# performance that lasts

## lamination guide

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# agitation

One of the most neglected procedures concerning resin is proper agitation. Proper agitation is as important as maintaining the correct laminate thickness and catalyst level.

Resin is made up of ingredients that have different densities. Shortly after packaging, these ingredients begin to separate. After a drum of resin has been packaged for thirty days or more, the thixotropes can settle in the drum. The lighter materials such as solvents (styrene) will float to the top, leaving the resin in the middle. More separation occurs the longer the material is stored.

To insure the separated materials are redistributed evenly, proper agitation is imperative. Rolling the drum over the floor or bubbling air through the drum or stirring with a plank will not adequately agitate the material and may also have safety implications.

Before you begin, make sure the resin has been properly agitated. The procedures for mixing bulk and drum resin will differ. Bulk resin should be mixed twice per day for 30 minutes at a time. Drummed resin should be mixed before use for at least 15 minutes. You may need to use a higher speed for the first 3 minutes to get the material moving. You can then lower the speed after the first 3 minutes. Record the Date, Resin Code, Resin Batch Numbers, and Operator(s) on the Laminate Documentation Card.

For 55 gallon drums, the recommended agitator should be the type that has pitched blades approximately 14-inches in diameter. Common suppliers of these agitators are MVP Inc. and Binks. Resin drums with a closed head (non-removable lid) will require a mixer which can be inserted into the 2" bung hole of a 55 gal drum. There are several agitator types for this type of mixer. The most common is an auger type. There are also configurations that have collapsible blades that fit down through the bung hole. Mix the resin for 15 minutes adjusting the agitator motor speed for adequate rotation in the drum. Adjusting the speed to the amount of resin in the drum is important, as a partial drum will not require as much speed as a full drum to properly mix the resin.

Pails also must be agitated.

Mixing must be done prior to taking any sample from the material.

Listed below are a few of the most common problems that can occur without proper agitation:

- draining
- laminate cure
- poor cosmetics

# laminate Procedure

Ashland resins are well known for providing reliable, durable, real world performance. To achieve this performance, it is important to properly apply the product. Ashland's technical service team regularly provides trouble-shooting and process guidance to composite manufacturers world-wide. This document will outline best practices for lamination with Ashland resin, which will provide lasting value to the end user.

## PPE

As a Responsible Care company, it is critical that we begin by ensuring our materials can be applied safely. Be sure to follow all safety procedures outlined by OSHA and your manufacturing facility. Before working with resin, review its Safety Data Sheet. Take note of all safety precautions, and use P.P.E. recommended by the Safety Data Sheet. To safely work with resin, eye protection and gloves should be worn at all times. A respirator and protective clothing should also be worn at the worker and manufacturing facility's discretion.

## cure

Before preparing for the lamination process, check the gelcoat layer to ensure it is properly cured. It should either be dry, or have a slight tack on all areas of the mold. Allow at least 90 minutes for cure time at a temperature of at least 70 degrees Fahrenheit or higher. Proper airflow is important for gelcoat to cure properly. Because styrene vapors are heavier than air, these vapors can lie in low areas of the part and cause under cured or wet areas.

## contamination

Regular maintenance to your gun filtration system will help avoid contamination. An air drying system and water separators should be used to remove oil or water contamination. These traps should be drained daily. Before spraying a part, open the traps and verify that they have been drained.

## temperature

Measure the temperature of the resin, ambient air, and the mold with an IR gun. Record each temperature on the Laminate Documentation Card. Ensure that all temperatures are above 70 °F.

Listed below are a few of the most common problems that can occur if temperatures are below 70 °F:

- draining
- laminate cure
- poor cosmetics

Although CHP blends give slower initial reactivity, they provide a similar degree of cure after 24 hours.

### temperature effect on gt

| temperature | gel time in minutes |
|---|---|
| 60 | 39 |
| 70 | 31 |
| 80 | 25 |
| 90 | 20 |
| 100 | 16 |

Tested at 1.5% MEKP catalyst

## catalyst selection

In the composites industry, initiator is often incorrectly called catalyst. However, since the term catalyst is used more frequently, we will refer to initiator as catalyst throughout this document.

It is strongly recommended that before using any catalyst and resin combination in an application, the fabricator should confirm that the catalyst and resin meet the manufacturer's specifications. Different brands of similar catalysts have shown to react differently with the same resin system.

Typically, Methyl Ethyl Ketone Peroxide (MEKP) catalyst can be used for most applications. MEKP catalysts yield a rapid resin cure development. Cumene hydrogen peroxide (CHP) or cumene blended catalysts tend to increase gel time, slow gel to peak and decrease exotherm.

