RESIN HANDLING GUIDE

American Chemistry Council/
American Plastics Council
Transportation & Logistics Committee

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TABLE OF CONTENTS

Purpose........................................................................................................3-4
Moving Resins in Bulk-Introduction..........................................................4-7
What Impacts Resin Quality.................................................................7
System Design.......................................................................................7-13
  Silos, bins and product receivers.....................................................8-9
  Bag houses filters..............................................................................9-10
  Transfer piping and hoses..............................................................11-12
  Transfer blowers.............................................................................13
Product Contamination.......................................................................14-16
  External, Internal Sources.........................................................14-16
Operating Conditions.........................................................................16-17
Guidelines for Dense Phase Unloading of Bulk Hopper Trucks....18-23
  Introduction.....................................................................................18
  Dense Phase Product Transfer.......................................................18
  Hopper Truck Delivery Objectives.................................................19
  Product Delivery Degradation Issues.............................................19-22
  Misperceptions Concerning Product Delivery Techniques....20-21
  Additional Concerns Regarding Hopper Truck Deliveries....21-22
  Further Suggestions for Unloading Include.................................23
Resin Properties Table........................................................................24
Unloading Hopper Cars and Hopper Trucks................................25
  Hopper Car...................................................................................25-26
  Hopper Trucks.............................................................................26
Safety.......................................................................................................27-28
  Static Electricity...........................................................................27
  Explosion Hazards.......................................................................28

This guide is intended to provide general information concerning the handling of plastic resin. The
guide is considered accurate as of the date of preparation. Additional or different measures may be
appropriate for the handling of particular resins, and such information may be obtained from each
producer regarding properties and particular handling appropriate to that producer’s materials.
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infringe privately owned rights.
PURPOSE:

This publication is a collection of general guidelines. These guidelines provide general operating considerations for safe, efficient and environmentally responsible pneumatic handling of plastic resins. Plastic resin in this document is understood to mean powder, flake or pellet forms. The information contained in this manual will help contain the plastic resin within the operating facility in order to protect the environment and will help the plastic resin come through pneumatic handling systems in an “as manufactured” condition. In addition, a section has been included which provides references for further information on handling plastic resin. One of the best sources of information is the manufacturer of the particular plastic resin that is being handled.

Most companies that produce plastic resins in the United States are members of the American Chemistry Council (ACC). As such these members are dedicated to the Responsible Care® initiative. This is an approach that recognizes that the best way to improve the public trust in the chemical industry is to demonstrate commitment and performance and to be responsive to public concerns. In addition, The American Plastics Council (APC) is a partner with the Society of the Plastics Industry (SPI) in the initiative known as Operation Clean Sweep®. Producers of plastic resins actively participate in following the principles of this initiative, which is aimed at preventing the release of plastic pellets to the environment. Although not generally considered “hazardous”, the Environmental Protection Agency (EPA) Storm Water Regulations classify plastic pellets as “significant materials”, making the exposure of even a single pellet in storm water run-off without a permit subject to regulatory action. This publication is intended to assist all companies that handle plastic pellets to fulfill the expectations of these initiatives. For further information on Responsible Care® or Operation Clean Sweep, contact the ACC/APC offices in Arlington, VA., or the SPI offices in Washington D.C.

The end uses of plastic resins are carefully engineered products that touch almost every phase of our daily lives. The designs of these products are based on the properties of the plastic resins, which have been specified for each end product. If these properties are altered through the handling process, the performance of the end use products may suffer. Some examples of this could be:

- Foreign contamination (like minute particles of dirt) can cause electrical failure of wiring and cables constructed with plastic resin insulation material.
- Foreign contamination can cause film to have weak points and also potentially contaminate the products wrapped inside the film.
- Contamination of one plastic resin with another of different properties can cause weak points in tubes or bottles, which may cause the tubes or bottles to fail. This could cause a leak of household cleaning chemicals, lubricants, antifreeze and many other hazardous materials.
Contamination of plastic resin can cause significant costs in defective final product or serious equipment damage to processing equipment for plastic resin.

It is the desire of all manufacturers of plastics resins to deliver those resins in an “as manufactured” condition to the point of end use. This publication is produced in the hope that these guidelines will help people who handle the plastic resins outside the manufacturing process accomplish that goal.

MOVING RESINS IN BULK—
INTRODUCTION:

Approximately 90% of the plastic resins produced in North America leave the producing plants in covered hopper cars. Many of these railroad cars travel directly to customers who remove the plastic resins from the hopper cars and process the resins into final products. The remainder of the hopper cars go to transfer stations where material is removed from the hopper cars to bulk trucks or to packaging lines where the resin is placed in bags or bulk cartons. Because of the importance of pneumatic transfer to the plastic resin industry, it is vital that the operating principles of pneumatic transfer systems and the impact of pneumatic transfer on plastic resins are understood. What follows are some general guidelines for the Plastics Industry.

