TempRite®

CPVC Material Solutions

Custom
Injection
Molding
Guide

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Introduction

This guide was developed to assist processors in the successful injection molding of TempRite® Plastic Custom Injection Molding compounds. The bulletin reviews the recommended injection molding equipment, processing parameters and appropriate mold design that will enable processors to be successful in the first molding trial and each succeeding production run.

Lubrizol has combined improved resins with state of-the-art compounding technology to produce a family of compounds that offer an outstanding blend of physical properties and excellent processibility. Today, these high flow TempRite® compounds are being molded into part configurations that were impossible to achieve just a few short years ago.

Significant advances in processibility now enable industrial designers and engineers to utilize the excellent physical properties that TempRite® plastic offers, including:

- *Elevated temperature performance*
- *Inherent flame retardance*
- *Excellent electrical properties*
- *Excellent toughness*
- *Excellent chemical resistance*
- *Excellent surface appearance*
- *Fluorescent UV stability*
- *Ease of post fabrication and weldability*
- *Ease of painting and decorating*
- *Excellent mechanical property balance*

The Lubrizol TempRite® CPVC compound family is the most complete line of compounds for injection molding. Included in this family are compounds that offer Underwriters Laboratories flammability and thermal index ratings and compliance with NSF listings.

Please refer to Lubrizol Bulletin called "TempRite® CPVC Product Selector Guide," or contact your Lubrizol representative for information on the appropriate compound for a specific application.

Lubrizol TempRite® CPVC compounds exhibit dramatic advancements in improved melt flow, increased thermal stability and reduced shear sensitivity. Optimum results will be obtained when they are processed according to the recommendations contained herein. Reviewing the contents of this bulletin prior to start up will greatly facilitate achieving successful first-time runs.

TempRite®
Engineering
Plastic
"It's the Answer"

Equipment

Machine Type

Properly equipped reciprocating screw injection molding machines are recommended for injection molding TempRite® CPVC. Because these compounds are largely amorphous (no sharp melting point), a plasticating screw is required to prepare homogeneous melt for injection into the mold cavity.

Plunger/ram machines should not be used for these compounds. Because of poor mixing and material stagnation, degradation may occur when processing TempRite® CPVC on this type of equipment.

Machine Size

Barrel capacity: To obtain the widest processing latitude and optimum physical properties of TempRite® CPVC, an appropriate match of shot size, i.e., volume of cavities, runners and sprue, to barrel capacity is very desirable. A shot weight of 60 to 75% of barrel capacity is recommended. This minimizes melt residence time in the barrel enabling processing at higher melt temperatures with optimum melt flow while avoiding degradation. Since the optimum match of barrel capacity is not always practical due to clamp requirements or machine availability, shot sizes as low as 30 to 35% may be used with the understanding that the processing latitude of the material may be significantly reduced. As a result, the ultimate physical properties of the plastic material will not be fully developed. When utilizing the lesser barrel capacities, lower melt temperatures are normally required to prevent thermal degradation due to the longer residence time in the barrel. Lower melt temperatures mean higher melt viscosity and more resistance to flow. Greater injection pressures will be needed to fill the part and molded-in stresses may result that could adversely affect dimensional stability and other properties of the finished part. Higher utilization of barrel capacity is recommended to reduce residence time.

When calculating optimum barrel usage for TempRite® CPVC, always consider its specific gravity versus the specific gravity of the material for which the machine was rated. Most machines are normally rated for kilograms (ounces) of general purpose polystyrene.

Example: Given that the specific gravities of TempRite® CPVC and general purpose polystyrene can be 1.35 and 1.05 respectively, a 1.7 kg (60 oz.) barrel rated in general purpose polystyrene will deliver 2.2 kg (77 oz.)* of TempRite® compound.

$${}^*1.7 \text{ kg} \times \frac{1.35}{1.05} = 2.2 \text{ kg or } 60 \text{ oz.} \times \frac{1.35}{1.05} = 77 \text{ oz}$$

A recommended shot weight, including sprue, runners and parts would then be 1.6 kg (58 oz.) on this machine. (2.2 kg x 75% capacity = 1.6 kg or 77 oz. x 75% capacity = 58 oz.). The shot size should not fall below 35% capacity (0.77 kg (27 oz.)).

Clamp capacity: A machine having a minimum clamp force of 300 to 400 kg/cm^2 (2 to 3 tons/square inch) of projected part area, including runners, is recommended.

Screw Design

Screws having a compression ratio (see *Figure 1*) of 1.5/1 to 2.0/1 and a L/D ratio of 16/1 to 24/1 are recommended for molding TempRite® CPVC.

To reduce the tendency of the product to adhere and degrade on the screw surface, and to provide protection against chemical attack, the screw should be deep nitrided to 67 Rockwell C. Do not remove more than 0.005 cm (0.002 in.) depth of the nitrided surface during polishing to ensure corrosion protection. The commonly used flame-hardened screws are not as resistant to wear and fatigue stresses.

Screw Tip

When filling large, thin-wall parts with easy-flow rigid TempRite® compounds, sliding check rings having ample unrestricted flow channels are recommended. Smooth, ample flow channels coupled with the check ring are essential to reduce melt shear while providing a positive shutoff to back flow over the screw flight. Both 1.5/1 and 2.0/1 compression ratio screws with a sliding check ring have proven to be a very workable combination for easy-flow TempRite® CPVC. Ball check tips are not recommended because of increased shear.

A screw tip of the smearhead (conical or needle-nose) design is preferred for **medium-flow** injection molding compounds (see page 3). The smearhead tip has been used successfully with easy-flow materials where thicker wall, simple part geometries are filled through unrestricted runners and gates.

