Bayflex®

Integral Skin Polyurethanes
A Processing Guide

covestro

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Introduction

Dear Bayflex Customer,

At Covestro, we pride ourselves on providing you with technical assistance to help you solve your most challenging production problems. But technology can be intimidating, especially for those of us without an extensive scientific background.

Recognizing this, we have developed the Bayflex Integral Skin Polyurethanes: Processing Guide as a resource tool to assist you in understanding the basic concepts and practices of polyurethane production. Because it is written to be generally applicable to customers in many different industries, it is not meant to be a substitute for your own training program. Such a program should instruct employees in relevant aspects of safety, chemistry and processing as they apply to your own business.

Written with the help of science education professionals, this guide explains the technology behind Bayflex polyurethanes in a way that is more simple and straightforward. We have made every attempt to take a complex subject and make it more understandable for our customers. In place of technical jargon and chemical formulas, you will find plain English and analogies to everyday activities.

But just because we have taken a less complex approach does not mean we take our subject lightly. Handling chemicals is serious business. For this reason, this guide references safety and product stewardship publications that you and your employees must read and understand before working with Bayflex products.

The Bayflex Integral Skin Polyurethanes: Processing Guide is not all-encompassing, nor is it intended to be. It is intended to be accessible and memorable. It is our hope that this guide will contribute to a safe, knowledgeable, and productive customer.

A Note to the Reader

Welcome to the dynamic world of polyurethane chemistry! It's a world full of fascinating chemical reactions like instant muffins and foam pancakes. (You'll see what we mean later.) It's our intent in this processing guide to introduce you to the basics of the chemistry you'll use as you make products with Bayflex polyurethanes.

If you're already experienced running production with the materials and equipment described here, consider this a helpful refresher. If you're just being introduced to polyurethanes and still learning your way, consider this a helpful guide to high-quality production.

The world of polyurethanes has its own special vocabulary. Many of these words may sound completely foreign to you. Others may sound familiar, but their meanings may be different from what you expect. Whenever you see a word in **green bold face type,** you'll know it's a word you should add to your own polyurethanes vocabulary. Definitions for all these words are in the glossary at the back of this guide.

Finally, the world of polyurethanes has its own safety rules. Most of these are just plain common sense, but then most good rules are. Before you begin to work with Bayflex polyurethanes, be sure to read the following section on health and safety considerations. And don't stop there, because that's just the beginning. There are plenty of other publications you must read before starting. The next section will tell you what they are and where to find them. Remember, it's your responsibility to know how to handle polyurethane chemicals safely.

Health and Safety Considerations

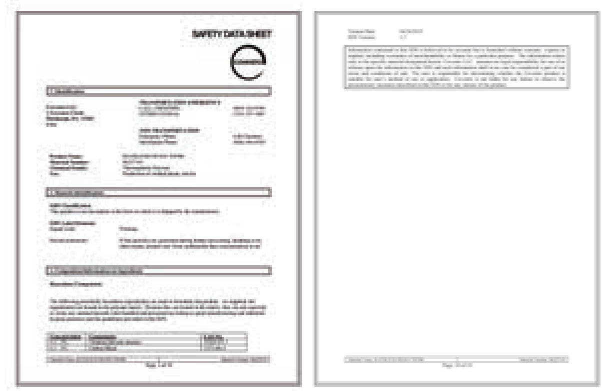
Health and Safety Information

Appropriate literature has been assembled which provides information concerning the health and safety precautions that must be observed when handling Bayflex chemicals. Before working with these products, you must read and become familiar with the available information concerning their hazards, proper use, and handling. This cannot be over-emphasized. Information is available in several forms, e.g., Safety Data Sheets (SDS) and product labels. Contact your local Covestro representative or contact the Covestro Product Safety and Regulatory Affairs department located in Pittsburgh, Pa.

Safety Data Sheets are supplied with all Bayflex systems and list specific safety recommendations. These must be read thoroughly before handling any chemical and kept available for ready reference. Covestro SDSs can be obtained via our product safety site, Product Safety First.

All persons who work around the chemicals must be trained in the safe use and handling of chemicals as well as emergency and first aid procedures found in the SDS form in the event of an overexposure.

For materials mentioned that are not Covestro products, appropriate industrial hygiene and other safety precautions recommended by the manufacturer should be followed.



Safety Data Sheets

Safety Data Sheets contain important Safety information about products you use.

Additional data on medical recommendations, spill procedures, and disposal of MDI-based isocyanates can be found in the following locations:

- https://www.productsafetyfirst.covestro.com/en/resources/resources
- https://polyurethane.americanchemistry.com/polyurethanes/Health-Safety-and-Product-Stewardship/Worker-Protection/
- https://dii.americanchemistry.com/Worker-Industry-Health-and-Safety-Guidance/

Basic Safety

Protect workers from the most common routes of chemical overexposure:

- Breathing vapors or mists (inhalation)
- Eye contact
- Skin contact
- Swallowing (ingestion)

Protect yourself from chemical overexposure:

- Wear long sleeves, chemical resistant gloves, and eye protection when working with or near chemicals.
- Never bring food, drinks or tobacco products into chemical work, handling, storage or laboratory areas.
- Clean up spills immediately. Appendix A contains the recommended cleanup procedure.

- Avoid contamination of isocyanates with water. Never re-seal an isocyanate container that has been contaminated with water. Pressure build up could rupture the container.
- Have medical clearance before beginning work in any chemical environment.

What Your Company Should Do

- Provide eyewash stations and showers near all potential exposure sites.
- Provide adequate exhaust ventilation at all potential exposure sites.
- Keep current Safety Data Sheets on file for all chemicals in the workplace.
- Provide thorough training in safety procedures and equipment.

Of course, the No. 1 rule is this: Don't take chances. If you're not sure that something is safe, don't do it until you consult the SDS or one of the other sites referenced on page 8.

Basic Chemistry

Why Should I know Basic Chemistry?

Imagine eating in a restaurant where the chef doesn't use clean cookware and doesn't mix ingredients. The food would be terrible! Chemistry works the same way; cleanliness and exactness are vital to producing quality products.

When you make parts with Bayflex integral skin polyurethanes, you are performing a chemical reaction. If you understand the basic chemistry of Bayflex integral skin polyurethanes, it's easier to understand how and why the manufacturing process works. Because cooking is household chemistry with which most people are familiar, we'll make comparisons to it where it's appropriate.

Technically speaking, Bayflex polyurethanes belong to a group of chemicals known as polymers. The word polymer comes from two Greek words meaning "having many parts" (poly=many; meros= part). You see many different types of polymers around you every day. The wrappers on your food, the tires on your car, and even the "slime" sold in toy stores are all made from polymers.

The differences between these polymers come from the parts, or units, which make them up. The polymer is just like a long chain, and the units (monomers) are the links in the chain.

Bayflex polyurethanes are a special type of polymer. They are made by combining two types of monomer units: isocyanates and polyols. When you process Bayflex polyurethanes, you combine these separate units to make the polyurethane polymer. Isocyanates are often called Component A and polyols are often called Component B. Together, Components A and B make up a system. Each system has a specific Bayflex name, such as "Bayflex 953."

Chemistry is like cooking — cleanliness and exactness are vital to producing quality parts.

You can think of isocyanates and polyols as electrical cords. The isocyanates have a plug on each end of the cord, and the polyols have a socket on each end. The cord in between can be any length; all the action occurs at the ends. When the isocyanates and polyols react, the plugs go in the sockets, and the many short chains become long polymer chains.

Think of isocyanates and polyols as electrical cords, with isocyanates having plugs and polyols having sockets.

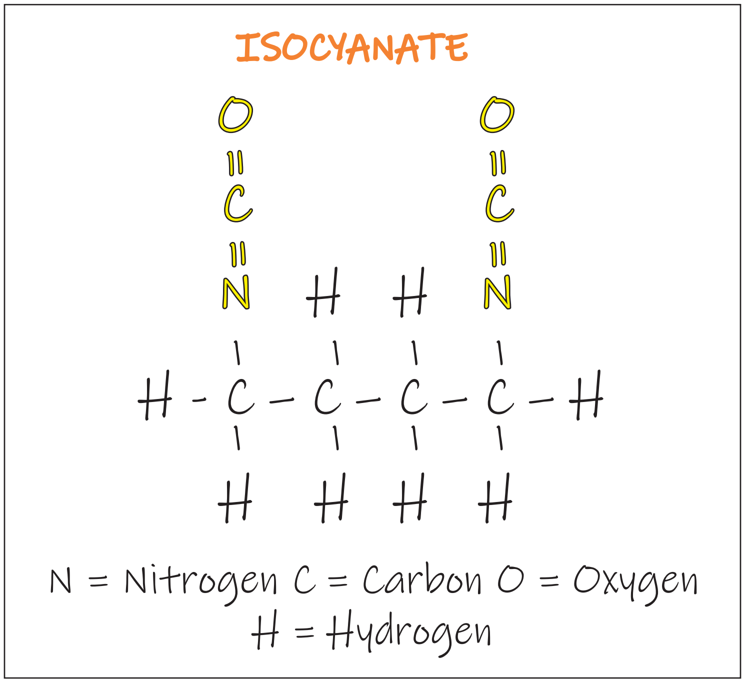
What Are Isocyanates?

Isocyanates (Component A) are very reactive. Isocyanates react with polyols (Component B) to make polyurethanes, but they can also react with many other things.

For example, isocyanates will react with water or even water vapor in the air. Think how bread or paint change when their containers are left open. They're still the same thing, but they're not as good as when they were fresh. Isocyanates are the same way: if left open to the air, they will spoil. This can have a negative effect on the manufacturing process, so isocyanates should always be kept in tightly sealed containers. Avoid prolonged exposure to air; keep them fresh.

Isocyanates can also react with themselves under extremely hot or extremely cold temperatures. Again, this can have a negative effect on the manufacturing process, so isocyanates should always be kept at the recommended temperatures.

Finally, isocyanates will react with human tissue, resulting in irritation of the skin, eyes, and respiratory tract. For this reason, you should always wear proper, recommended protective equipment and avoid breathing isocyanate vapors. Before working with polyurethanes, be sure you read and understand the section in this processing guide and the other materials referenced on page 8.