Pneumatic transfer systems are essentially moving product through the creation of either positive or negative atmospheric conditions. Therefore, creating the force to move plastic resins. The classifications by motive force are:

- Negative atmospheric pressure or vacuum systems create a negative pressure differential causing the flow of plastic resins and conveying air from the high pressure to the low pressure.
- Positive atmospheric pressure systems where plastic resins are moved from one point to another by applying a higher pressure at the starting point of the transfer and thus allowing resins and conveying air to flow to the desired end point.
- Pull/Push (or Push/Pull) systems that combine both vacuum and pressure sections.
The attached schematics (Figures 1 – 3) are examples of these systems.

The second classification is by the mass ratio of plastic resins to conveying air in the transfer system. In very general terms, these classifications are:
Dilute phase systems where the mass ratio of plastic resins to conveying air is 10:1.

Figure 4. Dilute phase systems

Dense phase systems where the mass ratio of plastic resins to conveying air is greater than 10:1

Figure 5. Dense phase system

Transfer systems using either dilute or dense phase can be designed to utilize any of the systems classified by using motive force. Dense phase transfer systems are usually stationary systems, common to manufacturing or processing facilities, which are dedicated to a very limited number of plastic resin grades. The dilute phase system is much more common at transfer stations and situations where multiple grades of plastic resins are
handled. Examples of dilute phase systems are vacuum/pneumatic trailers and portable transfer systems. See page 18 for a “Guideline for Dense Phase Unloading of Bulk Hopper Trucks.”

WHAT IMPACTS RESIN QUALITY:

The pneumatic transfer of plastic resins can negatively impact resin quality if not conducted properly. To maintain the quality of the plastic resins during pneumatic transfer, there are three areas that need careful consideration:

- System design can have a major impact on preserving the quality of plastic resins.
- The conditions under which the pneumatic transfer system is operated can have a major impact on the delivered quality of the plastic resins.
- The variety of plastic resins handled within the same system and the cleaning procedures between various grades of plastic resins can have a major impact on the properties of plastic resins.

Each of these areas will be discussed in the text below. The guidelines given come from the literature produced by the Plastics Industry. For specific questions about any one of the many grades of commercially available plastic resin, contact the resin manufacturer for details.

SYSTEM DESIGN:

A number of factors go into the design of systems for pneumatically handling plastic resins. The number of grades of plastic resins to be handled, the geography of the particular site at which the transfer is to take place and the rate of usage of the plastic resin are some of the more important factors. It would be impossible to have a design that would fit every situation. This guide will cover the things that are important considerations for each of the key components of the system. The manufacturer of the plastic resin(s) being handled is the best source of advice regarding a particular handling system design.
The major components of a plastic resin handling system are the silos, bins or product receivers, bag houses and filters, transfer piping and transfer blowers. Each area is discussed below with guidelines that should be considered when developing a system for handling plastic resins.

**Silos, Bins and Product Receivers:**

Almost any transfer system will have some point at which plastic resin is held for some period of time. The following items should be kept in mind when developing a system for handling plastic resins:

1. Commonly used materials of construction are:
   - Steel coated with an epoxy resin or similar coating.
   - Aluminum
   - Stainless Steel

2. No matter what the material of construction, achieving a smooth internal finish is important to the flow of the product.
   - Riveted construction is usually combined with the use of caulking or other sealants, which are used to fill the gaps between the plates. This sealant can be a serious contaminant in most plastic resin applications.
   - Flanged areas can also be a source of leakage. Deterioration of gasket material that comes into contact with the plastic resins may be a source of contamination in most plastic resin applications.
   - Any ledge or area that can trap plastic resin should be avoided.

3. Storage vessel size should take into account delivery increments and usage rates of plastic resins.

4. Cone angles on the bottom of all storage vessels should be designed to accommodate the particular flow characteristics of the products being handled. Contact your supplier to determine the optimal cone angle for your application.
5. Pressure/vacuum relief systems for storage vessels should be designed with the following in mind:
   - All connections should be airtight.
   - Vents should be sized to accommodate the conveying air without a build-up of pressure in the vessel.
   - Vents should be designed to contain fines, streamers and dust particles conveyed with the process air.
   - If fine particles or dust particles are involved, (i.e., less than 40 mesh, 420 micron particle size as defined by the Bureau of Mines and the National Fire Protection Association (NFPA)), consideration should be given to adding explosion relief devices that can handle the pressure rise from a dust explosion. In addition, a bag house might be required to eliminate atmospheric pollution.

6. If multiple grades of plastic resins are being handled, consideration should be given to cleaning of the system between grades of plastic resins. Not all grades of plastic resin are compatible and even small amounts of cross contamination will have serious consequences for some applications. Contact the manufacturer of the plastic resin(s) to discuss this issue.

