GEON® FIBERLOC
GLASS COMPOSITES

EXTRUSION GUIDE

GEON®
Performance Solutions

CONTENTS

INTRODUCTION

Vinyl is the third most produced thermoplastic in the world behind polypropylene and polyethylene, and hundreds of millions of pounds of rigid vinyl are successfully injection molded around the globe each year. Because vinyl is so versatile from a formulation and processing perspective, it can be injection molded into products for a variety of markets and applications.

Key Considerations for Successful Injection Molding

Glass Composites—GEON Fiberloc glass composites combine the increased strength, stiffness, and dimensional stability of glass with the flame, chemical, and UV resistance of vinyl. While the addition of glass fiber results in a more robust formulation for structural applications, it can create greater wear on processing equipment. As with all polymer glass composites, it is highly recommended that metallurgy specifically designed for use with glass composites be employed in the molding machine and mold when processing GEON Fiberloc glass composites. This guide provides recommendations for appropriate metallurgy.

Melt Properties—Rigid vinyl formulations including GEON Fiberloc glass composites, are heat and shear sensitive at processing temperatures. This means the polymer melt can degrade if it is left at processing temperatures for extended periods of time or if it experiences high shear when flowing through restricted gates, runners, or part walls. The melt delivery system, which includes the molding machine injection unit and the mold runner and gating system, must be streamlined in design to keep material flowing and avoid stagnant areas or dead spots, which can lead to degradation. The melt delivery system should also be designed to avoid highly restricted flow channels that can generate high shear. Injection molders who understand and follow these guidelines can successfully mold rigid vinyl into complex shapes in a variety of sizes.

Molding Machine Design and Processing Conditions—Successful production of injection molded parts starts by converting pellets into a homogeneous, easy flowing melt. This guide provides recommendations for the appropriate design of molding machine components and processing conditions to produce an optimal melt for molding high quality vinyl composite parts.

Mold Design—Every polymer has different melt properties. So in order to provide the greatest probability for success, molds should be designed with a specific polymer in mind. Factors such as metallurgy, gate and runner sizing, wall thickness, and part shrinkage can all change with polymer type. Contact GEON and ask for a GEON Performance Materials Technical Service Representative to obtain more information about designing molds for use with GEON Fiberloc glass composites.

Material Formulation—While many rigid vinyl suppliers have standard flowing compounds for simple, thick walled shapes like pipe fittings, not all suppliers have high flow formulations for complex shaped parts or glass composites for structural parts. GEON Fiberloc glass composites use state-of-the-art technology to provide enhanced physical properties, flow and processing stability to fill a greater variety of larger, more complex shapes. Contact GEON and ask for a GEON Performance Materials Technical Service Representative to determine the appropriate GEON Fiberloc formulation for your specific part design.

For more information, contact GEON:
Phone (Toll Free U.S.): 1-(800)-GET-GEON
Website: www.GEON.com

HEALTH AND SAFETY

As with all injection-molded thermoplastics, care must be taken to follow recommendations for proper equipment and processing conditions to keep workers safe. This section includes health and safety information regarding injection molding rigid vinyl glass composites.

WARNING:
Acetal Not Compatible with Flame Retardant Polymers Such As Vinyl

It is extremely important that vinyl formulations and acetal or acetal copolymers (such as Delrin® acetal or Celcon® acetal) never come in contact with each other at processing temperatures.[1] At processing temperatures, the small amount of acidic vapors from naturally flame retardant polymers such as vinyl can catalyze the rapid depolymerization of acetal to form formaldehyde gas. The formaldehyde gas, in turn, causes further generation of hydrochloric acid. An accelerated chemical reaction continues and can ultimately lead to a violent release of these gases.

GEON strongly recommends that acetal and vinyl need to be injection molded on different machines isolated from each other. If this is not possible, then the molder must thoroughly purge the molding machine between the two materials with general purpose ABS, acrylic, or other recommended purging compound and follow with a thorough mechanical cleaning of the barrel and screw.

Ventilation

It is necessary to have sufficient ventilation in any area where thermoplastics, including vinyl, are injection molded. Sufficient ventilation includes an overhead roof exhaust fan and/or a sidewall exhaust fan. U.S. Occupational Safety & Health Administration (OSHA) requirements regarding "adequate" ventilation for molding operations must be followed in the United States and are recommended for other locations where no specific regulations exist.

