

# A New Generation of Vacuum Conveying Systems for Handling Carbon Black

Many tire manufacturers may be familiar with vacuum conveying systems but not for the handling of fragile carbon black, and for good reason! In fact, pneumatic conveying just started to become popular with tire manufacturers when low velocity pressure type dense phase pneumatic conveying systems were introduced just a few years ago.

However, prior to purchasing such pneumatic conveying systems, most tire manufacturers usually did extensive testing to verify the ability of the systems to effectively convey the fragile carbon black. The extremely low velocities achievable with many of the pressure type dense phase pneumatic conveying systems proved they could keep product degradation very low, making them ideal for conveying fragile carbon black.

There are many obvious benefits to the new low velocity pneumatic conveying systems when comparing them to traditional pneumatic conveying systems or even older mechanical handling systems such as belt conveyors, bucket elevators, screw conveyors and vibratory conveyors.

Some of the benefits of pneumatic conveying systems are that they are totally enclosed and void of bearings to grease or maintain and are less costly to purchase, install and operate. They also eliminate cross contamination of material, have lower dust collection requirements and are more flexible to design.



*Shown above is a high density vacuum conveying system for unloading railcars.*

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In some situations the dense phase pressure type of pneumatic conveying systems, although applicable, require more headroom than might be available. In these situations a vacuum type system is much more appropri-

ate, because it requires much less headroom at the beginning of the system and can save considerably on construction costs.

In the past, however, the versatile and relatively low-cost vacuum type pneumatic conveying systems were not normally used or even considered suitable for handling carbon black. The primary reason vacuum types of systems were not used, was because of the very high conveying line velocities associated with them. The high conveying velocities created severe degradation and smearing of the fragile carbon black.

Since any degradation of the carbon black is considered

detrimental to the tire mixing process, and usually results in extremely high and unacceptable process handling and maintenance, vacuum type systems for the most part were just not considered for conveying carbon black.

Times have now changed and vacuum conveying technology has improved considerably. A whole new breed of very low velocity vacuum conveying systems have recently been developed for conveying carbon black and many other fragile materials. These higher technology systems can be generally categorized as either high density or dense phase vacuum conveying systems.

This article will examine the new high density vacuum conveying systems. But, before we talk about this new generation of systems, we must first understand the basics of how all vacuum conveying systems operate.

### The Basics of Vacuum Conveying Systems

The basic components of any vacuum conveying system are the pickup nozzle, conveying line, vacuum filter/receiver and the vacuum generator. The heart of



**Shown above is a high density vacuum unloading system utilizing a vacuum filter/receiver mounted above a dense phase full line system to convey carbon black.**

the system is the vacuum generator, which is the only power source. The vacuum generator creates the required negative pressure in the conveying line and vacuum filter/receiver.

The vacuum generator can be a fan, Venturi Eductor, positive placement blower or vacuum pump. The type of vacuum generator chosen will determine the maximum negative pressure

VACUUM CONVEYING SYSTEMS								
	LOW DENSITY (DILUTE PHASE)						HIGH DENSITY (DENSE PHASE)	
SYSTEM TYPE	FAN		VENTURI EDUCTOR		POSITIVE DISPLACEMENT BLOWER		VACUUM PUMP	
PRESSURE RANGE	-20 inches WATER	-37mm MERCURY	-8 PSIG	-55 BAR	-7 PSIG	-48 BAR	-13 PSIG	-.90 BAR
SATURATION	10 to 30 CUBIC FEET OF AIR PER POUNDS OF MATERIAL	3 to 14 CUBIC METERS OF AIR PER KILOGRAMS OF MATERIAL	15 to 35 CUBIC FEET OF AIR PER POUNDS OF MATERIAL	5 to 16 CUBIC METERS OF AIR PER KILOGRAMS OF MATERIAL	3 to 5 CUBIC FEET OF AIR PER POUNDS OF MATERIAL	3 to 14 CUBIC METERS OF AIR PER KILOGRAMS OF MATERIAL	.30 to .85 CUBIC FEET OF AIR PER POUNDS OF MATERIAL	.09 to .39 CUBIC METERS OF AIR PER KILOGRAMS OF MATERIAL
MATERIAL LOADING	1.3 to 0.45 POUNDS OF MATERIAL PER POUNDS OF AIR	.59 to 0.20 KILOGRAMS OF MATERIAL PER KILOGRAMS OF AIR	1.0 to 3.0 POUNDS OF MATERIAL PER POUNDS OF AIR	.45 to 1.36 KILOGRAMS OF MATERIAL PER KILOGRAMS OF AIR	4.2 to 2.5 POUNDS OF MATERIAL PER POUNDS OF AIR	1.91 to 1.13 KILOGRAMS OF MATERIAL PER KILOGRAMS OF AIR	85 to 30 POUNDS OF MATERIAL PER POUNDS OF AIR	38.56 to 13.61 KILOGRAMS OF MATERIAL PER KILOGRAMS OF AIR
CONVEYING VELOCITY	6,000 FEET PER MINUTE	1,829 METERS PER MINUTE	4,000 to 8,000 FEET PER MINUTE	1,219 to 2,438 METERS PER MINUTE	4,000 to 8,000 FEET PER MINUTE	1,219 to 2,438 METERS PER MINUTE	100 to 1,000 FEET PER MINUTE	30 TO 305 METERS PER MINUTE
PRACTICAL CAPACITY	10,000 POUNDS PER HOUR	4,536 KILOGRAMS PER HOUR	10,000 POUNDS PER HOUR	4,536 KILOGRAMS PER HOUR	100,000 POUNDS PER HOUR	45,359 KILOGRAMS PER HOUR	200,000 POUNDS PER HOUR	90,718 KILOGRAMS PER HOUR
PRACTICAL CONVEYING DISTANCE	500 FEET	152 METERS	150 FEET	46 METERS	300 FEET	91 METERS	100 FEET	30 METERS