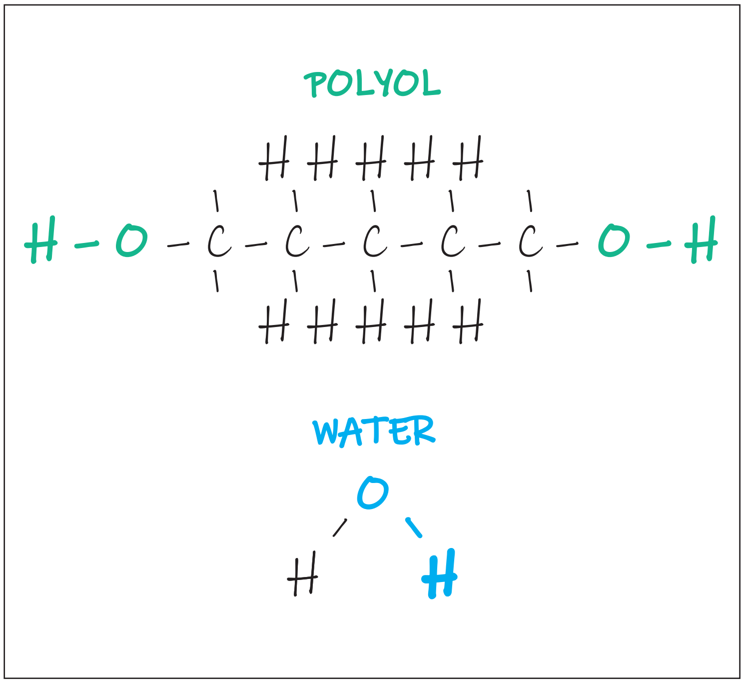


An isocyanate molecule. The highlighted areas are the business ends of the molecule — they do the reacting

Isocyanate Types

Isocyanates come in many types. Two of the most commonly used types are MDI and TDI. MDI and TDI are abbreviations for much longer chemical names: MDI stands for diphenylmethane diisocyanate; TDI stands for toluene diisocyanate.

The important thing to remember is that different types of isocyanates can have very different properties, just as two people from the same family can have different personalities. Normally, Bayflex systems are built around MDI-type isocyanates. Wherever we talk about isocyanates in this book, we mean MDI types. Some of the things we'll say about the MDI types aren't necessarily true for other isocyanate types. So if you're using TDI or any type of isocyanate other than MDI in your workplace, you must obtain information about these specific products!



OH, OH, who's got the hydroxyl? Both polyol and water molecules contain hydroxyl groups, which react with isocyanates.

MDI normally appears as a transparent, pale yellow to a reddish-brown colored liquid, depending on the specific grade used.

Isocyanate Strength

The strength or concentration of the MDI you're working with is called the isocyanate content. This is often abbreviated as NCO content or per cent NCO. (NCO is the chemical shorthand way of saying isocyanate, just like H20 means water.) The isocyanate content measures the amount of reactive material in the MDI (Component A).

The NCO content is important because it detemines how much polyol is needed to complete the reaction. The MDI and polyol must be combined in the correct amounts, or inferior parts will be produced.

If the MDI becomes contaminated (for example, with water), the NCO content will drop. This is because water and other foreign substances can react with the MDI and weaken it chemically. If you use a contaminated isocyanate and your machine settings are based on the original NCO content, you will not get the proper balance of isocyanate and polyol, and you will produce defective parts.

Effects of Temperature on MDI Isocyanate

The MDI used for Bayflex polyurethanes are liquids at room temperature. Like all liquids, they have freezing and boiling points, but these are different from water. Bayflex MDI can thicken and solidify at temperatures slightly below room temperature. Freezing can damage or ruin MDI, so correct storage temperatures should always be maintained. Although MDI will "boil" only at very high temperatures (usually 250˚-300˚F), there are other things that can happen at temperatures well below the boiling point. The MDI can be damaged or ruined by high temperatures. Even before it boils, though, MDI will produce harmful vapors as the temperature increases. These vapors can reach unsafe levels long before you are able to smell them. Protect yourself and protect the chemicals by keeping them in the recommended temperature range.

What Is a Polyol Blend?

The polyol blend, or Component B, is like a cake batter. It has many different materials combined according to a recipe, but until it is "baked," or reacted with MDI, it will remain unchanged. The recipe is designed to give the final product just the right properties. The most important materials contained in Component B, more commonly known as a resin, are:

- Base polyol. Makes up the bulk of the polyol blend and forms the backbone of the polyurethane polymer.
- Chain extender. A special type of polyol consisting of many short chains which connect the longer chains of the base polyol together.
- Catalyst. Like a spark plug, it makes the reaction between Component A and the resin go.
- Surfactant. Controls the foaming when Components A and B react. It gives the final product the right foam structure. (You'll also find surfactants in your laundry detergent, where they do a slightly different job.)
- Blowing agent. Creates the foam. In cooking, this would be baking powder or yeast. Without the blowing agent, the polyurethane is heavy and solid. Bayflex polyurethanes use water to make the polyurethane expand into a lightweight foam, but more on that later.

The right recipe is critical to making good parts. If anything is added to the resin, this changes the recipe and could lead to rejected parts.

Resin Reactivity

Just like NCO content measures the chemical strength of the MDI, there is a similar number for the resin. This number is the hydroxyl content, or OH number. (OH is the chemical shorthand for hydroxyl groups.) Later on, you'll see how the NCO content and OH number are used to determine how much MDI and resin are used together to make polyurethanes.

Additives

Many companies that use Bayflex polyurethanes add other materials to the resin to give special properties to the final product. The most common additives are pigments, which give polyurethanes color. Other special additives can protect the final product from ultraviolet light, oxidation, or microorganisms.

Because these additives change the original recipe of the resin, their effect on the final product must be taken into account. This can be done by a Covestro chemist or someone at your own company. If you must add any materials to a Bayflex polyurethane system, be very careful to add exactly the right amount. Adding too much or too little can lead to rejected parts.

What Are the Reactions Involved in Polyurethane Chemistry?

The Basic Reaction

The basic reaction to make polyurethanes is:

MDI (A) + polyol (B) = polyurethane + heat

The MDI and polyol must be combined in exactly the right amounts (in the right ratio). Otherwise, the reaction will be incomplete and defective parts may be produced. Using the wrong ratio is like a car in need of a tune-up. It runs, but you'd have a hard time selling it to anybody.

You must remember one thing when processing polyurethane chemicals:

BE EXACT!

Most of what goes wrong in production happens when changes occur in the chemicals or in the equipment that alter the ratio of MDI to polyol. A tiny change is all it takes to mess things up.

Finding out what went wrong after the fact can shut you down for hours or days. Being careful and exact beforehand can keep things from going wrong in the first place.

MDI and Water

Earlier, we talked about how MDI is very reactive and will react with water. The reaction is:

MDI (A) + water=

urea + carbon dioxide (gas) + heat

Gas bubbles formed in the reaction of MDI with water cause the polyurethane system to foam. Be sure to remember one important thing, though: the only water that should be allowed to react with the MDI is the water that is already contained in the resin recipe.

As already discussed, MDI should not come in contact with water or water vapor in the air. When MDI reacts with water, it cannot react again with polyol to make polyurethane. Remember the extension cords we talked about earlier: once they're plugged together, the ends are unavailable to be used elsewhere.

If MDI has become contaminated with water before processing, part of it becomes used up. This causes the NCO content to drop (the MDI loses "strength"). If the NCO content is too low, the MDI and polyol will not be combined in the right amounts, and bad parts will result.

Discovering Water Contamination

If your MDI appears cloudy or its surface has skinned over, it may have been contaminated by water.

Remember, MDI and water react to form carbon dioxide (CO2), which, in a confined space like a shipping drum, can build up pressure and rupture the container violently.

If the MDI has been contaminated, you can salvage the good material by transferring the MDI to a clean container, using a filter to catch any solidified material. Follow your company's procedure for disposing of the solidified material.

What is a Mixing Ratio?

As we mentioned above, the NCO content and OH number are used to calculate the proportion in which the MDI and resin must be combined in order to have a complete reaction. This proportion is called the mixing ratio. Your processing equipment should be set up to match this ratio.

In Appendix B, you can see how the mixing ratio is calculated. You should also remember this about the mixing ratio:

1. If anything is added to the resin after it is shipped from Covestro, the mixing ratio must be recalculated. Adding pigments, water, or other materials to the resin changes its reactive ability. The amount of each added material must be known exactly, so a new mixing ratio can be calculated. Never add anything to a Bayflex polyurethane system without knowing in advance what the consequences will be.
2. Many things can happen to your equipment that would cause Components A and B to be combined in the wrong ratio. What looks like a problem with the chemicals may, in fact, be a problem in the equipment. This guide will help you locate and solve the most common equipment problems.

Material Storage and Handling

How Are Bayflex Systems Shipped?

Different companies receive Bayflex polyurethane systems in different container types. Your company probably receives one or more of the following:

- **Drums.** 55-gallon steel drums can be either closed-lid or open-lid. With closed-lid drums, the lid is permanently fastened to the drum. The contents are removed through bung holes in the lid. With open-lid drums, the lid can be taken off to remove the contents.
- **Totes.** Totes usually hold about 275 gallons. There are several different types. Steel, plastic in a steel cage, and plastic in a cardboard box are the most common.
- **Bulk.** Some companies have chemical storage tanks that hold at least 5,000 gallons. There are separate tanks for MDI and resin. The MDI and resin are delivered in tank trucks, and the chemicals are pumped through a closed line from the truck into the storage tank.

Typical ways to store your chemicals.

What Are The Important Shipping Conditions?

Remember, MDI can freeze at temperatures slightly below room temperatures. To prevent freezing, MDI below is usually shipped in heated trucks.

Freezing is usually not a problem for the resin (Component B), so resin is usually shipped on an unheated truck. If the resin gets extremely cold, the individual parts of the mixture may separate out. If this happens, thorough mixing should be enough to return the resin to good condition.

How to identify your product.

What Should I Do Before Accepting Delivery?

Always perform a few simple checks before accepting delivery of your Bayflex products. These checks will make sure that you have the right material and that it is of good quality.

Paper Checks

- Product and lot identification. Check the product name on the label. It should have the Bayflex name and a number. The number should be exactly the same as the number you ordered. Also, make a record of the lot number.
- Certificate of analysis. This document contains important information about the chemical make-up of the material, such as NCO content for MDI (Component A) and OH number for resin (Component B). These values should be within the range set for the material. The certificate of analysis should be saved for future reference (mixing ratio calculations, etc.).

Visual Check

If the MDI is delivered in drums, open one or more of the drums and check the MDI's appearance. A flashlight might help for looking in the drums. The MDI should be clear, not cloudy. If it is cloudy, it may have frozen. Depending on the product, the color could range from water-like to amber or brownish (like iced tea or cola).

If the MDI is delivered in totes or a tank truck, take a sample of one to two gallons and perform this same check.

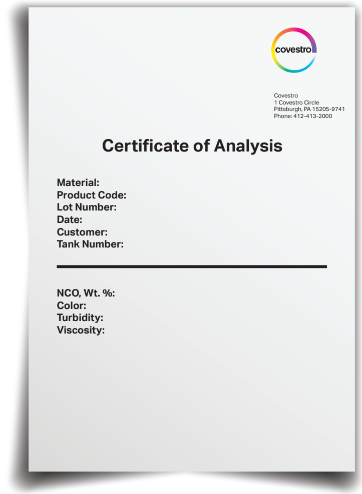
Chemical Check

The best receiving check is the hand mix. A hand mix is a test reaction between the A and B components and should always be done before accepting a new bulk shipment. The hand mix test is optional for drum or tote deliveries, because it is easier to return these materials if a problem is discovered later.