Addressing the above items will help reduce the probability of negatively impacting the quality of plastic resins in storage vessels.

**Bag Houses and Filters:**

In most transfers of plastic resin conveying air is usually drawn into the system from the atmosphere and exhausted once the transfer is complete. To prevent contamination of the plastic resin, any source of conveying air should be filtered to remove dirt and debris. Care should be taken to avoid drawing moisture into the system.

In addition, the following should be considered for filters:
1. Filter media commonly used will not pass particles that are greater than 1 micron. For some applications of plastic resins, even smaller filter media is required. Contact the manufacturer of the plastic resins you are handling for advice in this area.

2. If multiple grades of plastic resins are being handled, removal and cleaning of the filters is important. The specifics of how this is done will depend on the grades of plastic resin being handled. The manufacturer(s) of the plastic resin(s) is the best source of advice on this issue.

3. The material of construction of the filter media should be consistent with the end use application.

Once conveying air is drawn into the system it must also be exhausted; in this case confinement of fines, streamers and dust created in the handling process is the key issue. In most cases bag houses are used to cleanse the air before it is vented to the atmosphere or perhaps passed to the suction side of a transfer air blower. Some considerations for bag houses are:

1. The air to cloth ratio is normally between 3 and 7. This is measured in ft$^3$ per minute of conveying air per ft$^2$ of cloth.

2. The superficial upward air velocity between the bags usually does not exceed 250 feet per minute.

3. A pulse jet of air is normally used to remove entrapped particles from the filter bags. Typically, 90 psig of pressure in the air manifold is used.

4. Careful consideration should be given to grounding the bag house to insure continuity between the bags, the bag cages and the remainder of the equipment.

5. Again, if multiple grades of plastic resins are being handled in this system, careful attention must be given to cleaning of the bag house between the different grades of plastic resin. The manufacturer(s) of the plastic resin(s) is the best source of advice on this issue.

Attention to the above areas will produce a system that will reduce the chance of quality, safety or environment problems with handling systems.
Transfer Piping and Hoses:

With the pneumatic transfer of plastic resins the piping or hoses used can be the most critical part of maintaining resin quality. Contact of the plastic resin with the walls of hose or piping is inevitable. The consequences of this contact are all negative and everything possible should be done to minimize this contact. The following are guidelines, which should be carefully considered for any transfer system for plastic resins:

**Piping**

1. Distance is critical in the pneumatic transfer of plastic resins. Where possible the distances over which the resin is transferred should be minimized.
2. Piping should be either vertical or horizontal.
3. Any 90° bends should be wide radius. Wide radius conventionally means a bend radius of 6 to 12 pipe diameters.
4. Externally gasketed coupling joints should generally be used to minimize contact with gasketing material and prevent leakage of air into the system.
5. Scored, shot peened, or roughened piping is preferred over smooth piping.
Hoses (In contact with plastic resin):

1. Minimize the length of product transfer hose required to make the delivery connection.
2. Hoses are generally of spiral wound metal with either directional or bi-directional flow design. If directional flow hoses are used, the flow direction should be clearly marked.
3. Smooth wall plastic hoses are generally avoided because of potential pellet damage as described earlier and to avoid creation of static electricity.
4. Hoses should be routed to minimize sharp bends or sudden turns. When turns need to be made, they should generally have a radius that ranges between 6 and 12 times the diameter of the transfer hose.
5. Hoses should be supported off the ground to avoid damage to the outer windings and to prevent the introduction of contaminants into the system.

![Image of Hose Support](figure12.png)

Figure 12. Hose Support

6. Hoses should be stored in racks and capped when not in use.
7. Damaged hoses should be removed from service immediately.

This is probably the most critical part of any transfer system. Attention to the items above will help improve the chance of successfully transferring plastic resin.
Transfer Blowers:

Whether pressure or vacuum, air blowers are part of any transfer system. When considering a blower for pneumatic transfer of plastic resins, the following should be taken into consideration:

1. The blower should be designed for the lowest practical operating temperature. Generally speaking, conveying air should be delivered at temperatures not exceeding 100°C (212°F). Confer with the plastic resin manufacturer for the recommended operating temperature for each grade of plastic resin being handled.

2. The kind of system will be dictated by piping size, distance and transfer rate.

3. Any atmospheric air pulled into a blower should be filtered to remove dust and debris. The filter media should generally be capable of removing any particles greater than 30 microns in size.

4. The use of heat exchanger can assist in minimizing the temperature of the conveying.

   Since the transfer blower is a source of heat, it is an important part of any transfer system. Care should be taken to use a blower, which fits into the total system and minimizes the heat input to the transfer process.