Vapors During Processing

All thermoplastics emit vapors or off-gasses when processed at melt temperatures. The identity and concentration of these off-gasses around the injection-molding machine depends on variables such as the material formulation, amount processed, processing conditions, and the effectiveness of the ventilation. Under normal processing conditions with OSHA approved ventilation, injection molding of GEON Fiberloc glass composites does not pose a health risk to workers.

Vinyl resin itself does not have an odor during normal processing. The slight odor emanating during injection molding of vinyl glass composites comes from additives incorporated in the formulation that enhance processing and physical properties.

Vinyl formulations are heat and shear sensitive at processing temperatures. This means the polymer melt can degrade if it is left at processing temperatures for extended periods of time or if it experiences high shear flowing through restricted gates, runners, or part walls. When rigid vinyl overheats, it can degrade and generate a gaseous hydrogen chloride (HCl) fume.

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[1]Delrin® is a registered trademark of E. I. du Pont de Nemours & Company, and Celcon® is a registered trademark of Celanese Corporation.

Chlorine gas and vinyl chloride monomer vapor are not generated when vinyl degrades. HCl has a strong unpleasant acrid odor when present at low levels and irritates the nose and throat at higher levels. If you suspect material is degrading during molding, follow the procedures outlined in the **Processing** section under **Process Upsets.**

EQUIPMENT

Injection Molding Machine

Machine Type—Reciprocating screw injection molding machines designed to run engineering thermoplastics like ABS or PC are usually well suited for processing GEON Fiberloc glass composites. Avoid plunger type machines or machines with an extruder combined with a plunger because they tend to have stagnant areas which can lead to material degradation.

Machine Size—An injection-molding machine having a minimum clamp force of 2 to 2.5 tons per square inch (0.0028 to 0.0035 MT/mm2) of projected area is typical. Thinner walls or long flow lengths may require higher clamp tonnage.

Barrel

Barrel Capacity—A shot weight using 50% to 80% of the barrel capacity is recommended for all GEON Fiberloc formulations. A shot weight using 30% to 90% of the barrel capacity may be possible. However a long cycle time using a low shot weight percentage may lead to degradation of the material in the barrel. When a barrel's capacity is rated, it is rated by the ounces of polystyrene the specific barrel will hold. Polystyrene has a specific gravity of 1.0 while vinyl glass composites typically have a specific gravity of 1.4 to 1.6. This means a barrel rated at 80 ounces of polystyrene will actually hold about 120 ounces of a vinyl glass composite.

Barrel Metallurgy—Ideally, the injection barrel is bimetallic, meaning there are two layers of different metals. The inner layer facing the melt is chemical and wear-resistant while the outer layer is a stronger steel sleeve. Single layer barrels that are only nitrided do not provide the best chemical resistance, but they are commonly used when molding rigid vinyl and can work well if properly maintained. Barrel metals high in iron or cobalt are unacceptable for molding vinyl because they cause pinking or streaking in the vinyl end product.

Furthermore, the barrel metal should also be compatible with nickel-based materials used to harden feed screw flights such as Crucible CPM S90V metal.[2] Most screw and barrel manufacturers can supply recommendations for appropriate screw and barrel material combinations.

Segmented or vented barrels are not acceptable for molding vinyl because stagnant areas (also called dead spots) impede material flow, which can lead to degradation and ultimately black specs in the finished part.

There are several bimetallic barrels manufactured for polymer glass composites. One example recommended for GEON Fiberloc glass composites is Wexco Corporation's 777-Durocast™, which is a bimetallic barrel made from a tungsten carbide alloy for maximum wear resistance and good corrosion resistance against hydrochloric and other mild acid gasses.[3]

[2]CPM® S90V® is a registered trademark of Crucible Industries LLC.

[3]777-Durocast™ is a trademark of Wexco Corporation

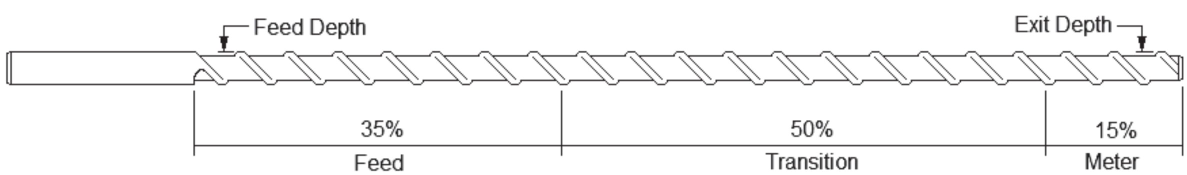
Table 1—Recommended Wear Resistant Barrel	
Bi-Metallic Barrel Material	**Manufacturer Information**
777- Durocast™	Wexco Corporation 1015 Dillard Drive Lynchburg, VA 24502 www.wexco.com Toll Free: +1 800 999 3926

