GEON™ RIGID VINYL
PROFILES

EXTRUSION GUIDE

PolyOne™

CONTENTS

INTRODUCTION

For a variety of reasons, polyvinyl chloride (PVC) is often the material of choice for profiles. PVC generally has excellent chemical resistance, low susceptibility to stress cracking, and good toughness. In addition, compounds can be designed for excellent weatherability, transparency, higher heat resistance, increased stiffness, etc. From a processing viewpoint, PVC is relatively easy to extrude, with good dimensional and shape control.

Geon™ PVC compound as manufactured by PolyOne contains PVC resin and other ingredients which are needed to give useful properties. Thermal stabilizers are used to prevent degradation during normal processing. Lubricants are used to give metal release properties and to avoid stagnation which could cause thermal degradation. Impact modifiers are added for toughness; pigments for color. Extrusion grades of Geon rigid PVC are available in cube, pellet, and dry-blend (powder) form.

Extrusion of PVC into profiles is accomplished by shearing and heating the cubes or pellets until they are soft and deformable, then forcing them through a die of appropriate size and shape. Shallow screws and high screw RPMs tend to cause a relatively higher proportion of shear heating.

This guide is intended to assist the reader in successfully extruding PVC profiles on single screw extruders. Consult other bulletins or contact PolyOne sales or technical service personnel for recommended formulations designed for your specific requirements.

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EQUIPMENT & PROCESSING

EXTRUSION EQUIPMENT

A typical extrusion line consists of an extruder, tooling, sizing and cooling equipment, take off (puller) and a method of cutting the profile. Requirements for each element of the extrusion line will be reviewed in more detail.

EXTRUDER REQUIREMENTS

The extruder should be a 24/1 L/D when extruding cubes/pellets. Longer barrels, such as a 32/1 LD with a vented barrel, may be needed for extruding dry-blend compounds, although it must be noted this is not a common practice. Please consult PolyOne technical service personnel for recommended compounds designed for your specific requirements.

Barrel materials should offer a superior chemical and wear resistance such as nickel-rich iron-boron alloys. A breaking-in period on new barrels is often required. PVC degradation at the metal surface (sometimes called “pinking”, even though it is gray) often will occur for up to a few days on a new barrel. This degradation reaction is usually reduced or eliminated by using low barrel temperatures and compensated for by using a high RPM. Occasionally, high barrel temperatures, which change the flux point on the screw, can help eliminate this degradation at the metal surface.

The thermal stability of PVC is a complex function of time and temperature. Melt temperatures of at least 188-193°C (370-380°F) are needed to develop the excellent physical properties of typical PVC sheet extrusion compounds. At these temperatures, and with properly chromed and streamlined equipment, long run lengths can be achieved. If increased rates and melt uniformity outweigh run length requirements, then melt temperatures of 202-210°C (395-410°F) are necessary. At these temperatures, run lengths vary from one day to one week. Higher processing temperatures are possible, but again, these result in earlier degradation and shorter run lengths.

Drive motors should have adequate horsepower and be geared for high torques at relatively low RPMs, 35 max.

2 1/2″ or 50 mm – 40 HP
3 1/2″ or 90 mm – 75 HP
4 1/2″ or 110 mm – 100 HP

Barrel cooling should occur either by circulating oil or high capacity air blowers. Thermocouples should be deeply set in the barrel. A pressure gauge should be located at the end of the barrel. Oil cooling or high capacity air blowers with finned heaters are preferred on the barrel with a deep thermocouple control system. A pressure gauge should be located at the end of the barrel.

