



SOLVING **SEPARATION/SEGREGATION** ISSUES IN PVC COMPOUNDING



YOUR GUIDE TO OVERCOMING PVC COMPOUNDING CHALLENGES

Batching PVC compounds requires accurate and repeatable multi-ingredient blending processes. When PVC compound segregation and separation occurs, it can cause issues at almost any point along the process line — like poor product quality, flow issues and rejected finished parts. This guide is meant to help you know when it is time to evaluate systems, how to identify where separation and segregation occurs through sampling, the latest industry trends and learn what factors in PVC processing contribute to material separation and segregation.



WHEN TO EVALUATE

Increased instances of separation and segregation taking place can be attributed to the industry trend of using finer fillers in greater percentages within a given blend. The addition of more regrind/recycled materials into blends has also been seen to cause segregation. Testing completed in the Horizon Systems Technology Center confirms that the changes in processing and blend makeup are responsible for common separation and segregation issues in facilities.

During the conveying and storage phases, these separation and segregation issues can appear as inconsistent blends when mixing and discharging from blenders, storage silos or receivers above extruders. If your PVC compounding process is experiencing these issues, it's time for an evaluation.



SAMPLING

In order to solve PVC compounding issues, it is critical to determine the process steps where separation and segregation occur. You should take samples for evaluation at each major step in the process to locate the area of occurrence. They must be evaluated directly after mixing – before the compound is handled and after every transfer and storage step between the blender and extruder inlets. Samples can be evaluated through a sieve analysis or lab analysis of chemical and physical properties.

You should also take enough samples over a period of time from the same sampling points to ensure statistically significant and accurate results. Horizon's recommendation is at least 5-10 to determine batch consistency and quality, and 10-20 samples over several hours to determine separation defects from different process transfer points.

Consider the following areas when evaluating where separation and segregation can occur:

- Blending performance
- Changes in ingredients/formulation
- Material handling/storage designs

BLENDING PERFORMANCE

The first thing to verify when searching for the cause of separation is if the starting blend quality is acceptable. Monitor material fill levels in the heat mixer to ensure the proper mixing vortex during sampling. Overfilling a mixer will reduce its blending efficiency. Mixer manufacturers can provide guidelines for proper fill levels and equipment setups to maximize a blender's performance.

Samples need to be taken and evaluated at the cooler discharge before any handling of the compound occurs. Take and analyze multiple samples across a single batch to determine blend quality. Samples should also be compared to other groups of samples in other batches of the same formulation to determine batch-to-batch consistency. If variations in blender process and maintenance occur, evaluate the condition of mixing blades and other elements in the blender, blender fill levels and blender process parameters. If variations in formulation and ingredients occur, determine if there has been a change made to ingredient proportions, changes made to an ingredient or if the functional quality of an ingredient has changed.





INDUSTRY TRENDS ON INGREDIENTS AND FORMULATIONS

Material properties can contribute to separation even after blending, because particle size, shape and density will affect how particles flow from hoppers and behave in freefall or pneumatic conveying. In our experience, changes in formulation related to fillers (calcium carbonate and talc) are most commonly responsible, since it is common for higher filler amounts to be used within blends. If there are any issues related to filler particle size, these issues will be more pronounced as filler percentages increase. Fillers can cause separation due to filler suppliers offering much finer fillers than previously available. In many cases these fillers are 1-2 micron or smaller in size, allowing fillers to be suspended in an air stream more easily.

Particles with large differences in terminal velocity will have a potential to separate when the blend is handled between mixing and processing.

A good gauge for the potential for different components to separate is their terminal velocity profile. Terminal (vertical suspension) velocities below 50-100 ft/min are common when testing fine fillers. Resins commonly have lower end terminal velocities around 150-300 ft/min. The differences in suspension velocities within a blend will contribute to separation, as will be described later in this document.

Regrind and reprocessed material have also been shown to affect blend segregation. More PVC compounding facilities have added regrind materials to keep up with industry trends of “green” or zero waste goals. These materials are added at the blending process instead of at the processing/extrusion point, which can lead to separation when the regrind is not finely pulverized to match the size of other materials.



HANDLING SYSTEMS EFFECT ON BLENDS

The two main processes that PVC compound is exposed between handling and extrusion are pneumatic conveying and storage in silos and hoppers. The following figure 1.1 shows physical properties of some common blend components.

Material	Particle Size Range (Mesh)	Bulk Density (lb/cu ft)	Terminal Velocity (ft/min)
PVC Resin	80 mesh	32-40	200-300
UFT	<300 mesh	45	<50-250
1 micron Talc	<300mesh	67	75-175
Calcium Carbonate	200 mesh	46	100-200
Calcium Carbonate	200 mesh	80	100-200
Calcium Carbonate	80-200 mesh	25	100-300
Calcium Carbonate	100-200 mesh	40	100-200
Regrind	10-60 mesh	48	400-2000
Regrind	6-20 mesh	33	1000-1400
Regrind	10-20 mesh	35	500-750

Figure 1.1



PNEUMATIC CONVEYING, FILTERS AND VELOCITY

Pneumatic conveying of compound exposes materials to velocities within the conveying equipment that can naturally separate the particles within a blend. Larger particles within a blend (resin and larger particle additives) typically have horizontal conveying velocity requirements of 3,600 ft/min to 4,400 ft/min. Fine particles within a blend like stearate, impact modifier and fine fillers can convey at a much lower velocity. If a transfer system's velocity is designed at too low of a velocity, separation can occur within the conveying line. Generally, the separation of product within the conveying line is minimal if systems are designed for the worst-case velocity needed for any component of a blend. Elbows and bends can also cause material to lose velocity and separate before reaccelerating downstream of the bend — especially if two or more elbows are closely placed in a conveying line.