In the hand mix test, small samples of the A and B components are mixed together and the different stages of the reaction are timed with a stopwatch. The reaction times for the hand mix are like a "fingerprint" for the system. If they don't match the expected times, there may be a quality problem. Your Covestro representative can tell you what the expected reaction times are for your Bayflex system.

To do the hand mix test correctly, you need to know the NCO content and OH number of the materials you are testing. You also need to know how to use these numbers in a ratio calculation. In Appendix C, we show you how to do the hand mix test. If you are responsible for accepting shipments, you should learn how to do this test.

Certificates of Analysis

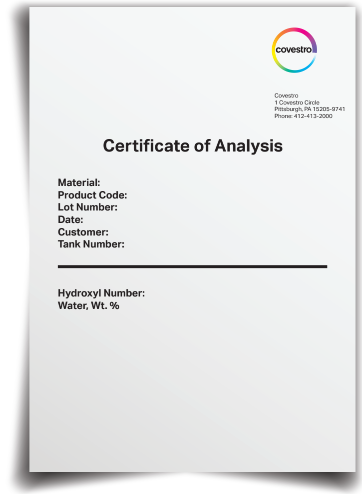

Covestro
1 Covestro Circle
Pittsburgh, PA 15205-9741
Phone: 412-413-2000

Certificate of Analysis

Material:
Product Code:
Lot Number:
Date:
Customer:
Tank Number:

NCO, Wt. %:
Color:
Turbidity:
Viscosity:

(COMPONENT A)


Covestro
1 Covestro Circle
Pittsburgh, PA 15205-9741
Phone: 412-413-2000

Certificate of Analysis

Material:
Product Code:
Lot Number:
Date:
Customer:
Tank Number:

Hydroxyl Number:
Water, Wt. %

(COMPONENT B)

The certificate of analysis contains vital information. Think of it as your product's birth certificate

DO NOT DROP

DO NOT LAY DOWN

DO NOT STORE IN A DAMP PLACE

DO NOT TURN UPSIDE DOWN

KEEP AWAY FROM DIRECT SUNLIGHT

How do I Unload Chemicals?

After the Bayflex materials have passed your receiving checks, the next step is to unload them into your storage area. Even though it may look like a routine job, only trained people should unload the Bayflex products. Improper handling can damage the chemicals or injure workers. If a spill occurs, emergency actions must be taken quickly by trained personnel.

During unloading of bulk chemicals, make sure the materials go into the right tanks: MDI in the MDI tank and resin in the resin tank. It may sound too obvious to mention, but there have actually been cases in the past where the material was put into the wrong tank. As you know from basic chemistry, the result is a chemical reaction that generates heat and pressure in the tank.

This reaction is dangerous while it's happening and extremely expensive to clean up afterwards. If you ever put material into the wrong storage tank, get everyone out of the building immediately. Then call Chemtrec at (800) 424-9300 to find out what to do next.

You must establish unloading procedures for your company. Follow them carefully, and be sure workers wear the recommended protective clothing and equipment. Remember, MDI can irritate the skin, eyes, and respiratory tract. Only those properly trained in your unloading procedures should be permitted to perform this activity.

How Should Bayflex Systems Be Stored?

As mentioned earlier, protect Bayflex systems from extreme temperatures and from contamination while in storage. Either of these can ruin the materials.

Drums and Totes

Keep drums and totes tightly sealed. If any were opened to do the receiving checks, re-seal them for storage. Never re-seal a drum of MDI that has been contaminated with water. The carbon dioxide gas produced by the water-MDI reaction can create enough pressure to cause the drum to explode.

Store both MDI and resin at a temperature of between 75° F and 90°F (23°C and 32°C). Keep MDI drums on pallets, since cold concrete floors can cause freezing, even if the room temperature is not cold. (Think how you feel sitting on a cold floor for a long time; it takes the heat out of you.)

Never store Bayflex systems outdoors or in a place where they will be exposed to direct sunlight.

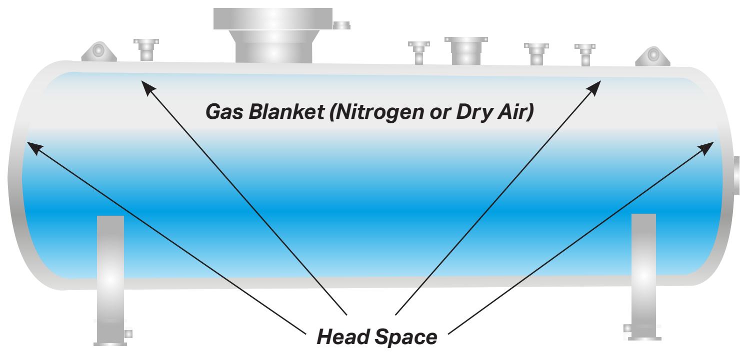
Bulk Tanks

Treat materials in bulk storage tanks with extreme care. Because tanks can hold thousands of gallons of chemicals, the results of improper storage can be very expensive, very dangerous, or both.

- ***Gas blanket.*** MDI tanks have a head space (the empty space between the surface of the liquid and the top of the inside of the tank) that is filled with dry air (target dew point of -40°F) or an inert gas such as nitrogen. The head space must be kept filled with this gas blanket. Otherwise, water vapor in the air will react with the MDI and possibly ruin it. If a tank of MDI is ruined, the costs for loss of material and clean-out can be very high. The gas blanket should be controlled with a tank-blanketing pressure regulator.
- ***Temperature control.*** Bulk storage tanks are usually connected directly to the polyurethane processing equipment. Because the right temperature is important in processing, the material in the bulk storage tanks must also be kept at a controlled temperature. Storage temperatures for both MDI and resin should be between 75°F and 90° F (23°C and 32°C).
- ***Recirculation.*** Recirculation is important for temperature control. By pumping the material at a slow rate from the tank, through the piping, and back to the tank, a constant temperature is held through the whole system. If the material just sat in the tank, the portions in distant parts of the piping system would quickly get too cold. This could cause processing problems at the machine, or result in a blockage caused by frozen material.
- ***Mixing.*** A big tank of resin is just like a small box of cereal in that some settling may occur. If the resin is not mixed continuously in storage, the individual ingredients in the "recipe" will separate out, and the material will not process correctly. Avoid this by making sure that your resin is continuously mixed at low speed in the tank. Mixing also works together with recirculation to help maintain a constant temperature.

MDI in bulk storage tanks does not need to be mixed. It normally does not contain anything that can settle out.

Isocyanate Tank



Be sure to keep the head space in your isocyanate tank filled with a blanket of nitrogen or dry air. This will prevent a reaction with moisture from the outside air.

How Do I Prepare Bayflex Systems for Production?

Resin in Drums

Before using Bayflex polyurethanes from drums, two aspects are very important to keep in mind: temperature control and mixing.

Store drums at the recommended processing temperature for 24 hours before use. This ensures that all of the material in the drums is at the right temperature. Adding material that is too hot or too cold to the day tanks (small supply tanks) can shock the system and cause processing problems.

Mixing of the resin (Component B) is necessary to make sure that all of the ingredients in the recipe are evenly spread throughout the mix. If the ingredients are not completely blended, the final product will probably not be uniform either. If you've ever bitten into a lumpy muffin and tasted a mouthful of flour, it's the same thing; somebody didn't mix the batter well enough. The ingredients in the resin can start to separate after a few hours, so mix your in-use drums at the beginning of every shift.

Mixers

There are three types of mixers that are commonly used to mix Bayflex resins:

- ***Propeller mixer.*** Propeller mixers give the best mixing. Propeller mixers are used with open-lid drums. Mix the drums with a propeller mixer for at least 30 minutes before using the material.
- Bung hole mixer. Bung hole mixers have smaller blades so they can fit through the bung hole of a closed-lid drum. Because the blades are smaller, bung hole mixers don't work as well as propeller mixers. Run a bung hole mixer for at least one hour before using the material.
- ***Emulsifying (high-shear) mixer.*** Emulsifying mixers work at very high speeds. Even though they shorten the mixing time, do not use emulsifying mixers to mix Bayflex polyurethane resin. Emulsifying mixers create rapid heat build-up that can ruin the material.

Propeller Mixer (left): Best all-around mixer. Bung Hole Mixer (center): OK, but takes longer to mix. Emulsifying Mixer (right): Careful! Can ruin material. Not recommended.

Resin in Totes

Handling resin in totes is very similar to handling resin in drums. Totes must also be stored at the recommended processing temperature for 24 hours before use.

Mixing is slightly different with totes. Use only propeller mixers. Bung hole mixers are too small for the large totes, and emulsifying mixers can damage the material. Mix resin in totes for one hour before the beginning of the shift. Continue mixing while the tote is in use.

Pigment Addition

At some companies, polyurethane parts are colored by injecting pigment directly at the mixhead. At most companies, pigment must be added to the resin before it is added to the day tanks. The right procedure for adding pigment depends on the type of container (drum, tote, or bulk) and the type of pigment. Follow the procedure very carefully; otherwise, you might end up making parts with colored streaks. In most cases, these become rejects.

Thick, Unpourable (High-Viscosity) Pigments Drums

If the pigment is in the form of a very thick (viscous) liquid or paste, the following procedure must be used.

1. Start with a thoroughly mixed drum of resin (see "Mixers" on page 21).
2. Remove and add an amount of resin from the drum that is equal to the amount of pigment that will be mixed and combine it with the pigment in a separate container. A clean 5-gallon bucket usually works well for this.
3. Use a mechanical mixer (such as a paint stirrer) to mix the resin-pigment blend until the color is uniform.
4. Pour the resin-pigment mixture back into the original drum and mix thoroughly. Follow the mixing procedure described on page 25.

Thin, Pourable (Low-Viscosity) - Pigments Drums

If the pigment is in a form that can be easily poured, it can be added directly to the resin drum before mixing.

Mixing thick (high-viscosity) pigments into the resin.

Totes and Bulk Tanks

Resin in totes and bulk tanks must be transferred to drums before pigment can be added. Make sure the resin has been thoroughly mixed before taking it out of the tote or the bulk tank. Once the material is in a drum, you can use one of the two procedures previously mentioned, depending on how thick the pigment is (high or low viscosity).

Other Additives

If you have to add any materials such as light stabilizers, antistatic agents, etc., add them immediately before the original mixing step. Be careful to add exactly the right amount, because too little or too much can change the way the system reacts and produce inferior parts. (Of course, you've made the necessary adjustments to the mixing ratio since you've changed the OH number. Right?) Before working with these additives, you must consult the SDS, product labels, and other safe handling information provided by the manufacturers of these products.

How Do I Fill the Day Tanks?