Screw

Screw Design—Compression ratio is defined as the depth of the first feed flight divided by the depth of the last metering flight. The recommended compression ratio for a rigid vinyl molding screw is 2.2:1. While screws with compression ratios between 2.0:1 and 3.0:1 have been used successfully, it is recommended the compression ratio of the screw should be closer to 2.2:1. As the compression ratio of the screw increases, the processing window for rigid vinyl may decrease. This is especially true when the compression ratio exceeds 2.8:1. A compression ratio less than 2.2:1 will tend not to squeeze all the air out of the melt, causing bubbles to be included in the shot.

Screw geometry is a very important aspect to the overall performance of the screw. The recommended configuration for a rigid vinyl molding screw is 35% feed, 50% transition and 15% meter.

Figure 1—Recommended Geometry for a Vinyl Glass Composite Screw



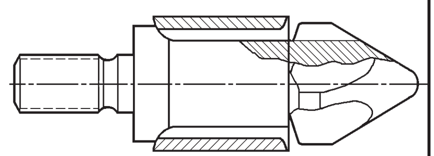
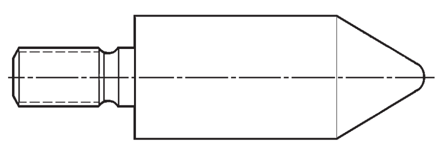
$$\text{Compression} = \frac{\text{Feed Depth}}{\text{Exit Depth}}$$

Table 2—Dimensions for Screw with a 2.2:1 Compression Ratio					
Screw Diameter (in)	**Feed Depth (in)**	**Exit Depth (in)**	**Screw Diameter (mm)**	**Feed Depth (mm)**	**Exit Depth (mm)**
2.0	0.297	0.135	45	6.6	3.0
2.5	0.352	0.160	50	7.5	3.4
3.0	0.396	0.180	65	9.0	4.0
3.5	0.440	0.200	75	10.0	4.5
4.0	0.485	0.220	90	11.2	5.1
4.5	0.515	0.234	100	12.3	5.6
5.0	0.550	0.250	115	13.0	5.9
5.5	0.590	0.268	125	14.0	6.4
6.0	0.630	0.286	150	16.0	7.3
			160	17.4	7.9

Screw Metallurgy—Stainless steel injection molding screws are highly recommended for use with GEON Fiberloc glass composites as they provide the appropriate combination of hardness and corrosion resistance. Screws manufactured with hardened tool steel (e.g. CPM®S90V®) or screws manufactured with PH stainless steel for the root (e.g. 17-4 PH) and a nickel-tungsten alloy for the flights (e.g. Colmonoy® 56) are also acceptable.[4] if the screw is manufactured with tool steel such as 4140, corrosion protection such as triple chrome-plating is recommended. Irrespective of the metallurgy, all root surface areas need to be highly polished. Certain types of Stellite® metals are not recommended as they are typically cobalt based and may lead to streaking.[5]

Screw Tip

Screw Tip Design—The screw tip design is also very important for rigid vinyl formulations. Restrictive tips can cause over shearing and burn or degrade. Like every component in the vinyl injection molding system, it is important that the screw tip be as streamlined as possible to avoid stagnant areas where material could degrade. Free-flow sliding check rings with ample clearance under the ring and base of the valve are strongly recommended. The clearance under the check ring should be 1 to 1.5 times the exit depth of the screw. This design is the least restrictive screw tip and is designed to achieve complete shutoff during injection. Complete shutoff is important as it prevents backflow and delivers full, continuous injection pressure. Smear tips are not recommended for most GEON high flow rigid vinyl molding formulations as there is no mechanism for shutoff and results in backflow and a loss of injection pressure. Smear tips can be used with higher viscosity vinyl formulations designed for pipefittings and other thick walled parts. Ball check tips are not recommended as they are traditionally more restrictive than sliding check rings. This design tends to create stagnant areas where vinyl can hang up, causing a problem with black specks during processing.

Table 3—Screw Tip Types and Recommendations	
Sliding Check Ring ✔ Recommended for GEON Fiberloc glass composites	 Sliding Check Ring
Smear Screw Tip ✗ Not recommended for GEON Fiberloc glass composites	 Smear Tip
Ball Check Screw Tip ✗ Not recommended for GEON Fiberloc glass composites	

[4]Colmonoy® is a registered trademark of Wall Colmonoy Corporation.
[5]Stellite® is a registered trademark of Kennametal Stellite.

