Surlyn Reflections® resins

Guide to Injection Molding

Technical Information

DuPont™ Surlyn®

A Guide to Injection Molding with DuPont™ Surlyn Reflections®

Surlyn Reflections® resins are a thermoplastic alloy made up of ionomer and polyamide, enabling manufacturers to mold tough and durable, high-gloss parts that require no painting. Surlyn Reflections® resins offer the following benefits: molded-in designer colors; high-gloss appearance; exceptional impact and toughness and resistance to scratches, abrasions, and chemicals. Surlyn Reflections® resins offer the opportunity for a weatherable part with lower costs and reduced environmental impact.

By varying the chemical composition the properties such as melt flow, impact resistance, chemical resistance will change. Surlyn Reflections® resins are offered in 5 and 12 melt flow index (MFI) grades. The 5 melt flow grade has balanced flow rate with exceptional cold temperature impact strength. The 12 melt has improved flow for molding more difficult parts where cold temperature impact is less important.

This brief, easy-to-read Users' Guide explains the fundamentals of injection molding with Surlyn Reflections® alloys. It is intended to help make your processing go as smoothly as possible and assist you in making each part that you produce reflect the benefits of Surlyn Reflections® alloys.

I. MATERIAL HANDLING

Material Safety Data Sheet (MSDS)

We provide a Material Safety Data Sheet to our customers upon initial orders and with the next order after an MSDS revision. The MSDS explains material aspects including hazardous components, health hazards, emergency and first aid procedures, disposal procedures and storage information. We strongly urge you to read the MSDS and follow its guidelines. If you have any questions concerning it, please contact us. Refer to the contact information at the end of this guide.

The Material

Surlyn Reflections® alloys are produced in the form of pellets. The material comes packaged in foil lined bags or foil lined boxes. This liner reduces the moisture that the resin will pick up. Each bag weighs approximately 55 lbs. / 25 kg, each corrugated box weighs approximately 1,200 lbs.

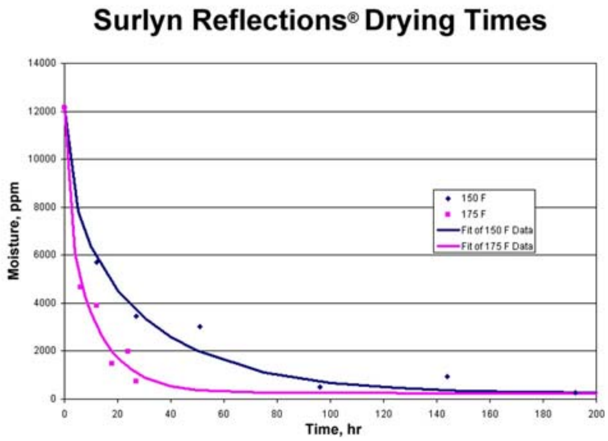
Drying

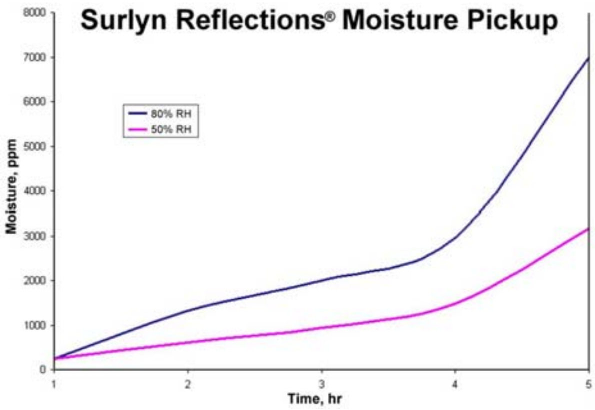
Surlyn Reflections® alloys are packaged in airtight bags or boxes for shipment. Typically the moisture content upon receipt by the customer is less than 0.15%. Nevertheless, as a precaution before processing, we recommend drying the material in a desiccant dryer for 4 hours at 160˚F. The maximum allowable moisture content for processing is 0.15%. The ideal range is between 0.08% and 0.15%. If a moisture analysis indicates the material is above 0.15%, dry it before use. Titration moisture analyzers are preferred. Weight loss analyzers are acceptable if programmed properly. Check with your specific analyzer manufacturer to get the correct program setting.