If you're adding a Bayflex resin or MDI to the day tanks for the first time, or you're changing to a different resin (different product number), follow the procedure described below.

Flushing

First, the old material must be flushed out of the tank. Material stuck on the sides of the tank and in the recirculation lines will contaminate the new material and probably cause bad parts to be produced.

First flush

1. Drain the old material from the tank.
2. Add 5 gallons of the new material to the day tank.
3. Let the material circulate for 15 minutes.
4. Empty the tank.

Second flush

1. Flush again with 5 gallons of fresh material.
2. Remove and clean the filter with an acceptable solvent.

Charging Day Tanks

Once the day tank is flushed, it can be filled (charged). Make sure the resin or MDI has been stored at the processing temperature for at least 24 hours (see "How Should Bayflex Systems Be Stored?" on page 19). After charging the day tank, let the material circulate for 30 - 45 minutes so it can settle out at the right temperature. During this time, you can also set the tank pressure. Be sure the tanks are tightly sealed. Air leaks can cause processing problems by creating pressure drops.

Charging MDI Tanks

When charging the MDI tank, follow all of the instructions above. In addition, remember: water is the enemy of MDI. Don't leave MDI drums open for a long time during the flushing and charging steps. Also make sure that no water or other foreign substances get into the MDI.

After the day tank has been charged with MDI, make sure it is completely sealed and pressurized with dry air or nitrogen. Remember, you want to prevent it from reacting with humidity in the air.

What Is Calibration and How Is It Done?

Calibration of the processing equipment is probably the single most important step in making good quality parts with Bayflex polyurethanes. Calibration is the process of setting the machine ratio to match the mixing ratio for the Bayflex system you are using. Different Bayflex systems will have different mixing ratios and need different machine ratio settings. It's not one-size-fits-all.

Are you getting what you think you're getting? Take frequent calibration shots to check the machine ratio.

Before setting the machine ratio, make sure the materials are at the processing temperature. If the temperature changes during or after calibration, the machine ratio will change too, and the machine will need to be recalibrated. Taking the time now to be exact will save you a lot of time later.

Each type of machine has its own recommended method of calibration. Some machines are calibrated directly at the mixhead, while others may have separate valves for calibration. Follow the instructions of your equipment manufacturer for proper calibration.

To calibrate, an average production shot is poured into pre-weighed cups. The cups are then weighed again to find out how much resin and MDI are coming out of the machine with each shot. The amounts of resin and MDI are compared to determine the actual machine ratio.

If the machine ratio is different from the mixing ratio for the Bayflex system you are using, the output of the pumps needs to be adjusted until the machine ratio matches the mixing ratio. The simplest way is to increase or decrease the pump speed of the resin pump, MDI pump, or both.

If your pumps are gear-driven, you can change the machine ratio by changing gears in the pumps. Increasing the number of teeth on the drive gear will increase the pump output. Increasing the number of teeth on the pump (idler) gear will decrease the pump output. It's just like a multi-speed bicycle. The bigger the chain ring in front, the farther you can go with each pedal stroke (higher output). The larger the sprocket in the rear, though, the shorter distance you can travel with the same pedal stroke (lower output).

To summarize, the steps in machine calibration are:

1. Remember to follow safe handling procedures, including protective equipment, when starting this operation.
2. Find out what the mixing ratio should be.
3. Secure the materials at the processing temperature; temperature changes must be avoided once calibration begins.
4. Weigh two cups big enough to hold a full production shot (this will depend on the size of the parts you are making). Write the weights on each cup.

Just like a car needs a tune-up every so often, your equipment should be recalibrated regularly. We recommend recalibrating at least once per shift.

5. Pour an average production shot of resin into one cup and MDI into the other cup. (Follow the machine manufacturer's instructions for how to pour a calibration shot.)
6. Re-weigh the full cups and subtract the weight of the cups. Record the actual weights of resin and MDI.
7. Calculate the machine ratio: divide the weight of MDI by the weight of polyol and multiply by 100.
8. Compare the machine ratio with the mixing ratio required.
9. If the ratios don't match, adjust machine output and repeat calibration.

Just like a car needs a tune-up every so often, your equipment should be recalibrated regularly. We recommend recalibrating at least once per shift.

What Should I Check Before Starting Production?

After the machine is calibrated, the last step before running production is the cup shot or free rise foam check. The cup shot test is done to make sure that the foam reactivities are normal. It's just like the hand mix test you read about earlier, except the chemicals are mixed by the machine instead of by hand. The cup shot can catch many of the common chemical and equipment problems which lead to production problems.

A cup shot is done by pouring a small shot from the mixhead into a pre-weighed paper cup. Pour in just enough material so that the foam expands above the top of the cup when it reacts. The results will probably look like instant "muffins."

Four tests can be done with the same cup shot: foam reactivities, throughput, free rise density, and foam structure.

Charging Day Tanks

Four reactivity times are measured when the cup shot is poured:

Cream time. The time, in seconds, from beginning the pour until the material starts to expand. At this point, you should see the mixture become milky and start to rise in the cup.

Rise time. The time from beginning the pour until the foam stops rising. By this time, it should look like a polyurethane muffin.

Tack free time. The time from beginning the pour until the foam surface is no longer tacky. Touch a clean wooden stick lightly to the surface; if it sticks, you haven't reached the tack free time yet.

Pull time. The time from beginning the pour until the top of the foam can be pinched and pulled without tearing.

These reactivity times are like a "fingerprint" for the Bayflex system. There are standard times that are typical for each system. It's the beauty of chemistry: if you do everything right, the same reaction should occur exactly the same way every time. If the times you measure are different from the standard, this may be a sign of chemical or machine problems.

There are also typical reactivity times for the hand mix test. In general, hand mix reactivities are slower than machine reactivities. The machine mixes the chemicals much more thoroughly, which makes the reaction go faster.

Another point to keep in mind is that different machines can produce different reactivities with the same Bayflex system. When checking foam reactivities, make sure you are comparing them to the right numbers for your specific equipment. If you are unsure what these numbers should be, ask your Covestro representative.

Throughput

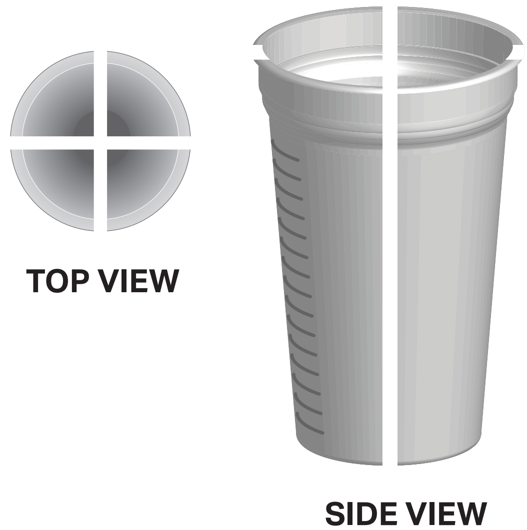
Throughput is measured by weighing the cup of reacted foam, subtracting the weight of the empty cup, and then dividing by the length of time the material flows from the mixhead, known as the shot time. Throughput is usually measured in grams per second.

Free Rise Density

Free rise density measures the foaming power of the Bayflex system and gives an idea how easily it will fill out the molds in production. After doing the reactivity tests above:

1. Cut off the top of the reacted foam so that it is flush with the top of the cup.
2. Weigh the cup and subtract the weight of the empty cup to get the weight of the foam.
3. Divide the weight of the foam by the volume of the cup to get the free rise density. (You can find the volume of the cup by weighing the amount of water needed to completely fill it. The weight in grams equals the number of cubic centimeters (cc) in the cup.)

You can convert free rise densities from grams/cc to pounds per cubic foot (pct) by multiplying by 62.4.



Check the foam structure by cutting the cup lengthwise in quarters. The foam should be uniform and have a smooth, velvety texture. Splits, swirls, or other imperfections are usually signs of equipment problems.

Foam Structure

You can check the foam structure by cutting the cup lengthwise in quarters. The foam should be uniform and have a smooth, velvety texture. Splits, swirls, or other imperfections are usually signs of equipment problems.

Production

After you have done your pre-production checks, you are ready to start production. The sections below cover the most important things you need to know about running production with Bayflex polyurethanes.

How Do I Dispense the Materials Into the Mold?

The heart of the production process is the mixhead, which combines the resin and MDI and pours, or dispenses, the mixture into a mold. There are two main types of equipment setups: open pour and direct-inject.

- ***Open pour.*** In an open-pour configuration, the mixed polyurethane system is poured into an open mold. The mixhead is moved clear of the mold lid, and the mold is closed. Open pour molding can be done by hand, or the mixhead can be machine-controlled.
- ***Direct-inject***. In a direct-inject configuration, the mold is closed, and the material is injected into the mold through a small hole, or injection port. If you have machine-controlled open pouring or direct injection, filling the molds is as simple as pressing a button. If you have an open-pour configuration with hand pouring, you must control how the molds are filled.

Hand Pouring

With hand pouring, the way you fill the mold is very important. Even if everything else is perfect, the wrong pouring pattern can cause rejected parts. Some of the common problems that can result from a bad pouring pattern are:

- Flow lines
- Air bubbles/trapped air
- Pinholes
- Mold not filled
- Hard and soft spots in same part
- Liquid level lines
- Knit lines
- Mold not venting properly

Pouring Pattern Tips

The main purpose of a good pouring pattern is to make sure the mold is filled evenly and smoothly. It's just like making pancakes: if you pour the batter in the wrong way, they look funny after they're cooked.

Finding the right pouring pattern is sometimes tricky and takes skill. The same pattern will not necessarily work for different part designs. Trial and error is the only way to find a good pouring pattern, but there are a few guidelines you can follow to help find the right pattern faster:

- ***Never back-track.*** Always pour in one direction only. Back-tracking will lead to knit lines or other problems in your finished parts, so don't do it.
- ***Follow the mold design.*** If the part has some areas that are thicker, these need more material so pour a little extra here. Likewise, thin areas should get less material.
- ***Watch tilted molds.*** If your molds are tilted, remember the material will run downhill before it can react and fill up the mold. In this case, pour a little extra material in the uphill part of the mold to make up for what will flow downhill.
- ***Pay attention to vents.*** Most good molds are "feather vented." That means there is a slight clearance between the two mold halves running the whole way around the mold. When the Bayflex polyurethanes begin to react and foam up, the air in the mold is pushed out through this small gap.

