

Working with PUR HM in textile lamination

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Introduction

The Purpose of this Manual

This manual has been created to give you a basic understanding of the technology of Hot Melt Polyurethane (HMPUR) adhesives. The content of this manual will educate you regarding the chemistry, handling, safety and application of HMPURs. In addition, this manual also addresses key issues for starting up a trouble-free production line and pinpoint common problems on the *Troubleshooting* chart.

After completing this manual, you may have additional questions regarding your specific application. Please feel free to contact **Coraltek** to clarify any questions or other issues you may have.

This manual has been especially created for you. It is our intent to assist you in your polyurethane hot melt start up needs. It is our pledge to supply as much technical information and support that you request to improve your productivity.

We thoroughly understand your business focus. Having us as your partner, it will be a positive force in providing technical, mechanical and industrial information. We look forward to working with you and your team.

Thank you for considering **Coraltek** a preferred consultancy partner. You can be assured we have the right partners to provide quality products and technical service now and in the future.

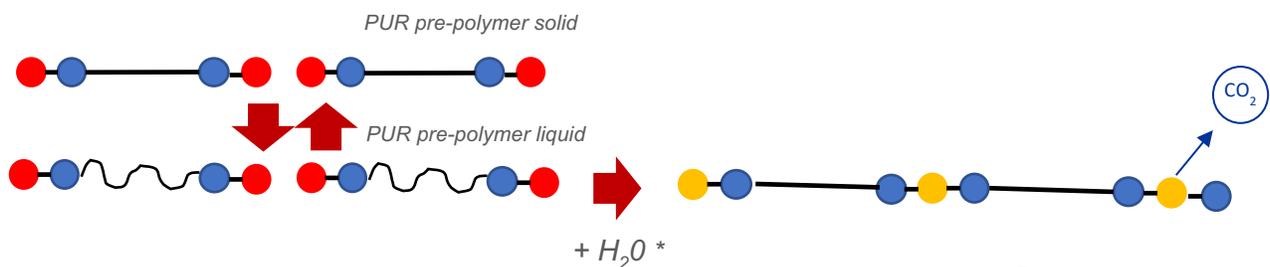
Understanding Hot Melt Polyurethane (HMPUR) Adhesives

Recent developments in reactive Hot Melt Polyurethane (HMPUR) adhesive technology have made these products viable candidates for use in high performance applications. Specifically, technical advantages that combine desirable properties such as fast set (curing), rapid green strength development, and exceptional environmental resistance, are now available.

HMPURs are the reaction product of the combination of a polyol and an isocyanate. Once reacted, the product formed is an isocyanate terminate prepolymer, which is moisture sensitive. After application, this product cross-links through a reaction with moisture in the air and surrounding substrates, forming a thermoset polyurethane polymer. Once thermoset, the HMPUR will possess exceptional strength and durability. Because these products contain isocyanates and must be heated for application, our partners work with lesser volatile isocyanates, such as MDI (diphenylmethane diisocyanate).

HMPURs work through two distinct stages to develop the characteristics of a high-performance adhesive. First, the HMPUR is heated to become molten or fluid for application. At this stage, HMPUR is similar to conventional hot melts because thermal cooling solidifies the adhesive after application. Accordingly, HMPUR has an open time and set time. It will develop enough strength upon cooling to allow for trimming in line and other handling of parts.

In the second stage, the HMPUR reacts with moisture to form a thermoset polymer resistant to heat, moisture, cold and solvents. This reaction occurs over time and under normal conditions^[1] 75% cure is reached within the first 24 hours. As the cross-linking continues, assembled substrates will continue to build strength. The time it takes to reach this state is dependent on at least one of the following:



1. Adhesive formulation
2. Moisture content of substrates
3. Ambient conditions (relative humidity and temperature)
4. Amount of adhesive applied

^[1] Normal conditions at 50% relative humidity and 21°C.

Handling Procedures

Receiving Adhesives

Coraltek recommends that you, the customer, read and understand the Material Safety Data Sheet (MSDS) and Technical Data Sheet (TDS) prior to receiving, handling, applying, and/or disposing of any adhesives discussed in this manual.

It is important to develop a habit of recording observations within the production environment. Once the adhesives have been received, it is important to record the conditions of the drums before they are removed from the truck. The first observation that should be recorded is the batch number of the HMPUR upon receiving. Utilize older stock first by rotating inventory (FIFO – first in, first out). Most HMPUR types have a twelve (12) month shelf life.