Screw Tip Metallurgy—The free-flow sliding check ring is one of the more important items requiring stainless steel construction. The screw tip constantly experiences shear so using stainless steel minimizes the need for resurfacing. While 420SS stainless steel is ideal, other stainless steels such as 17-4 or CPM® S90V® are also good choices.

End Cap

End Cap Design—It is important to prevent stagnant areas in the end cap. The flow channel should be tapered, radiused, and match the screw tip angle. The smaller the included angle of the end cap, the more streamlined the design is and the easier it will be to process any thermoplastic. However, streamlined end caps do require more maintenance to keep a high polish and prevent material from sticking to the end cap surface. An included angle of about 60° (30° each side) is a good compromise to the streamlined designs and requires less maintenance. End cap designs with long straight bores should be avoided because they create higher shear and restrict the material flow.

End Cap Metallurgy—The end cap should be made out of stainless steel, such as 420SS or 17-4. If it is not feasible to purchase a stainless steel end cap, triple chrome-plating should be used to protect the base steel. However, due to the inherent abrasiveness of glass fibers, chrome plating may not be an ideal solution.

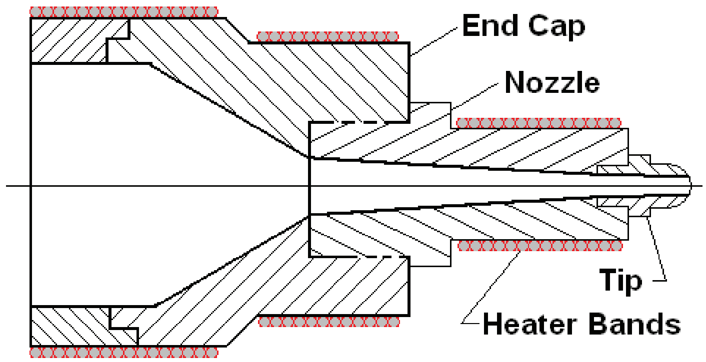
Nozzle

Nozzle Design—A nozzle length of 1 to 6 inches (2.5 to 15.2 cm) is suggested. Longer nozzle lengths may lead to shear burning. The minimum recommended exit diameter of the nozzle is 0.25 inch (0.64 cm)—for a 6 to 8 oz shot. As the shot size is increased, the nozzle exit diameter should also be increased. Nozzles with a full internal taper are preferred, although straight-bore nozzles are acceptable with shorter lengths. The nozzle tip diameter should be up to 0.04 in (1 mm) smaller than the rear-opening diameter of the mold sprue bushing so that a complete seal is formed and no flash occurs.

Nozzle Metallurgy—Longer, more restrictive nozzles are more likely to result in shear burning. Because degradation accompanies shear burning, constructing the nozzles with stainless steel is an important preventative measure. For molders who do not injection mold vinyl often or have short, non-restrictive nozzles, stainless steel may not be a feasible investment. In such cases, standard tool steel such as 4140 is acceptable. Nozzles made of 4140 must have their internal bores polished and well maintained.

Connecting Nozzle to Barrel—The barrel end cap should taper smoothly from the barrel diameter to the nozzle rear opening as shown in Figure 2. The nozzle length should be as short as possible, and the nozzle should be equipped with a separate heater control. A provision for thermocouple monitoring of the nozzle temperature is necessary. The thermocouple should not project into the melt stream. Proportional, solid-state temperature controllers are also strongly recommended. Depending on temperature requirements, a silicon controlled rectifier (SCR) or triacthyristor circuit may be used. However, a variable transformer or an on/off relay control are not as effective for maintaining the processing control desired for rigid vinyl.

Figure 2—Properly Connected End Cap, Nozzle, and Screw Tip



PROCESSING

Key Considerations

Developing Optimal Properties—To develop optimal physical properties of GEON Fiberloc glass composites, the material should be processed at the maximum feasible melt temperature without degrading. It should be injected at a moderate speed, packed with the minimum pressure required to fill out the mold details, and allowed to relax sufficiently during the cooling stage.

Regrind—As with all polymer glass composites, putting reground parts and runner systems made with GEON Fiberloc glass composites back into the molding process for prime finished parts is not recommended. Glass fibers can be broken down to the point where physical properties are significantly affected.