Nozzle

The nozzle length should be as short as possible, and should be equipped with a separate heater control. A provision for thermocouple monitoring of the nozzle temperature is highly recommended. The thermocouple should not project into the melt system. Proportional, solid state, temperature controllers are also strongly recommended. Depending on temperature requirements, a silicon controlled rectifier (SCR) or triac thyristor circuit may be used. The usual variac or on/off relay controls are not as effective for maintaining the processing control required.

Figure 1: *Typical Screw Used in Injection Molding*

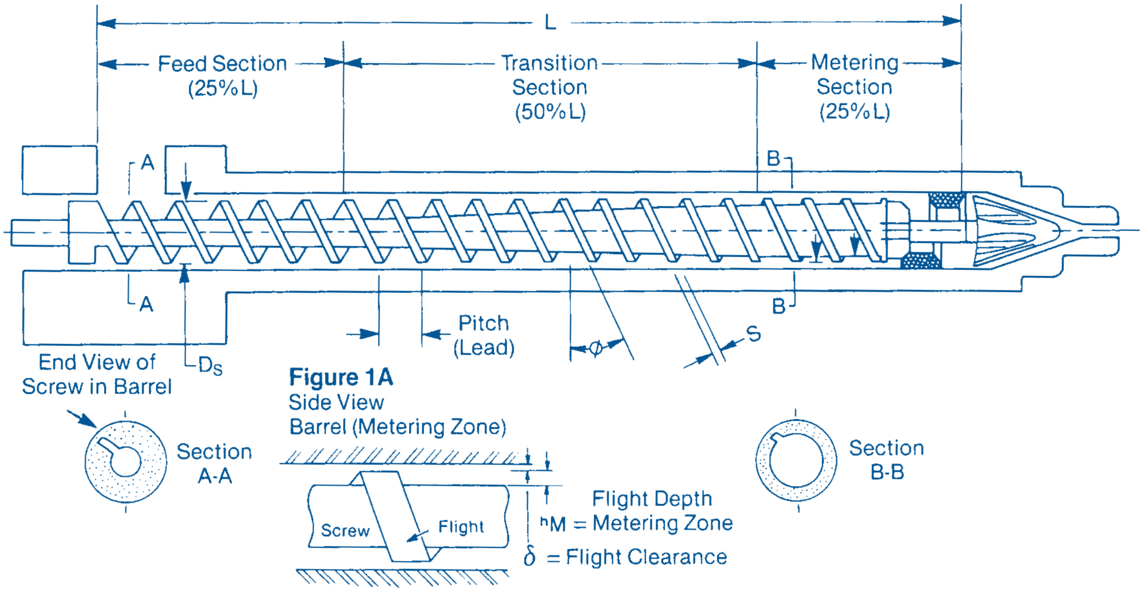
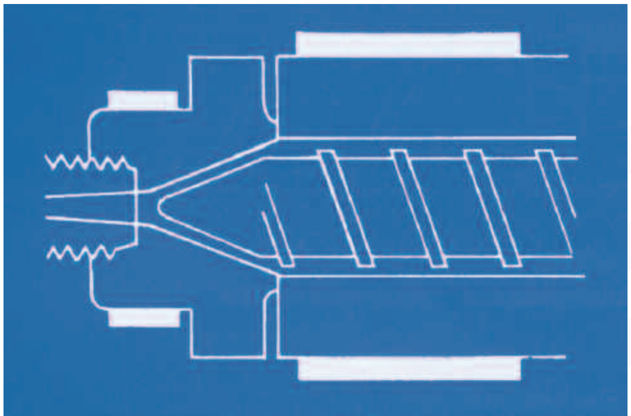


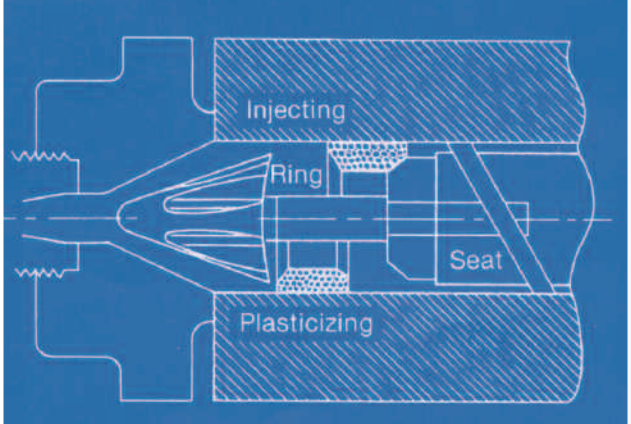
Figure 1A
Side View
Barrel (Metering Zone)

D_S = Diameter screw (nominal)
17.8° Ø = Helix angle (one turn per screw diameter)
0.250 S = Land width
A-A = Annular cross sectional area in the feed zone (actual area occupied by the plastic which is cylinder area minus screw area)
B-B = Annular cross sectional area in the metering zone
L = Overall length
0.005 δ = Flight clearance (radial)
16:1 to 24:1 L/D = Ratio of length to diameter
1.5-2.0 A-A/B-B = Screw compression ratio

Figure 2: *Screw Tip Design (Illustration only)*



Smearhead Type

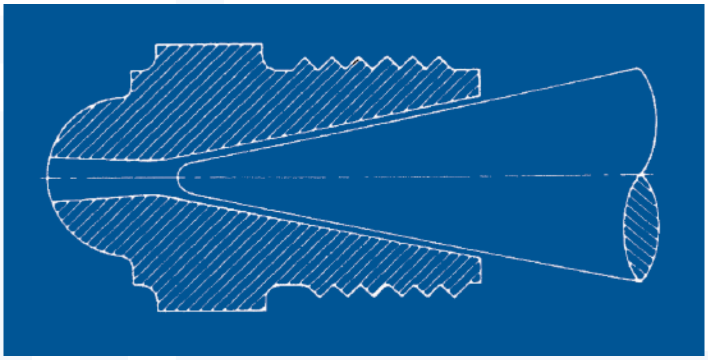


Sliding Check-Ring Type

Chrome Plating

All surfaces which contact molten TempRite® CPVC should be chrome plated. A hard chrome plate should be applied to a total thickness of .0015 in., applied .0005 in. at a time, polishing between applications.