By following the above guidelines, a transfer system can be developed which will handle the movement of plastic resins from one point to another with a minimum of problems. Good maintenance practices for all of the above components are critical in maintaining plastic resin integrity.
PRODUCT CONTAMINATION:

External Sources:

Just as it is important to protect the environment from plastic resins, it is also important to protect plastic resins from the environment. Is it critical that a means of filtering any external opening be installed where air can enter the plastic resin handling system. The filtering should generally be capable of blocking any particles which are 30 microns and larger in size. The hopper car inlet(s) opposite the unloading hose connection and the top hatch(s) of the hopper car are critical places where dust, dirt and debris can be pulled into the plastic resin during transfer. Dust, dirt and debris can have a major impact on the processing of plastic resins causing both operating problems and rejected product as well as potential equipment damage.

A second major source of contamination is moisture. Most plastic resins have a very low water sorption. However, the water will cling to the surface of the pellet and will cause problems in the processing of the plastic resins.

Internal Sources:

Product contamination can occur from within systems as well. One source of contamination is gasket material. Where possible, couplings should be used in a manner that minimizes the contact of the plastic resin with gasket material during transfer. The plastic resin pellets can be abrasive and could break pieces of the gasket material off introducing this into the resin stream as a contaminant. Similarly, metal particles can be picked up in plastic resins due to wear on systems. When transfer lines are scored or shot peened, they must be...
carefully cleaned prior to use in the transfer of plastic resins. When mechanical repairs are made on a transfer system, the system should be cleaned carefully prior to returning the transfer system to service.

A second possible source of internal contamination occurs when transfer and handling systems are used for multiple grades of plastic resins. There are many grades of plastic resin and they are not all compatible. When considering the use of a system for multiple grades of plastic resins, the following issues should be considered:

- The density of each grade of resin and the relative difference in the densities.
- The melt characteristics (melt index) of each grade of plastic resin to be handled needs to be considered. This is important because:
  - Most plastic resins are melted before they are formed into the final product. The viscosity of the melt and its consistency is very important.
  - Two resins with similar densities but different melt characteristics can cause very poor performance of a final product.
- A plastic resin is not like a liquid. Small quantities of one liquid in another (assuming they are mutually soluble), can blend together and the performance of the resultant liquid is not impacted significantly. With a plastic resin, each particle must be melted and mixed before passing into an extruder, injection molding or whatever the final forming process. The important thing to remember is that the process for forming the final product really does see each particle or pellet of a plastic resin and will recognize differences between them.
- Certain plastic resins have additives that cause chemical reactions during processing. This is known as cross-linking or vulcanization. Mixing grades of plastic resins that do not have these additives with those that do have these additives can cause very serious problems in the manufacture of the final product and potentially cause major damage to processing equipment.
- Various colors of plastic resins are produced, but colors should not be mixed. A very small amount of color contaminant goes a long way in causing color rejections in a final product.

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1 The melt index (defined by ASTM 1248) is a test that determines the viscosity of a resin. A high melt index value means a low viscosity and a low molecular weight of the plastic resin. A low melt index value means just the opposite.
All of the points made above should be given very careful consideration when handling multiple grades of plastic resin within a single system.

The best source of information about the compatibility of various plastic resins is the manufacturer(s) of the various grades of plastic resin(s). In general, each manufacturer can provide guidance as to what density and melt characteristic differences can be tolerated for the grades of plastic resins it supplies.

When handling multiple grades of plastic resins in a system, some thought should be given to cleaning between grades. The cleaning required will be dictated by the following factors:

- The differences in properties between the grades of plastic resin.
- The design of the system.

The differences in the grades of plastic resins have been discussed previously. The design of the handling system then becomes the concern. A “clean system” means that there are no particles or pellets of the previous grade in the system and that any coating on walls, piping, filters (filter bags), rotary valves or other equipment has been removed. The best source of information on cleaning a handling system is the supplier(s) of the various grades of plastic resins.

OPERATING CONDITIONS:

Transfer of plastic resins pneumatically has two control variables which can have a major impact on successfully transferring the plastic resin while maintaining the “as manufactured” quality of the resin. These two variables are temperature and pressure of the conveying air and they are directly tied to the velocity of the conveying air during transfer. The management of transfer velocity is critical to maintaining the integrity of plastic resins.
Most pneumatic transfer systems for plastic resins are considered to be a dilute phase transfer system.\(^2\) In a dilute phase transfer system operating under static conditions increasing the air pressure through injection of more product actually results in a drop in product velocity. Reducing line pressure will typically result in an increase in product velocity. Product velocity above reasonable ranges will increase the number of high-speed interactions between the plastic resin and the walls of the transfer piping. This will damage the plastic resin by reducing the plastic pellet to a fine particle or causing the pellets to deposit a small particle of plastic on the pipe. Numerous pellets impacting the pipe will accumulate small deposits over time and gradually coat the interior of the pipe with a fine layer of plastic. This plastic will eventually peel off in what we call a streamer or a snakeskin. This can cause difficulties in the processing of the plastic resin into a final product. The “right” operating pressure is a function of the transfer system design. The pressure should be just sufficient to overcome the pressure drop from the point of resin introduction into the system and the discharge of the transfer system. Temperature is the second variable. Above \(100^\circ \text{C} (212^\circ \text{F})\) most plastic resins will begin to soften and become more susceptible to damage in a transfer system when the pellet interacts with the walls of transfer piping. For these reasons holding the temperature as low as practical is the best operating practice. In Table I are some typical values for the various categories of plastic resins.