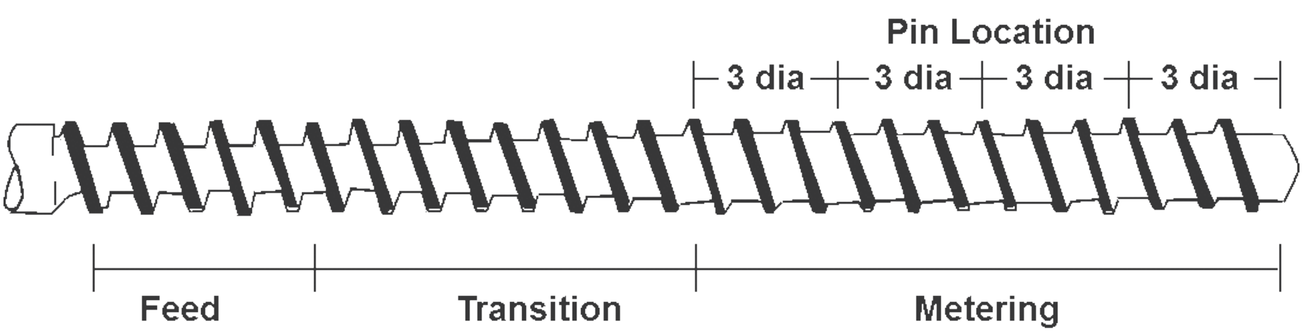
Drying the cubes or pellets is normally not required for profiles. However, some specialty compounds require drying for 2 hours at 160°F. Consult technical data sheets for specific requirements.

GENERAL PURPOSE SCREW DESIGN – SINGLE SCREW

The screw should be single flighted, constant pitch, with the pitch equal to the diameter and the length equal to 24 diameters. It should be bored for potential cooling. Screw flights should be flame hardened or capped with Colmonoy 56 and the entire screw should be hard chrome plated. The following designs will produce good results under a variety of conditions. It should be noted that other designs, like barrier mixing screws, are effective as well.

Screw Diameter inches/mm	Flights			Pounds/ Hour
	Feed	Transition	Metering	
2-1/2 / 63	5 @ 0.500″	7	12 @ 0.210″ 4 rows of pins	50–80
3-1/2 / 89	5 @ 0.625″	7	12 @ 0.260″ 4 rows of pins	80–300
4-1/2 / 114	5 @ 0.770″	7	12 @ 0.320″ 4 rows of pins	150–500

*Typical pin placement - on a 3-1/2” screw for each row, use 27 pins made of 316 SS 5/32” diameter on a 36 hole index for each row. Press fit into 1/4” deep holes and a grind to screw diameter. Do NOT interrupt the screw flight. Place four rows of pins at 3, 6, 9, and 12 flights from the screw tip. Use 1/8” diameter pins on a 30-hole index on a 2-1/2” extruder and 5-32” diameter pins on a 43-hole index for a 4-1/2” extruders. Again, do not interrupt the screw flights.



CUBE EXTRUSION – TWIN SCREW

Special low shear screws are available for cube extrusion on twin screw extruders. This allows extrusions at lower temperature, where simple finger sizing can handle the melts.

DRY-BLEND (POWDER) EXTRUSION - SINGLE SCREW

Extruding dry-blend PVC compounds on a single screw is typically not recommended because the physical properties needed for most profile applications will not be fully developed, especially in larger profiles. If attempting to extrude small scale profiles, an extruder with a longer barrel (32:1 L/D) with a vented barrel should be used for optimal results. Consult PolyOne technical personnel for specially designed compounds for these applications.

BREAKER PLATES AND SCREENS

Breaker plates are required to prevent the melt from twisting in the die, thus avoiding swirls in the product. Screen packs are also recommended. They may be used to increase the pressure and temperature, thereby achieving better toughness; or they may be used to filter the melt stream. Screen packs should be stainless steel. If multiple screens are used, always put the coarser screens downstream to back up the finer screens. A 20/40 mesh combination screen pack should be sufficient. The cross-over design may be used if "pinking" is a problem. Use a breaker plate made of 440c stainless steel, hardened and polished. Avoid carbon steel, aluminum or brass which can lead to degradation of the PVC. Entrance and exit should be chamfered to avoid stagnation.

DIES FOR RIGID PVC

Flat plate dies are adequate for short runs of about 6 hours at low melt temperatures. However, for longer run lengths, all sections of the die and adaptor should be streamlined to prevent stagnation and degradation. Transitions in the adaptor should be smooth with approach angles of about 30° or less. Die materials must be chosen for corrosion resistance and durability. It is common to use softer metals that can be machined easily but which can be subsequently hardened after machining for durability. Good die materials would be 316 SS, 17-4PH SS, or 420 SS. Aluminum, brass, and copper dies are not recommended since they are reactive with PVC. (Refer to the Technical Service Report #9 for additional information.)

