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How Pre-Engineered Vacuum Conveying Systems Evolve

Page 6

IN THIS ISSUE

Diagnose Problems With Pneumatic Conveying Systems

When diagnosing and troubleshooting problems with pneumatic conveying systems, it frequently requires a whole system approach.

Page 5

Pneumatic Vacuum Conveying Lessons Not Taught in School

While engineering schools typically focus on foundational principles, designing conveyors, and other bulk material handling machinery, real-world applications demand hands-on experience and problem-solving.

Page 13

Pneumatic Conveying, Abrasive Materials, & Minimizing the Impacts

When transferred material is abrasive, the very physics that make pneumatic conveying efficient can become a primary cause of contact surface degradation and process instability.

Page 20

Corrosive-Resistant Conveyor Solutions

The new corrosion-free conveyor system is built for chemical manufacturing facilities. These conveyors feature construction made entirely from high-performance plastics, including HDPE, UHMW, acetal, and nylon, eliminating metal components and ensuring long-lasting durability, product safety, and contamination prevention. The conveyors are rugged and modular, allowing chemical manufacturers to phase in additional system components. This flexibility enables the conveyors to withstand daily exposure to harsh chemicals.
Dynamic Conveyor, Norton Shores, MI 231-798-1483
dynamicconveyor.com

Mixing & Grinding Solution

Bühler introduces CompactMix, a solution that combines mixing and grinding for precision fineness, consistent quality, flexible production capacity, and high energy efficiency. From soft praline centers to coatings for snack bars and ice cream, this solution enables efficient manufacturing of confectionery masses for spreads, fillings, and various other applications. CompactMix brings together the ShearMix mixing system with a spiral agitator for fast, uniform mixing, and the Aurora ball mill to reduce particle size.
Bühler AG, 9240 Uzwil, Switzerland +41 71 955 26 75
buhlergroup.com

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Mobile Vacuum Conveying Systems

VAC-U-MAX mobile vacuum conveying systems offer easy mobility between process areas. Systems incorporate an adjustable suction wand where operator introduces material to the process. Material is conveyed from containers, feed bins, or pick-up adapter to up and over processing or packaging equipment. Rolling frame includes control panel, vacuum receiver, and vacuum producer. Vacuum receiver is easily hoisted up and down. **Scan QR code for RFQ**

Activator™ Bulk Bag Unloader

VAC-U-MAX Bulk Bag Unloading Systems offer flexible unloading options, including a screw discharger for weighing materials, a rotary valve for direct charging with metered feed, or a standard pick-up adapter. The Activator™ Bulk Bag Unloading System enhances material flow with a unique 4-paddle design, using 50% less compressed air. Additional options include iris valves, loss-in-weight designs, AEROFLEX flexible screw conveyors, and dust collectors. **Scan QR code for RFQ**

Central Vacuum Cleaning Systems

VAC-U-MAX Central Vacuum Cleaning Systems provide robust, continuous 24/7 operation, supporting anywhere from 3 to 100 pick-up points and multiple operators at once, making them ideal for demanding industrial environments. With over 70 years of application expertise, these systems are integral in applications ranging from clearing dusty spills at rail car unloading stations to maintaining cleanliness in high-output food processing plants. Engineered with high-efficiency filtration capable of handling up to 5 tons per hour, VAC-U-MAX central systems reduce clean-up time, improve plant safety for OSHA compliance, enhance working conditions, and boost productivity and profitability, making them an invaluable asset for industrial facilities. **Scan QR code for RFQ.**

Explosion-Proof Vacuum Cleaners

VAC-U-MAX offers a full line of intrinsically safe ATEX certified, explosion-proof, compressed air operated industrial vacuum cleaners designed for Class I and II hazardous areas. Available in 15, 30, and 55 gallon models, each intrinsically safe system operates without electricity or heat, and includes the vacuum cover, drum, conductive hose, dolly, tool cleaning kit, compressed-air hose with quick-disconnects, and polybag drum liners. Ideal for combustible dust environments. **Scan QR code for RFQ.**