Melt Temperature—The ideal melt temperature range for GEON Fiberloc glass composites is 390°F to 405°F (199°C to 207°C). The most efficient method to determine an accurate melt temperature is to pull the injection unit away from the mold and take an "air shot". The air shot should be measured using a calibrated needle probe pyrometer using the 30-30-30 method. The 30-30-30 method consists of the following:

> **The first 30**—Allow the machine to stabilize for 30 shots or run parts for 30 minutes. This will allow the melt pool to stabilize at the production melt temperature.
>
> **The second 30**—Preheat the pyrometer needle to within 30°F of desired melt temperature. This eliminates the thermal shock of inserting a cold needle into a hot melt producing a frozen layer of plastic which insulates the probe.
>
> **The third 30**—Insert the pyrometer probe into the center of the purge for 30 seconds and obtain your reading.

Neutralize the Mold—Using neutralizer spray on the mold cavity surfaces is inexpensive and the best defense against tool corrosion. For best overall tool life, neutralize the mold cavity surfaces once per 24-hour day. Any tool, regardless of metallurgy, must be neutralized at least once a week. To properly apply neutralizer, spray all mold surfaces and runner blocks, with particular attention to the sprue bushing and other hard to reach spots.

The neutralizer spray must have a low moisture content to effectively work with vinyl. It is also important that the neutralizer be strong enough to effectively neutralize hydrochloric acid residue left after molding vinyl. Neutralizer also acts to protect the mold from corrosion caused by fingerprint acids and other damaging chemicals from the injection molding environment. Table 4 lists recommended neutralizer sprays and their suggested use.

Table 4—Recommended Neutralizer Sprays

Spray	Supplier Information	Comments
PPE®[6] Step One Cleaner Acid Neutralizer and Dehydrator	Plastic Process Equipment, Inc. 8303 Corporate Park Drive Macedonia, OH 44056 www.ppe.com Toll Free: +1 800 321 0562 Telephone: +1 216 367 7000 e-Mail: sales@ppe.com	Recommended as a neutralizer during production and as the first step neutralizer for mold storage or short term shutdown
PPE® Step Two Rust Preventative	Plastic Process Equipment, Inc. 8303 Corporate Park Drive Macedonia, OH 44056 www.ppe.com Toll Free: +1 800 321 0562 Telephone: +1 216 367 7000 e-Mail: sales@ppe.com	Recommended as the second step rust preventative for mold storage or short term shutdown
Slide®[7] Acid Vapor Neutralizer Rust Preventative and Inhibitor	Slide Products, Inc. PO Box 156 430 S Wheeling Road Wheeling, IL 60090 slideproducts.com Toll Free: +1 800 323 6433 Telephone: +1 847 541 7220 e-Mail: info@slideproducts.com	Recommended as a one-step neutralizer/rust preventative for mold storage or short term shutdown

Recommended Purge Materials—The selection of a purge material depends on the effectiveness of the material in the changeover or cleanout and the cost of the material. Some purges may have a lower cost per pound but will require significantly more material to produce a clean changeover or cleanout. Table 5 shows a list of purge materials found to be effective with rigid vinyl formulations for cleanout during production or for shutdown after production.

[6]PPE® is a registered trademark of Plastic Process Equipment, Inc.
[7]Slide® is a registered trademark of Slide Products, Inc.

Table 5—Recommended Purge Materials		
Purge	**Supplier Information**	**Comments**
Dyna-Purge®[8]	Shuman Plastics, Inc. 35 Neoga Street Depew, NY 14043 www.dynapurge.com Toll Free: +1 866 607 8743 Telephone: +1 716 685 2121 e-Mail: info@dynapurge.com	Recommended for machine shutdown—Dyna-Purge K, M, and V work well for cold runner systems, especially to purge out the injection unit for shutdown. The machine is started back up with Dyna-Purge, which remains in the barrel during the down time. Recommended for hot runners and sprues—Dyna-Purge K or M work well with hot runner and hot sprue bushing molds. They can be run through the hot runner system or hot sprue bushing to clean out rigid vinyl during production cleanout or for machine shutdown.
ABS, Polystyrene, or Acrylic (regrind)	Various	Recommended for cleanout during production or for machine shutdown—If it is not feasible to use a commercial purge material, virgin ABS and polystyrene or acrylic regrind can be effective purge materials for rigid vinyl during production cleanout or machine shutdown. Use only general purpose natural grades which are free from colorants and flame retardant additives, ideally with a recommended melt temperature similar to that of vinyl.

Hot Runner Systems—As with all polymer glass composites, injection molding GEON Fiberloc glass composites through a hot runner system is not recommended.