Figure 3: *Optimum Nozzle Design*

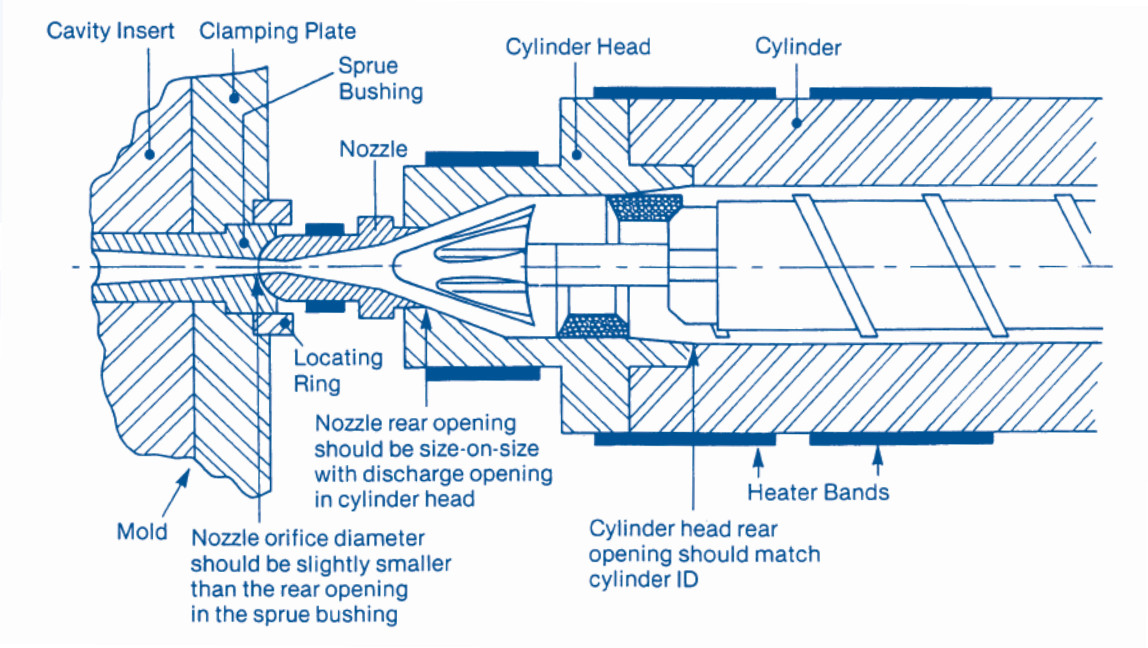


The reverse-taper nozzle design shown in *Figure 3* is preferred. Ideally, shear effects on the material are minimized by a "zero" orifice-land nozzle. The restriction created by the reverse taper promotes sprue break off further back in the nozzle, thus avoiding a potential source of cold slugs or stagnated, degraded material. If a nozzle with a finite orifice-land is used, the land length should not exceed 0.5 cm (0.2 in.). An acceptable alternative is a commercially available full-taper nozzle.

The nozzle discharge-orifice diameter should be at least 0.6 cm (0.25 in.). Small orifice nozzles restrict melt flow. Short shots, sink marks, shear burn or other defects may occur. In all cases, the nozzle orifice diameter should be slightly smaller than the entrance diameter to the sprue. Nozzle orifice diameters larger than the sprue diameter will not release properly during part ejection and will leave a "cold slug" of plastic in the nozzle, as well as create an undesirable shear edge.

Proper sizing of the nozzle rear-opening is also important. The opening should precisely match both the diameter and taper of the discharge hold in the barrel head. If the nozzle opening is too small, a shear edge is created; and if the opening is too large, stagnation areas are formed. A properly sized nozzle is shown in *Figure 4*.

Figure 4: *Proper Nozzle Sizing*



Molds

Construction

Stainless steel is the preferred material for mold core and cavities for TempRite® CPVC. Although 420 type stainless steel is recommended, the moving parts of the mold (knock outs, sliding cores, etc.) should be made from a hardened steel and plated. Metal galling occurs when two stainless steels move in contact with each other. Prehardened and conventionally hardened steels are also acceptable mold materials, but require plating on all plastic contact surfaces. Both hard chrome and electroless nickel plating have been successfully used. Electroless nickel has been found to be an acceptable first layer prior to chroming. It is especially suitable in deep or narrow mold recesses not accessible to chrome. Multiple hard chrome plating has good resistance to hydrochloric acid and is recommended over electroless nickel when possible. Unplated, hardened tool steels and aluminum have all been successfully used for prototyping and limited production molds. Conventional two or three-plate molds can be used.

Draft Angle

Required mold draft angle is dependent on part size and dimensions, but a minimum 0.5° draft angle is usually sufficient. If textured mold cavity surfaces are perpendicular to the platen travel direction, increased draft angle will be necessary. Otherwise, the texturing will act as an undercut and can cause the part to stick in the mold.

Shrinkage Allowances

TempRite® plastics exhibit fairly low mold shrinkage. However, if strict part tolerances are required, the mold cavity should be oversized to allow for 0.004 cm/cm (in./in.) shrinkage. Actual shrinkage is dependent ultimately on the cavity pressure achieved during processing. Higher cavity pressure produces lower shrinkage upon removal from the mold. Parameters affecting cavity pressure are: melt temperature, injection and mold pressures, gate size and wall thickness. Shrinkage is also proportional to flow length.

