

Professionally Processing Polyurethane Systems

Polyurethane adhesives, coatings, and encapsulants provide many important benefits to the including excellent mechanical and electrical properties, abrasion resistance and toughness, high productivity and excellent cost effectiveness. However, successfully processing these materials can sometimes be tricky and it sometimes requires specialized knowledge or experience to consistently yield satisfactory results. It is the goal of this publication to share our several decades of experience and technical knowledge in the formulating and processing of polyurethane materials with our customers.

The following information is general in nature and should be considered carefully in light of the particular chemistry and properties of the polyurethane systems that you are processing.

Processing and Handling Polyurethane Systems:

Mixing & Deaeration

[if !supportLists] 1.) [endif] **Weighing equipment** - a digital scale or triple-beam balance is recommended for use in weighing both resins and hardeners. The scale's accuracy should be appropriate for the quantity being weighed. For small quantities such as 50 grams a scale with an accuracy of ± 0.1 grams or less is recommended. An accuracy of ± 0.5 grams is generally appropriate for mixed quantities greater than 100 grams and for large quantities, such as 10 or more lbs. (>5 kg), an accuracy of as much as ± 0.5 lbs. (± 0.2 kg) may be appropriate. Any scale used should be regularly cleaned and checked for accuracy. It should be re-calibrated using NIST traceable standards as necessary - preferably at least annually.

[if !supportLists] 2.) [endif] **Material Handling** - When using polyurethane systems, the material should be protect from moisture and other environmental contamination when not in immediate use. Before resealing a container, thoroughly clean the lip or threads of the

container and then blanket the contents with a dry inert gas such as nitrogen or PUR-TECT II.

Store material in a warm, dry place. This is important because the resin component of most polyurethane systems will react with water even at trace levels yielding carbon dioxide and insoluble crusts at the air-resin interface. See later section on Product Containers & Storage for more information

[if !supportLists] 3.) [endif] **Weighing the Resin and Hardener** - Place the empty mixing container on the scale and tare or zero the scale. Check the container labels or the product datasheet to determine the correct mixing ratio. If the polyurethane material contains fillers, gently stir the components for 2 - 3 minutes or until the fillers are re-dispersed before weighing out material from the container. (To reduce air entrapment in the material during re-mixing of the fillers, gentle stirring is recommended.) If the resin or hardener exhibits a crystalline or solid appearance that is not normal for the material it may be possible to heat the material to re-liquefy it prior to mixing. See later section on material storage for more details. Once ready, carefully weigh each component into the mixing container. It is highly desirable to use the exact mix ratio recommended by the manufacturer. In most cases, variations within $\pm 2\%$ are desirable.

[if !supportLists] 4.) [endif] **Hand Mixing** - Use clean, dry utensils and weighing containers. Plastic or metal mixing containers are best as paper containers can contain absorbed moisture and may absorb some parts of the polyurethane formulation resulting in an off-mix-ratio condition. Wax or plastic coated paper is less subject to moisture absorption and/ or absorption of parts of the polyurethane formulation, but vigorous mixing can scrape the wax coating off of the container walls and mix it into the polyurethane potentially resulting in defects in the cured product. For mixing, plastic or metal spatulas with square rather than rounded ends are recommended.

To ensure complete mixing, containers should have flat bottoms and straight sides with no ridges or indentations that could hold poorly mixed material. The container should be large enough to allow ample room for stirring of the resin and hardener without

spilling or splashing. (Typically a total container volume 50 - 100% larger than the volume of material being mixed is adequate.) A minimum mixing time of 2 minutes is recommended unless the system has an extremely short pot-life or gel-time. We recommend timing the mixing step as operators tend to under-mix when not using an objective measure of mixing time such as a clock or stop watch. During blending, scrape the mixing container sidewalls and bottom as well as the mixing stick or spatula several times to ensure complete mixing of system components. (Container walls and bottom and mixer blades must also be scraped when using a mechanical mixer.)

Avoid unnecessary agitation during mixing; hand stirring should be thorough but not too vigorous to help prevent unnecessary air entrapment. For further assurance of complete mixing, transfer the mixed material to another mixing container and then mix for an additional 30 seconds or longer prior to use. This will further reduce the possibility for any unmixed materials to be used in your parts.