Movement and Storage of Adhesives

After reception of the drums, it is recommended that the adhesive is kept on its original pallets prior to use. If possible, do not disrupt the packaging of the drums. The packaging of the drums should be designed preventing denting. However, if the drums are dented, please call your supplier immediately after inspection. Dented drums are usually caused by careless movement of material. Dented drums may also cause dispensing problems for platen type adhesive unloaders. Round and small dents are OK, but sharp edged or punctured dents may cause damage to the melting equipment.

Do not stack pallets with drums higher than 2 stores. Excessive weight can cause damage to the drum's seal and allow moisture to enter the drum. This will diminish the shelf life of the adhesive.

Store drums in a cool, dry place, away from direct sunlight. Ideal storage conditions are between 10 - 30°C. Excessive moisture and/or water should be kept away from drums (sheltering). See the TDS for more specific storage information.

 **Do not open drums until they are ready to be used.**

Unloading the Adhesive and Safety

Since HMPURs are moisture-curing adhesives, it is important to protect them from moisture prior to application. To assist in this process, special systems for packaging, melting, unloading,

dispensing, and applying have been developed. These systems are “airtight” to prevent moisture exposure until the point of application.

Packaging of HMPURs requires specific techniques for sealing containers to ensure protection from moisture exposure. Regardless of the package selected, such as straight walled 18 kg and 200 kg drums, great care is taken in the packaging process. Ambient air is replaced by dry nitrogen during the filling process. This manufacturing process and special packaging features assures premium quality and consistent productivity.

NOTE

Special equipment is necessary to handle HMPURs and specific procedures should be followed for the unloading of adhesive to this equipment.

1. Ensure that the adhesive is within the advised shelf life prior to use.
2. Be certain that the unloading and application equipment are at the recommended temperatures.
3. Record the ambient plant temperature, humidity, equipment temperatures, date, and batch number of the drum that is to be used. Record other miscellaneous information, such as operator’s name, general notes, fabric type, etc. Overall, it is beneficial to record too much information rather than too little.
4. Remove the drum lid, unfold the aluminized plastic bag and cut it open from the top. Wrap the bag around the top of the drum and wrap adhesive tape to keep the inliner bag in place. Check the adhesive’s surface. It should be smooth and slightly sticky. Make sure there is no “cured film” on top. In case of doubt, a electric paint-blazer can be used to melt it for inspection. Once the drum is opened, it must be used immediately. **Do not reseal drums after initial opening for later use.**



5. Place the drum in or under the unloader or dispensing equipment. Please refer to the dispensing equipment’s operational manual for specific instructions.
6. At the desired application temperature, the HMPUR generally takes 30 minutes to melt after the platen has touched the adhesive’s surface or has been exposed to heat from an inverted unit.
7. The dispensing equipment’s procedures may require you to bleed the air out of the unloading device (generally a platen unloader). If this is necessary, you may notice the bleed off to be slightly foamy. This is dissolved nitrogen that was entrapped in the adhesive during the packaging process. This is **not** due to curing of the adhesive. This is not uncommon.

8. Consult the dispensing, unloading, and application equipment suppliers for appropriate pressures and operating instructions for their equipment.



While limitation of moisture exposure is important, proper handling of the active ingredient **MDI** (isocyanate) is also important. MDI is considered to be a respiratory and skin sensitizer and needs to be handled accordingly. Although MDI is only present in small quantities, typically less than 2.5% by weight, proper techniques must be used to limit potential exposures. Ventilation systems with positive air displacement should be incorporated in the areas where MDI could be released into the air, mainly in areas of unloading, application, and assembly of the adhesive and coated substrates.

Monitors are available which are calibrated to detect levels of MDI in the work environment. These are reliable instruments and we strongly recommend monitoring your work environment. Past as well as present experience indicates that these types of adhesives can be used safely and effectively for your application. Please refer to the Material Safety Data Sheet for specific instructions regarding spills, personal protective equipment, and other information regarding the safe use of this product.