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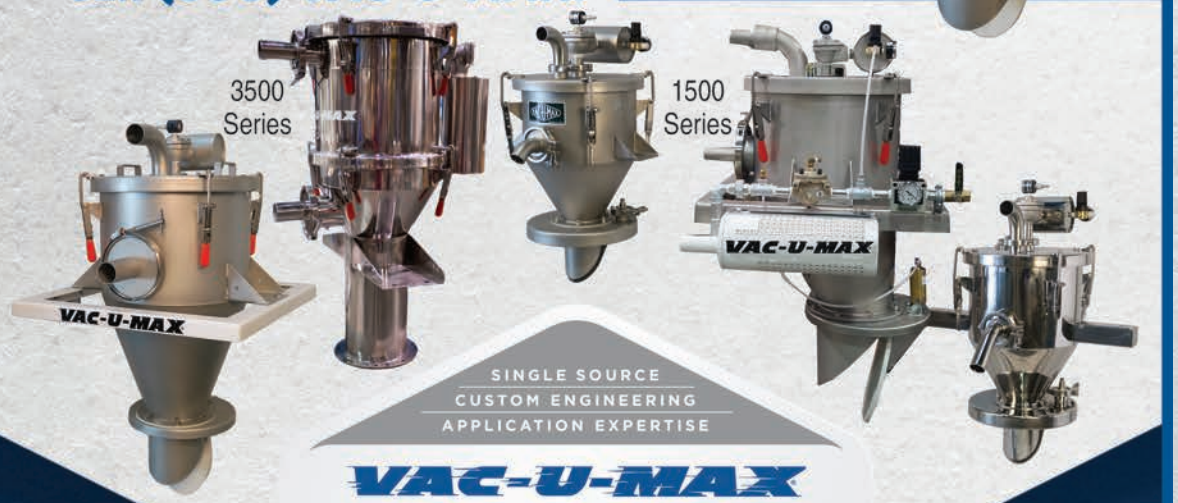

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VAC-U-MAX direct-charge loading systems provide exclusive, turnkey solutions for direct transfer into blenders, mixers, reactors, or any vessel capable of withstanding vacuum. Systems include power source, filters, controls, adapters, and VAC-U-MAX expertise, enabling continuous, spill-free transfer of powders and bulk materials, while reducing waste, and exposure to dust. **Scan QR code.**

Tube Hopper Vacuum Receivers

VAC-U-MAX straight-sided tube hopper material receivers are ideal for non-free flowing materials, offering rapid discharge rates that minimize non-conveying time and enable higher transfer rates. The straight-wall, no edge, no ledge design features an automatic discharge valve the same size as the tube, ensuring quick discharge of even difficult-to-handle materials. **Scan QR code.**

How Pre-Engineered Vacuum Conveying Systems Evolve to Meet Demand

By Doan Pendleton, Vac-U-Max

Pneumatic conveying is a critical technology in the dry bulk solids processing sector, delivering powders and granular materials through controlled airflow. For process engineers, its value extends far beyond simple material transfer: Vacuum conveying minimizes dusting, eliminates manual handling, reduces wear on downstream equipment, and enables consistent, repeatable convey rates that support tight process tolerances. As industries push for cleaner operations, improved worker safety, higher automation, and seamless integration with mixing, dosing, blending, packaging, and extrusion, vacuum conveying continues to gain traction as the preferred method for dry bulk material handling and transfer.

Although the fundamental physics remain consistent, practical system design can vary significantly based on material behavior, plant footprint, throughput targets, and regulatory or safety constraints. Over the decades, Vac-U-Max has advanced the field with innovations such as pre-engineered vacuum receivers, direct-charge loading into vacuum-rated process vessels, and fully mobile conveying solutions, bringing vacuum conveying to the process. While specific equipment may differ among suppliers, the engineering principles that guide reliable pneumatic conveying remain universal across the industry.