The shrink rate is less perpendicular to the flow than it is parallel to the flow direction. Whenever possible, gates should be located so that flow lengths are equalized.

Venting

Localized burning and short shots can result when trapped air, gas or moisture vapor becomes superheated under compression. Therefore, the mold should be adequately vented to allow for gas escape. Vents should be placed near weld lines as well as at the last areas of the cavity to be filled. Typical vents are slots 0.6 to 1.3 cm (0.25 to 0.50 in.) wide by 0.001 to 0.003 cm (0.0005 to 0.0010 in.) deep, located on the mating surface of one of the mold halves. Venting may also be accomplished by grinding small flats on core or knockout pins. In general, vents should be cut to a minimum depth initially then increased in depth as necessary.

Sprue Bushing

A sprue bushing with a standard 2½° included angle, approximately 42 mm taper per meter (0.5 in. taper per foot), should be used. The entrance diameter of the bushing should always be slightly larger than the nozzle exit orifice. To promote a balanced pressure to the runners and cavities, the exit diameter of sprue bushing should be larger than the diameter of the main runner. The use of a heated sprue bushing is not generally recommended when molding TempRite® compounds. Also, an excessively recessed sprue bushing is undesirable because it usually requires a long nozzle.

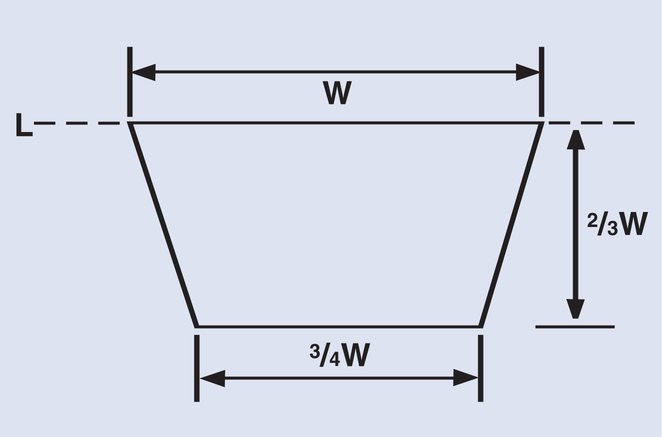
Runners

In a two-plate mold, full-round runners are preferred because they provide the highest volume- to-surface ratio, the least pressure drop, and are the easiest to eject from the mold. Depending on the part size and weight, typical full-round runner diameters are 0.6 to 1.0 cm (0.25 to 0.4 in.). Because of excessive flow restriction, small diameter runners, less than 0.6 cm (0.25 in.) diameter, should be avoided. Excessively large diameter runners offer little advantage and contribute to longer cycle times and greater material usage.

If a three-plate mold is being implemented, full-round runners are still preferred, but trapezoidal or half-round runners can be used. Rectangular runners are not recommended for TempRite® CPVC.

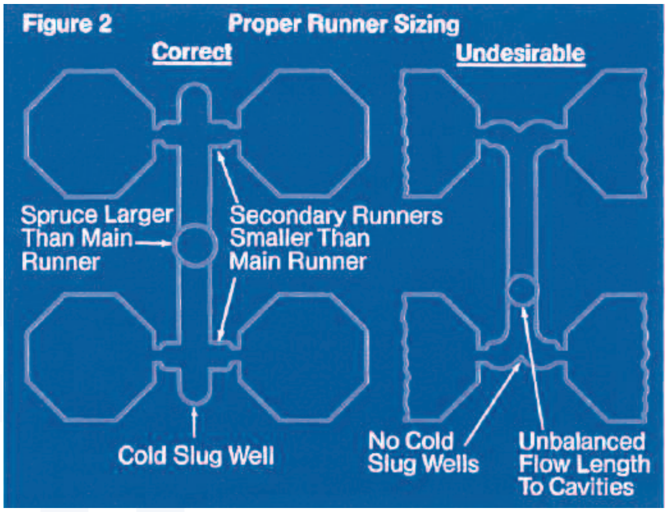
Figure 5 shows typical relative dimensions of a trapezoidal cross-section runner. The flow through a trapezoidal runner is equivalent to that of the largest circular runner whose cross-section can be inscribed within the trapezoid.

Figure 5: *Relative Dimensions of a Trapezoidal Runner for use in a Three-Plate Mold*



To maintain pressure and balanced flow during injection into a multiple cavity or multi-gated mold, the secondary runners should be slightly smaller in cross section than the main runner. Secondary runners should be perpendicular to the main runner, and the runner junction should be radiused and polished to remove burrs and sharp edges. *Figure 6* shows a properly sized runner system.

Figure 6: *Proper Runner Sizing*



In addition to proper runner sizing, the layout of the mold is also an important consideration. A runner system should be designed to give balanced flow to all gates, ideally designed so that the melt reaches all of the gates simultaneously.

Insulated runner and hot runner systems should not be used under any circumstances.

Cold Slug Wells

During injection, the initial surge of material is generally cool since it has remained dormant in the nozzle while the previous shot was being ejected from the mold. To prevent this cold material from entering the cavity and causing a visual defect, cold slug wells or runoffs should be incorporated into the runner system before material is allowed to enter the cavities. Properly sized runner systems designed for balanced flow which incorporate cold slug wells are shown in *Figure 7*.

Gates

TempRite® compounds have been satisfactorily molded through a wide variety of gate designs including fan, tab, edge, submarine and sprue. In general, the gates should have a generous cross-sectional area to allow the material to flow freely with a minimum of pressure loss. The gates should be polished smooth with all rough edges and sharp corners removed. *Figure 8* illustrates several acceptable gate designs with rounded corners for minimum restriction.