Prior to Molding

Prepare the Mold

- ✔ Clean both mold halves thoroughly using a good recommended cleaner.
- ✔ Make sure all vents are thoroughly cleaned and free of any pre-applied rust preventative, dirt or other material build-up.
- ✔ Address all water leaks and check for adequate water flow through the tooling.
- ✔ Clean and polish sprue bushing. Check for rough spots.
- ✔ Check nozzle and sprue orifice for proper match and size.
- ✔ Review your process set up sheet for proper mold temperature settings. If none exists, refer to this manual or contact GEON and ask for GEON Performance Materials Technical Service.

[8]Dyna-Purge® is a registered trademark of Shuman Plastics, Inc.

Prepare the Molding Machine

- ✔ Set barrel temperature controllers to desired or recommended temperatures.
- ✔ Reduce injection pressures, back pressures, and screw RPM to the lower end of their operating ranges.

Prepare the Material

Drying—Drying is not usually necessary for rigid vinyl. However, surface moisture can form on the pellet, especially in hot, humid summer months or in tropical locations. To reduce the need for drying, store material covered in a cool dry location. When drying is necessary, it should be done at 120°F–150°F (49°C–66°C) for approximately two hours.

Starting Equipment Settings

Heater Band Temperatures—Table 6 represents typical starting heater ban settings for molding rigid vinyl. On most molding machines designed for engineering thermoplastics, these starting parameters will result in a melt temperature close to the recommended range of 390°F to 405°F (199°C to 207°C). The melt temperature should be measured using the previously mentioned 30-30-30 method.

The heater band settings in Table 6 represent an ascending temperature profile which is most commonly used. Sometimes a reverse or descending temperature profile is useful. It melts the pellets soon after they are fed to the screw, resulting in reduced abrasion, more efficient pumping of the melt forward, and reduced pinking or black streaks.

Table 6—Starting Heater Band Settings

Machine Size	Screw Diameter	Rear Zone (feed)	Middle Zone (compression)	Front Zone (metering)	Nozzle
75 to 150 ton (68 to 136 MT)	1–2 in 25–50 mm	370°F (188°C)	370°F (188°C)	370°F (188°C)	370°F (188°C)
175 to 350 ton (159 to 318 MT)	2–3 in 50–75 mm	340°F (171°C)	350°F (177°C)	350°F (177°C)	360°F (182°C)
375 to 500 ton (340 to 454 MT)	3–4 in 75–100 mm	340°F (171°C)	345°F (174°C)	345°F (174°C)	360°F (182°C)
550 to 1,000 ton (499 to 907 MT)	4–6 in 100–150 mm	340°F (171°C)	345°F (174°C)	345°F (174°C)	350°F (177°C)
1,100 to 2,500 ton (998 to 2268 MT)	>6 in >150 mm	320°F (160°C)	320°F (160°C)	320°F (160°C)	350°F (177°C)

Screw RPMs and Back Pressure—Screw RPMs and back pressure work together to put work into the melt and greatly affect melt temperature. Table 7 shows the recommended starting screw RPM settings for a range of machine sizes. Screw RPMs and back pressure settings will depend on the screw compression ratio and screw configuration. More severe screw designs will require lower screw RPM and back pressure settings. Back pressure settings should start between 75 and 150 psi (5.2 and 10.3 Bar). Sufficient back pressure on the screw is needed to squeeze air bubbles out of the melt and provide a more consistent melt temperature, both of which lead to good shot-to-shot consistency.

Table 7—Starting Screw RPM Settings

Machine Size	Screw Diameter	RPMs Recommended
75 to 150 ton (68 to 136 MT)	1–2 in 25–50 mm	50 to 75
175 to 350 ton (159 to 318 MT)	2–3 in 50–75 mm	50 to 75
375 to 500 ton (340 to 454 MT)	3–4 in 75–100 mm	30 to 50
550 to 1,000 ton (499 to 907 MT)	4–6 in 100–150 mm	20 to 30
1,100 to 2,500 ton (998 to 2268 MT)	>6 in >150 mm	10 to 15

Injection Velocity—The injection speed is dependent on the nozzle and sprue bushing diameters as well as the gate size and wall thickness. Moderate speed settings of 0.75 to 1.0 inch/sec (1.9 to 2.5 cm/sec) are reasonable to start. If shear burning is present in the part, reduce the injection speed. If no shear burning is present in the part and the part is not completely filled, increase the injection speed until shear burning is observed and then reduce injection speed in small increments until no shear burning is present. On molding machines with variable injection speed, it is sometimes helpful to use lower injection speeds until the material has filled the runner, gates, and initial regions of the part.