Drum Exchange and Disposal

Procedures for the exchange and disposal of drums are of great importance from a performance and safety perspective. It is necessary to exchange drums quickly and safely when they must to be changed. The moisture that is in the air may cause pre-curing to the product if the exchange is too slow. As the old drum is removed from the unloading device, remember the drum is hot and may contain some residual molten adhesive. This molten adhesive may be emitting free isocyanate into the air. Please follow the outlined procedure:

1. If a drum alarm sounds (optional) indicating that the drum is almost empty, prepare the second drum as detailed in the unloading procedures.
2. Refer to the dispensing supplier's procedures for drum exchanges. If the system is a platen unloader, it is necessary to inspect the bottom of the platen for excessive adhesive or charred remaining adhesive. If this has occurred, wipe the bottom of the platen to remove as much of the excess adhesive or charred adhesive as possible. A clean platen will prevent future problems.
3. Exchange the drums as quickly as possible. Remove the almost empty inliner bag from the first drum, cut a corner and dispense (normally one or two kilos) HMPUR into the freshly opened drum. Try to limit the exchange to under five minutes. See Material Safety Data Sheets (MSDS) for further information.
4. After the exchange is made, remove the used drum to a well-ventilated area. Let the drum cool to ambient conditions. Do not reseal the drums. After 24 hours, the drums can be safely disposed. Please consult with the local authorities for proper disposal. Disposal procedures may vary depending on the location of your manufacturing facility. See the MSDS for specific details. These drums are usually classified as metal scrap with residues of solid waste, meaning that drums can be disposed of as steel scrap.

5. If a spill occurs, refer to the MSDS for specific information. All employees should read and review the MSDS.

Application of the Adhesive

Ideal Conditions for Application

Although HMPURs are applied at elevated temperatures (100-130°C), the surrounding environment is critical to achieve a sound, durable bond. The plant temperature and humidity will affect the adhesives' open time, transfer, cure time, and adhesion onto certain substrates.

For a consistent HMPUR application process, it is recommended that the operating plant temperature is between 18 - 35°C with a relative humidity of no less than 40%. The recommendations mentioned above may vary for certain processes and substrates. If conditions are maintained within these guidelines, potential problems are dramatically reduced.

It may be necessary to induce moisture into the environment when the relative humidity falls below 40%. Water can be misted (using ultrasound or steam) into the air within the plant to increase the relative humidity. This process should be located near the substrates and the application equipment. This is an inexpensive process that ensures enough moisture necessary for curing and "wet out" for certain substrates. **Coraltek** does not recommend misting actual substrates after the adhesive has been coated onto the part. This is a dangerous method because the oversized droplets may cool the adhesive prematurely causing poor transfer and adhesion.

It may also be necessary to pre-condition substrates prior to adhesive application. If substrates are kept outside or have just arrived at your manufacturing facility, the substrates may be colder than 18°C. If the HMPUR is applied to substrates colder than 18°C, the substrates might "shock" the adhesive (poor wet-out) and cause it to cool too quickly causing little or no transfer, poor adhesion and possibly de-lamination of the substrates. It may be necessary to condition substrates in the plant for 24 hours prior to lamination in order to elevate substrate temperatures. If your plant is not warm enough to pre-condition substrates, it is necessary to invest in infrared heaters to warm the environment.

Application Temperature

Hot Melt Polyurethane adhesives are intended to be applied from 80 to 130°C but may vary depending on the adhesive type and application. There are temperature guidelines that should be followed when melting, dispensing, and applying HMPURs. These guidelines vary according to equipment type.

Do not exceed maximum temperature of 140° C when melting, dispensing, or applying HMPURs. Temperatures over 140° C will cause degradation to the adhesive and possibly emit

excessive amounts of MDI into the surrounding environment. This degradation is known as *heat aging* and will cause the adhesive to have a yellowish/brownish color.

Unloaders

The melting device may change depending on the unloading equipment that is available in your manufacturing plant. The unloading devices on the market today are either the platen or the inverted drum (pail) unloaders.

The other type of unloader, inverted units and “melting on demand units” melt the “whole” drum and hold the adhesive in a hopper. This is different than platen unloaders which melt the surface. The inverted units have several different melting points and the adhesive’s temperature must be regulated.

Line and Hoses

The hose temperature is recommended to be set between the drum melter and application unit temperature.