[if !supportLists] 5.) [endif] **Power Mixing** - For some applications, power mixing or the use of meter-mix dispensing equipment is strongly recommended. Power mixing - such as using a drill powered jiffy mixer or anchor blade is very useful for mixing large quantities of material where hand mixing would be difficult or impossible. Propeller-type mixing blades are not recommended as they can produce a difficult-to-remove froth. Use the same recommendations in selecting a proper mixing container for power mixing as described above for hand mixing (i.e. plastic or metal recommended, flat bottoms and straight sides, etc.)

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2 types of Jiffy style mixers

When using a power mixer it is important to try to minimize air entrapment unless a foamy mixture is desired or unless a technique for removing the air is planned (ex. vacuum degassing). When power mixing, use the lowest mixing speed that gives a thorough mixing motion within the mixing container. Try to keep the mixer blade far enough below the surface of the liquid to prevent or minimize the formation of a funnel or vortex around the mixer blades as such a vortex will rapidly add air into the mixture. When using a power mixer it is important to stop mixing frequently and use a spatula or other tool to scrape the sides and bottom of the container and the shaft and blade of the mixer to ensure that unmixed or poorly mixed material does not collect at these locations. For further assurance of complete mixing, transfer the mixed material to another mixing container and then mix for an additional 30 seconds or longer prior to use.

[if !supportLists] **6.)** [endif] **Meter-Mixing** - Meter-mixing is the ultimate form of mixing - it is the use of equipment that is able to pull properly proportioned resin and hardener out of reservoirs and mix them together either using some form of power mixer or using a static mixer. Many, but not all, meter mix equipment also include the ability to dispense the properly metered and mixed polyurethane through a dispensing head or sprayer thus allowing precise control of the material application to parts or into molds. Factors that tend to recommend the use of meter-mix equipment over hand mixing or power mixing include the following: the need for continuous throughput, rapid gel times (less than 20 minutes), high viscosity materials (>50,000 cP), a desire for void free

material without the use of vacuum de-aeration, and many other factors. If you have any questions about the suitability of hand mixing, power mixing, or meter-mix processing for your application please contact SP&S and we will be happy to review your application.

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2 examples of simple bench top meter-mix equipment

[if !supportLists] 7.) [endif] **Deaeration** - If void-free parts are desired, degas the mixed polyurethane system before use to remove any entrapped air. Start by placing the mixed system in a container large enough to accommodate at least two to three times the materials initial volume, as the mixture will expand under vacuum. Place the mixture into a vacuum chamber and bring the vacuum level to at least 28-29 inches of mercury. De-air for 2-3 minutes under 28-29 inches of mercury. During this process, the material will froth and then collapse to a smooth liquid that will bubble slowly as it completely degasses. The material is considered fully degassed when the rate of bubbling becomes slow and steady or stops. It is generally not necessary to wait for all bubbling to stop. If the froth takes a long time to break or bubbles remain on the surface after vacuum de-gassing, consider using an air release agent such as AIROUT, D-AIR, or X-Air to assist in releasing entrapped air. Once the material is fully de-aired, release the vacuum slowly until atmospheric pressure is reached.

Applying, Casting & Curing

[if !supportLists] 1.) [endif] **Mold Materials** - If molding components, the preferred mold materials are metals or polymers such as epoxies, polyurethanes or RTV silicones. Wood or plaster molds can also be used, but should be thoroughly sealed with a barrier forming material

such as REN RP 802 prior to casting or encapsulation. Any such barrier forming sealer must be capable of maintaining its protective film during the heat generated by the urethane curing process.

[if !supportLists] 2.) [endif] **Casting/potting/coating** - If using a mold it should be thoroughly sealed and/or released prior to casting. When pouring the material into the mold or component. Maintain a thin continuous stream of material. Pour in the lowest part of the mold or component and, as much as possible, allow the material to slowly flow to fill the mold or component rather than moving the stream of material to fill different areas. If the material is going into a potting shell or is intended to impregnate tightly packed components or coils consider either heating the mixture prior to pouring or heating the component or mold prior to casting. Care should be taken to balance the effect of the heat on the pot life of the system with the reduced viscosity and enhanced wetting that heating will produce.