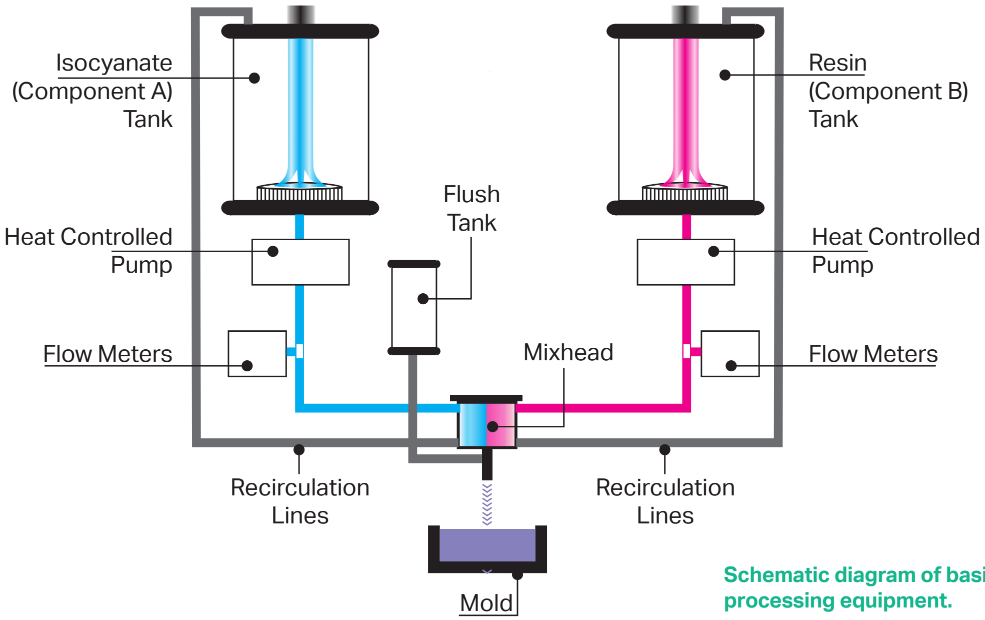
If your molds are not feather vented, they will have notched vents to let the air escape. Because the foam can come out the vent hole also, you need to adjust your pouring pattern for this type of mold. Usually, you should start pouring on the end opposite of where the vents are.

The purpose of a good pouring pattern is to make sure the mold is filled evenly and smoothly. It's just like making pancakes - if you pour the batter the wrong way, they look funny after they're cooked.

Getting Started

Here are two simple pouring patterns to get you started. These may not work for you as-is, but you can use the tips above to modify them into something that does work.

- ***Puddle Pour.*** Start with the most basic pattern: the puddle pour. Simply pour the entire shot into the middle of the mold in a big puddle. After the mold is closed, the reacting material will flow and expand to the other parts of the mold.
- ***End-to-End Pour.*** The next step up from the puddle pour is an end-to-end pour. Pour from front to back or back to front. Make adjustments to this basic pattern depending on how the finished parts look.



Schematic diagram of basic polyurethane processing equipment.

What Should I know About Molds?

Temperature Control

Temperature control is not only important for the chemicals, it's also important for the molds. If the mold is too hot, the finished part will have blisters on the surface which will cause it to be rejected. If the mold is too cold, other problems will result. The finished part may be difficult to get out of the mold; it may tear when demolding; or it may swell up after the mold is opened.

For Bayflex polyurethanes used to make footwear, the mold temperature should be between 110° F and 120° F (43°C and 49° C). For other types of products, the mold temperature should be higher - between 130° F and 140° F (54° C and 60° C).

Check the mold temperature occasionally to make sure it is in the right range. A digital surface temperature probe normally is used for this. Not all parts of the mold will be the same temperature, so measure at least three different spots and take the average reading.

Mold Releases and In-Mold Coatings

Why Are Mold Releases Used?

Mold releases are used for the same reason that you use grease in a frying pan: to keep things from sticking. Without mold release, parts made with polyurethanes will be difficult or impossible to take out of the mold. There are also two secondary benefits of mold releases: they help material flow in the mold, and they can improve the surface quality of the finished parts.

Although the mold release can have an effect on the quality of your parts, it does not affect the mixing ratio. You don't need to recalculate your mixing ratio for the mold release; it's just a spectator to the chemical reaction between the resin and MDI.

How Are Mold Releases Used?

Mold release is sprayed into the mold either by hand or automatically with a robot. Because mold release products are different from manufacturer to manufacturer, you should follow the mold release supplier's instructions for spraying. (A list of suppliers is available from Covestro.) In general, you want to lightly cover all inside surfaces of the mold.

Don't forget that spraying mold release agent must be done in a well ventilated area. Consult the manufacturer's SDS for hazard information and handling recommendations.

If a Little Bit of Mold Release Is Good, Then More Is Better, Right?

Wrong. Too much mold release can be just as bad as not enough. Using too much mold release can cause surface quality problems and rejected parts. In fact, using too much mold release is a more common mistake than not using enough.

Am I Using Too Much Mold Release?

There are two ways to tell if you're using too much mold release. You'll notice obvious puddles in the mold after spraying, or you'll see surface quality problems when the parts are demolded. Problems such as wet spots, pinholes, streaks, and a hazy appearance can all be signs that too much mold release was used.

Like cooking grease, the right mold release helps your parts come out of the mold easily.

Not enough mold release and your parts are bound to stick.

Too much mold release and they're bound to have surface quality problems.

What Are In-Mold Coatings?

An in-mold coating is a special kind of paint. Instead of painting the part after it is molded, the coating is applied to the inside of the mold before the chemicals are dispensed from the mixhead. After the reaction is complete, the part comes out of the mold already painted.

This sounds simple enough, but it doesn't work for every application. Discuss in-mold coating with your Covestro Technical Representatives and paint supplier to see if it can work for your company.

If I Use an In-Mold Coating, Do I Still Need to Use Mold Release?

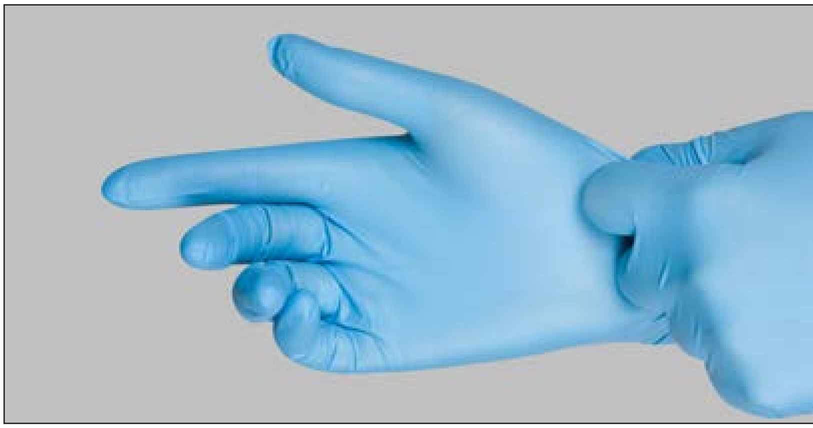
Usually. Some in-mold coatings have mold release built in, so they don't need a separate mold release. More often, a separate mold release has to be used. The mold release is sprayed into the mold, then the in-mold coating is sprayed, then the polyurethane is molded.

If you use an in-mold coating, follow the manufacturer's instructions for spraying. In general, the same rules apply as for mold releases. Just like with mold releases, spraying too much in-mold coating is often a problem. Wet spots and peeling of the coating on the finished part are signs that too much in-mold coating was used. When in doubt, consult the manufacturer's instructions.

Inserts

What Are Inserts and Why Are They Used?

Inserts are anything that is molded into the polyurethane part. Inserts can be used for many reasons. They can be used to give more support to the soft foam, or to act as an attachment point for screws and bolts. (Plastic plates and metal rods often serve this purpose in furniture parts.) Inserts can be used to add special features to the foam (air bags and gel bags molded into shoe soles are good examples), or they can be used just to fill up space.



Grease, dirt, mold release, and fingerprints are the villains that can ruin your part. Make sure your inserts are completely clean. To avoid fingerprints, wear gloves when handling inserts.

What Should I Know About Molding With Inserts?

There are three basic things to keep in mind when working with inserts: temperature, contamination, and positioning.

- Temperature. Inserts should be heated to the same temperature as the mold before being placed into the mold. Avoid injury by taking all necessary precautions, like wearing gloves, when handling the insert. If the inserts are too cold, the finished part will have sinkholes and will probably have to be rejected.
- Contamination. Inserts must be completely clean. Grease, dirt, mold release, or even the oil from your fingers can cause the part to be ruined. Foreign substances like these can destroy the bond between the insert and the polyurethane foam.

  Inserts should be completely degreased before they are put in the mold. To avoid fingerprints, always wear gloves when handling inserts. Fingerprints are actually oily spots that you leave behind, and they will ruin the part. Finally, make sure inserts are put in the mold after mold release and in-mold coatings are sprayed.

Check with the supplier of your degreasing agent to find out how to use these products correctly.

- Positioning. Inserts must be correctly positioned in the mold. If pins or clips are used to hold the insert in place, make sure that the insert is completely seated on them. Inserts that are not securely in position may be bumped out of place by the forceful movement of the reacting foam in the mold. This can lead to rejected parts.

Mold Clamping

When polyurethane foam systems react in the mold, they create high pressures as they expand. Molds must be clamped shut with a pressure that is higher than this internal mold pressure, or the expanding polyurethane will force the mold open. If this happens, polyurethane can flow out of the mold and create rejected parts. Molds are clamped either mechanically or hydraulically. When molding polyurethanes, make sure the clamping systems are working correctly and that the mold is shut completely after each shot.

Mold Cleaning

Why is Mold Cleaning Necessary?

Over time, molds get dirty from the buildup of mold release and polyurethane material. Even before it's visible, this thin film can affect the surface quality of the molded parts and possibly lead to rejects. This is especially true with highly detailed parts.

How Can I Tell If the Molds Are Dirty?

The first sign of dirty molds is usually seen when the polyurethane parts are demolded. Here, a whitish buildup may be seen on the parts. Also, dirty molds might make demolding difficult by causing parts to stick in the mold. In extreme cases, a whitish buildup will actually be seen on the molds themselves.

How Often Should Molds Be Cleaned?

This depends on the molds, mold release, and polyurethane system being used. In general, molds should be cleaned no less than every few days and no more than once per shift. Follow the instructions of the mold cleaner manufacturer.

Mold cleaners are very aggressive chemicals and can cause injuries, so be sure to use protective clothing and equipment, gloves, and eye wear when working with these products. Follow the manufacturer's recommendations when using mold cleaners.

Why Should I Flush the Mixhead?

Flushing agents are liquids used to keep the mixhead clean. During operation, reacted material can build up on the mixhead and eventually cause blockages or other mixing problems. If the machine is stopped frequently, this buildup can happen very quickly.

Your machinery should have a specific control button for flushing or purging the mixhead. The location of this button will be different for different types of machinery. Most machines flush by forcing flushing agent and high-pressure air through the mixhead.

Usually the mixhead is flushed into an empty drum used specifically to collect the flushing agent. Make sure this drum is well away from your molds to prevent splashing or spraying flushing agent into the molds. (Flushing agent is one of those foreign substances you read about earlier which can change the chemistry of your system.)

