

## Mixing Rigid PVC

With the use of the proper equipment and procedures, rigid PVC can be mixed to accommodate a variety of application needs. In most instances, PVC powder compound is directly extruded into an end product. A major consideration should be extrusion/molding equipment suited for PVC powder compound.

Use of powder compounds requires different screw and die design, downstream sizing and extrusion or molding techniques. Extensive trial runs with powder compounds are recommended to help prevent additional expenses and problems in processing.

### Handling

The manufacturer will need two silos of 200,000 lbs. capacity, one silo for PVC resin and one for the powder compound. A bulk conveying system from bulk railcars to the silo, mixer, compound silo and extruder will be needed. If pellets are made for injection molding, they will have to be made in the bulk handling system. Below is a list of additional needed equipment.

- Mixer dust collector
- Liquid stabilizer tank / scale
- Resin scale

### Weighing Equipment

In the past, processors have weighed non-PVC ingredients by hand.

Automatic weighing scales are increasingly being used to eliminate inconsistencies, minimize random weighing errors and reduce required manpower. In addition, if total weight is above or below recipe weight, the automatic weighing equipment will shut down, allowing the mixing personnel time to find the problem. The following equipment is needed:

- Six load cells and associated equipment
- Conveying system for minor ingredients
- Platform for six load cells
- Dust collectors and venting

### Mixer and Cooler

The mixer and cooler is the heart of the mixing system. This includes control panels for the mixer/cooler, the silos and conveying systems. After cooling, the compound should be screened to remove mixer bland flakes (10 mesh for pipe, 30 mesh for siding). If they are not removed the flakes of material will hang up in the die.

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## Mixing Procedures

With changing economic conditions and technological advances, mixing procedures have evolved. The following procedure was among the earliest in the industry:

### *Procedure A*

1. Start high- intensity mixer at low speed and add resin.
2. Shift to high speed and add stabilizer.
3. Mix until temperature reaches 60°C(140°F).
4. At 60°C(140°F)., add titanium dioxide color pigments, processing aids, fillers.
5. Mix until temperature reaches 71°C(160°F).
6. At 71°C(160°F), add lubricants.
7. Mix until temperature reaches 88°C(190°F), then drop into cooler.
8. Cool at 43°C(110°F).

After extensive experimentation, the following procedures were developed. Procedure B eliminates the temperature addition of non-PVC ingredients, simplifying the mixing process and resulting in a more consistent mix.

### *Procedure B*

1. Start high-intensity mixer at low speed and add resin.
2. Shift to high speed and add stabilizer.
3. Add all dry ingredients.
4. Mix until temperature reaches 88°C(190°F), then drop into cooler.
5. Cool at 43°C(110°F).

Procedure C was developed to produce large quantities in a mixer with a minimal increase in cycle time. This procedure increases mixer capacity by 150 to 175%. This is called a one-to-one dilution or double batching. A mix at this level of dilution extrudes very well, but mixes above 1.2-to-1 dilution levels develop consistency problems.

### *Procedure C (double batching)*

1. Start high-intensity mixer at low speed and add half the resin.
2. Shift to high speed and add stabilizer.
3. Add twice dry ingredients.
4. Mix until temperature reaches 88°C(190°F), then drop into cooler.
5. Add second half of resin to cooler.
6. Cool at 43°C(110°F) or below.

To prevent metal graying of siding powder compound, the titanium dioxide should be held out until 5-6°C(10°F) before dropping from the mixer.

Both Procedures B and C have proven to be very successful. Procedure C allows for increased mixer productivity with minimal increase in cycle time. Procedures B and C have been followed for siding, pipe and cellular vinyl with very few differences on the extruder. Because they are less complicated, Procedures B and C are recommended.

## **Problems**

Three common problems encountered in mixing rigid PVC are high mixer amps, no vortex and fluffy powder.

High mixer amps are usually caused by overloading the mixer with resin or other ingredients. This problem can be corrected by changing the batch size.

High batch size can also prevent a vortex from forming. This poor mixing can cause the extruder to vary in amps and affects impact resistance of the end products. Achieving a deep vortex will correct these problems.

When mixer blades are worn, the cycle time of the mix increases. Mixing is still correct, but mixing costs will be high and capacities are reduced.

The problem of fluffy powder compound is frequently caused by static which the compound may have acquired from the resin during conveyance from the bulkcar, in the mixer or the silo. The powder may look wet and "snowballs" can be formed. When exposed to steam, the powder will change from "flour" to "sugar" in texture.

Static retention of resin or compound is dependent upon the amount of moisture present. Consequently, it is more of a problem in the winter when relative humidity is low.

Adding water to the mixer (8 to 30 oz. per 600 lb. batch) can reduce static in suspension resin/compound. The water is added right after the stabilizer addition and mixed as previously stated. Part of the water vaporizes to steam, reducing static during mixing. The remaining water helps to dissipate any static after mixing. Over-dried resin or mixing to a high drop temperature tends to make the static problem worse. (This method will not reduce static on mass resins.)