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 melt temperature, injection speed, mold temperature and mold design. Generally, pressures in the range of 50% to 70% 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 the screw completes its relatively fast forward travel leaving a 0.125 to 0.25 inch (0.32 to 0.64 cm) cushion. 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 cross sections usually require greater holding pressure. Over-packing the part with excessive holding pressure or time on the second stage injection pressure increases molded-in stress that can be detrimental to physical properties. Generally, sink marks away from the gate indicate that more injection pressure or time is needed while sink marks near the gate indicate that more hold pressure or time is needed. Once it is apparent that gates are frozen off, hold pressure should 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.

Mold Temperature—Accurate mold temperature control is essential for optimizing cycle time and finished part quality. Rigid vinyl formulations are usually run with mold heater-coolers between 40-120°F (4°C-49°C). Higher mold temperatures usually give improved surface appearance, better material flow, improved weld line integrity and lower part stress. Cooler mold temperatures give shorter cycle times. High pumping rates of the temperature control medium with minimal line and coupler restrictions will improve temperature control in the tool and optimize the combination of part quality and cycle time. Running the “B” half of the mold cooler than the “A” half usually facilitates easier part ejection and removal.

Start Up Procedure

1. IMPORTANT DETAIL: Purge the barrel with natural general purpose ABS, styrene, acrylic (regrind), or approved purge material (see Recommended Purge Materials) prior to introducing vinyl to the injection unit. Use of polyethylene or polypropylene is not recommended because they are immiscible with vinyl and will result in delamination of finished parts.
2. Injection and back pressures should be checked and set during purging or after start of molding cycle.
3. After barrel temperature settings have stabilized, introduce the vinyl into the machine.
4. Take air shot melt temperatures and check using a hand held pyrometer and needle probe. If melt temperature is in the range of 380°F to 395°F (193°C to 202°C), proceed. If not, adjust heater band settings, screw RPM or back pressure to reach proper melt temperature. Recheck melt temperature after machine stabilizes in a production mode and maintain 390°F to 405°F (199°C to 207°C) melt.
5. Observe molten vinyl appearance during the air shots. A smooth glossy surface is indicative of a good homogenous melt temperature. A smoking or frothy melt suggests melt temperature may be too high. Porous or steaming melt may indicate moisture.
6. Lightly, spray mold release into the core, cavity and sprue bushing, and commence molding vinyl into the mold.
7. Start molding parts in the semi-automatic operation mode.
8. Check and adjust injection pressures. Use medium range to start.
9. Check and adjust injection velocities. Slow to moderate to start. Adjust up or down as needed.
10. Adjust pressures and times to make acceptable parts.
11. Adjust screw RPM and back pressure to obtain optimum melt temperature.
12. Check heater zones for override and correct settings.
13. Mold temperatures should be checked with a hand pyrometer and surface probe.
14. If a sprue should hang up in the sprue bushing, never try to shoot through the hung up sprue to remove it. This may cause extensive shear heating leading to degradation of the vinyl.

Process Upsets

Expected Cycle Interruptions—Rigid vinyl is susceptible to thermal degradation upon prolonged exposure to processing temperatures without moving through the barrel, runners, etc. Therefore, if an interruption in the molding cycle is expected to last longer than 15 minutes, the injection unit should be pulled back from the mold and the rigid vinyl should be processed through the barrel by making occasional air shots. If the delay is lengthy, the vinyl should be completely purged from the barrel with natural general purpose ABS, styrene, acrylic (regrind), or recommended purge material (see Recommended Purge Materials).

Unexpected Cycle Interruptions—In the event a power failure occurs during the molding operation and the vinyl cools and solidifies in the barrel, the following procedures should be used.

1. Shut off heaters to barrel and nozzle.
2. Cool barrel with fans if emergency power is available.
3. Restart injection molding press when power is restored.
4. Set barrel and nozzle heater band temperatures to 250°F (121°C) for one hour.
5. Increase barrel and nozzle heater band temperatures 25°F (14°C) every 30 minutes until reaching 350°F (177°C).
6. When the barrel heater band temperatures approach 350°F (177°C), start jogging the screw until full rotation starts and then purge barrel with purge material.

Once the barrel is fully purged, the rigid vinyl being used can be reintroduced into the barrel and production resumed.

Degradation During Molding—If you experience slight degradation of vinyl from the barrel during molding (color shift and odor change), use the following procedure to eliminate the degradation.

1. Continue vinyl molding operation.
2. Recheck all nozzle and barrel temperatures controllers to make sure they are within recommended guidelines and operating properly.
3. Recheck screw RPM and injection speed to make sure they are within recommended guidelines and operating properly.
4. Resolve these or other issues that can lead to higher than recommended melt temperatures or long residence times.
5. Resume normal operations.