For more information on both these areas, contact the manufacturer of the plastic resins being handled.

\(^2\) Dilute phase systems typically have a ratio of 10 pounds of plastic resin per pound of conveying air. Systems with as little as 1 pound of plastic resin per pound of conveying air are also considered “dilute phase” systems.
Guideline for Dense Phase Unloading of Bulk Hopper Trucks

Introduction:

In recent years the hopper truck industry and the producers of certain types of resins have been faced with the difficult task of transferring new softer materials while avoiding the problems that occur from such transfers. Much work has been done in an attempt to develop more efficient methods of product transfer, which minimize product degradation and still accomplish reasonable unloading times. The utilization of “dense phase” unloading is one such effort. “Dense phase” unloading is a process that involves conveying high concentrations of plastic pellets at a low velocity. The actual unloading of the truck is a combination of dense and dilute phase conveying. While numerous technical publications are available on the subject, the following is a basic explanation of the process. The extent to which the process can be followed will vary according to the specific unloading conditions.

Since all unloading systems are different in design and the specific equipment used, the unloading recommendations in this Guide may need to be modified to conform to the operating conditions that exist in each individual facility.

Dense Phase Product Transfer:

For dense phase product transfer, there is an inverse relationship between pressure on the product delivery line and the product speed in the delivery line. When delivering product in conditions where blower speed is constant; the more pressure, the slower the product moves, the less pressure, the faster the product moves. In situations where blower speeds are variable, like with hopper truck deliveries, a good general rule of thumb is to run the blower at the lower end of the operating range and increase line pressure by increasing product flow. You must do both!

Following these unloading recommendations accomplishes the primary objective of maintaining product integrity (minimizing angel hair, fines and clump formation). Because of the lower tractor engine speeds and higher line pressures, more product is placed into the delivery pipe. This increases line loading and slows the pellet velocity. The reduction in pellet velocity minimizes the generation of angel hair, fines & clumps. At the same time, the increase in the amount of product in the line increases the product per minute to the silo and in most cases the total delivery is faster. This process meets all of the delivery objectives.
Hopper Truck Delivery Objectives:

Maintain product integrity by minimizing or eliminating the generation of clumps, angel hair/streamers and fines.

Product Delivery Degradation Issues:

A clump is usually formed by pellets moving through the delivery line becoming lodged in a sharp corner, rough surface, or in a pipe or compression coupling separation or misalignment. This phenomenon is aggravated when the pellets are warm or hot. Other pellets strike the lodged pellet creating a small mass, which gradually builds up over time. They will continue to grow to a point where they block the pipe completely, or they may cool off and become dislodged and move through the system along with the pellets. A clump will eventually (days, months, sometimes years) surface in another spot, where it will block a pipe downstream from its original starting point or at an inlet line feeding a machine.

Angel hair is the caused by the repeated contact of pellets against the walls of the conveying pipe. Each pellet deposits a very tiny piece of polymer on the wall, which subsequently fuses with other small pieces into very long strings. Eventually, the string breaks away from the wall and moves along with the product streams and
clogs a line on a machine or other collection point. Most angel hair/streamers are formed in bends (high centrifugal forces) and in the straight portion of pipe following bends. The amount of angel hair generated is dependent upon the type of plastic being handled. Typically the softer the plastic is the higher the generation rate becomes. Angel Hair has been experienced with all types of polyethylene (HDPE, LDLPE, LLDPE), polypropylene, styrene butadiene copolymer, etc.

Pellets striking the pipe surface and chipping off a part of the pellet create **fines**. Pellets moving at sufficiently high velocity will have sufficient energy to break off a portion of the pellet when it strikes the pipe, particularly the bends. There are a number of conditions that will promote fines generation. The situation is worsened by pipe layouts with lots of bends, misaligned pipes or flanges, poor pipe surface finish, poor pellet cutting (lots of tails on the pellets), to name just a few. The faster the velocity in the pipe the greater the rate of generation of fines. Product velocity in the pipe is the largest single cause of fines generation. In general, if the product velocity doubles in the pipeline, the amount of fines generated would increase by a factor of ten. It is important not to confuse the terms, product velocity and product rate. The product velocity in the pipe is the actual speed of the pellets and the product rate is the transfer rate of pellets (usually in lb/hr) out of the truck.

