batches in at least 4000-liter minimum quantities (on the resin side of the two-part system) and should perform and provide detailed batch testing data for each lot produced, to ensure conformation with published properties. Another good indication of superior manufacturing entities is that they employ their own chemists and have the internal capabilities to test the products that they produce.

Superior manufacturers will blend their own isocyanate side as well, as modifications to this component formulation are critical in the production of more complex formulations. Many manufacturers do not produce the isocyanate side and buy stock isocyanates from the larger chemical conglomerates such as Bayer and ICI. Isocyanate blending requires water-cooled twin shell reactors and is more complex than production of resin side materials, which do not require the reactors to produce.

Companies that blend material in 55-gallon drums, and there are many companies producing polyurea formulations in this manner, should be avoided as the manufactured volumes will be inconsistent in both physical properties exhibited and color continuity. In addition many companies promote products manufactured by others under private label contracts, meaning that the end-user may be purchasing a product from a second or third party. These situations can result in products being sold for application types for which they were not designed or produced with the actual manufacturer’s data being revised or exaggerated by the intermediary party.

This does not imply that all distributors or private label suppliers do not provide excellent products and/or services but does mean that care should be taken to insure that the end-user knows where and how the products they are purchasing are being designed and produced.

5.2 Qualifying the Formulation

Polyurea, polyurethane and hybrid or modified coating products should be qualified prior to making a decision to use them. This qualification process should include; review of the products physical properties to ensure that it will perform in the application being considered, review of the products use in projects of a similar type, review of test data that is specifically related to the application being considered and its manufacturing origin. Many of these products are designed to fit a wide range of properties so they can be utilized in as many project types as possible. These formulations may be acceptable for waterproofing projects or other normal construction applications but specific projects, like pipeline anticorrosion systems require specific performance in key areas such as cathodic disbondment, adhesion, bend-ability and so on. Generic products will not perform as well as products designed, formulated, produced and tested to meet these specific attributes.

5.3 Qualifying the Contractor

Qualifying the contractor who will be applying the products is closely tied to the manufacturer, especially in locations outside or Europe and North America. Application of polyureas is not a difficult process as long as specific procedures are followed. In the North America and Europe there are many companies experienced in the application of these polymers that can apply virtually any manufacturers products that are specified. In other countries these contractor resources are limited and manufacturers and distributors are required to train and certify applicators for these product types.

In areas outside of North America and Europe, qualified polymer manufacturers and/or their distributors maintain local technical personnel to provide training and support for project specification, estimation and application. Products that are offered, but not supported locally, should be carefully considered to avoid potential problems during the project application period.

5.4 Qualifying the Product Summary

The end-user should use common qualification practices in the selection of a product. During this qualification process both the manufacturer and the local distributor or contractor that is actively promoting the products use should be reviewed.

A determination should be made that defines the product’s manufacturer and their process controls including batch volumes, quality assurance testing on a production

batch basis. Further controls are recommended including requiring random testing of delivered products, by independent laboratories. This would ensure that the manufacturer, distributor and contractor are presenting the coatings properties clearly and is willing to have this verifed as a contractual term or condition. Another control is recommended that requires the manufacturer be a party to any required product warranties, including installed warranties. This will require the manufacturer to verify the product's suitability for the application, the contractor's capabilities and their willingness to support this by being party to the warranties that apply.

The contractor should also be reviewed to determine experience in application of the products in similar projects and territories. The manufacturer should certify that the contractor is trained and qualified to install their products (again by tying the manufacturer to the warranty the contractors qualifications will virtually be guaranteed).

6 APPLICATION TYPES

The new polymer technologies summarized in this document represent dramatic advances within the industry which actually reflect a paradigm shift in coating, liner and membrane technologies. Historically these three application types used dramatically different types of products to meet the needs of the projects specific requirements. Coatings were spray, brush or roll applied; liners were rolled goods either mechanically or chemically bonded to substrates (or sometimes both); and membranes were roll or spray applied products that formed films or membranes. The new breed of polymer technologies, which include Polyureas, Polyurethanes and Modified or Hybrid products in fact perform as a coating, a liner or a membrane. The spray applied nature of the product not withstanding, the products are rigid enough to act as a liner (even as non-adhered liners), can be spray, brush and roll applied and create films typical of membrane systems. This fact alone creates a plethora of application types suitable to the products in general.

The ability to formulate these products for varying physical properties, chemical resistance, temperature resistance, flexibility and rigidity make them suitable for almost any application type as long as the formulae utilized is designed with the specific projects processes in mind. These products can have shore hardness from A40 to A 100+, elongation values from 15% to 800%, and a complete range of other properties as well. The products can be formulated for UV stability, color stability or even color fast capabilities. This ability to formulate to specification is unique in the industry and in fact many customers have formulations designed specifically for their needs. In fact there are very few applications types that can not be met by a Polyurea, Polyurethane or Modified formulation of these two product types. Within these product types are further classifications of Aromatic and Aliphatic (for both Polyurea and Polyurethane), Polyaspartic Aliphatic (for Pure Polyureas only) and water catalyzed single component products (or Polyurethanes only). Both Polyureas and Polyurethanes can be expanded using new patented technologies, providing even further application variations.

6.1 Specific Application Types

The common classification types available include; Primary Containment, Secondary Containment, Waterproofing, Anti-Corrosion, Anti-Abrasion, Architectural Coatings, Marine Coatings and so on.

These classifications can be further broken down into project types that include; Floor Coatings, Roofing Systems, Waste Water Treatment Containment, Potable Water Containment, Nuclear Waste Containment, Chemical Containment, Oil and Gas Containment, Bridge Coatings and Bridge Deck Coatings, Oil and Gas Transportation Coatings (pipelines, vessels, tanks both internal and external), Marine Coatings (holds, decks, bilges, tanks, hulls, superstructures), Off Shore Rig Coatings (decks, legs, heli-pads, accommodations), Insulated Composite Systems (roofs, walls, floors, pipelines using insulation materials in a composite), Geotextile Composite Systems (secondary containment of many fluids and chemicals using Geotextile fabric and polymer composites), and so on. The list of application types is virtually endless and all of the above items (and many more not mentioned) have historical references for these application types.

The products are also used in a variety of manufacturing processes by many of the world's largest companies. These manufacturing processes are wide ranging and include products from undercoating of vehicles by the world's major automotive companies, to famous brand tennis shoes, to electrical switch gear manufacturing and everything in between. The applications that are suitable for a properly formulated and applied advanced polymer are virtually endless.

7 CONCLUSION

With the proper qualification of the product, its formulation when compared to a specific projects requirements, the manufacturer of the product and the contractor applying the product, the end-user can be confident that they will be receiving a cost effective solution, that meets their specific needs and which will extend the life of their asset while performing at higher levels than any alternative available, regardless of the application type or process environment involved.

The seamless, monolithic, hydrophobic, and durable nature of this product type resolves the key problems and failure points of traditional coating, liner and membrane products. Historically seams and disbondment of layering were the primary cause of failures (second only to damage during installation or process) regardless of which product type you review. These products resolve all of these issues and allow for application in environments where traditional products can not be applied or are extremely slow to apply, due to high humidity, temperature extremes, etc.

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