[if !supportLists] 3.) [endif] **Bonding or Sealing** - Polyurethanes are often used as adhesives, sealants, or grouts. Before applying the adhesive, the surface to be bonded should be prepared to optimize the bond strength. Ensuring a clean, dry surface, free of grease, oils, and other contaminants is very important to prevent bond failures or weak bonds. Wiping the surface with a solvent such as isopropyl alcohol or another cleaning solution will assist in ensure the surface is clean and ready for bonding. After cleaning ensure the surface is dry prior to applying the polyurethane to prevent bubbling and other defects. If bonding materials that absorb moisture, dry thoroughly in an oven, desiccator, or using another method to ensure the moisture doesn't negatively affect the adhesive.

Rough or textured surfaces will generally provide better bonds than glossy or very smooth surfaces. Lightly roughening the surface with an abrasive pad, steel wool, or wire brush is often helpful as it increases the surface area to which the adhesive can bond and also creates the opportunity for mechanical locking to occur. Unlike some other types of adhesives, polyurethanes are generally not affected by the thickness of the bond-line or the size of the sealant bead. However, the optimum strength bond-line is typically about 2 -5 mils (0.002 - 0.005 inches or about 0.05 - 0.12 mm) in thickness. Only the minimum pressure necessary to hold the substrate together while the bond sets is recommended. Too

high a clamping pressure can squeeze all or most of the adhesive out of the bond-line leading to a weak or starved bond.

Some difficult to bond surfaces, such as some plastics and oxide forming metals such as aluminum, may require etching, priming, or surface treatments with flame, chemicals, or energetic ions in order to provide bond strengths that are satisfactory. Contact SP&S for recommended surface treatment methods if you are not achieving the desired bond strength to your substrate.

[if !supportLists] 4.) [endif] **Curing** - Although most polyurethane products can be demolded or handled within 24 hours at 25°C, the full physical properties of a room temperature curing polyurethane will develop over 3 - 7 days at 25°C. For the demold time and time for full cure for the system you are using consult the technical data sheet for the product or with the material manufacturer. Temperatures lower than 25°C can extend the time required to reach full properties and higher temperatures will often shorten the required time. Review the technical data sheet for each product for alternate cure schedules or contact your local Sales Manager or our technical staff for recommendations.

Product Containers and Storage

[if !supportLists] 1.) [endif] **Product Containers** - Our polyurethanes are packaged in tightly sealed containers blanketed with a dry inert gas to keep moist air from contaminating the products. It is recommended that the containers should be opened only when the material is ready to be used. Once opened any unused resin or hardener should be re-blanketed with a dry gas such as PUR-TECT II prior to re-sealing the container.

To properly reseal the container, start by thoroughly cleaning the lip or threads of the container with a rag or paper towel. This is important because any resin in these areas can react with atmospheric moisture and produce a crystalline solid that prevents the container from being tightly resealed. After cleaning the lip or threads, apply a dry gas blanket and then tightly reseal the container.

When using dispensing equipment, it is not recommended to allow air to be drawn back through the material reservoirs. Instead, vent reservoirs with approximately one psi dry gas pressure or use a desiccant cartridge in the vent line.

[if !supportLists] 2.) [endif] **Storage** - For consistent performance, store the resin and hardener at temperatures between 65°F and 80°F. Some resins will store best at slightly elevated temperatures such as 80°F - 90°F - check the technical data sheet for the products you are working with to see the recommended storage temperatures. Drums or pails should be stored on pallets away from cold surfaces. When first opening a container, visually inspect the compound to be sure it hasn't crystallized during storage. If the resin is normally clear and is instead opaque or if it appears solid, gummy or grainy the material should be heated to 120 - 140°F for several hours and then stirred gently to re-homogenize. Please note that this is a general recommendation - please review the technical data sheet or MSDS for each product before heating or contact your Regional Sales Manager or our technical staff.

Ancillary Products for use with Polyurethane Systems:

These items have some history of successful use with one or more of our polyurethane systems. They may or may not be suitable for use in your particular process or with the specific systems that you are using, but may be a good starting point for your evaluations:

Primers & Etchants:

[if !supportLists] – [endif] REN RP 870 two part primer - an excellent primer for metals

[if !supportLists] – [endif] CPD 9660 - excellent long open time primer for ABS, metals, phenolic & powder coated metals, vinyl, and many other substrates.

[if !supportLists] – [endif] Conap AD-1146 reported to work well as a primer for metals

[if !supportLists] – [endif] Master bond X17 reported as a primer for polyolefins such as polyethylene and polypropylene, but may not be suitable for priming metals.