Drying time depends on the moisture content, the relative humidity of the drying air and the surface-to-volume ratio of the resin pellets. Materials with a smaller surface-to-volume ratio (e.g., regrind material) will take longer to dry. We recommend using drying air with a dew point of 0˚F (-18˚C) or less, and if the material is fully saturated, dry it for approximately 24 hours at 160˚F -- until the moisture content falls within the 0.08% and 0.15% allowable range. One word of caution -- do not over dry the material. It can lead to cosmetic flaws and processing difficulties.

The graphs on the next page show the drying times at various temperatures and moisture pickup at 50% and 80% RH. The times are based on a standard resin pellet surface-to-volume ratio.

Be sure to periodically check the entire system for leakage. Hopper dryers, vacuum dryers, or rotary vacuum tumbler types work equally as well.





II. MOLDING MACHINE REQUIREMENTS

Conventional molding machines work fine with Surlyn Reflections®. Manufacturers are regularly molding Surlyn Reflections® in various sized injection molding machines.

When processing Surlyn Reflections® alloys, basic machine requirements and recommendations include the following:

Clamp Unit and Force

Surlyn Reflections® alloys require a clamping force between three and five tons per square inch of the projected area of the part and runner. When the mold is fully packed with resin, the clamping pressure is crucial to producing a good quality part because it directly influences the surface gloss.

Caution: Excessive platen and mold deflection can diminish the surface gloss of the part -- even when the clamping force is between three and five tons. Ideal platen and mold deflection is less than 0.005 inch.

Injection Unit

The injection unit and its controls play a vital role in repeatability. The machine must be capable of precisely controlling the injection velocity of the screw while accurately monitoring the fill, pack and hold pressures. This feature is essential to producing a good quality part each and every time.

Barrel and Barrel Heats

Standard barrels and heater bands work well with Surlyn Reflections®. Be sure to periodically verify the accuracy of your temperature control system.

Screw Design

For Surlyn Reflections®, a general-purpose, chrome-plated screw is preferred, with a compression ratio of 2.2:1 to 2.6:1 and a minimum length-to-diameter (L:D) ratio of 18:1. The screw is divided into three separate zones: the feed, the transition, and the metering zone. The feed zone should be 50% of the overall length of the screw and the transition and the metering zones should be 25% each.

Mixing screws will help disperse color concentrates, however, be aware they can cause processing difficulties (e.g. temperature over-ride in the transition zone).

Barrel Sizing

The shot weight should be between 30% and 70% of the melt capacity of the machine. The melt capacity is the maximum amount of melted resin the injection unit can put in front of the screw. Keeping the shot weight in the 30-70% range enables better control of the machine and an adequate residence time. Because some fully color compounded Surlyn Reflections® alloys contain pigments that are more heat sensitive than others, residence time is a key factor in ensuring good color stability.

Non-return Valve

When molding with Surlyn Reflections®, use of free flow valves with non-interlocking check rings made of a hard material such as CPM 9 or CPM10 is recommended. Verify the check ring dimensions and seat prior to installation.

Nozzles

Generally, the nozzle should be as short as possible. The barrel seat opening and the nozzle body opening must match, and the nozzle body must match the nozzle tip. With Surlyn Reflections®, using a reverse taper nylon tip is recommended. If the tip extends 3/4" or more from the end of the nozzle, it will require a dedicated heater, a controller and a thermocouple. The shear rate at the choked portion of the tip must not exceed 10,000 (sec)-1. Calculate the shear rate with the following formula:

$$SR = \frac{(C)\,(SW)}{FT\,(TD)^3}$$

Where:

SR = Shear Rate (1/sec)

C = 9,749 (mm3/gm)

SW = Shot Weight (grams)

FT = Fill Time (sec)

TD = Tip Diameter (mm)

Shutoff nozzles are not recommended, and beware of longer nozzles, filters, metal traps, restrictive inserts or other attachments -- they can cause processing difficulties (e.g., hold-up spots, skin layers, etc.).