If you experience severe degradation of vinyl from the barrel during molding (significantly discolored material and strong, pungent odor of HCl), use the following procedure to eliminate the degradation.

1. Protect eyes, nose, and throat from hot release of vapors from degraded material. Wear a National Institute for Occupational Safety and Health (NIOSH) approved air-purifying, full-facepiece respirator with a chin-style, front- or back-mounted canister providing protection against the compound of concern.
2. Retract the injection unit from the mold.

3. Evacuate the air around the injection molding machine.
4. Remove rigid vinyl from hopper.
5. Put purge material such as general purpose ABS, PS, or acrylic into hopper.
6. Completely purge barrel of rigid vinyl as rapidly as possible into small portions of melt (less than 1.5 lb/0.7 kg).
7. Place degraded melt into bucket of water and eliminate employee exposure.
8. Resolve issues with errant heater zone settings, defective controllers, or other issue that can lead to higher than recommended melt temperatures or long residence times.
9. Purge barrel with a small amount of rigid vinyl to ensure the machine is operating properly.
10. Consult site Environmental Health & Safety function prior to resuming normal operations.

Shutdown Procedure

When the molding of GEON Fiberloc glass composites has completed, the injection molding machine should not be shut down with material in the barrel as it is susceptible to thermal degradation upon prolonged exposure to processing temperatures without moving through the barrel. The injection unit should be pulled back from the mold and the vinyl must be purged from the barrel with natural general purpose ABS, styrene, acrylic (regrind), or recommended purge material (see Recommended Purge Materials). Polyethylene or polypropylene are immiscible with GEON Fiberloc glass composites and should not be used as a purge material. Flame retardant materials should also not be used since they are susceptible to the same degradation characteristics.

If GEON Fiberloc glass composites are inadvertently 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 natural general purpose ABS, polystyrene, acrylic (regrind), or recommended purge material (see Recommended Purge Materials) at the current temperature. If this method does not work, remove the screw from the barrel and clean mechanically.

1. Maintain production settings for barrel and nozzle heater bands, screw RPM, and injection velocity.
2. Retract injection unit away from mold, leaving ample room for purge to exit nozzle.
3. Empty and thoroughly clean the hopper of any vinyl.
4. Empty the barrel of rigid vinyl by bringing the screw completely forward and running the extruder in the forward position until barrel is empty. Use high back pressure to maintain forward position. Approximately 500 psi (34 Bar) of back pressure will be needed depending on equipment type.
5. Feed purge material into the barrel and run extruder until the rigid vinyl is flushed from the barrel.
6. Lower back pressure and manually make air shots at 25% of injection capacity to ensure barrel is clean and free of vinyl.
7. Empty the barrel of purge material by bringing the screw completely forward and running the extruder in the forward position until barrel is empty.

8. The molding machine can now be safely shut down or used to mold another polymer except acetal. (If acetal will be processed in the same machine as vinyl, the injection unit must be disassembled and completely cleaned mechanically).

TROUBLESHOOTING

Sink marks	Part is not completely filled
• Not enough material injected in to the cavity • Injection pressure too low • Packing and hold pressures are too low • Packing and hold times are too short • Cooling time is too short • Reduce ratio of rib to wall thickness in part design	• Not enough material injected in to the cavity • Injection pressure is not high enough to overcome resistance in thin areas • Injection speed is too slow • Melt temperature is too low • Air is trapped in the mold • Part wall is too thin and material solidifies before filling the mold cavity
Poor knit lines	**Gate blush marks**
• Melt temperature is too low • Mold temperature is too low • Injection speed is too slow • Poor venting in mold • Packing and hold pressures are too low • Adjust gate locations on part • Nominal wall thickness too thin	• Melt temperature is too low • Mold temperature is too low • Injection speed is too fast • Moisture in material • Hot spot in mold • Poor venting in mold • Sprue and gate diameters are too small • Insufficient cold slug well • Nominal wall thickness too thin
Silver streaks or splay	**Delamination**
• Melt temperature is too high • Injection speed is too high • Contamination in melt • Poor venting in mold • Gate diameter is too small • Nozzle and barrel temperatures too high	• Melt temperature is too low • Mold temperature is too low • Injection speed is too fast • Contamination with purge material • Gate diameter is too small

If these suggestions do not resolve your problem, contact your GEON Technical Service Representative or contact GEON and ask for a GEON Performance Materials Technical Service Representative.

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