After flushing, make sure the mixhead is wiped clean. This will help to prevent dripping of the flushing agent into the molds when you start pouring again. Again, clean chemistry is good chemistry! We recommend that you flush the mixhead every 30 minutes. Also, if the mixhead is idle for more than a few seconds, it must be flushed. If the idle time is longer than the cream time of the Bayflex system (usually 5-20 seconds), the chemicals will begin to react in the mixhead and must be cleaned out.

When Should I Recharge the Day Tanks?

After you have run the machine for several hours, you should watch the level of resin and isocyanate in the day tanks. The tanks need to be refilled, or recharged, long before they are actually empty. Once the level in the tanks goes below 1/4 of capacity, it is hard for many machines to hold a steady temperature.

Don't let your mixhead choke on built-up residues. Flush the mixhead regularly to keep it clean.

You read earlier that changes in material temperature can lead to processing problems and rejects. To avoid this, the tanks should always be kept at least 1/4 full.

Once the level in the tanks falls near 1/4 full, they should be recharged in the same way as described in the section, "How Do I Fill the Day Tanks?," on page 23. As long as the same product is being used each time, it's not necessary to flush the tanks before recharging. Remember to watch the temperature of the new material going in. If it's too hot or cold, you will see processing problems.

What If I Have to Change to a Different Bayflex System?

If you have to change from one Bayflex system to a different one, the changeover procedure is very important. The new system will have a different chemical composition (different "recipe"), which means that a new mixing ratio will need to be calculated and set on the machine. Also, the viscosities (thickness) of the resin and MDI may be different, which means that machine pressures have to be adjusted.

If all of these adjustments are made correctly, the new system should run smoothly. If they are not, you will probably see processing problems that create expensive downtime. This could mean the machine could be out of service for hours or days. Taking a few extra minutes to make sure the changeover is done correctly will pay off down the line.

The most important steps to remember are:

1. Flush out the old system with the new material.
2. Set the right temperatures.
3. Calibrate the equipment, making sure to use the right mixing ratio.

When changing to a different Bayflex system, machine adjustments may be required. If these adjustments are not made properly, you may see processing problems that create expensive downtime.

If there's a production problem, who do you think is better prepared to solve the problem?

How Do I Keep Track of Product Information?

Use a Data Log

Keeping a data log is nothing more than keeping good records. Just as maintaining good records can make it easier for you to balance your checkbook or do your income taxes, good records can also make it easier for you to keep production running smoothly.

If you run into problems, a detailed data log can make it easy for you or a Covestro technical service representative to troubleshoot the problem and keep your production levels up. Sometimes, it's not even necessary to look at the equipment to spot the problem because the part tells the whole story.

What Data Should Be Logged?

The company may already have forms and procedures for logging production data. If not, at least the following information should be recorded:

- Date
- Time
- Product name
- Lot numbers of resin and isocyanate
- Color of parts being produced
- Type of parts being produced (part name or number)
- Mixing ratio
- Temperature in day tanks
- Reactivity profile (cream time, rise time, tack-free time)
- Free rise density

How Often Should This Information Be Recorded?

At the beginning and middle of each shift, or when changing materials or mixing rates.

What Happens to the Parts After They're Molded

Degreasing

Many times, the polyurethane molding operation is only one part of a bigger manufacturing process. After molding, polyurethane parts are often painted, glued, or put together with other pieces to make more complex products.

Especially with painting and gluing, it is very important to remove all mold release from the finished polyurethane part. This slippery film is helpful in getting parts out of the mold, but it will also prevent the paint or glue from sticking to the part.

Usually, special equipment is used to degrease polyurethane parts. Instructions for this equipment

Don't let your defective parts get out the door! There are many different tests that can be used to catch bad parts before they can be sold.

should be followed closely. Even if a part doesn't feel slippery, it can still have enough leftover mold release to cause problems with painting or gluing. Once parts have been degreased, do not handle them with bare hands because oil from fingerprints can cause the same problems as leftover mold release.

Quality Control

When parts come out of the mold, even if they look good, they may have problems that make them unusable. Many different tests are used to catch bad parts before they can be sold. A few basic tests can show whether the system was processed correctly:

- Part weight (density)
- Hardness
- Flexing life (special to the footwear industry)

The company may have more or different quality control tests. All these tests have one purpose: to spot bad parts before they reach your customer. High quality is achieved by identifying problems in the manufacturing process early on and making the necessary changes quickly.

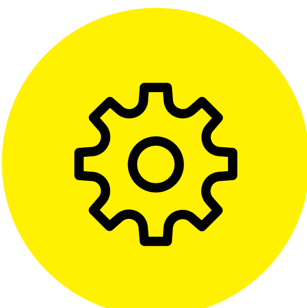
The Bottom Line

Details, Details, Details

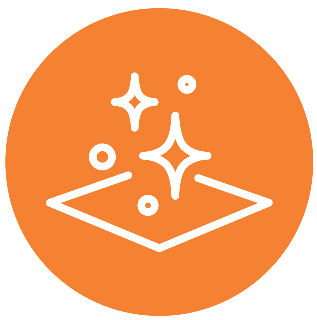
As you can see, working successfully with Bayflex polyurethanes requires knowledge and skill. But basically, it all boils down to this:

Be Safe

Know your Chemistry



Know your machinery



Be Clean!

A final Note

Our goal at Covestro is to give you the materials and service you need to make high-quality products. This processing guide is only the first step in helping you do this. If and when you have questions about Bayflex polyurethanes, call your Covestro representative or one of the sales offices listed on the back cover.

Appendix A
Suggested Spill Cleanup Procedure

Implement site emergency response plan. Notify all required federal, state and local authorities in a timely manner and follow clean-up procedures required by law. Evacuate non-emergency personnel. The magnitude of the evacuation depends upon the quantity released, site conditions, and the ambient temperature, since higher levels of airborne isocyanates may be expected as ambient temperatures increase. Isolate the area and prevent access of unauthorized personnel. Notify management. Call CHEMTREC at 800-424-9300 for assistance and advice.

Wear appropriate personal protective equipment (PPE) as specified in Section 8 of the applicable Covestro SDS. Ventilate and remove ignition sources. Control source of the leak. Contain the released material by damming, diking, and retaining, or diverting into an appropriate containment area.

Absorb or pump off as much of the spilled material as possible. When using absorbent, completely cover the spill area with suitable absorbent material (e.g., vermiculite, kitty litter, Oil-Dri®). Allow for the absorbent material to absorb the spilled liquid. Shovel the absorbent material into an approved metal container (i.e., 55-gallon salvage drum). Do not fill the container more than 2/3 full to allow for expansion, and apply lid loosely. Repeat application of absorbent material until all liquid has been removed from the surface. Proceed to decontamination of the spill surface.

Decontaminate the spill surface area using a neutralization solution (for detailed information on neutralization solutions, consult Section 6 of the applicable Covestro SDS). Scrubbing the surface with a broom or brush helps the decontamination solution to penetrate into porous surfaces. Wait at least 15 minutes after first application of the neutralization solution before applying absorbent. Cover the area with absorbent material and shovel this into an approved metal container. Check for residual surface contamination using a surface wipe method (refer to section VII for information on surface wipes).

If isocyanate remains on the surface (red color on pad), repeat applications of neutralization solution, with scrubbing, followed by absorbent until the surface is decontaminated (no color change on SWYPE™pad). Apply lid loosely to metal waste container (do not tighten the lid because carbon dioxide gas and heat can be generated from the neutralization process). With the lid still loosely in place, move the container to an isolated, well-ventilated area to allow release of carbon dioxide. After 72 hours, seal the container, and properly dispose of the waste material and any contaminated equipment (i.e., broom or brush) in accordance with existing federal, state and local regulations.

Oil-Dri® is a registered trademark Oil-Dri Corporation of America.

Appendix B
How to Calculate the Mixing Ratio

As discussed in the main portion of the processing guide, one of the most important parts of polyurethane chemistry is combining the resin and MDI in the right amounts. If there is too much MDI or too much polyol, the chemical reaction will not be complete.

What Is the Mixing Ratio?

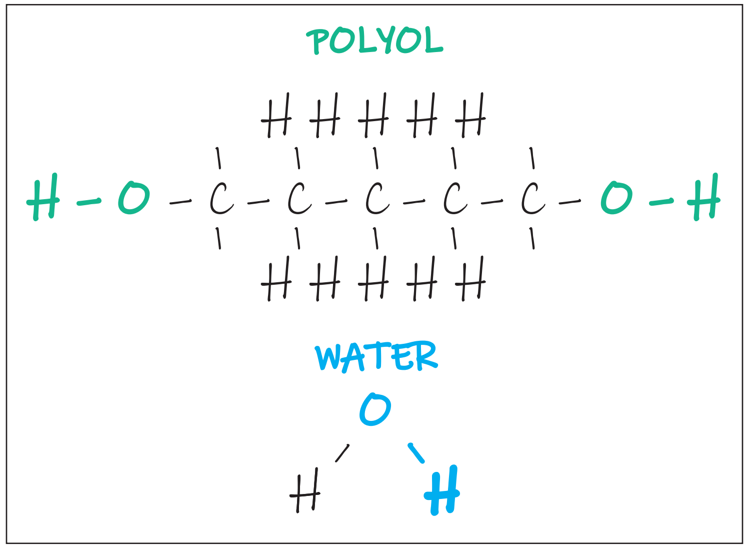
The mixing ratio, sometimes called the mix ratio, measures the specific amounts of isocyanate and resin combined in the reaction. In order to figure out the mixing ratio, you need a calculator and the Certificate of Analysis supplied by Covestro.

- The hydroxyl content, or OH number, of the resin (Component B)
- The amount of water (as a percentage) present in the resin
- The isocyanate content, also called NCO content or percent NCO, of the MDI (Component A)

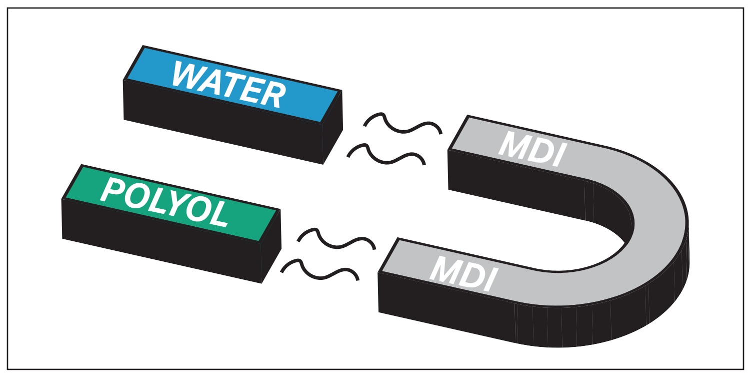
What Is the Water Content and Why Is it Important?