**Misperceptions Concerning Product Delivery Techniques:**

In the past few years, many of the generally accepted operating practices regarding the unloading of dry plastic pellets have been recognized to not always be the best practices for avoiding product degradation. Beliefs we have found to be in error are:

1. Low pressure in truck unloading lines is necessary to minimize speed or heat friction from pellets brushing against pipes,
2. High pressure in truck unloading lines increases the velocity of the pellet moving through the delivery line or creates heat,
3. High pressure on the delivery line will pressurize the silo and/or increase the volume of air going into the silo,
4. Moving the product through long or horizontal unloading lines does not degrade product,
5. Taking more time to deliver the product is better than less,
6. It is not important how fast you run the blower on the truck as long as you maintain low pressures.

Additional Concerns Regarding Hopper Truck Deliveries:
When unloading a hopper truck, it is very important to avoid creating excessive heat sources and to minimize product velocity. There are two primary sources for heat. The first is the blower on the tractor and the second is the friction created when moving plastic pellets through the unloading pipes. Blowing pellets through the delivery lines causes the pellets to brush against the sides of pipes or run into corners, which creates friction. This creates heat, warming the pellet. The faster the airflow through the pipes (velocity), the greater the speed and friction; hence the warmer the pellets get and the greater the potential for a pellet to become soft and start to melt, especially at bends where much of the pellet’s kinetic energy is converted into heat. If the pellet is hard and has a high melt point the same action will cause fines.

In addition, moving the product through greater distances will produce more heat or create more fines. This occurs:

1. When there is a greater amount of pipe to blow the product through, which results in more pellet contact with the pipe wall:
2. As a result of more pipe joints, which can shave more of the pellets or create an impediment for the pellet to lodge itself on creating a clump or angel hair.
3. As a result of the longer distance, the blower must run faster, producing higher transfer velocity to move the product. Otherwise there is a risk of filling the lines up and blocking them.

Long horizontal piping causes special problems. In order to keep all the product suspended and not settling on the bottom of the pipe, the blower speed should be increased (velocity), potentially creating more opportunity for fines. This is particularly the case for dilute phase conveying because as the line length increases, the
pressure drop increases and the blower speed must be increased in order to maintain sufficient velocity at the pick up point.

In order to combat the formation of unwanted fines, clumps and streamers, it is advantageous to reduce the air velocity in the conveying pipe. This results in a conveying condition known as dense phase conveying. In this case sufficient product is allowed to flow into the conveying line with low conveying velocities. This causes plugs or slugs of pellets to be conveyed in the pipe (this can be seen in transparent unloading hoses or sightglasses). This results in a low velocity unload with high product discharge rates from the truck. In order to achieve a dense phase conveying unloading condition, the recommended process while unloading from a hopper truck is as follows:

1. Eliminate any unnecessary piping. Get the hopper truck right to the bottom of the silo. This permits a reduction in the operating speed of the blower and creates less surface area (piping) for the pellets to come in contact with.

2. Run the hopper truck motor more slowly, i.e.: run the blower at a slower speed-either by lower engine RPM’s or changing PTO ratio (this may not be practical) to get air velocity to an acceptable range. Slowing the motor will run the blower more slowly, therefore slowing the product velocity down in the pipe. Again, reducing the speed at which the product hits the pipe walls minimizes heat friction and fines caused by the product impaling itself in corners or shaving itself on rough surfaces.

3. If the trailer has an “air cooler” the driver can put the maximum pressure required to create a dense phase environment (up to about 12 PSI of pressure) in the trailer and unload with approximately a pressure difference of 1 PSI between the trailer and the conveying line. To do this the driver puts a large amount of product in the unloading line. This creates more pressure, but it also slows the velocity of the product moving through the delivery line substantially. An “air cooler” eliminates the heat caused by the blower, which is the only other source of heat other than product friction.

4. If the trailer does not have an “air cooler”, the increased blower discharge gas temperature will cause an even greater reduction in truck engine speed to keep the gas velocity in an acceptable range. However some product types may form “clumps” due to the higher air temperature in the pressurized trailer (pellets are exposed to high temperature air for extended periods of time). If this is the case, both lower line pressures and truck engine speed should be reduced. This will most likely result in longer unload times.

FURTHER SUGGESTIONS FOR UNLOADING INCLUDE:
1. Deliver into the unloading lines that run right down the side of the silo and have connections at the base for the trailer to unload. Try to avoid setting up delivery systems that have long lengths of piping with multiple elbows and or curves.

2. Generally avoid installing conveying piping that is not running either horizontally or vertically (minimize sloped lines).