III. PROCESSING

The physical and chemical properties of a resin define the way in which it is best molded. Properties such as melt temperature, energy content, melt viscosity, behavior at the melt temperature, freezing and crystallization rates, cycle time and shrinkage, give a resin its unique processing characteristics. Processors must consider and understand these characteristics prior to molding. For these reasons it is best to have a good, working knowledge of Surlyn Reflections® alloys.

Startup

With Surlyn Reflections®, a clean barrel and screw are essential for a proper startup. This usually requires removing the screw from the barrel and cleaning both barrel and screw. If any residual material is left on the screw or barrel, Surlyn Reflections® will scrub it off, causing contamination problems (i.e., black specks).

The recommended startup procedure for Surlyn Reflections® is: With the barrel temperature appropriately set (see Melt Temperature), fill the barrel with high density polyethylene. Then, without starving the barrel, immediately follow with Surlyn Reflections®. Remember, mixing oxygen with molten Surlyn Reflections® can produce surface defects (i.e., splay and black specks).

Shutdown

The following shutdown procedure is recommended: While molding on cycle, shut the hopper feed and empty the hopper. Do not starve the barrel. Add an appropriate amount of polyethylene and thoroughly purge the screw. These steps will reduce contamination and restarting time. Leave the screw in the forward position and turn off the barrel heaters. When the barrel cools, turn off the nozzle and the adapter heaters.

Purging

High density polyethylene, polystyrene, and cast acrylic are effective materials for purging Surlyn Reflections®. When using cast acrylic, however, remove the nozzle tip before purging. The following purging procedure for Surlyn Reflections® is recommended: Retract the injection unit from the platen and raise the back pressure to hold the screw forward. Next, running the screw at high speed, push out as much resin as possible. Add purging material to the hopper until the extrusion runs clean. Depending on the type of purging material, you may have to adjust the cylinder temperature. Before adding the new resin, release the back pressure and make several air shots, using long strokes and a fast injection speed. Remember, during purging, never starve the screw.

Melt Viscosity

Surlyn Reflections® alloys are available in two melt viscosity levels:

HIGH -- ~320 PA-sec., ~5 MFI

LOW -- ~250 PA-sec., ~12 MFI

Melting and Processing Temperatures

Surlyn Reflections® alloys are semi-crystalline materials having a distinct melting point of 350˚F (177˚C). Semi-crystalline materials have heat of fusion and require more specific heat to melt than amorphous materials.

The temperature processing range for Surlyn Reflections® alloys is 450˚F to 495˚F (232˚C to 257˚C).

Cylinder Temperature Profile/Melt Temperature

The barrel temperature profile depends on the percentage of the available shot (i.e., melt capacity) being used. For example, when using 50% of the available shot, a flat temperature profile is recommended; i.e., a single set-point for the front, middle and rear of the barrel. When using 30% of the available shot, dropping the temperature of the rear zone by 10 to 20˚F and the middle zone by 5 to 10˚F is suggested. For 70% of the available shot, raising the temperature of the rear zone by 10 to 20˚F and the middle zone by 5 to 10˚F is recommended.

The actual baseline temperature set-point depends on the specific screw design. To determine the baseline temperature, measure the temperature of a purge shot. Typically, with Surlyn Reflections® alloys, set points are about 20˚F lower than the actual purge temperature. The recommended ideal purge temperature for Surlyn Reflections® alloys is 475˚F (246˚C).

Nozzle Temperature

Precise control of the nozzle temperature is critical to good processing. During a shot sequence with proper temperature control, a cold slug forms between the break point and the freeze line in the nozzle tip. The slug provides a vital barrier that prevents oxygen from infiltrating the molten resin accumulated for the next shot. Oxygen within the melt stream degrades Surlyn Reflections® alloys and can cause black specks and other surface defects to appear on the part. If the nozzle is too hot, the cold slug will not form. If the nozzle is too cold, the nozzle will freeze off, forming a slug so large it will prevent the next shot. A thermal insulator between the nozzle tip and the mold can help ensure good temperature control of the nozzle.

Mold Temperature

To produce a part with good surface gloss, a minimum mold surface temperature of 130˚F (54.4˚C) is recommended. Generally, the hotter the mold, the better the part will perform. However, hotter temperatures can sometimes cause parts to stick to molds. In most cases a release type plating on the tool is required to ensure adequate part ejection. See the Tooling section for specific plating types.