You learned about the OH number and NCO content in the main section, but we haven't talked about the **water content**, or **percent water** yet. All resins have water in them, and you saw already that water will react with MDI. Notice the drawings of the polyol and water molecules. They both have the same OH, or hydroxyl, group. The MDI doesn't care if the OH group is part of a polyol molecule or a water molecule; it will react with the OH group wherever it finds one.

You need to take the water content of the resin into account when you calculate the mixing ratio. You might think the OH in the water should already be included in the OH number of the resin, but the normal methods for measuring OH number don't detect the OH in water. You have to account for this separately.



OH, OH, who's got the hydroxyl? Both polyol and water molecules contain hydroxyl groups, which react with isocyanates.



Isocyanate will react with OH groups wherever it finds them: in polyol or water molecules.

Where Do I Find the NCO Content, OH Number, and Water Content?

The NCO content, OH number, and water content can usually be found on the certificate of analysis that is done when your Bayflex product is made. If you don't have this certificate, contact your Covestro representative to find out what these values are. (Be sure to have the complete product name and lot number handy.) Don't use values from a previous delivery, because they may be slightly different each time.

How Is the Mixing Ratio Calculated?

Once you know the values for NCO content, OH number, and percent water, finding the mixing ratio is a snap. Simply plug them into the following formula:

$$\text{Amount of MDI} = \frac{[(\text{resin OH\#} \times 100) + (\% \text{ water} \times 6233)]}{[\text{NCO content} \times 13.35]}$$

The result that you get is the amount of MDI to add to every 100 parts of resin. (This is where the 100 comes from in the formula above.) Let's try an example:

Suppose the resin has an OH number of 95 and a water content of 0.45%, and the MDI has an NCO content of 23%. What is the mixing ratio?

$$\text{Amount of MDI} = \frac{[(95 \times 100) + (0.45 \times 6233)]}{[23 \times 13.35]}$$

$$\text{Amount of MDI} = \frac{(9500 + 2850)}{307}$$

$$\text{Amount of MDI} = \frac{12305}{307} = 40.1$$

So, you need 40.1 parts of MDI for every 100 parts of polyol.

What is the Isocyanate Index?

When you calculate the mixing ratio in real life, there's one more number you need to know: the isocyanate index, sometimes just called the index. It lets you fine-tune your mix.

The mixing ratio you found above tells you how much MDI is needed to react exactly with all of the OH groups in the resin. But sometimes you don't want exactly that amount. Some Bayflex systems give the best results using a little extra MDI, while others give the best results using a little less. In these cases, you want to adjust the mixing ratio slightly. The isocyanate index is the number that tells you exactly how much to adjust.

Use the isocyanate index to keep your mix tuned for high performance.

Use the same example on page 53 and assume that the Covestro chemist recommends an index of 98 for the Bayflex system you are using. This means that you want to use 98% of the amount of MDI predicted by the above formula. Your mixing ratio would now be 98% of 40.1, or 39.3 parts of MDI for every 100 parts of polyol. On your calculator, it's .98 x 40.1 equals 39.3.

On the other hand, if the recommended index is 103, you want to use 103% of 40.1, or 41.3 parts of MDI per 100 parts of resin. Again, that's 1.03 x 40.1 equals 41.3 on your calculator.

You've probably figured out by now that an isocyanate index of 100 means to make no adjustment in your mixing ratio: 100% of 40.1 is, after all, 40.1 parts of MDI. Sometimes you may see the index written with a decimal point. In this case, the number has already been converted to a percentage for you by dividing by 100.

For example, 98 becomes 0.98 (98 + 100), 103 becomes 1.03 (103 + 100) and 100 becomes 1.00 (100 + 100). Don't be confused; they mean the same thing. Just know which one you're using when you do the ratio calculation.

Keep in mind that even though we're making a change from the original mixing ratio we calculated, it is a very exact change. It's not like throwing a little extra cheese on top of your pizza; it's more like changing the dough recipe to get thin or thick crust.

We're finding the exact mixing ratio that will give us the results we want.

What about additives?

Now that you see how the isocyanate index complicates your ratio calculation a little bit, let's consider additives. You learned earlier that additives can also contain substances that might react with MDI. If you're using pigments or other additives with your Bayflex resin, their effect on the reaction has to be included in the ratio calculation also.

If you really want to know how to do it, give us a call, and we'll explain it to you. Otherwise, just make sure someone accounts for the additives when determining what mixing ratio to use.

Appendix C
How to Perform a Hand Mix

The hand mix test is a quick way to make sure the reactivity of your Bayflex product is what it's supposed to be. If you recall from the main text, this is the instant muffin test. To do the test, all you need are a clean 1-pint paper cup (like a two-serving ice cream container), a laboratory scale, and a laboratory mixer.

1. First, calculate the mixing ratio. The procedure for this is described in Appendix B. Also, make sure the chemicals are at the right temperature. The recommended temperature is 77° F (25° C).
2. Weigh an empty 1-pint paper cup and write the weight on the outside. You'll need it later.
3. Weigh a convenient amount (usually 100 grams) of the resin into the cup.
4. Add the correct amount of MDI from the mixing ratio calculation.
5. Place the stirrer into the cup containing the chemicals.
6. Start a stopwatch and, at the same time, begin stirring.
7. Mix for a period of time at least 3- 4 seconds less than the expected cream time. Your Covestro representative can tell you the expected cream time for your product.
8. Remove the stirrer from the cup. Be sure it stops spinning before you take it the whole way out in order to avoid being sprayed with material.
9. Record the following reaction stages:

Cream time. The time in seconds from beginning the pour until the material starts to expand. At this point, you should see the mixture become milky and start to rise in the cup.

Rise time. The time from beginning the pour until the foam stops rising. By this time, it should look like a polyurethane muffin.

Tack-free time. The time from the beginning of the pour until the foam surface is no longer tacky. Touch a clean wooden stick lightly to the surface; if it sticks, you haven't reached the tack-free time yet.

Tools of the trade: a laboratory mixer, laboratory scale, and 1-pint paper cup.

Pull time. The time from beginning the pour until the top of the foam can be pinched and pulled without tearing.

After the foam has cured, check the free-rise density. This is a measure of the foaming power of the Bayflex system and can be found with the following procedure:

1 . Cut off the top of the reacted foam so it's flush with the top of the cup.
2. Weigh the cup and subtract the weight of the empty cup to get the weight of the foam. You should have written down the cup weight on the outside earlier.
3. Divide the weight of the foam by the volume of the cup to get the free-rise density. (You can find the volume of the cup by weighing the amount of water needed to completely fill it. The weight in grams equals the number of cubic centimeters (cc) in the cup.)

You can convert free-rise densities from grams/cc to pounds per cubic foot (pcf) by multiplying by 62.4.

Appendix D
Lead-Lag Pancake Check

Lead-lag is a condition that exists if the resin and MDI don't enter the mixhead at the same time. One component leads and the other lags behind, resulting in a poorly mixed area in the foam. This condition usually appears at the start of a pour and can result in a variety of different problems.

To do the lead-lag pancake check:

1. Pour a thin film of foam onto a polyethylene sheet, making sure to separate the beginning and end of the shot (start and end the pour on opposite ends of the sheet).
2. Allow the foam to cure for three minutes.
3. Peel the foam "pancake" from the polyethylene sheet.
4. Brush the bottom side of the foam (the side that was in contact with the sheet) with a 20% solution of hydrogen peroxide.

The hydrogen peroxide acts as an indicator for the component that is leading or lagging. It's similar to how a pH test indicates the acid/base level in a swimming pool. After brushing on the hydrogen peroxide, you should see one of the following:

- The entire surface turns pale yellow. This is what you want to see. No lead-lag problem.
- A dark yellow halo appears around the initial shot point. This indicates an MDI lead.
- A white halo appears around the initial shot point. This indicates a resin lead.
- The surface is covered with alternating white and yellow streaks. This indicates poor mixing.

Pour your lead-lag pancakes end-to-end instead of center-out.

Glossary

Additive: any material that is added to a Bayflex resin to give certain extra properties (such as color, resistance to ultraviolet light, electrical conductivity) to the final product. Additives often change the chemical makeup of the Bayflex system, and their effect must be taken into account when calculating the mixing ratio.

Base Polyol: with the isocyanate, forms the backbone of the polyurethane polymer. The base polyol makes up the bulk of the Bayflex resin, usually more than 75% by weight.

Blowing Agent: creates the foaming action when isocyanate and resin are combined in a reaction. Bayflex polyurethanes use water as the blowing agent.

Boiling: the physical process through which a liquid turns into a gas. All liquids have boiling points. Some, such as rubbing alcohol, boil at a much lower temperature than water. Others, such as isocyanates and polyols, boil at a higher temperature than water.

Bulk: one form of chemical delivery and storage. Bulk deliveries are typically several thousand gallons and come in tank trucks or railroad tank cars.

Bung Hole Mixer: one common type of mixer for Bayflex resins. Bung hole mixers have small blades which fit through the bung hole of a closed-lid drum. They are less effective than propeller mixers and take longer to achieve good mixing.

Calibration: the process of setting the output of polyurethane processing equipment so that the proper balance of isocyanate and resin is delivered to the mixhead. Proper calibration is one of the most critical steps in making quality parts with Bayflex polyurethanes.

Carbon Dioxide: a common component of the air we breathe. Bayflex polyurethanes use the reaction between water and isocyanate to produce carbon dioxide, which creates the blowing, or foaming, action.

Catalyst: a chemical compound which helps control the timing and speed of a chemical reaction. The catalyst is contained in the Bayflex resin blend.

Certificate of Analysis: a document prepared for every Bayflex product which gives information about its chemical composition. The information in the certificate of analysis, commonly abbreviated GOA, is useful in calculating the mixing ratio.

Chain Extender: a special type of polyol which helps tie together the isocyanate and base polyol when they react to form a polyurethane polymer. The chain extender is part of the Bayflex resin blend.

Charge: a technical word for “fill” or “pour.” To charge a tank with chemicals means to put a measured amount into the tank.

Closed-Lid Drum: a type of chemical drum which has a non-removable lid. Access to the chemicals is through one or more “bung holes” in the lid.

COA: see certificate of analysis.

Component A: see isocyanate.

Component B: see resin.

Cream Time: the time from mixing the resin and isocyanate until a visible reaction begins. This is usually between 5 and 20 seconds. The cream time is part of the chemical “fingerprint” of a Bayflex system.

Cup Shot: a type of test where a small sample of foam is poured from the processing machine into an open cup. By timing the stages of the reaction and examining the foam, the operator can spot many machine and chemical problems which affect product quality.

Day Tank: a small tank which feeds the mixhead on a polyurethane processing machine. Each machine has at least two day tanks - one for resin and one for isocyanate. Day tanks should be kept properly filled and at the recommended temperature for best results with Bayflex polyurethanes.

Direct-Inject: a type of mixhead configuration where the mixed resin and polyol are injected through a small hole into a closed mold.