**Illustration No. 1**

that can be generated and the overall capability of the system. It will also determine the system's efficiency and general operating characteristics.

Since the maximum vacuum that can be generated in any situation is only 29.9 inches of mercury, the vacuum system performance is more limited than the pressure type systems. Therefore, for maximum performance, vacuum conveying systems should be utilized for shorter conveying distances only. (See *Illustration No. 1*)

During operation, the material to be conveyed in a typical vacuum system is pulled through the conveying line and into a vacuum filter/receiver by the negative air flow created by the vacuum generator. When the material reaches the vacuum filter/receiver, the conveyed material drops by gravity into the hopper of the vacuum filter/receiver. The conveying air is then separated from the conveyed material by passing through the filter media in the vacuum filter/receiver.

When continuously discharging material from the vacuum filter/receiver, a rotary airlock or gatelock must be utilized to maintain the proper vacuum required for conveying. For batch discharging, only a simple outlet valve is required. Also, it must be understood that the conveying velocity in a vacuum system is always lowest at the beginning of the system, which is the pickup point. The conveying velocity then gradually increases and is highest at the end of the conveying line.

Conversely, the air pressure is always highest at the pickup point and gradually decreases with distance, and is lowest at the end of the conveying line. (See *Illustration No. 2*)

It is also important to understand that the overall performance of a

vacuum conveying system, and the general conveyability of any given material, will vary greatly depending upon its physical characteristics and the type of vacuum generator chosen.

Therefore, laboratory testing of a material to be conveyed is usually mandatory to verify conveying rate, conveying pressure, line size, conveying velocity and energy values. Testing is also necessary to verify system characteristics like conveyability and buildup tendencies.

Vacuum systems can generally be categorized into two different groups. These two groups are

low density, typically called dilute phase or lean phase vacuum systems, and high density, typically called dense phase vacuum systems.

### Low Density Vacuum Conveying Systems

Low density, or dilute phase vacuum conveying systems, are usually the most basic and lowest priced vacuum systems available. They are best suited for vacuum conveying applications where material degradation or wear is not a major concern, but where low initial cost is.