3. Allow the driver to slow the blower down and create a high-pressure unloading situation.

4. If the blower is running at the rated speed and the pressures are high, the time it takes to deliver should not be a concern. Product will periodically sound like it is running through the pipes in slugs. This is totally normal.

5. Paint a marker on the pipes either side of each compression coupling on the delivery piping. This will determine if the coupling has started to separate and point out locations where a pellet can get caught or create air leaks in the system. (Note: On new installations, it is important that the piping be checked and retightened about 90 days after initial use, and again about 6 months after initial usage. It would not be unusual to find that a joint has slipped creating a void for pellets to accumulate and form clumps, or begin coming apart creating an environment for a spill, or air leak which also disrupts the flow of product.)

Following these suggestions the driver will unload the trailer quickly and the customer will not experience product contamination generated from the delivery process. The hopper truck will be in and out of the plant quickly, reducing both congestion and the time needed for monitoring the delivery process.
<table>
<thead>
<tr>
<th>Common Abbreviation</th>
<th>General Product Nomenclature</th>
<th>Bulk Density, Pounds per cubic foot</th>
<th>Softening Point, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS</td>
<td>Acrylonitrile-Butadiene-Styrene</td>
<td>50 pcf</td>
<td>215</td>
</tr>
<tr>
<td>PC</td>
<td>Polycarbonate</td>
<td>45 pcf</td>
<td>315</td>
</tr>
<tr>
<td>HDPE</td>
<td>High Density Polyethylene</td>
<td>35 to 39 pcf</td>
<td>255</td>
</tr>
<tr>
<td>LDPE</td>
<td>Low Density Polyethylene</td>
<td>30 to 35 pcf</td>
<td>185</td>
</tr>
<tr>
<td>LLDPE</td>
<td>Linear Low Density Polyethylene</td>
<td>26 to 32 pcf</td>
<td>220</td>
</tr>
<tr>
<td>LLDPE Powder</td>
<td>Linear Low Density Polyethylene Powder</td>
<td>24 pcf</td>
<td>190</td>
</tr>
<tr>
<td>LDPE with EVA</td>
<td>Vinyl Acetate copolymer with Low Density Polyethylene</td>
<td>30 to 35 pcf</td>
<td>170</td>
</tr>
<tr>
<td>COPP</td>
<td>Copolymer Polypropylene</td>
<td>30 to 35 pcf</td>
<td>220</td>
</tr>
<tr>
<td>HOMO PP</td>
<td>Homopolymer Polypropylene</td>
<td>35 to 39 pcf</td>
<td>220</td>
</tr>
<tr>
<td>GPSS</td>
<td>General Purpose Polystyrene</td>
<td>38 to 40 pcf</td>
<td>220</td>
</tr>
<tr>
<td>HIPS</td>
<td>High Impact Polystyrene</td>
<td>40 to 42 pcf</td>
<td>220</td>
</tr>
<tr>
<td>PVC Resin</td>
<td>Polyvinylchloride Resin</td>
<td>32 to 35 pcf</td>
<td>200</td>
</tr>
<tr>
<td>PVC Compound</td>
<td>Polyvinylchloride Compound</td>
<td>40 to 50 pcf</td>
<td>220</td>
</tr>
<tr>
<td>SAN</td>
<td>Styrene-Acrylonitrile</td>
<td>45 pcf</td>
<td>230</td>
</tr>
<tr>
<td>PET</td>
<td>Polyethylene Terephthalate</td>
<td>49 pcf</td>
<td>280</td>
</tr>
</tbody>
</table>

Table I – Resin Properties, Bulk Density and Softening Point

APC/Transportation & Logistics Committee - Resin Handling Guide
24
UNLOADING HOPPER CARS AND HOPPER TRUCKS:

Most suppliers of plastic resins have detailed literature for handling the plastic resins they supply. Each individual company’s specific requirements should be reviewed prior to developing guidelines for their own operation. Provided is a partial list of areas that need to be considered in developing procedures for a plastic resin handling system. These areas by receiving mode are:

Hopper Car: (Figure 16 – Unloading hopper car with hatch filter disc)

- Secure the track with a derailer and a “blue flag”.
- Be sure the wheels of the hopper car are chocked.
- Ground the hopper car body to the transfer hose and to ground to protect against static discharge. A hopper car sitting on a rail track is not grounded!

Open the top hatch cover, remove plastic covers and attach a filter on the compartment to be unloaded. (Figure 17 – Inserting 600 Micron (30 Mesh) hatch filter disc)

- Place pellet retention devices (pans) below the outlet caps.
- Remove the outlet caps and remove the plastic dust caps on both sides of the hopper car outlet.
- Attach a clean filter to the side of the outlet opposite the transfer hose.
- Wipe the outlet valve and the adapter clean.
- Connect and support the unloading hose at the outlet adapter. Secure the hose to the hopper car.
Begin the unloading and adjust the flow rate to the desired level.
Complete the unloading and be sure the compartment is empty.
Disconnect the unloading hose and remove the filter. Close and lock the outlet caps.
Remove the hatch ring filter. Close and lock the top hatch covers.
Prepare the hopper car for return shipment.