Other specialty catalysts or combinations of catalyst types can be used for specific applications. They can speed up or slow down the gel time, gel to peak, increase or decrease exotherm, improve thin laminate cure, etc. Please consult Ashland Technical Service for recommendations on the type of catalyst to use in your process.

### initiator type effect on GT and cure

| | gel time in minutes | 934 barcol at 4 hours | 934 at 24 hours |
|---|---|---|---|
| MEKP | 25 | 40 | 40 |
| MEKP/CHP (2:1) | 32 | 25 | 35 |
| MEKP/CHP (1:1) | 40 | 10 | 35 |

MEKP = Methyl Ethyl Ketone Peroxide at 9% active oxygen
CHP = Cumene Hydrogen Peroxide
Tested at 1.5% catalyst

Most chopper guns internally mix catalyst and resin. On an internal mix unit, the proper catalyst pressure is influenced by the pump ratio, pump pressure, and viscosity of the material being pumped. The pump ratio will be either 6 to 1 or 7 to 1. A typical catalyst pressure range would be 250–400 psi. To determine your catalyst pressure, use the following calculation:

Pump ratio x pressure = catalyst pressure

For example, if you have a 7 to 1 pump with a pump pressure of 50 psi, the catalyst pressure should be in the range of 350 psi.

| Amount of catalyst | Gel time in minutes |
|---|---|
| 1.5 | 25 |
| 2.0 | 20 |
| 2.5 | 17 |

Tested with MEKP catalyst

You will need to follow manufacturer specifications to verify the correct catalyst pressure specs. Be especially careful with new o-rings. If at any time you see the pressure dropping, it indicates that you are losing back pressure, which may cause inconsistent dispersion of catalyst on each pump stroke. You can verify catalyst line pressure is correct by checking its gauge. Dyed catalyst can also be used to insure the correct catalyst pressure is set and catalyst and resin are mixing properly.

## Laminate Documentation

Date ______________________________

Resin mixed?__________ Y__________ N

Temp ____________ Humidity ________

Resin Code ________________________

Resin Batch Numbers (last two bulk loads loaded into storage tanks)

Batch 1 _________ Batch 2 _________

Operator(s) ________________________

Skin layer

Catalyst type and percent __________

Mils applied _____________________

Glass type and percent ____________

Barcol prior to bulk layer __________

Operator(s) ________________________

Bulk layer

Catalyst type and percent __________

Mils applied _____________________

Glass type and percent ____________

Barcol at demold _________________

Additional Comments ______________

___________________________________

___________________________________

___________________________________

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It's crucial to use the proper amount of catalyst. Always verify that you are using the proper catalyst percentage before spraying a part. The recommended catalyst range is between 1.25 to 2.5% for Ashland resins. The skin coat typically runs at 2.0% catalyst to help achieve a faster cure and higher Barcol. Bulk laminate and coring materials normally run at 1.5% to keep exotherms low and allow cure to develop slowly. This will lead to improved cosmetics. Adjust catalyst levels to get proper working times in mold for ambient conditions. Record the amount of catalyst used on the laminate documentation card.

## glass reinforcement selection

There are many different types of reinforcements, including E-glass, S-glass, Aramid fibers, and Carbon fibers. These materials come in many orientations and sizes. Laminate reinforcement will be dependent on the part requirements. Chopped strand or chopped glass should always be used in the skin coat to facilitate an even layer without air voids. It may also be used in other areas as determined by engineering and the laminate schedule. Generally, woven roving is used to add strength and reinforce high stress areas, due to the weave pattern and size of strands. Structural, stitched cloth, knit cloth, and other weave patterns are also available and provide similar performance. Engineering will determine where to use any or all of these materials within a laminate. Both woven and structural mats should be applied after the skin coat has reached a 934 Barcol of at least 20–40 for cosmetics and bonding.

## core material

A wide range of core materials can be used in a composite part. Most cores are used to add stiffness and strength, as well as reduce weight within the laminate. Core materials can also be used for screw retention. Core types consist of balsa wood, different density foams, such as PVC and urethane, spun fiber materials and marine grade plywood. The engineering team for the facility will determine the appropriate core for the part being built. Using a balanced laminate on each side of the core will strengthen and stiffen the laminate and produce the best results. For guidance to properly wet out and bed core materials, follow the best practices recommended by the core manufacturer or contact Ashland Technical Service.

# types of equipment for hand lay-up/roll-out

Laminate consolidation is essential to make a quality part. There are different types of rollers for different jobs. For skin coats, a finish roller should be used. Bubble buster rollers are better suited for the second skin or bulk laminate layer. This type of roller has become widely and sometimes overly used in the open mold FRP industry due to their ability to easily compact the laminate and remove large air pockets. However, they can leave resin rich lines on the part which will transfer to the cosmetic surface. They can also leave fine air in the laminate that can create rework and warranty issues, like blisters in skin coats. It's best to use them only for bulk lamination.