The land length of a gate should be kept as short as possible, 0.08 to 0.1 cm (0.03 to 0.04 in.). This will reduce shear heating and promote the best combination of cycle time and injection speed.

In multi-gated cavities, the gate location and number of gates are very important to the appearance and performance of the molded part. Since gate areas are almost always more highly stressed due to orientation, gates should be located in non-critical sections of the part.

Gating in thick sections of the part, allowing the material to flow to the thinner sections, keeps sink and splay marks to a minimum. When gating into a thick section, the flow should be directed toward a cavity wall or deflector pin to break up the melt entering the cavity and to prevent a condition known as "worming." Worming is a random pattern of weld lines opposite the gate caused by the rapid cooling of the injected melt. If the design of the part requires a split in the flow front coming from the gate, a weld line will result where the flow fronts again meet. Consideration should be given to designing parts with a minimum number of gates. Multiple weld lines will weaken the part and could detract from surface appearance. Oversized subgates may result in poor degating at the part.

Figure 7: *Runner Systems with Balanced-Flow Cavity Layouts and Cold Slug Walls*

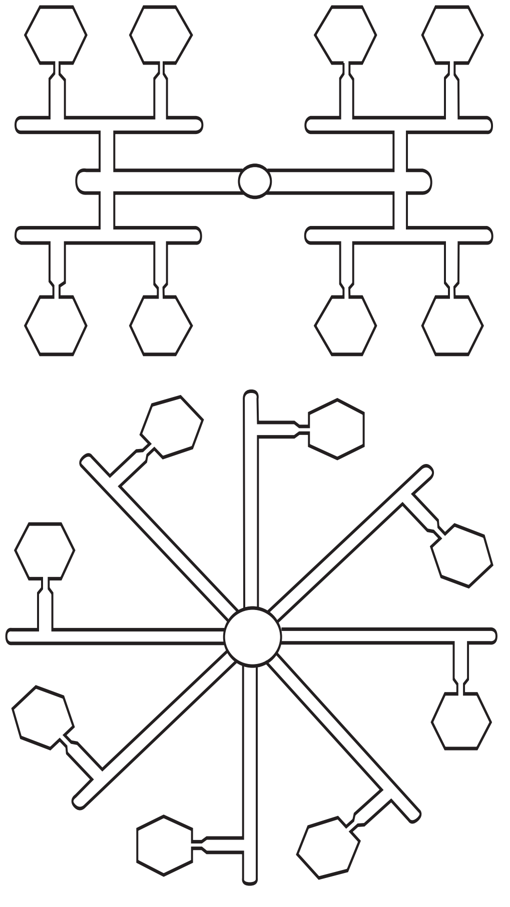
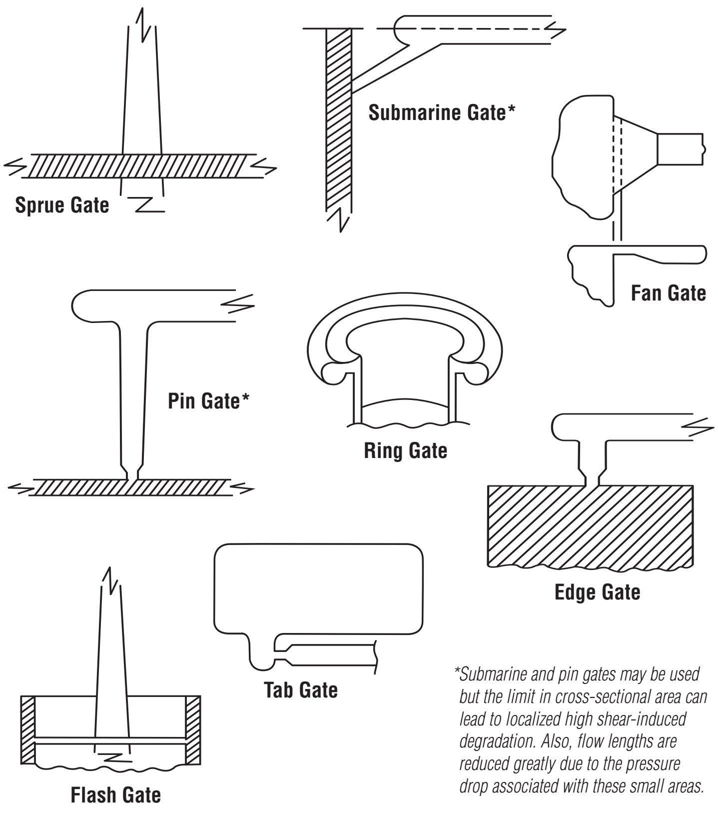


Figure 8: *Gate Designs*



**Submarine and pin gates may be used but the limit in cross-sectional area can lead to localized high shear-induced degradation. Also, flow lengths are reduced greatly due to the pressure drop associated with these small areas.*

Processing

Successful processing of TempRite® CPVC by injection molding is dependent upon a wide range of variables, such as machine size, shot size, screw geometry and mold design. Due to these factors, exact machine conditions for optimum processing must be determined by the processor for every individual system. The following sections review the conditions a molder should strive for when using TempRite® CPVC in order to achieve the best processing latitude and ultimate properties in the molded part.

Also discussed in a later section are the conditions applicable to the higher viscosity (lower flow) compounds. Finally, start-up and shut-down procedures are summarized in the *Processing Guide* section. This section and the *Trouble Shooting Guide* should be readily available to set up personnel and machine operators.