Low density vacuum conveying systems are normally designed to

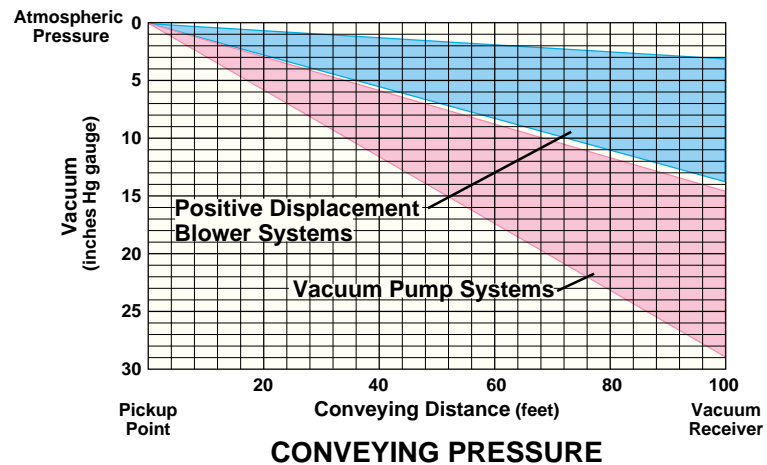
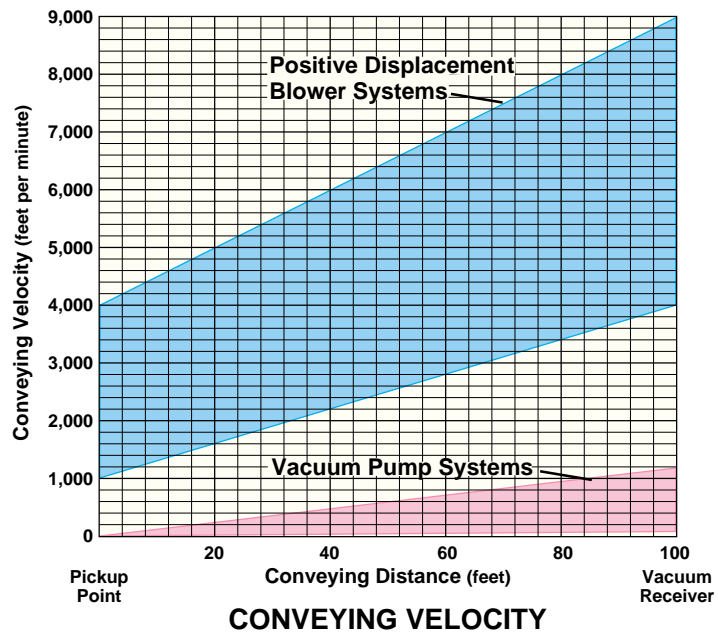
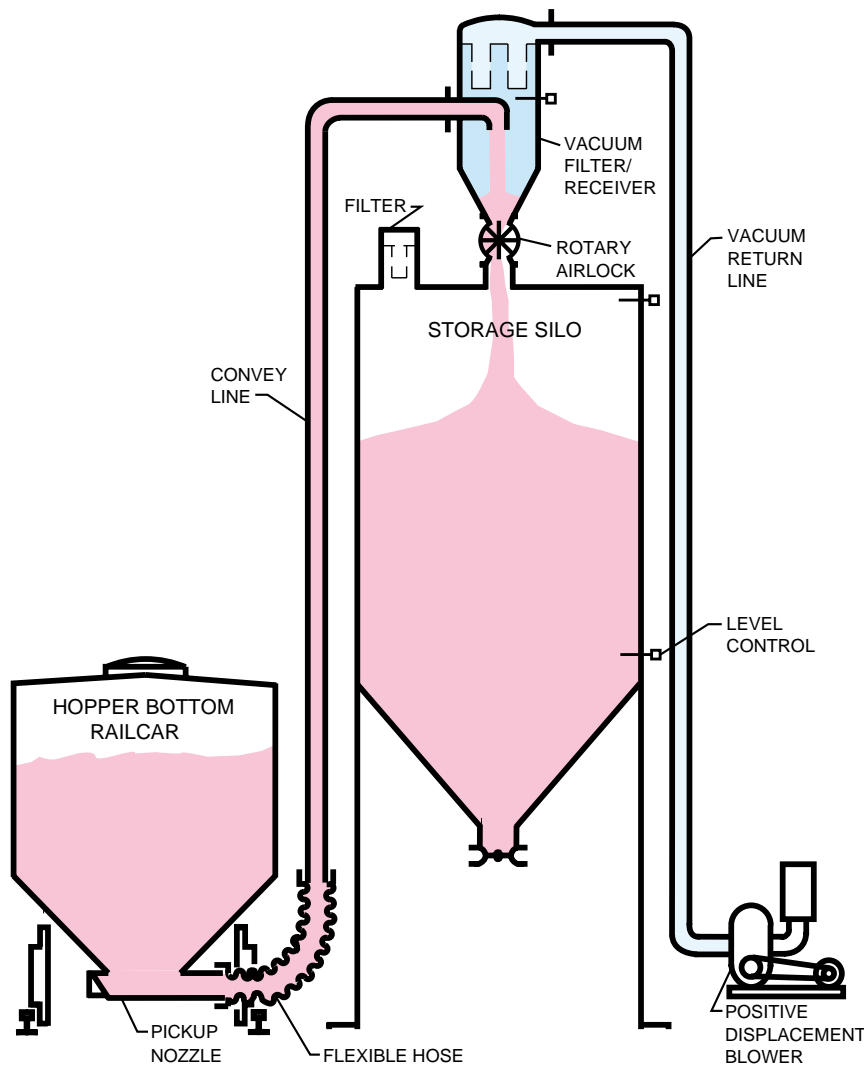