Drum: a common type of chemical container. Chemical drums are usually made of steel with a 55-gallon capacity. They can be either closed-lid or open lid types.

Emulsifying Mixer: a type of chemical mixer which operates at very high speeds. It is also known as a high-shear mixer. Emulsifying mixers should not be used to mix Bayflex resins because the heat they generate can ruin the resin.

Flushing Agent: a special type of liquid which is used to flush or purge the mixhead on a polyurethane processing machine. Regular flushing of the mixhead can prevent blockages which lead to lost production time.

Foam Reactivities: refers to the timed stages of a polyurethane reaction. The most common stages are cream time, rise time, tack-free time, and pull time. These make up the chemical "fingerprint" of a Bayflex system.

Foam Structure: refers to the appearance of a polyurethane foam, usually observed by cutting the foam into sections. The interior of the foam should have a smooth, velvety texture. Visible bubbles or air pockets are usually a sign of equipment problems.

Free-Rise Density: the weight per unit volume of a polyurethane that has been allowed to react in an open container. The free-rise density is part of the chemical "fingerprint" of a Bayflex polyurethane and is a measure of the foaming power of the system.

Free-Rise Foam Check: see cup shot.

Freezing: the physical process through which a liquid turns into a solid. All liquids have freezing points. Some, such as antifreeze (ethylene glycol), freeze at a much lower temperature than water. Others, such as isocyanates and polyols, can freeze at a higher temperature than water.

Gas Blanket: refers to the gas which fills the head space in a bulk chemical storage tank. Isocyanate tanks must have a gas blanket of dry air or nitrogen to prevent the reaction of water vapor with the isocyanate.

Gas Pad: see gas blanket.

Hand Mix: a quality control test in which a polyurethane system is mixed using a laboratory stirrer and the foam reactivities are observed. The hand mix test can identify problems with the isocyanate or resin before they go into production and should always be performed before accepting bulk deliveries.

Head Space: inside a chemical tank, the empty space between the liquid level and the top of the tank. The head space in an isocyanate tank must be filled with dry air or nitrogen to prevent the reaction of water vapor with the isocyanate.

High-Shear Mixer: see emulsifying mixer.

Hydroxyl Content: a measure of the reactive potential of a polyol or resin blend. Along with the isocyanate content and water content, it is used to calculate the correct mixing ratio for a Bayflex polyurethane system. Also known as OH number.

Hydroxyl Group: abbreviated OH, the part of a polyol molecule which reacts with an isocyanate group to form a polyurethane. Water also contains the hydroxyl group and will react with isocyanates.

In-Mold Coating: a special type of paint which is sprayed on the inside surface of a mold before molding the polyurethane part. The molded part comes out already painted.

Index: see isocyanate index.

Injection Port: a small hole through which the polyurethane reaction mixture is injected into the mold in a direct-inject mixhead configuration.

Insert: any item which is molded directly into a polyurethane part. Inserts help give strength, stiffness or other special properties to the final part. Inserts must be thoroughly clean and free of grease before use, or they will separate from the polyurethane foam.

Integral Skin: a type of foam that forms its own outer skin when it is produced. Bayflex polyurethanes are integral skin foams.

Internal Mold Pressure: the pressure exerted by the reacting Bayflex polyurethane foam against the inside of a closed mold. If molds are not clamped properly, this pressure can be enough to force the mold open.

Isocyanate: one of the two main components of a polyurethane polymer. In Bayflex polyurethane systems, the isocyanate is also known as Component A. Isocyanates are very reactive and must be handled with caution.

Glossary

Isocyanate Content: a measure of the reactive potential of an isocyanate. Along with the hydroxyl content and water content, it is used to calculate the correct mixing ratio for a Bayflex polyurethane system. Any contaminants, such as water, which react with the isocyanate will cause the isocyanate content to drop, or reduce its reactive potential. Also known as NCO content or percent NCO.

Isocyanate Group: abbreviated NCO, the reactive part of an isocyanate molecule. Reactive isocyanate groups usually make up about 15%-25% of the total weight of the isocyanates used to make Bayflex polyurethanes.

Isocyanate Index: an adjustment factor used to fine-tune the mixing ratio when working with polyurethanes. An isocyanate index above 100 (sometimes also written 1 .00) means to adjust the amount of isocyanate upward; an isocyanate index below 100 means to adjust the amount of isocyanate downward.

Knit Line: an undesirable seam in a molded polyurethane part, usually caused by an incorrect pouring pattern.

Lead-Lag: a condition that exists if resin and isocyanate do not enter the mixhead at the same time. One component leads and the other lags behind, resulting in a poorly mixed area in the foam.

Lot Number: identifies when a Bayflex isocyanate or resin was produced. Has the form X-XXX. For example, for Bayflex 905 B component, lot 5-003, the “5” refers to 1995, and the “003” means it was the third lot of Bayflex 905 B component produced in that year.

Machine Ratio: the relative output of resin and isocyanate on a polyurethane processing machine. In the calibration process, the machine ratio is adjusted to combine the resin and isocyanate in the correct mixing ratio.

Safety Data Sheet (SDS): a document which contains essential information for a particular chemical substance, including chemical composition and health and safety information. An SDS must accompany any chemical shipment.

Mixhead: the part of a polyurethane processing machine where the resin and isocyanate are combined before being poured into a mold. The mixhead can be either the low-pressure type, where a rotating screw mixes the chemicals, or the high pressure type, where chemicals are mixed by colliding at high pressure inside a chamber.

Mixing Ratio: measures the specific amounts of isocyanate and resin which are combined in a polyurethane reaction. The mixing ratio for Bayflex polyurethanes is usually expressed as parts of isocyanate per 100 parts of resin. For example, a mixing ratio of 77/100 means that 77 grams of isocyanate should be used for every 100 grams of resin. Using the right mixing ratio is crucial to making quality polyurethane parts.

Mold Release: a chemical product which is used to prevent polyurethane parts from sticking in the mold. Not all mold releases are compatible with each Bayflex polyurethane system, so it is important to select the right product.

Monomer: the repeating unit which makes up a polymer. Just as many individual links fit together to make a chain, many individual monomers fit together to make a polymer.

SDS: see Safety Data Sheet.

NCO Content: see isocyanate content.

OH Number: see hydroxyl content.

Open Pour: a type of mixhead configuration where the mixed resin and polyol are poured into an open mold. After pouring, the mold lid is closed, and the mixture reacts to fill up the mold and form a polyurethane part.

Open-Lid Drum: a type of chemical drum which has a removable lid to allow access to the contents.

PEL: see Permissible Exposure Limits.

Percent NCO: see isocyanate content.

Percent Water: see water content.

Permissible Exposure Limits (PELs): standards for airborne concentrations of chemicals and other substances set by the federal Occupational Safety and Health Administration. PELs are legally binding.

Glossary

Pigment: a type of additive used to give color to Bayflex polyurethanes. Pigment can be added to the Bayflex resin before processing or, with special equipment, injected directly into the mixhead. The effect of the pigment on the polyurethane reaction must be taken into account when calculating the mixing ratio.

Polymer: a special type of chemical which consists of many individual units (monomers) linked together like a chain. The word "polymer" comes from two Greek words meaning "having many parts."

Polyol: one of the two main components of a polyurethane polymer. In Bayflex polyurethanes, one or more polyols is combined with other chemicals to form the resin blend, also known as Component B.

Polyol Blend: see resin.

Polyurethane Polymer: a special type of polymer made by reacting isocyanates and polyols. Polyurethane polymers can be hard and solid or soft and lightweight. Bayflex polyurethanes are a special class of polyurethane polymers which are durable but lightweight.

Pouring Pattern: the specific way in which the resin/isocyanate mixture is poured from the mixhead into the mold. Using the wrong pouring pattern will result in defects on the surface or inside the finished part.

Product Name: for Bayflex polyurethanes, consists of the "Bayflex" name and a number, for example, "Bayflex 905" or "Bayflex 953." Each different product name identifies a different chemical formula, or "recipe." Components with different product names are not interchangeable.

Production Shot: the specific amount which is poured from the mixhead to produce a certain polyurethane part in production. The size of the production shot is controlled by the machine throughput and the shot timer.

Propeller Mixer: a type of chemical mixer with large blades, appropriate for use with open-lid drums. Covestro recommends propeller mixers for blending Bayflex resins before use.

Pull Time: in the hand mix test or cup shot test, the amount of time from mixing the chemicals until the top of the foam can be pinched and pulled without tearing. The pull time is part of the chemical "fingerprint" of a Bayflex system.

Ratio: see mixing ratio.

Recirculation: the process of continuously pumping a Bayflex resin or isocyanate from its tank, to the processing equipment, and back into the tank. Recirculation aids mixing and keeps a constant temperature through all parts of the system, an important part of quality control.

Resin: a blend of a base polyol with other chemicals which is reacted with an isocyanate to produce a polyurethane polymer. In Bayflex polyurethane systems, the resin is also called Component B.

Rise Time: in the hand mix test or cup shot test, the amount of time from mixing the chemicals until the foam stops rising in the cup. The rise time is part of the chemical "fingerprint" of a Bayflex system.

Shot: a single dose of mixed isocyanate and resin which is dispensed from the mixhead of a polyurethane processing machine.

Shot Time: the duration of a shot; the amount of time the mixhead remains open to dispense material.

Surfactant: one of the chemicals which makes up the resin. The surfactant helps to control the foaming action of Bayflex polyurethanes.

System: refers to an isocyanate and resin purchased together under a common product name. Bayflex 905 components A and B together make up the system.

Tack-Free Time: in the hand mix test or cup shot test, the amount of time from mixing the chemicals until the foam surface is no longer sticky. The tackfree time is part of the chemical "fingerprint" of a Bayflex system.

Threshold Limit Values (TLVs): chemical exposure guidelines recommended by the American Conference of Governmental Industrial Hygienists which refer to airborne concentrations of chemicals and other substances. TLVs represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect.

Throughput: the weight of material delivered to a polyurethane processing machine's mixhead over a certain amount of time. Throughput is usually measured in grams per second.

TLV: see Threshold Limit Values.

Tote: one form of chemical delivery and storage. Tote containers usually contain 275 gallons, or about the equivalent of five chemical drums.

Urea: along with carbon dioxide gas, one of the products of the chemical reaction between water and isocyanate.

Viscosity: a measure of a material's resistance to flowing. High-viscosity materials, such as peanut butter, flow very slowly. Low-viscosity materials, such as water, flow very easily. As materials are heated, their viscosity usually decreases.

Water Content: refers to the amount of water present in any substance which may be reacted with an isocyanate. Resins, pigments and other additives usually contain some water. The exact water content must be known in order to calculate a mixing ratio.

For more information about Covestro LLC polyurethane materials and technologies, call 412-413-7454 or visit www.polyurethanes.covestro.com.

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