Cycle Time

As a general rule, Surlyn Reflections® alloys require a cycle time of approximately 30 seconds for each millimeter of part thickness (e.g. 3 mm part ≈ 90 second cycle time).

Injection Pressure

The normal range of plastic injection pressures for Surlyn Reflections® is 5,000 to 20,000 psi. Thin wall applications (< 1 mm) will require higher pressures. Optimize the fill time by using de-coupled molding techniques. Set the first stage high enough to keep the screw at a constant rate of injection velocity. When transferring from fill to pack, the mold cavity should be about 90% to 95% filled. Adjust the fill time by altering the injection velocity. Most often, a single injection speed works best. Depending upon the application, however, ramping the start and finish fill speeds are options for improving the gate appearance and diminishing any witness lines.

Fill Time

The optimum fill time (injection rate) depends on the geometry of the part, the size of the gate, and the melt temperature of the resin. For thin parts, a faster rate works best because it quickly fills the part before the resin freezes. For the same reason, a faster rate also provides a more uniform surface gloss. Generally, the optimum fill rate for Surlyn Reflections® is one pound per second. For example a two pound part would have an optimum fill time of approximately two seconds.

Packing and Holding

The pressure and time of the pack and the hold stages are responsible for maintaining consistent shot weight, dimensional stability and surface appearance.

Pack and Hold Time

As a general rule, when the gate is properly designed, Surlyn Reflections® alloys require ten seconds of pack and hold time for each millimeter of part thickness. To determine the precise moment the gate freezes, it is recommended that you perform a gate-freeze study with your tool. If the gate should freeze too early, the part will not be fully packed and the surface appearance will suffer. Remember, the gate must remain open long enough to fully pack out the part. (See the Tooling section for information on proper gate design.)

Pack and Hold Pressures

For ideal processing of Surlyn Reflections® alloys, the pack and hold pressures should be set just high enough to achieve an acceptable surface finish. Generally, to produce acceptable surface gloss, Surlyn Reflections® requires approximately 3,500 - 4,000 psi of plastic pressures for packing and hold at the end of the fill. Reaching this pressure may require a gate pressure of approximately 8,000 - 12,000 psi. The actual pressure will depend on the geometry of the part and the distance the resin must flow to fill the mold.

High gate pressures of 8,000 to 12,000 psi can cause flashing. To prevent this, a staircase pack and hold pressure profile is recommended, one that elevates the pressure incrementally in two steps.

For example:

Step One: 3,500 - 4,000 psi for 2-5 seconds. This step enables the part to skin over, which prevents flashing from occurring when the higher pressure is applied in step two.

Step Two: 8,000 - 12,000 psi until the gate freezes. (See the Pack and Hold Time section.)

Cooling Time

Generally, Surlyn Reflections® alloys take 20 seconds of cooling time for each millimeter of part thickness. For example, a 3 mm thick part requires 60 seconds of cooling time.

Screw Speed

For Surlyn Reflections® alloys, set the screw speed just fast enough to ensure that the screw consistently retracts in time for each subsequent shot. In short, the screw speed should be as slow as possible with a recovery time approximately 5 seconds shorter than the cooling time.

Back pressure

Back pressure aids in mixing and can improve the quality of the melt. Too much back pressure, however, can lead to excessive shear, producing unwanted heat in the melt. For fully compounded colors, a back pressure between 50 and 100 psi works very well.

For concentrated blends (salt and peppers) have been proven to be difficult in injection molding machines with L/D's of less than 25:1. Raising back pressure help with dispersion but may create excessive heat in the transition zone of the barrel resulting in a color shift in the parts.

Shrinkage

In tests conducted with various colored plaques measuring 3" x 5" x .125", shrinkage for natural Surlyn Reflections® alloys is .005" - .009" per inch in the flow direction and .009" - .012" per inch in the cross flow direction. Several factors can influence shrinkage, including the geometry of the part, the thickness of the part, the location of the gate, the pigmentation of the resin and various processing parameters. Because there are so many variables that can affect shrinkage, a thorough analysis is recommended prior to mold fabricating. Performing a shrinkage study on parts designed with similar geometry, gating and thickness can be particularly helpful.