Illustration No. 2



**Illustration No. 3 - Low Density Vacuum Conveying System**

vacuum convey at a higher air-to-solids ratio and a higher conveying line velocity. They have a simple design and generally use a rotary airlock feeder for material discharge, and most often utilize a lower cost vacuum generator. Most non-abrasive, fine, granular, low bulk density, fibrous and/or large light particle materials can be easily handled in these low density vacuum systems.

Low density vacuum conveying systems require a minimum starting, or pickup velocity of about 2,000 to 4,000 feet per minute. The conveying velocity then increases to a higher terminal velocity at the end of the system

from about 6,000 to 9,000 feet per minute. Due to air pressure limitations, practical conveying distances should generally be limited to about 500 lineal feet.

Because of the higher conveying line velocities associated with low density systems, these types of systems are not really suitable for the handling of fragile carbon black. The high conveying line velocities create smearing and buildup of the carbon black on the inside of the conveying line and the eventual plugging of the system.

Also, due to the higher velocities, conveying line wear becomes a

major issue, especially if the conveyed material is considered abrasive.

Primary components in the low density vacuum conveying system include a pickup nozzle at the beginning of the system; a method to control material flow; a vacuum conveying line with couplings and tubing bends; a vacuum filter/receiver; a secondary filter and a vacuum generator such as a positive displacement blower. (See Illustration No. 3).

The vacuum generator is used as the power source. It might be a positive displacement blower that produces vacuum levels of about 14 inches of mercury.

For continuous conveying applications, a rotary airlock feeder or optional gatelock hopper is installed at the end of the system. The rotary airlock is most common, but it must only be used on a non-abrasive application. Otherwise, severe wear will occur and system performance will



**Shown above is a high density vacuum unloading system utilizing Dyna-Chek® 4 booster fittings and a vacuum hose to convey material from a hopper-bottom railcar.**

deteriorate. Also, if the rotary airlock is used, it must be remembered that due to its construction, it will typically leak about 18 to 20% of the conveying air.

All the air needed to convey the material is normally added at or near the vacuum pickup nozzle. The material is then metered into the pickup nozzle by a volumetric feeder, such as a rotary airlock and/or by controlling the air volume and pressure.

The material is then mixed with the conveying air and moves through the conveying line to the vacuum filter/receiver.

### High Density Vacuum Conveying Systems

High density vacuum conveying systems have the highest performance and are the most energy efficient of any of the vacuum systems. They are the best vacuum systems for conveying materials that are fragile, abrasive, heavy, light, fine, coarse or difficult to handle, such as carbon black.

These systems operate with a very high solids-to-air ratio and have the ability to produce very low conveying line velocities. This enables fragile materials like carbon black to be conveyed with minimal degradation and abrasive materials to be conveyed with very low wear on the system.

The primary power source is a high pressure vacuum pump that can produce up to 29 inches of mercury. With high density vacuum systems you can determine a conveying velocity that suits your material, not the other way around.

Typical terminal conveying velocities for high density vacuum systems are from a low of 50 feet per minute up to about 800 feet per minute. However, for optimum performance, the conveying distance should be limited

to 100 feet, and the conveying line velocities for carbon black should be no greater than 250 feet per minute.

An important component of high density vacuum conveying systems is the addition of Dyna-Chek® 4 booster fittings spaced along the conveying line. The Dyna-Chek booster fittings provide added performance, adjustability and much better reliability for most types of carbon black conveyed.

In addition, the high density vacuum system with the Dyna-Chek booster fittings can easily be operated in what is termed the "Full Line Concept®" mode. In the Full Line Concept mode, purging

of the conveying line, and the degradation associated with it, for the most part is totally eliminated. This mode provides the ultimate control when conveying carbon black, to lower material degradation and to minimize any maintenance.