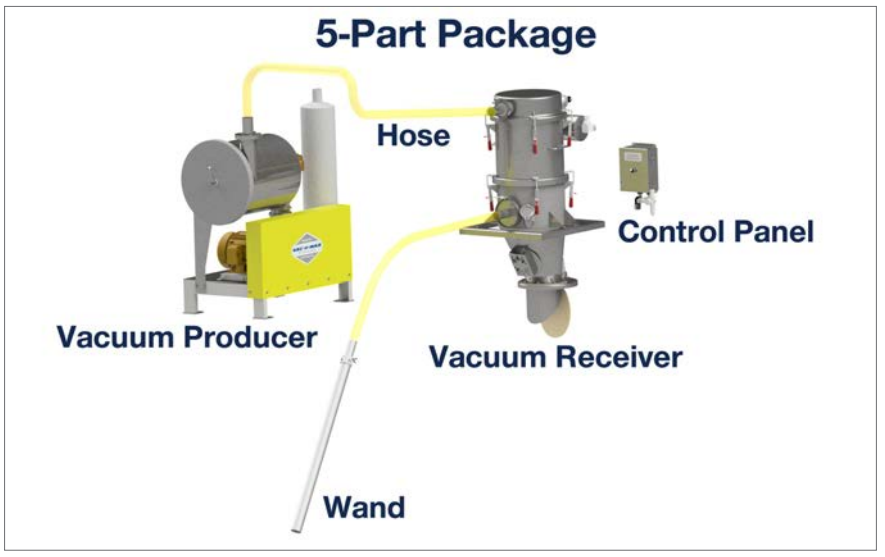
Vacuum conveyor shown as part of a two-stage system: One unit fluidizes and transfers powder to the mixer, while a second unit conveys finished material from the mixer to the next process.

Functional Components

A pre-engineered vacuum conveying system is designed as a modular, flexible solution for vacuum conveying of dry bulk solids and powders. While configurations can vary depending on the material and application, each system is built around five core components that work together to ensure reliable, efficient transfer of dry bulk solids.

At the heart of the system is the vacuum conveyor, the primary vessel where conveyed material is collected. These conveyors are designed for quick, clean discharge and easy maintenance, often incorporating specialized filter media to handle fine or dust-prone powders. Providing the necessary suction is the vacuum pump or blower system, which may use rotary lobe, regenerative, or venturi vacuum technology, depending on material characteristics and throughput requirements.

Material moves through tubing or piping, engineered to reduce friction and protect the integrity of the product as it travels from source to destination. A wand is supplied with pre-engineered systems, and material enters the conveying line, ensuring smooth, non-plugging operation. Completing the system is the filtration or dust collection assembly, which protects the vacuum producer from fine particulates and ensures clean air discharge through cartridges, filter bags, or cyclonic separation. Together, these elements form a cohesive, dependable vacuum conveying solution for a wide range of dry bulk materials.



Pre-engineered vacuum conveying package showing the five core components: vacuum producer, flexible hose, pickup wand, control panel, and vacuum receiver.

Conveyor–Filter–Discharge Valve Interface

Vacuum conveying performance is fundamentally influenced by the design of the vacuum conveyor body, its interaction with material flow behavior, and the equipment being loaded. Vacuum conveyors are manufactured in three primary body styles, each engineered to address distinct material characteristics and process conditions.

Vacuum conveyor body style selection is driven by material flow behavior. Concentric-cone designs are suited for easy-to-convey, free-flowing powders that move reliably under low cohesion. Offset-cone vacuum conveyors are used for harder-to-convey materials with moderate cohesiveness, variable bulk density, or irregular particle shape that require improved flow conditioning.

Stainless steel concentric-cone vacuum conveyor, designed for free-flowing powders such as sugar, salt, flour, resins, and other low-cohesion materials.

Offset-cone vacuum conveyor, ideal for harder-to-convey materials that require improved flow control, including protein powders, granulated chemicals, and irregular powders.

Stainless steel tube hopper vacuum conveyor, engineered for difficult-to-convey powders prone to clumping, bridging, or ratholing, such as high-fat powders, starches, cocoa, and fibrous materials.

For the most challenging applications, tube hopper configurations are engineered for difficult materials that tend to clump, bridge, or rathole, providing the vertical-wall flow assistance needed to maintain consistent discharge and prevent flow obstruction. Selecting the appropriate vacuum conveyor body style is foundational, as conveying performance is directly linked to the material's mass flow.