(Engraved) Roll Coaters and Print Heads

For the correct temperature setting of the equipment, follow the TDS and as **Coraltek** for advice in case of doubt. Temperature settings might vary depending on the application and used substrates. In some cases, the temperature can be raised in order to improve the coating weight, transfer to the substrate and to increase the open time of the adhesive. Reasons to deviate from the advised temperature settings might be: Size of the (engraved) roll coater, the adhesive consumption rate, used substrates, and the type adhesive. Please consult us for further details.

Please remember, the temperature pre-set on most roll coaters do not always indicate the true temperature of the adhesive in the reservoir of the (engraved) rollers. The majority of these applicators are heated with oil using an external thermal heating device. This may cause a loss of temperature between 5 and 10 °C. Therefore, it is essential that the actual adhesive temperature be checked by a probe or thermocouple.

Application of the Adhesive

1. Start Up of the Equipment

Please read the Product Data Sheets (TDS) and the Material Safety Data Sheets (MSDS) of the HMPUR of choice **prior** to receiving, handling, storing, and running the product. Please discuss any application questions you may have prior to testing or running the adhesive. It is important from a production and safety point of view that you understand the product and how it performs.

Before actually starting up a new line, application, or production day, it is suggested that a logbook is kept recording daily activities. This will help track the adhesive, the application and should contain the following information:

- Adhesive's batch number and sequence (drum) number
- Temperature and relative humidity (of the environment, pre-sets on equipment, and actual adhesive temperature on the application equipment)
- Operator's name, the date, and the time at which the drum is started and finished
- All relevant info about the substrates (type, batch numbers, weight, etc.)
- Coating weights, applied pressure (roll and lamination), tension, etc.

This information is a good starting point for the documentation that is needed to produce consistent products and assists in identifying possible problems. It is also recommended that the coating weights are checked and recorded every hour during production. A good method of monitoring adhesive coating weight over time is to check the adhesive consumption divided by the number of square meters during a production day.

It is recommended that the adhesive unloading temperatures and the applicator temperatures be as close as possible when running full production. This will save time when allowing the adhesive to equilibrate to the desired roller temperature.

Always inspect substrates to ensure they are clean and free of processing oils, dirt, and dust prior to lamination. Also, be certain that the substrates are not colder than 18°C or warmer than 35°C.

It should be noted that the surface tension should be at least 38 dynes per centimeter when bonding substrates. Surface tensions below 38 dynes per centimeter may inhibit adhesion. This is critical with polyethylene, polypropylene films, some TPU type films, some PVC films and pretreated fabrics. It is recommended to evaluate the surface energy (of surface tension) prior to lamination. Substrates can be treated to enhance the surface tension. This will improve wettability of the adhesive and increase the adhesion.

2. Idling on the Equipment

The adhesive has an open time on open roller and print heads for approximately one (1) hour without changing any chemical properties. Open time here, is defined by the amount of time the adhesive sits on the moving rollers without coating the adhesive onto the substrates. The rollers must always be in motion during downtime. Do not let the adhesive sit on the rollers for more than one (1) hour. If this is exceeded, the viscosity may increase causing poor transfer and wettability when bonding substrates.

If the material has remained in the reservoir of the rollers for more than one (1) hour, dispose the old adhesive and refill the system with fresh adhesive. This step takes approximately five (5) minutes.

3. Clean Up and Maintenance

After eight (8) hours of production, it is recommended to remove the adhesive from the rollers. In some cases, customers apply the adhesive twenty-four (24) hours a day, seven days a week. Regardless of production hours, it is necessary to clean applicator heads after a full day of use. Cleaning the applicator regularly will extend the life of the rollers, adhesive dams, and improve the overall cleanliness of the equipment.

For exact cleaning procedures and cleaning agents, please consult the equipment manufacturers for proper instructions pertaining to their equipment. The following steps can be used as a guideline for cleaning HMPURs from rubber and metal (engraved) rolls:

- 1) Run the gravure as empty as possible and let the HMPUR out from the reservoir
- 2) Close the reservoir and fill it with Cleaner 2579 (powder) and let the rollers run between 10 and 20 minutes. You will see that the HMPUR dissolves and gets water thin. Now open the rollers and reservoir and let the liquid off.
- 3) Repeat step 2
- 4) Clean the (engraved) rollers with old cotton cloth or run it empty on foam or cotton substrate.
- 5) Clean the siliconized rollers with ethylacetate and be sure to remove adhesive trails.
- 6) Clean the engraved roller on a weekly or monthly basis using cleaning agent advised by the machine supplier or alternatively Cleaner HMP-X. This can be done in an external washing tank or in the equipment.
- 7) Purge the melter and hoses on an annual basis using Cleaner 2434 L. It can also be used to protect and cleaning the engraved roller.