Drying

The moisture sensitivity of TempRite® CPVC is similar to many other molding materials. The product should be dried prior to molding. Certain conditions, including exposure to high humidity, can result in an accumulation of surface moisture and processing problems and part blemishes may result. Inability to attain a consistent reproducible cycle, intermittent short shots, localized burning, poor weld line strength, and/or silver streaking at the gate (splay) may be indicative of a moisture problem.

Predrying 80°C (176°F) for two hours should eliminate moisture as a potential cause of molding problems. Prolonged or overnight drying is not recommended. A hopper-mounted, dehumidified air dryer is preferred. If it is necessary to use a tray oven, the depth of the cubes on the tray should not exceed 5 cm (2.0 in.).

Mold Temperature

To obtain optimum appearance and production rates, molds should be provided with good temperature control. Inlet water temperatures of 30 to 70°C (86 to 158°F) are normally used. This will vary depending on the size of the part, wall thicknesses and required flow length. The ejector side of the mold is usually maintained 5°C (10°F) lower than the stationary side to facilitate part removal.

Melt Temperature

The melt temperature can be controlled by a proper combination of the heater band settings, screw back pressure and screw RPM. To develop ultimate physical properties, it is imperative that recommendations for melt temperature be followed when molding TempRite® CPVC.

The recommended melt temperature for processing TempRite® CPVC is 204 to 227°C (400 to 440°F). The melt temperature should never exceed 238°C (460°F).

To measure melt temperature, use an accurately calibrated needle-probe hand pyrometer. When making a temperature measurement with a needle pyrometer, the molten material should be injected directly from the nozzle onto a piece of heavy cardboard or some other insulating material that will not readily conduct heat from the plastic. The injection pressure, injection speed and back pressure are usually adjusted to a lower setting for taking these air-shots than when at normal cycle; therefore, a melt temperature of approximately 5 to 10°C (10 to 20°F) lower than the recommended range is a good objective when starting. The needle should be jabbed into the molten plastic successively four or five times in different locations before the actual reading is taken.

Occasional wiping of the needle probe with some mold release agent will help prevent “freezing” of CPVC on the probe during the initial portion of the reading. If material “freezes” to the probe on the first insertion, it acts as an insulator on the probe’s surface and erroneously low values for melt temperature will be obtained.

If gassing or bubbling of the hot plastic is observed during the air-shot, it generally indicates a higher than recommended melt temperature is being achieved. Melt temperature should be rechecked. The CPVC extrudate (rope) should appear smooth and reasonably glossy if the melt temperature is near optimum. Voids on the surface and in the core of the extrudate could also be indicative of a moisture problem.

Regrind

Runners and trim material can normally be reused. Regrind materials should be kept very clean. Grinding generates heat. To avoid thermal degradation, material should be cooled and stored below 66°C (150°F).

Regrind is commonly used in combination with virgin compound at 10-30% levels. If the bulk flow of the regrind material is satisfactory, 100% regrind may be acceptable.

Degraded or contaminated regrind materials should not be used. It will only cause degradation of the good material used with it.

Heater Band Settings

Heater band settings depend greatly on machine size, screw design and other settings, such as back pressure and screw RPM. Because of heat generated by shear, most molding machines yield melt temperatures higher than heater band settings.

For the initial trial of TempRite® CPVC on machines over 450 ton clamp capacity, a starting barrel profile of 166°C (330°F) and a nozzle temperature of 177°C (350°F) can be used. A barrel profile of 177°C (350°F) and a nozzle temperature of 177°C (350°F) for machines less than 450 ton clamp capacity should be satisfactory. These settings should be adjusted to achieve an airshot melt temperature which is 5 to 10°C (10 to 20°F) less than the desired temperature (more heat will be generated once the machine is cycling continuously). Since heat is being generated by the screw within the material, it is quite normal for the middle and front barrel temperature zones to override the set point. As long as the machine is stabilized; i.e., cycling regularly, these set points do not require adjustment. Carefully monitor melt temperature with a needle pyrometer during initial start-up and after any condition changes.

Once heater band settings have been established and the desired melt temperature is achieved, subsequent runs on the same machine may be started at these conditions. Close monitoring of melt temperature is still recommended.

Screw Back Pressure

Screw back pressure will vary from machine to machine, but generally the back pressure should be in the 0.3 to 0.7 MPa (50 to 100 psig) range. Low compression ratio screws may require higher back pressures to obtain proper mixing and melt homogeneity.

Screw RPM

For a screw of recommended geometry (see *Screw Design* section), a rotating speed of 40 to 50 RPM should be satisfactory. Due to increased diameter, a larger screw has greater circumferential velocity than a smaller screw at a given RPM. The greater velocity promotes more shear heating of the molding compound. Therefore large machines generally require lower RPM at optimum conditions.

Injection Speed

A slow to moderate injection speed should be used at the start of the molding run and increased to the point where the part fills and no signs of weld lines or sinks exist. If the injection speed is too fast, excessive frictional heat build up can result in velocity burning as the material flows through restrictions or over sharp edges. This frictional heat can result in surface appearance defects, brittleness or even degradation of the material. Injection speeds for air-shots should be relatively slow since there is very little resistance to the material flow.

Injection and Holding Pressures

The amount of first stage injection pressure (booster pressure) that is required to fill the mold cavity will depend on the stock temperature, injection speed, mold temperature and mold design. Generally, pressures in the range of 50 to 75% of the maximum available offer the best consistency and processing latitude. It is advisable to start with lower pressures and increase to the desired pressure to avoid flashing the mold. The timer for the first stage injection pressure should be set to switch to holding pressure just as the part is completely filled. This should coincide with the moment that the screw completes its relatively fast forward travel leaving a 0.3 to 0.6 cm (0.125 to 0.25 in.) cushion. Smear tip screws often continue to slowly creep forward and may eventually bottom out.