COOLING AND SIZING

Profile cooling and sizing can be accomplished by using a combination of vacuum sizers, finger sizers, air cooling, water immersion or water spray. Profiles must be pulled down the line using a constant speed puller. The profiles must be cut to the desired length using a sharp saw, fly knife or guillotine cutter prior to packaging.

REGRIND

Extruded rigid Geon PVC can be ground and blended back in with the virgin material at a 10-30% ratio. Larger amounts of regrind may be added if an acceptable surface is still attainable. It may be necessary to increase the extruder barrel temperatures by up to 10°F to compensate for the higher work level of the regrind.

TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	SOLUTION
Orange peel Alligator skin	Too much fusion	Reduce melt temperature
Small chunk	Too little fusion Poor regrind quality	Increase screw RPM Use tighter screen pack Check for proper screw/barrel fit Use correct regrind Use sharp blades in grinder Cool regrind properly Check for contamination Run 10°F hotter than virgin
Sandpaper finish	Sticking in die	Reduce die temperature Reduce melt temperature Chrome die land Polish die
Swirls	Melt flow problem	Use breaker plate Use pins on screw Reduce barrel temperature Reduce rate Increase inventory behind die land Check for proper screw/barrel fit
Colored streaks	Degradation Sizer wear Color concentrate not dispersing Degradation in center of profile	Break in new barrel or screw Reduce barrel temperature Increase barrel temperature Use inverted breaker plate Use anodized aluminum or SS Use correct screw design Check compatibility of color concentrate Use screw cooling Use offset screw tip Allow 1/2″ clearance between screw tip & breaker plate

PROBLEM	POSSIBLE CAUSE	SOLUTION
Dull surface	Low temperature	Increase melt temperature Low temperature Increase melt temperature Increase screw RPM Polish die Check compound selection
Bubbles	Moisture Trapped air Degradation	Dry the cubes/pellets Decrease rear zone temperature Reduce melt temperature Check die and barrel set points for override
Die lines	Nicked die approach Plate out	Polish die Use brass tools to avoid die damage Polish adapter Run colder
Edge tear	Uneven velocity across profile Contamination	Increase die temperature Increase RPM Increase melt temperature Radius inside corners of die Avoid blowing air on die Use finer screens Eliminate, stop using regrind
Build up in die (plate out)	Compound ingredient sticking to die metal	Reduce head psi Reduce die land length Chrome plate adapter Polish adapter Check compound selection

TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	SOLUTION
High head PSI	Long die land Using restrictor High melt viscosity Improper breaker plate or screens Excessive adapter length Oversize extruder for profile	Reduce die and length Eliminate restrictor Increase melt temperature Check temperature controls Use lower viscosity compound Use course screens Use larger hold breaker plate Use smaller extruder
High drive motor amps	Cold melt Plugged screen Incorrect gear box ratio Motor too small	Increase die temperature Increase melt temperature Slowly increase RPM Coarser screens Contact manufacturer
Lip bleed	Compound ingredients exuding	Radius exits of die land Reduce head pressure Reduce melt temperature Use finer screens
Brittleness	Poor fusion Excessive draw down	Increase screw RPM Increase melt temperature Use finer screens Re-cut die
Inconstant die flow	Uneven die temperatures Thermocouple placement Set-up	Check heater bands & controllers for proper operation Eliminate drafts across die Locate thermocouple closer to die opening and be sure it is well seated Confirm set up is the same as last good run Purge barrel

PROBLEM	POSSIBLE CAUSE	SOLUTION
Profile warping	Non-uniform profile cooling Insufficient profile cooling On one side of profile retaining heat Equipment misalignment	Adjust cooling Increase cooling capacity, reduce rate Improve cooling, heat the cooler side Line up extruder, cooling, puller, etc
Dimensional control	Surging Temperature variation	Verify constant puller speed Is profile slipping in puller? Reduce vacuum Verify constant screw RPM Maintain constant hopper level Use feed throat cooling Check for tailings in compound or large regrind Increase screw cooling Check for screw/barrel wear Use correct screw Reduce feed zone temp Check and tune temperature controllers Eliminate drafts on die Check thermocouple seating
Excessive thermal shrinkage	High residual stress	Reduce draw down, reduce cooling rate

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