Also, static can be controlled by heat loss of the resin, keeping the resin coarse (12% through 140 mesh screen), making resin particles spherical, or conveying with humidified air. The finer and more popcorn-like resins have higher potential for static. The manufacturing process or systems used can also affect resin static retention. Some OxyVinyls suspension resins have antistatic properties.

However, mixing over 77°C(170°F) can destroy the antistatic properties of suspension resins. To retain these properties while still achieving good mixing, Procedure D should be followed.

### *Procedure D*

1. Start high-intensity mixer at low speed and add half the resin.
2. Shift to high speed and add twice the stabilizer.
3. Add twice the dry ingredients.
4. Mix until temperature reaches 88°C(190°F), then drop into cooler
5. Cool to below 77°C(170°F) and add second half of resin to cooler.
6. Cool at 43°C(110°F) or below before transfer or packing.

By following this procedure, the antistatic properties of half the resin are destroyed, while the other half retains enough of these properties to prevent static problems.

## Pelletizing PVC Powder

Some molders elect to pelletize the compound instead of running powder. This method generally yields better results than molding from powder, minimizes housekeeping and eliminates the capital expenditure for retooling the molding screws for cube to powder design. If this option is taken, the following equipment and costs must be added:

- Multiscrew extruder
- Pelletizing head
- Bulk handling equipment
- Installation cost
- Dust collector

## Testing Equipment

After mixing and before the compound is stored, several quality control tests are necessary.

## Testing Compounds

Three characteristics of each compound are frequently tested - density of compound, flow of compound and fluxing rate.

Bulk density and flow time are tested according to ASTM D 1895. These tests measure the amount of material that is picked up on the screw and how well it flows into the screw. Wide variations will cause problems in the operation of the extruder.

The bench extruder measures both torque and fluxing rate of the compound. If the compound has been miscompounded, a large variation between torque, fluxing point and the shape of the curve will occur. Below is a description of the test for a Brabender. Generally the twin screw bench extruder should be used to test compound used in multiscrew production equipment.

Test	Resin/Compound Equipment	Reason
Apparent bulk density	Graduated cylinder balance	Consistency/ production rates
Flow time	Funnel	Bulk handling/ static
Screen analysis	Sonic sifter	Contamination/ fines
Bench type extruder	Compound 1) Brabender 2) Krauss-Maffei	Recipe accuracy/ runnability

## Brabender Plasticorder Testing Procedure

This procedure is for testing powder compound on a Brabender Plasticorder with a circulating bath and No. 6 roller mixer. Running condition for powder is 175C at 50 RPM on a 60 gram sample.

With mixer running at low speed (23.0 rpm +/- 1.0 rpm on variable speed Plasticorder), center the chart on the 1.5 sensitivity scale.

Allow 10 minutes of chart time for runs. (Start at the zero minute point so the chart will be at zero again after 10 minutes. This will provide a zero reference point for start-up and degradation time determination). This allows time for recovery and adjustment of the chart after clean-up.

At exactly zero minutes on chart, shut off Plasticorder and lift pen from chart. Lift ram all the way open and turn Plasticorder on again. With a stopwatch, time sample loading to three minutes and allow about 30 seconds for pouring sample in with mixer running. Shut off Plasticorder. Work as much of the sample in as possible with the ram, and brush the powder that has spilled around the top of the mixer down into the slot. If necessary, turn the mixer on and off very quickly to discharge all of the sample into the slot. Close the ram, engage the chart clock plug, replace the pen on the chart and turn on the Plasticorder at the end of the three minute loading time allowed.

As the material begins to grab and work up to the fusion point, the torque required to overcome this will quickly reach the limit of the chart so that loading of the lever-arm will become necessary. When the chart indicates a reading of 1000 (meaning 5000 because of being in the X5 position —  $1000 \times 5 + 5000$ ), pull out the kilo bar to the No. 1 position. If the reading again reaches 1000 (meaning  $6000 - 100 \times 6$ ) pull the weight to the No. 2 position, etc.

For some rigid vinyl powder compounds, the weight must be pulled out to the No. 4 position. Generally, once determined, the amount of weight will remain the same for any type of powder. This must be determined by trial and error.

After the fusion point (maximum point) has been reached, the torque level will immediately begin to drop off. (In many cases this will occur immediately and the fusion point will be at zero minutes.) It may be necessary to push the weight back to a lower position on the preload arm to swing the recorder pointer back to the middle of the chart.

At exactly five minutes after the fusion point, the variable speed dynamometer will be increased to 50 rpm. Run until a steady state is reached.

Thoroughly clean the rollers inside the mixer. Use tongs to remove material inside the from chamber and brush out the remaining particles with a small paste brush. Clean the rollers with a brass brush, flicking the mixer on and off to expose all surfaces. With rollers running, blow out the equipment with an air hose and turn off.

To determine the time to degradation, the fusion point must be found. The fusion point or maximum torque pint maybe determined by scribing average lines, following the increasing portion of the curve to the peak, and the decreasing portion of the curve from the peak. The fusion point is where the two lines intersect. The degradation point will be an increase tin torque to the break-down point. This is measured ion minutes from the fusion point to the degradation point.