**Hopper trucks:**
- Be sure the wheels of the hopper truck are chocked.
- Ground the hopper truck body to the transfer hose and to ground to protect against static discharge.
- Insure the pellet retention devices (pans) are in place below the outlet cap.
- Remove the outlet cap on the hopper truck outlet.
- Wipe the outlet valve and the adapter clean.
- Connect and support the unloading hose at the outlet adapter.
- Begin the unloading and adjust the flow rate to the desired level.
- Complete the unloading and be sure the hopper truck is empty.
- Disconnect the unloading hose. Close and lock the outlet cap.
- Prepare the hopper truck for return shipment.

**Figure 17. A hopper car is unloaded into a hopper truck**
SAFETY:

Static Electricity:

The movement of plastic resins in a stream of conveying air generates static electricity. Plastic resins are, in general, non-conductive and the charge is carried on the surface of the particles. A portion of this charge may be lost when a pellet or particle of plastic resin strikes a grounded metal conductor such as the wall of a hose or transfer pipe or bin wall. Because of the high resistivity of the plastic resin, most of the charge remains on the particle. Therefore, a mass of resin in a bin or a silo will retain a high surface charge for an extended period of time. The total electrical energy stored in a mass of plastic resin after pneumatic conveying can be quite large. This is of little consequence from a safety standpoint because the high resistivity of the plastic resin prevents the discharging of large surface areas by a single spark. Such sparks from a bed of plastic resin to ground or between oppositely charged particles are very low energy levels and do not constitute a significant hazard. The total energy stored in a plastic resin bed is gradually dissipated over a long period of time depending on the plastic resin properties and the humidity of the air.

On the other hand, an ungrounded metal conductor such as a bin, a section of metal conveying pipe or a dust collector bag cage can be a significant hazard. Such a conductor becomes charged from the plastic resin to a voltage equal to that of the resin. When the voltage builds high enough to jump an air gap to ground, the entire metal surface is discharged in a single spark. The energy dissipated under such circumstances depends on the metal surface area and the magnitude of the charge. It can exceed the minimum ignition energy required to ignite a dust cloud of plastic resins or other materials such as pigments or additives. Therefore, proper grounding of all metal parts of any bulk handling system is essential to prevent ignition sources.

As indicated in the attached graphics all conveying equipment and lines, whether rigid or flexible, must be made of an electrically conductive material such as aluminum, stainless steel, conductive rubber or plastic. All conveying and storage components including bins, rotary valves, dust collectors including internal bag cages and conveying lines, both rigid and flexible, must be properly bonded together so that ungrounded sections do not act as a capacitor and develop a large static discharge. Hopper cars and hopper trucks must also be grounded. Care must be taken to maintain proper grounding.

The resistance to ground of each individual component must be less than $10^8$ ohms. An exception is components subject to brush discharges from a bed of plastic resin. Because of the higher current carrying capacity in this case, resistance to ground must not exceed 10 ohms. If higher readings than these are obtained, corrective action should be taken to reduce the resistance to an acceptable level before use of the equipment. It should be noted that a piece of equipment, such as a bag house, can be comprised of multiple individual
components: bag cages, bag clamps, inspection doors, etc. Small components, such as bolts, are excluded from this requirement because capacitance is too low to cause an ignition source.

**Explosion Hazards:**

Plastic resin particles small enough to pass through 30 mesh screens are considered as fines and dust particles. Some plastic resin fines and dust are defined as a Class I dust i.e., lowest explosive level, by the Bureau of Mines and the National Fire Protection Association (NFPA) Standards. The following are important issues when dealing with plastic resin fines and dust:

1. There are three important values to know when dealing with plastic resins fines and dust:
   - The Kst is the maximum rate of pressure rise, which is a measure of explosion severity. There are different Kst values depending on the particle size.
   - The MIE is the minimum ignition energy required to ignite a dust cloud.
   - The explosive concentration range of the plastic fines and dust is related to particle size.
2. As particle size decreases the hazard of a dust explosion becomes greater. As particle size gets small enough to pass through 200 mesh screens, the Kst values increase and the MIE values decrease.
3. The humidity of the air also plays a part. Drier air is more favorable to dust explosions than moist humid air. You should review the data with the resin manufacturer for the particular plastic resins being handled. Also avoiding concentrations of dust and fines is certainly desired.

For more information on this topic the NFPA Standards (Standards 68, 69 and 654) should be consulted. The Bureau of Mines is also a good reference source for information in this area.