Filters Determine System Efficiency

As the vacuum producer establishes the system's driving force, the filtration assembly focuses on airflow quality and stability. Vacuum conveyor filters commonly incorporate non-stick, static-conductive media delivering 99.9% efficiency at 1 micron, ensuring reliable air-material separation and rapid dust release with each batch conveyed.

Vacuum conveyor filtration options are selected based on particle size distribution, overhead space, hygiene or sanitation requirements, and maintenance constraints. Filter options include:

- **Sock-type filters:** Sock-type filters feature smooth-surface media for low residual dust retention and fast pulse-cleaning, making them ideal for pharmaceutical and food applications requiring stringent sanitation.
- **Cartridge filters:** Cartridge filters provide a high surface-area-to-volume ratio that supports compact conveyor designs, while maintaining filtration efficiency capacity and stable vacuum levels under continuous-duty operation.
- **Side-access pleated bags:** Side-access pleated bags offer expanded filter area with improved dust release and stable differential pressure across extended cycles, along with convenient service access in confined spaces.
- **Top-access pleated bags:** Top-access pleated bags enable clean-side filter removal, potentially eliminating confined space procedures, for facilities that require reduced exposure maintenance procedures.
- **Uni-filter:** For lower-rate conveying systems, uni-filter assemblies deliver excellent dust release and simplified upkeep where maximum filter area is not a primary requirement.

Filter selection must align with expected dust loading, particle size distribution, material abrasiveness, and the pulse-cleaning frequency required to preserve steady-state airflow.

Discharge Valve Selection & Integration

Discharge valve integration with the vacuum conveyor and filtration assembly is essential for maintaining batch consistency, discharge reliability, and overall vacuum integrity. Discharge options include powered or counterweighted dump valves for rapid-cycle batch release; knife or orifice gates for

precise metering into downstream equipment; rotary valves that provide airlock functionality for continuous conveying or metered discharge; and wafer or butterfly valves suited to compact installations requiring straightforward flow isolation. Selecting the appropriate discharge valve requires evaluating sealing performance, material compressibility, downstream pressure conditions, and the mechanical demands imposed by the conveying duty cycle.

Material Behavior & Conveying Dynamics

From a process engineering standpoint, understanding material behavior is the starting point, and often the limiting factor, in successful pneumatic conveying design. Dry bulk solids do not behave uniformly; their conveying performance is governed by a complex interaction of particle size distribution, shape, bulk density, cohesiveness, friableness, moisture content, and angle of repose. Fine, cohesive powders — such as silica, starch, carbon black, and titanium dioxide — tend to agglomerate, resist flow, and require higher energy to entrain. In contrast, free-flowing granular materials — like sugar, salt, or polymer pellets — accelerate more readily in an airstream, but may carry risks of impact damage or attrition under excessive velocity. Even small formulation shifts, environmental changes, or batch-to-batch variability can alter how a material behaves inside a conveying line.

Whether transferring as little as a few pounds per hour or up to 25,000 lb/hr (11,340 kg/hr), vacuum conveyor performance is determined by the material's flow characteristics and the conveyor's design, ensuring reliable handling across a wide range of powders and bulk solids.

Besides pickup velocity at the beginning of a convey line, a key design parameter for any pneumatic system is the saltation velocity — the minimum air velocity required to keep solids fully suspended and prevent particle dropout in horizontal lines. Determining this velocity is fundamental to sizing the vacuum pump, selecting pipe diameters, defining safe operating velocities, and predicting system stability under different load conditions. Falling below saltation velocity increases the likelihood of line plugging, surging, excessive wear, and process interruptions; exceeding it can cause product degradation, segregation, or loss of yield.

Because every material responds differently to acceleration, entrainment, and airflow, material testing is especially important. Controlled laboratory trials allow engineers to characterize flowability, assess cohesive tendencies, measure entrainment behavior, and observe potential issues such as agglomeration, abrasion, or electrostatic charging. These insights directly shape decisions such as pickup device geometry, vacuum receiver design and configuration, filtration strategy, line routing, and allowable velocity range.