The end of exit to a conveying pipe is typically the area of a transfer system with the highest potential for separation. When compound exits a conveying system, it enters a larger vessel and starts to fall via gravity to a pile within the vessel, counteracting the upward airflow direction to exhaust from the vessel. This upward velocity will cause particles to suspend in the air stream if it is too high. In silos this velocity is very low due to the cross section of the vessel. In filter receivers — like those above extrusion lines — the velocity can be high enough to suspend finer particles. The suspension velocity of the larger particles in a blend is typically between 300 and 600 ft/min while the suspension velocity of commonly used fine fillers is 50 to 150 ft/min. If the velocities within a filter are above a given component's suspension velocity, that component will separate and go up toward the filter media instead of falling into the hopper.

The technical terms for the velocities within a filter receiver are “can velocity” and “interstitial velocity.” Can velocity is the upward velocity of the airstream as it enters the filter housing. Interstitial velocity is the upward velocity between the filter elements or bags in the filter section. Filter receiver designs with small diameters and tightly packed filter media have higher can and interstitial velocities.

If velocities within a filter receiver are too high, the fine particles will tend to go up and the coarse particles will go down as they enter the receiver. If the flow of air and product into the filter receiver is continuous, this effect can cause the filter media to blind over and damage cartridges or bags.

Intermittent product and airflow that is typical on vacuum sequencing receivers above extruders may not have an issue with blinding of filters, but it does have a high potential for separation in blends. It is common for extruder receivers to have smaller housings/cans and tightly-packed media. The traditional designs minimize space requirements and costs but have more issues with separation of finer ingredients used in larger percentages. Figure 1.2 shows the differences in well-designed dilute phase transfer systems vs. systems that have a higher potential to segregate product.



Optimum Dilute Phase Conveying	Conveying Conditions Contributing to Segregation
Conveying Velocity is above the worst-case minimum saltation velocity.	Conveying velocity is below optimum for come particles causing “strand” flow or plugging.
Elbows and bends are kept to a minimum.	Elbows and bends cause material to lose velocity and can separate before reaccelerating downstream of the bend.
No “back to back” bends or elbows.	If two (or more) elbows are close coupled in a conveying line the product can lose over half of its velocity.

Figure 1.2

Separation will occur during the convey cycle of a receiver with too high can or interstitial velocity. The fine particles will go up into the filter media section and hold there until the conveying airflow is stopped. Once the airflow stops there is nothing to hold the fine particles up as they are pulsed off the filters and dropped in a layer on top of the coarse product that fell into the hopper. These layers of product then discharge into the extruder. If it is determined that the separation of blends is occurring in a filter receiver, the receiver must be replaced with a unit that has lower can and interstitial velocities to solve the problem.

Silo/Bin Fill and Discharge

PVC compound has a high risk of being exposed during silo/bin fill or discharge phases, causing separation during storage. Product will have a velocity trajectory when exiting a conveying system into a silo. Different size and density particles will travel at varying distances before they settle. The entry point when filling a bin or silo should be as close as possible to the center top of the vessel. Blowing product horizontally into the side of a larger silo or bin should be avoided.

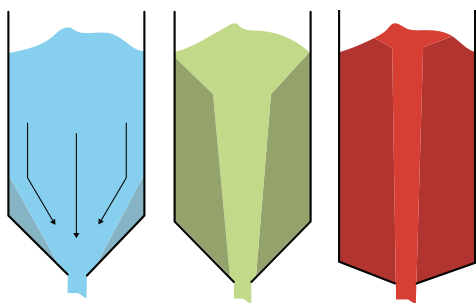
Flow patterns when discharging from larger storage vessels can contribute to separation. There are two kinds of product flow from large vessels: mass flow and funnel flow, shown in figures 1.3 and 1.4.

MASS FLOW

- Causes the entire cross section of product to move at the same rate toward the discharge
- Results in first in/first out performance discharging of material
- Results in steep cone angles in hopper slopes and more internal devices to interrupt a funnel flow pattern

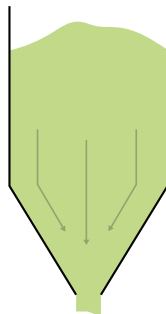
FUNNEL FLOW

- Pattern where center product in the vessel moves toward the outlet at a higher velocity
- Product on the perimeters of the vessel moves much slower or not at all until the center is empty
- Results in last in/first out performance discharging of material
- Can cause separation as product discharges
- May help to remix separated product
- Silos need to be fully or nearly emptied regularly



Funnel or core flow

Figure 1.3



Mass flow

Figure 1.4





NEXT STEPS

Once you've identified separation, it is time to develop a corrective plan. These plans can be made with Horizon System's knowledgeable and skilled team of experts, mixer companies and other outside resources. Equipment suppliers are another resource to help determine possible remedies. Two common remedies to separation and segregation in PVC compounding could even be as simple as identifying if transfer equipment is sized and configured properly for specific blends, or determining if blend properties have changed enough that current storage designs need to be modified to minimize separation.

CONSULT WITH HORIZON SYSTEMS ENGINEERS

If the steps outlined in this book don't help resolve the separation or segregation issues in your plastics process, it may be time to consult with outside experts. At Horizon Systems, we have more than 40 years of experience diagnosing material segregation and separation issues, and engineering and manufacturing solutions that deliver consistent results. Whether you're building a brand-new top-down blending tower or need help with an existing bottom-up process, you can trust our team to work as part of your team.

Contact us at horizonsystemsinc.com/contact or call 800.842.1600 to get started.



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