[if !supportLists] – [endif] Ditzler DP-40 primer from PPG is excellent at priming/sealing cured urethane surfaces so that they will accept paint

[if !supportLists] – [endif] Etching solutions are recommended when bonding aluminum and other metals that readily form oxide layers. Removing the oxide layers improves the adhesive bond and reduces variability in the production process. The following etching methods have been found to be successful:

[if !supportLists] 1. [endif] Mixture of 55% by weight of Di-ionized water, 38% of sulfuric acid, and 7% of sodium dichromate with fumed silica added as necessary to make a paste. Etching is accomplished by applying the paste to the aluminum and allowing it to work for about 15 minutes. The aluminum should then be wiped clean, rinsed with DI water and dried in an oven at 60°C for at least 1 hour before the adhesive is applied.

[if !supportLists] 2. [endif] Mixture of 55% of DI water, 38% of sulfuric acid, and 7% of sodium dichromate heated to 60C. The aluminum is dipped in the liquid solution for at least 3 minutes then rinsed thoroughly with DI water and dried for 1 hour at 60°C.

[if !supportLists] – [endif] For other materials please contact SP&S for a copy of our guide to adhesive surface treatment. This guide provides recommended methods of preparing many types of surfaces for bonding.

Purging Agent:

[if !supportLists] – [endif] **PUR-TECT II** - Cost effective dry purging agent available in aerosol cans. Each can delivers 75 one-liter doses of dry purging gas. Compared to typical dry nitrogen gas it provides approximately 18 times more doses per canister. This dramatically reduces the cost/use and the amount of packaging waste generated.

Mold Releases & Sealants:

- [if !supportLists] – [endif] **SP 13** - Exceptionally effective liquid silicone release agent. Suitable for brush or wipe-on application. Excellent for use in high volume and high temperature applications.
- [if !supportLists] – [endif] **SP 78** - Silicone based aerosol release agent.
- [if !supportLists] – [endif] **SP 79** - Teflon based, dry film aerosol release agent. Contains no waxes or silicone and resists transfer to finished parts.
- [if !supportLists] – [endif] **SP 82** - Sealer for woods, plaster, or other mold materials that may contain moisture.
- [if !supportLists] – [endif] **SP 83** - wax based release agent that can be applied by brush, cloth, or sprayer to provide an exceptionally thin film coating.
- [if !supportLists] – [endif] **SP 85** - paste wax release agent

Colorants:

- [if !supportLists] – [endif] **Color Pastes** - These easy to work with color pastes are excellent for use in opaque systems. They can be added in percentages from 0.1 - 3% by weight of the system. It is recommended that they be mixed with the hardener prior to adding the resin for best results. White, red, yellow, green, blue, brown, gray and black versions are standard and custom colors and color matching services are available from SP&S.
- [if !supportLists] – [endif] **Liquid Dyes** - Highly concentrated liquid dyes can be used to add bright colors to polyurethane systems. At low levels transparency is often not affected. White, Yellow, Blue, Black, Green & Red colorants are standard. Custom colors & color matching services are available.

Thinners, Thickeners, Strippers, & Cleaners:

- [if !supportLists] – [endif] **Ultralane Thinner** - a high efficiency, urethane grade solvent blend that is compatible with most polyurethane resins and hardeners. It can be used to thin polyurethane systems for dip or spray applications, to obtain a thinner coating thickness, or to achieve more uniform coverage. Use of this

thinner in potting and encapsulation applications is not recommended without suitable testing.

[if !supportLists] – [endif] **Ultralane Stripper** - For polyurethane coating & adhesive applications this advanced, halogen free, two component stripper is an excellent way to rapidly remove the cured polyurethane without harming most types of embedded or coated materials.

[if !supportLists] – [endif] **Ultralane TX** - this thixotropic additive allows the user to thicken most urethane systems from a liquid to a paste depending on the quantity used. Contact our technical support staff for assistance in using this additive with your systems.

[if !supportLists] – [endif] **SP 70** - this product is the industry' premier water-less hand cleaner. It can be used prior to working with polymeric materials to coat the hands and reduce the likelihood for materials to stick to or stain the skin. It also can be used with or without water to remove most types of inks, adhesives, coatings, and other polymeric materials. It is also effective for cleaning uncured material from tools and equipment.

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