It is important to read the material data safety sheets of each of these products prior to cleaning your equipment. Consult with your equipment manufacturer to approve cleaning agents before using them.

Coraltek will assist you in selecting the best cleaning agent for your application. The cleaning waste should be disposed of in compliance with your local regulations and you should consult the local authorities. Please refer to the MSDS of the adhesive and the cleaner prior to use. Consult with your equipment manufacturer before using any cleaning agent.

Troubleshooting

Problem	Possible Cause	Solution
Little to no transfer of adhesive	Not enough compression to wet out substrates	Check compression and verify compression is tight. Try to nip as tight as possible without causing damage to the substrates.
	The open time has been exceeded or the adhesive is setting too fast.	A. Make sure coating weights are correct. B. Make sure the substrates are warm enough. C. Increase the adhesive temperature. D. Check line speeds.
	Substrates are contaminated or surface tension is too low.	Clean substrates before coating. Treat substrates to increase surface tension.
	Too low coating weights	A. Increase the coating weight. B. Dump old material and start over with fresh adhesive. C. Clean applicator Roll.
	Plant temperature and humidity	A. Make sure temperature range is within 18-35°C. B. Make sure humidity is above 40%.
Substrates releasing after nip & the final adhesive bond on one or both sides	Adhesive is not setting fast enough	A. Make sure substrates are chilled after lamination. B. Make sure the coating weights are correct. C. Reduce the adhesive's temperature. D. Use an adhesive with higher green strength.
Bald spots on coated substrates	Pieces are not getting full coverage	A. Make sure substrates are in full contact with the (engraved) rollers. B. Make sure substrates are not too cold and well wetted-out. C. Make sure the temperature of the adhesive is accurate.
The adhesive will not extrude out of the hose	Moisture contamination	Call Coraltek and/or your equipment manufacturer for the best solution.
	Adhesive is not up to temperature	Wait 30 minutes for the adhesive to equilibrate to temp.

Overview:

Closed System:	Term that describes the production, storage, dispensing, and application of urethane adhesive systems, indicating that exposure to air/moisture is restricted prior to application.
Cross-linking:	The process of chemically connecting individual polymer chains at several points to form a multi-dimensional network. The polymer is then considered to be “thermoset”.
Cure Time:	The amount of time needed (dependent on temperature and moisture) to fully cross-link the polymer chains. Usually, 75% cure is achieved in the first 24 hours and full cure in 72 hours.
Green Strength:	Term used to describe the initial bond strength of the HMPUR.
Isocyanate:	A compound containing the isocyanate radical, -NCO. Examples include MDI, MBI, PMDI, etc.
MDI:	An isocyanate called “diphenylmethane diisocyanate.”
Moisture Cure:	A method of chemically cross-linking the polymer chain, utilized by one component polyurethane systems, driven by the reaction of isocyanate with moisture (water) found in the surrounding air and substrates.
Nitrogen Blanket:	The use of dry nitrogen air in the drum and/or inliner to protect the HMPUR from moisture.
One Part, Reactive Adhesives:	Polyisocyanate pre-polymers that react with moisture (water) to form a cross-linked, thermoset adhesive. Also known as moisture cure urethanes or one component urethanes.
Open Time:	Maximum time frame for the adhesive to transfer to a secondary substrate.
Polyol:	A compound containing two or more hydroxy groups, -OH. Examples include Ethylene Glycol, PPG, and Castor Oil.

Prepolymer:

An intermediate stage in the preparation of a polymer in which the product is partially formed and is either a liquid or softened by heat.

Reactive Hot Melt Polyurethane (HMPUR) Adhesive:

An adhesive system that initially works similar to a conventional hot melt adhesive with properties of open and set times, then over time reacts with moisture to form a thermoset adhesive.

Thermoplastic:

A material capable of flowing under heat and hardening by cooling.

Thermoset:

Polymers that have cross-linked and will not flow or cannot be dissolved under any conditions.

Urethane/ Polyurethane:

A specific group of polymers ranging from flexible to rigid. Formed by the reaction of a polyol and an isocyanate