IV. TOOLING

To process Surlyn Reflections® and produce a good, quality part, proper tooling is a primary consideration. The type and the surface finish of the steel used to fabricate the mold are critically important to meeting the surface finish requirements of the part. Moreover, the design of the runners, gates and vents also has a crucial bearing on the overall quality of the part. Hot runners present a special challenge and need to be properly designed by a manifold producer.

Tool Steel

For Surlyn Reflections® alloys, tools maded with polished P20 steel having sulfur contents below <.01% are recommended. Prior to fabrication, sample polish a small area of the chosen tooling steel and analyze it for pits and other imperfections. If the analysis indicates the steel is flawed, do not use it. Remember, imperfections in the tool steel will transfer to the finished part during molding.

Tool Finish

Parts made with Surlyn Reflections® alloys will acquire the surface finish of the mold. If the part requires a high-gloss finish, the tool itself must have a high-gloss finish. An A1 tool surface that has been thoroughly polished with .01 - .03 micron 03 diamond paste is recommended.

Plating

The high-gloss finish on parts made with Surlyn Reflections® alloys can sometimes cause them to stick to their molds. For this reason, it is often beneficial to fabricate tools with non-stick plating. There are several types available, however, the plating process consists of a series of sequential steps that must be performed correctly to ensure an acceptable mold. If any of step is deficient, the mold finish -- and the part -- will be adversely affected. Generally, the plating process includes the following steps: polishing the tool steel, applying the plating, applying the release material to the plating, and repolishing.

Conventional Runners

Conventional runners should be designed to provide a shear rate of approximately 3,000 (sec)-1 , use the formula in Section II. In addition, they should be full round with a large cold slug well at every turn and have a minimum diameter equal to the part thickness plus two millimeters.

Hot Runners

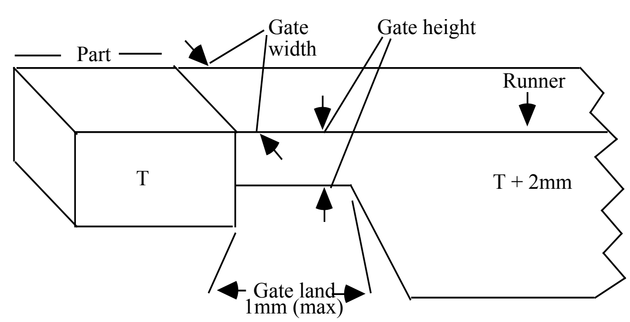
Generally, hot runners are used in place of conventional runners to lower the injection pressure and center the part in the mold. They also eliminate large runners and sprues, which in turn reduces regrind.

A hot manifold should be avoided if possible. The affinity of Surlyn Reflections® to metal makes it difficult for manifolds to perform properly. Common problems with using hot manifolds are color shift, slow color changes, splay, resin degredation, and black specs.

Gates

A properly designed gate is important to controlling the filling, packing and holding stages of the injection cycle. The geometry of the gate land and runner will determine the amount of time the part is exposed to pack and hold pressure.

As a general recommendation, the following diagram shows the ideal gate land and runner geometry:



T = Part thickness
GH = Gate Height -- .8 x T (min)
GW = Gate width -- generally it is 2 (T+2mm)

For Surlyn Reflections® alloys, the tool design should include the appropriate shear rate of less than 7,000 (sec)-1. Prior to fabrication, check the shear rate of your design with the following formula:

$$SR = \frac{(C)\,(PW)}{FT\,(H^2)\,(W)}$$

Where:

SR = Shear Rate (1/sec)

C = 11,540 (mm3/gm)

PW = Part Weight in grams

FT = Fill Time (sec)

H = Gate Height (mm)

W = Gate Width (mm)

Vents

The vent allows trapped air to escape from the mold cavity. The following design features are recommended:

- an opening between 0.001" and 0.0015"
- land between 0.050" and 0.100"
- a minimum vent to atmosphere height of 0.200" and
- width of 0.375"
- peripheral vents and venting the runners

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