The diameter of a roller is as important as the type. There are various diameters which will fit into different radii of the part surface. Using a roller with a larger diameter than the radius that you are rolling will cause resin to puddle in the radius next to the gel coat. This will cause excess shrinkage, which in many cases leads to print problems and heat lines. This resin rich area can also lead to a weaker part of the laminate that is prone to cracking.

# spray pattern development

Once you have selected all the proper materials and equipment to build your part, you are ready to begin applying the material. First verify the pump pressure of the spray gun. The chopper gun tip selection should be matched to the cutter speed and number of glass strands of the chopper gun to ensure that the correct glass to resin ratio is achieved. Two strands will use a larger tip than a single strand. Start with low pressure, and incrementally adjust the pump pressure up to the lowest possible pressure that will support an even pattern. Position the chopper motor to evenly distribute the glass into the resin stream. The glass usually intersects with the resin approximately 6-8 inches from the spray tip. Adjust from side to side to ensure glass is hitting and dispensing in the pattern evenly. From here, adjust the cutter head speed to obtain proper glass to resin ratios. Use a disposable surface like booth paper or cardboard to observe and adjust the glass and resin distribution prior to spraying the part.

# glass calibration

Ensuring the correct glass to resin ratio is critical to manufacturing the best quality parts. Tie plastic bags to capture the resin and glass separately. First, weigh an empty bag to zero the scale. With a timer, spray the gun for 15 seconds capturing the resin and the glass in their respective bags. Next, weigh the bag of resin and record the weight. Use the same weighing procedure to determine the weight of the glass. Weigh an empty bag to zero the scale. Weigh the bag of glass and record the weight. Use the weight of the resin and the weight of the glass to calculate the resin to glass ratio using the following calculation:

Weight of glass / (weight of glass + weight of resin) x 100 = % Glass

Glass ratios typically run 35% to 40%. A higher glass content reduces issues with heat or shrink lines and produces lighter and stronger parts with better cosmetics. It is very important to use the correct ratio of resin to glass. Using the incorrect amount of glass will alter the strength of a laminate and can lead to an increase in cracking. It can also cause a variety of rework issues, such as excessive sanding and buffing to remove cosmetic defects.

# proper spray techniques

Inspect the spray pattern and make sure the glass is not being thrown outside the resin pattern. Use the proper spray technique of cross-hatching the glass up and down and side to side as you build the layers to the proper mil thickness. Overlap each stroke by approximately 50%. This will ensure a more consistent laminate. Have an operator check mil thickness with a laminate mil gauge as the part is being chopped to ensure uniformity of the laminate.

Laminates that are too thick are difficult to roll out which can lead to air voids. These air voids can cause weak points in the laminate and can lead to excessive and time consuming rework. Thick laminates may also cause fiber print issues on the part. Skin coats that are too thin will not develop Barcol hardness properly and may allow the bulk laminates to print through the thin skin coat. Also with a thin skin coat, fibers may be difficult to roll-out around edges and corners.

## proper skin application and cure

The purpose of the skin coat is to create a first layer of reinforcement behind the gel coat. It should be free of air voids and creates a hardened layer to help block fabric print from the addition of other layers of fiberglass reinforcement. Proper skin coat thickness is an engineering and company preference, depending upon quality and weight recommendations. A proper skin coat will range from 2.0 oz at 60 mils (thousandths of an inch) to 3.0 oz at 90 mil depending upon the design.

To properly skin coat the part, first pre-wet the surface with a light misting of resin. This will help ensure that no dry glass fibers are up against the gelcoat surface. Dry glass fibers can cause blisters to form under some circumstances. Next chop the desired thickness as outlined by the build schedule. Verify the thickness by utilizing a laminate mil gauge. It is important to roll out and compact the chop well and remove all air. Entrapment of air bubbles in the skin coat layer can cause costly rework issues and cosmetic problems. It is also important to keep the glass content as high as possible (35–40%). The high glass content will shrink less, have a better cosmetic surface, and be stronger than a lower glass loading. Do not back wet the resin after compacting the laminate as this will only create a resin rich layer on the back of the skin coat. This resin rich layer can reduce the strength, cosmetics, and effectiveness of the skin coat.

The thickness of the skin coat should be even throughout the part. To avoid creating thin or thick areas on the part use proper cross-hatching techniques while applying the material. A laminate mil gauge should also be used in several different spots on the part to verify thickness and uniformity.

A thicker skin coat of 90 mil is recommended to create the best print protection. Skin coat applications exceeding 90 mils are not recommended as it is very hard to roll and eliminate the entrapped air.

