Vacuum Conveying: Safe, Secure, and Clean

By Nick Hayes, Volkmann Inc.

Powder transfer is a difficult business given the wide variety of products and differing conditions under which transfer has to occur. There are many issues to be considered depending on material properties, distances to be conveyed, risks of degradation and segregation, as well as the need to achieve suitable transfer rates. Moreover, with the increased awareness of explosion, emission, and environmental risks in today's manufacturing environment, the modern facilities manager now has to give serious thought to these factors when deciding on the best method of conveying bulk powders.

While the legislative requirements on safe operation may not be as stringent here in the U.S. as they are within Europe, recent changes to NFPA 654 and similar standards, compounded by plant explosions such as the Georgia sugar refinery, are leading to an ever-increasing awareness of the dangers associated with powder transfer.

There is ample evidence of the need for dust-free powder transfer to minimize these dangers and, as a result, modern conveyor manufacturers are increasingly raising the standards of the equipment available.

Three critical operational aspects should be identified before investing in any system. These are:

- Safety – does the system eliminate the explosion risk?
- Security – does the system protect the product from contaminates and/or protect the operators from the material being transferred such as in the case of an antibiotic?
- Sanitation – does the system provide easy access for cleaning, rapid changes of product, and maintenance of the equipment?

Vacuum conveyors are increasingly being found as the most suitable method of powder transfer, meeting all three criteria due to their inherent "closed system" functionality, providing easy and safe transfer. One obvious advantage to conveying under vacuum is that should a leak occur, it is always inwards. However, there is much more to this technique that qualifies it as the most effective.

For the purpose of this article we are concentrating on in-plant transfer using conveying systems with transfer rates from as little as a few hundred pounds an hour to rates in the 10,000 lb/hr range. Generally speaking these systems have conveying line diameter sizes of up to 4 in., and have particular advantages when it comes to safety.

Vacuum Conveying Safety

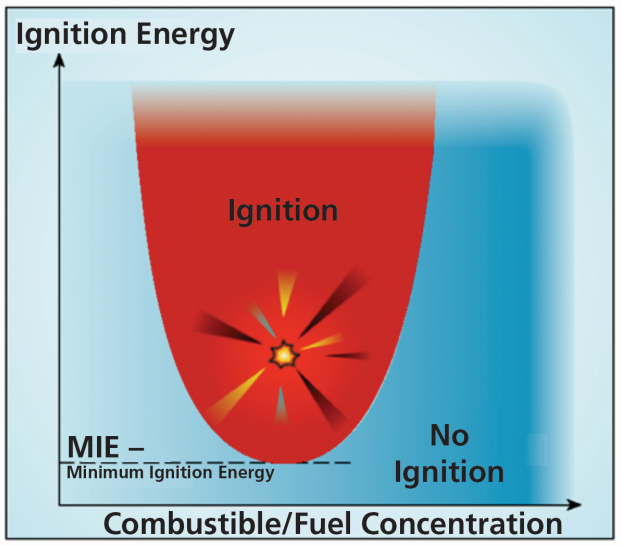
Beginning with explosion risk, according to NFPA 654 any vessel having a volume of less than 8 cu ft is exempt from the requirement to provide explosion vents or quick closure valves. Even so, any explosion, no matter how small the vessel might be, is a potential issue. Who amongst us would want to stand next to a 55-gal drum if it explodes? Better then to use a system that is inherently explosion-proof as standard. Using compressed air-driven vacuum pumps, and particularly those that are certified as explosion proof as European systems under the ATEX 94/9/EG & 99/92/EG guidelines, safe conditions can be assured.

The ATEX standard identifies a list of 13 potential ignition sources as follows:

1. Chemical reaction
2. Hot surfaces
3. Mechanical sparks
4. Flames, hot gases
5. Electric units
6. Flash of lightning
7. Electric compensation currents
8. Ultrasonic
9. High-frequency radiation
10. Electromagnetic waves
11. Adiabatic compression
12. Ionizing radiation
13. Electrostatic charges

If a vacuum conveyor is completely grounded and has been suitably certified, that vacuum conveyor is safe for use on any powder that has a Minimum Ignition Energy (MIE) of greater than 1 mJ when transferred in a powder-only environment (Class II or Zone 2). Unfortunately, MIE is not a term well understood in the U.S. where typically Kst is used as a measure of explosion risk. However, Kst actually measures the rate of an explosion. MIE, by contrast, measures the amount of energy needed to ignite a powder within a given powder air mixture. It follows that no ignition results in no explosion. In simple terms, MIE is established by lowering the amount of energy required to cause ignition.

Where flammable gases are present, such as in Class 1 Div 1 applications, using a system that can be run in an Inert Explosion-proof manner (INEX certified) using nitrogen as the conveying medium, is a safe approach.



Examples of Typical MIE values:	
Toner	1mJ
Cornstarch	3–5 mJ
Epoxy Resin	10 mJ
Sugar	30 mJ
Wheat Flour	50 mJ
Aluminum Powder	3mJ
Paracetamol	<10 mJ
Magnesium	20mJ
Cellulose	40mJ
PVC	1500mJ

(Note: The above are typical and for general reference purposes only. MIE can vary with individual site conditions. Testing should be carried out with the exact product in conditions as close to actual use to establish the specific values.)

Secure Conveying

By its very nature vacuum transfer is inherently clean and contained. Simply put, because of the vacuum, in the unlikely event of a leak, air leaks inward. Thus the potential for escaping powder to pose a danger to operators or the environment is avoided with simple steps such as ensuring adequate venting at discharge or transfer points, and the use of correctly designed connectors.