A test facility capable of full-scale testing can measure critical material properties, including bulk density, flowability, particle attrition, vacuum conveying rates, and vacuum conveyor designs.

Cohesive or poor-flowing powders often require specialized pickup assemblies, regulated feed mechanisms, or enhanced vacuum levels to achieve stable transfer. Abrasive materials may necessitate wear-resistant elbows, reinforced receivers, or velocity management to extend system life. Friable or fragile materials benefit from gentler acceleration profiles and reduced conveying velocities to avoid breakage.

Ultimately, material conveying behavior dictates nearly every engineering choice in pneumatic conveying — from the vacuum source and filtration strategy to discharge options — and testing ensures the vacuum conveying system performs reliably under real-world operating conditions.

Because pneumatic conveying performance is directly influenced by how a material behaves in an airstream, its cohesion, aeration response, bulk density, moisture content, and susceptibility to attrition, the selection of a vacuum conveyor depends on accurately understanding these properties. Even modest variations can alter the required conveying rate, receiver configuration, or filtration approach, making material characterization a critical engineering step when scaling up a process, or adding a new packaging line.

When process engineers partner with experienced pneumatic conveying specialists, much of the guesswork in specifying a conveying system is eliminated. Pre-engineered vacuum conveying packages offer “off-the-shelf” conveying know-how, available in standardized five-part packages and ready to install and integrate into new or existing lines. These packages help ensure the system aligns with the application’s required throughput range, cleaning methodology, footprint, headroom constraints, and the control packages, while reducing design guesswork keeping up with manufacturing demands.

Application-Specific Engineering Across Industries

Vacuum conveying requirements vary widely across pharmaceutical, nutraceutical, food, and petrochemical and chemical processing environments. Each industry imposes distinct considerations, including sanitary designs, containment levels, abrasion resistance, moisture sensitivity, or compatibility with combustible dusts. Optimal system performance is achieved through material characterization, process evaluation, and collaboration with vacuum conveying specialists who can match conveyor design, filtration media, and discharge valve technology to the material’s behavior and operational demands.

Streamlining Material Transfer

Pre-engineered vacuum conveying systems simplify bulk material handling by delivering ready-to-deploy solutions engineered for specific applications and material types. By matching conveyor design, filtration, and discharge technology to the material’s flow characteristics, these systems ensure reliable, repeatable, and hygienic transfer while minimizing installation complexity and engineering time.

This mobile vacuum conveying system is engineered for flexible material transfer between process points, minimizing manual handling, dust, and operator effort.

Direct charge blender loading and mobile vacuum conveying highlight the flexibility and efficiency of pre-engineered solutions. Direct charge blender loading systems vacuum convey powders and granules precisely into blenders, reducing manual lifting, improving batch consistency, and maintaining material integrity. Mobile vacuum conveyors allow quick relocation between process points, minimizing dust, stair climbing, and handling labor while maintaining high-performance vacuum conveying across multiple production lines.

These pre-engineered systems are purpose-built for their respective application niches, from free-flowing powders to highly cohesive or fibrous materials, helping process engineers optimize production, reduce downtime, and improve workplace safety. By integrating targeted designs, filtration, and discharge technology, pre-engineered vacuum conveyors streamline workflows, enhance efficiency, and allow engineers to focus on maximizing process performance rather than managing material transfer challenges.

Pre-engineered vacuum conveying systems represent a turnkey approach to bulk material handling, delivering precision, reliability, and safety while making the process engineer’s job faster, easier, and more efficient. They are the engineered solution that transforms how powders and bulk solids move through the production process.

Doan Pendleton is president of Vac-U-Max, a manufacturer of bulk material handling systems and industrial vacuum cleaning solutions (Belleville, NJ). With more than 35 years of experience, Pendleton is recognized for his expertise in the design, engineering, manufacturing, and dry bulk material transfer systems, as well as other technologies. Pendleton has cultivated extensive application knowledge across a diverse spectrum of industries, including food processing, pharmaceuticals, plastics, chemicals, and additive manufacturing/3D printing. For more information call 973-759-4600 or visit www.vac-u-max.com.