The skin coat should also be well cured prior to applying bulk laminates and other reinforcements. It should achieve a 934 Barcol hardness of 20–40 before bulk laminate application. A higher Barcol reading on the skin coat indicates a more thorough cure, which will help ensure good quality cosmetics. Record the catalyst type and level, mils applied, glass type, and Barcol on the Laminate Documentation Card.

## proper bulk laminate application

Once the skin coat has achieved the proper Barcol hardness, the main laminate can be applied. Bulk laminates will vary with build schedule and part type. Using heavy laminates on an under cured skin coat or too much glass at one time can cause excessive heat and print in the laminate.

Structural layers should be back wet for faster and sufficient wetout of the fibers. Using the correct roller for the part's geometry, the structural layers should be rolled out well, removing all air from the laminate and compressing the layers. Excess resin should be removed with a squeegee or paint roller. When hand laminating, do not apply more than one layer at a time. Record the catalyst type and level, mils applied, and glass type for the bulk layer on the Laminate Documentation Card.

## laminate cure

Cure of the laminate is affected by catalyst type and amount, air temperature, resin temperature, mold temperature, laminate thickness, and lamination process. Consult with Ashland tech service in order to achieve the ideal laminate cure.

Use a Barcol 934 to check the bulk laminate's hardness. The ideal hardness is between 30–40 Barcol, depending on the part. Before demolding a part, take a temperature reading. The laminate temperature should be at ambient or room temperature. This ensures that the parts are cured and have enough green strength to be pulled. Record the Barcol at demold on the Laminate Documentation Card.

## proper demold process

To begin demolding, use plastic or wood wedges to gently break the sides of the part loose from the mold. Avoid using metal tools during demold, as they can damage the part and the mold. Be careful not to flex more than necessary, as this can cause damage to the mold and the part. With the wedge in place, use regulated air pressure to blow air between the open space between the mold and the part to help break it loose. For safety purposes, do not use air pressure above 35 psi for demolding parts. Continue to do this on all sides of the part until it is completely loose from the mold.

You may need to add bracing or additional reinforcement to the part near lifting points to ensure pressure is applied evenly when lifting with a hoist and make sure that the part does not over-flex, crack, or bind in the mold during the pulling process. This is best determined by observing the pulling of a few parts and finding the problem areas. Apply even pressure on the lifting hoists for easier demold. Using excessive force can stress parts, which can result in cracks developing as the part ages. In extreme cases parts can actually be cracked during the demold process. Some parts may be more challenging to demold, due to part design or a slightly negative draft.

## transfer of part

Use a padded cart to transfer the demolded part to next station. This eliminates the chance of a finished part being dropped, reduces lift fatigue, and protects the gelcoat from being scratched or damaged.

## thermal cracking

Scribing and countersinking are done to reduce the propagation of cracks from fasteners. A metal screw has a thermal conductivity much greater than the composite laminate. As a result of thermal cycle exposure, the metal experiences a more rapid change in temperature, which leads to a higher rate of expansion and contraction relative to the composite material. The difference in the rate of dimensional change between the metal and composite laminate can induce stresses that promote crack formation.

Countersinking screws will reduce stress on the laminate, and reduce the chance of crack initiation and propagation. Small cracks created by non-countersunk crews, often propagate under stress at low temperatures causing costly warranty issues. The interface between the gelcoat and the laminate can allow these cracks to propagate, as it is a non-reinforced resin rich layer. Countersinking screws will ultimately minimize the risk of chipping and cracking in both the laminate and gelcoat.

Another technique to avoid crack propagation is a scribe line. Using a scribe tool, cut completely through the gelcoat and into the laminate. The scribe line will give a surface crack a stopping point, if a crack develops from a screw, as it disrupts the non-reinforced interface layer. The most common place to put a scribe line is on the deck and hull between the area where the two will be screwed together. The scribe is then covered up by the rub rail. The disruption in the gel surface will help keep a crack from extending past the cut line onto the main surface of the deck or hull.

## trimming and cutting

Diamond wheels, hole saws, and router bits are recommended for trimming and cutting to create the smoothest edge of the fiberglass surface. These tools will give the best cut to avoid chipping of the gelcoat or damage to the laminate.

Be sure to monitor the blade itself and ensure it remains sharp at all times. A dull blade will severely affect performance. Carbon steel drill bits should be used in conjunction with countersinks, as all holes drilled need to be countersunk and remain smooth with minimal damage or chipping of the gelcoat.  Chipping of the gel coat around the cutting surface is an indication of a dull cutting tool or too much manual force being applied.

As with fasteners, chips in the gel coat caused by an improper cut can start the initiation of a fracture in the gelcoat or laminate at the cutting surface. Stresses applied to the laminate can cause these fracture initiation points to propagate through the resin rich interface between the gel coat and the skin coat under extremely cold conditions.

**Common scribing tool**

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