Filtration and separation of the product from the airstream is also critical. Commonly used felt seals, or 'O' rings, as a means of sealing the connection between the vacuum pump and the product areas are increasingly being found to be ineffective. Modern designs such as the patented QX (Quick Exchange) filter (Fig 1) have a rating down to 0.3 microns. For even greater security the addition of a secondary HEPA filter is possible.

The addition of an exhaust air adaptor to the rear of the vacuum pump allows the air already filtered from the conveying system to be piped away to a safe area.

Operator exposure limits (OELs) are particularly common in the pharmaceutical production areas where again, the advantages of conveying under vacuum become readily apparent. The use of glove box design, bag-opening stations such as the one shown on the next page, can further assist in making the complete operation emission free.

Clean Conveying

Clean material handling is not just limited to the issue of potential emissions during transfer. The ability to clean the equipment is critical, as is the requirement to do so in such a way that operators do not waste time in the process. High-quality stainless steel such as 316L conveyors constructed with simple modules that can be disassembled and cleaned without tools, play an important part in maintaining clean operations (Fig 2). Simplicity of the standard operating procedures (S.O.P.) for cleaning by using common size seals, non-adjustable clamps, and quick connects for everything from the valve actuators to the pneumatic connections, all save time.

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When there is a requirement for more stringent cleaning, often terms such as clean-in-place, wash-in-place, or wet-in-place are used. These techniques usually involve the use of spray nozzles and/or a flooding of the conveyor, useful for containing dust when disassembling the equipment. However, one must always remember the biggest challenge in the cleaning process is not wetting the unit, but rather drying it and doing so in such a manner that a swab test can verify the cleanliness. This is one area where conveyor parts manufactured for ease of assembly and access, without the use of tools, becomes particularly beneficial.

Fig 1 - Volkmann's patented QX filter and seal featuring both radial and lip seal features

Volkmann's Contained Rip and Tip Dump Station (RNT-CON) with its glove-box design allows for contamination- and dust-free opening and discharging of high-quality, high-potency powders and fines from bags, boxes, and small containers.

Hose designs that are light and sanitary can also play a big part in the effectiveness of a system and recent advances using static dissipative opaque hoses that include molded cuffs with sanitary fittings have improved the practicalities of hose handling.

Other Vacuum Considerations

Vacuum conveying is available in various forms using Venturi, regenerative blowers, positive displacement, and screw type vacuum pumps for the motivating force. Of these, some vacuum conveyors based on a Venturi pump principle, have an advantage over alternative pump technologies in that they are able to transport the material with a substantially higher negative pressure, pulling up to 28 in. Hg of vacuum.

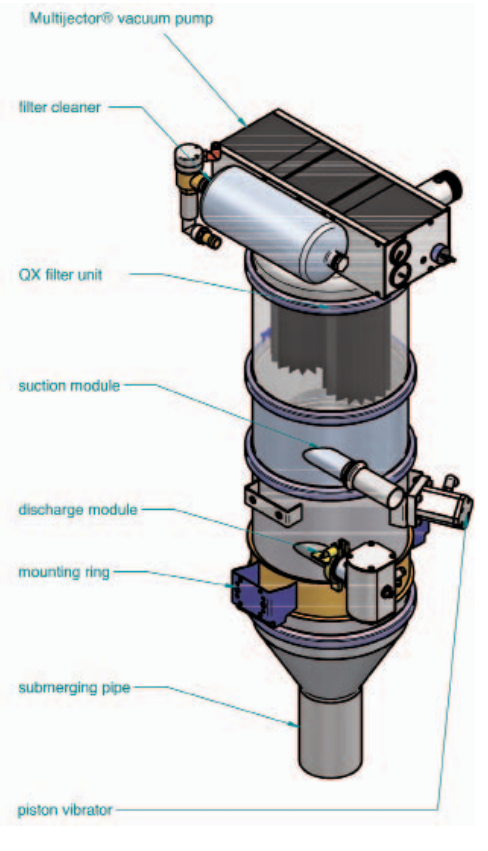

Fig 2: Volkmann Multijector conveyors offer no-tools disassembly/assembly to aid cleaning.

This suction ability allows a far larger application field and, together with the other inherent advantages of a compressed air-driven system, makes it a versatile method for transferring powders, granules, and tablets. While more basic vacuum conveyors can suffer suction line blockages when moving difficult and poor-flowing bulk materials, this is not the case with more sophisticated designs offering a high negative pressure differential, which are easily able to draw agglomerates and plugs of material through the conveying pipeline.

The lesser pressure differential of most conventional vacuum pump-driven suction conveyors allows only dilute (lean) phase conveying which, owing to the high velocities involved, leads to strong mechanical stress on the material being conveyed, resulting in product degradation and/or to extensive abrasive wear on the conveying line itself. In contrast, some technologically advanced systems can convey effectively at low velocities in plug (dense) flow conditions with the additional advantage of avoiding product segregation.

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Vacuum conveying has evolved to be an extremely versatile, safe, secure, and clean method of transporting bulk powders, particularly when those systems are ATEX certified, have quality filters and are easy to disassemble, assemble, and clean. Many more applications are now being handled using these state-of-the-art systems, while they improve plant efficiencies ultimately improving the profitability of manufacturers.

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Nick Hayes is president, Volkmann Inc. Volkmann engineers and manufactures high-quality, high-performance Multijector vacuum conveyors, bag dump stations, unloaders, and equipment for the safe handling of fine chemicals, granules, pellets, tablets, food particles, and small components for the pharmaceutical, nutraceutical, food, chemical, and lacquer industries. For more information, call 609-265-0101 or visit www.volkmannusa.com.