Primary components of the high density vacuum system include a pickup nozzle at the beginning of the system; a vacuum conveying line with couplings and tubing bends; Dyna-Chek 4 booster fittings; a vacuum filter/receiver; a secondary filter; and a high pressure vacuum pump. (See *Illustration No. 4*).

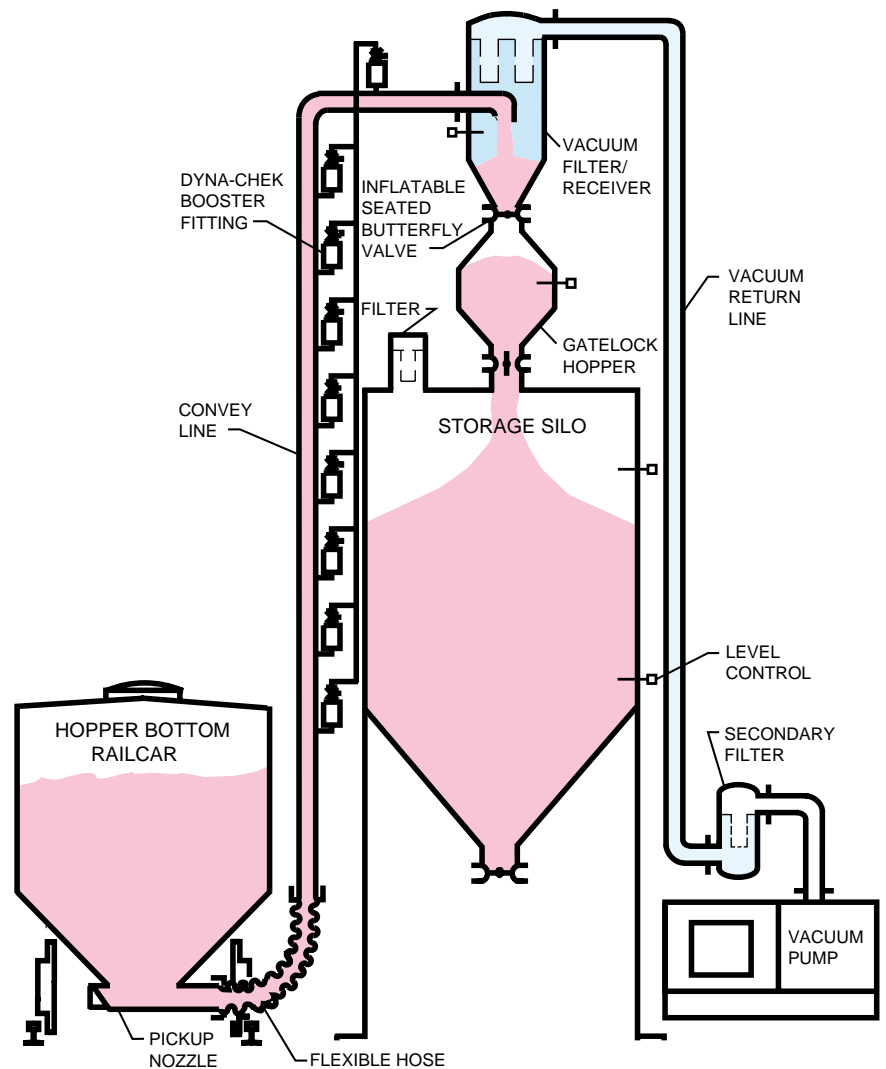


Illustration No. 4 - High Density Vacuum Conveying System

For continuous conveying applications, a gatelock hopper with an inlet and outlet valve is installed at the end of the system.

Unlike low density vacuum conveying systems where all the air needed to convey is added at the start of the conveying line, the high density vacuum system with booster fittings requires only the displacement air to be added at the beginning. The balance of the air needed to convey is then introduced through the Dyna-Chek 4 booster fittings that are spaced along the conveying line.

At the start of the system, or at the pickup point, carbon black is flood fed into the conveying line inlet, eliminating the need for metering of the material. The material and air move through the conveying line to the vacuum filter/receiver.

As material enters the vacuum filter/receiver, the conveying air is separated from the material and the air passes up through the filter media and then through a secondary filter before entering the vacuum pump.

The result of this new vacuum conveying technology is that the conveying velocities, when handling fragile carbon black or any suitable material, can be adjusted to the type of material conveyed.

System performance can then be optimized to provide a tire manufacturer the control desperately needed to keep pace with the various grades of carbon black that may be encountered now and in the future.



**Shown above are multiple conveying lines conveying carbon black to six storage silos.**

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