The second stage injection pressure (holding pressure) should be just enough to maintain a full part as the part cools and shrinks in the cavity. Holding pressure is typically 1/2 to 2/3 of the first stage injection pressure. Parts having thicker sections usually require greater holding pressure.

Overpacking the part with excessive holding pressure or time on the first stage injection pressure increases molded-in stress that is detrimental to properties. Generally, sink marks opposite the gate indicate that more injection pressure/time is needed while sink marks near the gate indicate that more hold pressure/time is needed. Once it is apparent that gates are frozen off, hold pressure can be reduced to save on energy consumption.

A small cushion of material must be maintained ahead of the screw to compensate for part shrinkage as it cools under holding pressure, thus preventing sink marks. Ideally, the screw should only reach the full forward position after material movement has ceased.

Processing Higher Viscosity TempRite® CPVC

Many of the recommendations previously discussed for the high- flow injection molding TempRite® CPVC are also applicable for the higher viscosity (lower flow) materials. Certain points of emphasis and exceptions are:

1. *Lower compression screws are more effective and are necessary to achieve optimum processing latitude.*
2. *Screw check rings should not be used. Smearhead (conical tip, needle-nose) screws are much preferred.*
3. *Larger gates are recommended. Pin gates should not be used.*
4. *Higher mold temperatures, up to 88°C (190°F), may be necessary to aid low. These stiffer materials will set up at higher temperatures.*
5. *Higher melt temperatures will likely be required to fill a given part. Temperatures of 221 to 232°C (430 to 450°F) are typical.*
6. *Matching of shot size to barrel capacity is more important.*
7. *Higher clamp capacity is generally required as these materials require greater injection pressures. Allow 3 to 4 tons of clamp capacity per square inch of projected part area.*
8. *Thin-wall, large surface area parts are more difficult to fill with these materials than with the higher flow TempRite® CPVC.*

Processing Summary

In summary, to develop the ultimate physical and appearance properties of TempRite® CPVC, the material should be processed at the maximum allowable melt temperature without burning. It should be injected at a moderate speed, packed at the minimum pressure required to fill out the mold details and allowed to relax during the cooling stage.

Processing Guide Start Up Procedure

1. *Thoroughly clean the injection unit by either physically dismantling and cleaning, or purge the barrel with general purpose ABS or acrylic. The use of polyethylene or polypropylene as purge material is not recommended. (See below). Note: See warning concerning acetal polymers.*

2. *Set temperature controllers and reduce injection pressure settings, back pressure setting and screw RPM to the lower end of their operating ranges.*

3. *After temperature zones have stabilized, introduce the TempRite® CPVC to the machine.*

4. *Take air-shot melt temperatures and make adjustments to temperature settings and screw RPM to approach the desired melt temperature. Observe the appearance of the molten plastic very carefully at this stage. A smooth, glossy surface is indicative of a good homogeneous melt, while a bumpy rope and matte surface indicate non-homogeneity and low melt temperature. A smoking or frothy melt suggests that the melt temperature is too high. Another evidence of good melt temperature is the ability to draw down the hot rope into a thin monofilament. A brittle break indicates a low melt temperature. Back pressure should be set to achieve adequate mixing and optimum melt temperature.*

5. *Spray some mold release in the cavity and sprue bushing and move the nozzle into position against the sprue bushing.*

6. *Start molding parts in the semiautomatic mode of operation while adjusting screw travel (feed), injection pressures and injection speed to obtain a full part.*

7. *Consult* Trouble Shooting Guide *for correcting any defects in the molded part.*

8. *If a sprue should happen to hang-up in the sprue bushing, never try to shoot through the hung-up sprue to remove it. This can cause extensive shear heating of the material which could lead to degradation of the TempRite® CPVC.*

9. *Some TempRite® CPVCs have lead stabilization systems. Do not mix these with plastics having tin stabilization systems or staining of equipment will result. Consult your Lubrizol representative about products that have lead stabilizers.*

Purging and Shutdown Procedure

TempRite® CPVCs are susceptible to thermal degradation upon prolonged exposure to a high heat environment. Therefore, if there is an interruption in the molding cycle, the injection unit should be pulled back from the mold and the melt should be processed through the barrel by making occasional “air-shots.” If the delay is lengthy, the product should be completely purged from the barrel with general purpose ABS or acrylic regrind. At the end of a molding run, the injection molding machine should not be shut down with TempRite® CPVC in the barrel; it must be purged from the barrel with an effective purge material. The carriage (barrel) of an injection molding machine should never be left in the forward position with the machine idle.

If TempRite® CPVCs are accidentally overheated in the barrel, both the screw and barrel may have to be cleaned. If the condition is not severe, this may be accomplished by purging the barrel with acrylic or ABS at very low temperatures. The “cold” acrylic or ABS will scour the barrel and remove any degraded material. If this method does not work, remove the screw from the barrel and clean mechanically.

In the event that a power failure occurs during the molding operation, and the melt cools and solidifies in the barrel, special start-up procedures should be used when power is restored. Initially, the heater bands should be turned on low heat, 93 to 121°C (200 to 250°F), and held there until the material in the barrel has had time to warm through. The heater band setting should then be increased to slightly below normal operating temperatures. As soon as the machine reaches the higher temperatures, the screw should be manually jogged; and as soon as the material moves, the temperatures should be raised to those for normal molding conditions. The remaining material is then purged from the barrel with one of the other thermoplastic materials recommended above. At this time, the TempRite® CPVC being used can be reintroduced into the barrel and production resumed.

Polyethylene or polypropylene are immiscible with TempRite® CPVC and should not be used as a purge material. Flame retardant materials should not be used since they are susceptible to degradation themselves.

Care should be taken when putting a mold into storage to minimize the possibility of rusting and corrosion. The mold to be stored should be thoroughly washed with a baking soda solution or commercially available spray to neutralize any residual acids present, dried and then sprayed with a commercial rust inhibitor, lubricant or mold release agent. At the end of a workday or over a weekend, it is also advisable to neutralize spray or brush a thin layer of commercially-available mold protective solution on the mold core and cavity. This temporary protective layer will be automatically removed by the first production shots.

Warning

It is important that TempRite® CPVC compounds never come in contact with acetal or acetal copolymers (such as Delrin* or Celcon*) within an extruder or molding machine, since at processing conditions the two materials are mutually destructive and involve rapid degradation of the products. Care must be taken to avoid even trace quantities of these materials coming in contact with each other in the machine, as well as preventing any cross contamination of feedstocks. If possible, TempRite® CPVC compounds and acetal polymers and copolymers should never be processed in the same machine; however, when this is not possible, the machine must be purged with acrylic, ABS or other purge compound followed by a thorough mechanical cleaning of the machine. For information on physical and chemical properties and health and safety information on these materials, see the respective Material Safety Data Sheets.

*Delrin is a product of E. I. du Pont de Nemours & Company, Plastic Product and Resins Department. Celcon is a product of Celanese Plastics and Specialties Company.

Trouble Shooting Guide for Injection Molding TempRite® CPVC Compounds

Defect: Short Shots

Possible Causes:

1. Insufficient material
2. Injection pressure too low
3. Injection speed too slow
4. Cylinder temperatures too low
5. Mold temperatures too low
6. Insufficient venting
7. Sprues, runners or gates too small
8. Improper gate location
9. Melt temperature too low
10. Insufficient back pressure

Defect: Sink Marks or Excessive Shrinkage

Possible Causes:

1. Insufficient material
2. Injection pressure too low
3. Hold time too short
4. Cooling time too short
5. Melt temperature too high
6. Mold temperature too high
7. Sprues, runners or gates too small (improper mold design)
8. Injection hold pressure too low

Defect: Weak Welds

Possible Causes:

1. Mold temperature too low
2. Injection speed too slow
3. Melt temperature too low
4. Injection pressure too low
5. Insufficient mold venting
6. Improper gate locations and/or size
7. Cylinder temperatures too low
8. Screw back pressure too low
9. Nozzle diameter too small

Defect: Part Sticking in Cavity

Possible Causes:

1. Injection pressure too high
2. Hold pressure too high
3. Hold time too long
4. Core side of mold too hot
5. Rough surface on sprue bushing
6. Rough surface on cavity side of mold
7. Fill rate too fast
8. Shot size too large

Defect: Blush Marks Around Gates

Possible Causes:

1. Mold temperature too cold
2. Injection fill speed too fast
3. Melt temperature too high or too low
4. Improper gate location
5. Sprue and nozzle diameter too small
6. Nozzle temperature too low
7. Insufficient cold slug well
8. Imperfections in gate openings
9. Moisture in the compound

Defect: Dullness on Molding Surface

Possible Causes:

1. Cylinder temperatures too low (increase in small increments)
2. Screw back pressure too low
3. Injection fill speed too slow
4. Mold temperature too cold
5. Melt temperature too low
6. Moisture in the compound

Defect: Silver Streaks on Part Surface

Possible Causes:

1. Melt temperature too high
2. Nozzle temperature too high
3. Injection speed too fast
4. Excessive moisture on material

Defect: Flashing

Possible Causes:

1. Injection pressure too high
2. Insufficient clamping pressure
3. Injection speed too fast
4. Melt temperature too high
5. Mold faces not plane and parallel
6. Improper venting (one cavity venting while another fails to fill)
7. Improper mold design

Defect: Dull Streaks, Flow Lines

Possible Causes:

1. Melt temperature too low
2. Runners too small
3. Improper gate size and/or location
4. Mold temperature too low
5. Inadequate cold slug wells

Defect: Warpage

Possible Causes:

1. Mold temperature too high (for thick wall sections)
2. Melt temperature too high
3. Insufficient hold time
4. Injection and holding pressure too high or too low
5. Injection speed too fast
6. Cycle time too short

Defect: Lamination

Possible Causes:

1. Purging compound left in cylinder
2. Mold temperature too low
3. Melt temperature too low
4. Injection speed too fast
5. Gate size too small
6. Injection pressure too high

Defect: Temperatures Over-Riding on Front Zones

Possible Causes:

1. Compression ratio of screw too high
2. Excessive back pressure
3. Insufficient air circulation on over-riding zones
4. Screw RPM too high

Defect: Burn Streaks in Center of Sprue

Possible Causes:

1. Front zone temperature too high
2. Screw speed too high
3. Excessive back pressure
4. Compression ratio of screw too high
5. Melt temperature too high

Defect: Burn Streaks at Gate

Possible Causes:

1. Injection speed too fast
2. Injection pressure too high
3. Gates or nozzle diameter too small (improper design)
4. Shear burning due to cold material

Defect: Discoloration or Burned Areas in Part

Possible Causes:

1. Screw speed too fast
2. Back pressure too high
3. Cylinder temperatures too high
4. Faulty temperature controllers
5. Gates too small
6. Dead material hung up on screw or nozzle
7. Insufficient mold venting
8. Melt temperature too high
9. Moisture in compound

Defect: Weld Burning

Possible Causes:

1. Injection speed too fast
2. Melt temperature too high or too low
3. Screw RPM too high
4. Back pressure too high
5. Nozzle diameter too small
6. Sprue, runner or gates too small
7. Injection pressure too high
8. Insufficient mold venting
9. Excessive moisture on the material

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