Factors that affect pneumatic conveying — Part II

In past “Pneumatic points to ponder…” columns we’ve addressed the issue of material properties. A material’s bulk density and particle density, as well as its particle size distribution, are some of the main physical properties that we deal with daily when working with bulk solids and designing pneumatic conveying and other material handling systems.

Knowing these parameters, we can go to the Geldart Model, as shown in Figure 1, which classifies powders according to their fluidization properties. Determining to which classification group a material belongs gives us a good start on our choice of pneumatic conveying equipment and system design.

A variety of other system and material factors also must be considered and analyzed. In Part I of this column, *(PBE, March 2019, p.18)*, we discussed dealing with conveying air temperature and moisture content. In this column, we’ll discuss material explosibility, chemical reactivity, and toxicity. We’ll also discuss how closed-loop conveying systems can offer advantages when dealing with certain types of materials and situations.

**Handling combustible and reactive materials**

A combustible fine powder suspended in air (or other gas) can create an explosive mixture. If a spark or ignition source is present, this explosive mixture can react violently, damaging equipment. Other materials can ignite spontaneously in the presence of oxygen due to their chemical composition, causing a chemical reaction that damages material and equipment. Some materials don’t even need oxygen for combustion because their chemical composition is a self-supporting combustible. Materials such as explosives and rocket propellants, for example, will react even when submerged in water.

In general, there are numerous precautions that need to be addressed when handling combustible materials in a pneumatic conveying system:

- Eliminate the ignition source.
- Inert the atmosphere.
- Use explosion relief such as panels, flameless arrestors, etc.
- Construct the equipment strong enough to contain the pressure consequence of an explosion following the appropriate NFPA guidelines and specifications.
- Use a fire-suppression system.
- Maintain a clean working environment with respect to dust buildup on equipment, building structure, and other flat surfaces, etc.

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**Figure 1**

Geldart’s classification model
• Be sure the proper electrical area classifications are being met
• Become familiar with the requirement for having a Dust Hazards Analysis (DHA) performed on your installation

The following information only briefly covers the basics of these precautions. For more information and the latest applicable NFPA standards, which are constantly being updated for explosion prevention, venting, suppression, and related topics, contact the NFPA.¹ Also check out past PBE articles and webinars that specifically address these issues related to the risk and responsibility involved when conveying a combustible dust.²

• Eliminate the ignition source. Be sure all of your pneumatic conveying system’s components are grounded because conveying a powder through a conveying line can create electrostatic charges. These charges are detrimental in several ways. They can discharge through a person working in the area, discharge in the conveyed material and cause it to ignite, and affect the conveying process by attracting the material to the conveying line wall or causing the material to agglomerate.

Using explosion-proof motors for the conveying system’s air supply, feeder, and diverter valves (if present) isn’t necessary because the motors are located outside the conveying equipment. However, if your material is combustible and your plant has a dusty atmosphere, also consider using explosion-proof motors and control cabinets.

Using nonconductive conveying line, which serves as an insulator, also can create a problem because an electrostatic charge can build up across the insulator. In some instances, transparent, nonconductive conveying line has shown material clinging to the line’s inside wall and then traveling back toward the feed point, opposite the airflow, due to electrostatic charges. To prevent problems, be sure the two conveying line sections on either end of an insulated section are grounded to each other.

One of the most difficult to remedy — and controversial — points in a pneumatic conveying system is the filter-receiver (a combination of a material receiver and integral dust collector). Many filter-receiver users believe material passing through the unit’s bag filters can create an electrostatic charge, which, when discharged, will ignite the fine dust in the bag filter area. To minimize potential electrostatic charge buildup in your filter-receiver, use grounded cages and bag filters. When properly designed — such as with metal fibers woven through the filter fabric — these filters and cages can conduct electrostatic charges and minimize explosion hazards.

• Inert the atmosphere. If the material being conveyed in your pneumatic conveying system will react with oxygen, consider using an inert conveying gas, such as nitrogen. Other options are flue gas or air in which additional nitrogen has reduced the oxygen content. Because using nitrogen can be costly, you can consider using a closed-loop conveying system, which we’ll discuss later in the column.

• Use explosion vents. Wherever a vessel such as a storage bin, silo, or dust collector will collect material — and especially if freeboard space lies above the collected material — consider using one of the several available explosion-protection venting technologies. These technologies are based on a material’s combustibility and the vessel size. The vent type and location choices also should take into account the equipment’s location within a building and the ability to vent outside that building to a safe area to prevent secondary combustion, injury to workers, or damage to the plant or equipment.

• Construct equipment so it’s strong enough to contain any explosion. If you can calculate the force that will be generated by your material’s combustion, you can design the conveying system’s vessels and conveying components to withstand these internal forces and contain the explosion. If the conveyed material doesn’t require oxygen to support its combustion and, instead, sustains combustion on its own, you may need a containment system. A material’s rapid combustion creates energy; use information on the energy levels that a material’s combustion can create (obtained from explosibility tests) to help you establish design limits for containing an explosion of that material in your conveying system. The details and formulas for making these calculations are available in the previously referenced NFPA documentation.¹

• Use a fire suppression system. You can install a fire suppression system inside a vessel where an explosion may occur. The system detects the start of combustion and reacts within a fraction of a second by releasing a suppressant that extinguishes the combustion before any damage occurs. Occasionally a fire suppression system reacts and releases the suppressant when no indication of a fire exists. In such a case, you may never know whether the system misfired or reacted so fast it prevented any sign of combustion.

The final three precautions on the list — maintaining a dust-free environment, meeting proper electrical area classifications, and familiarizing yourself with and meeting DHA requirements —
Using a closed-loop conveying system

As previously mentioned, if the material you’ll be conveying is toxic or reactive, or you’re using more expensive nitrogen as a conveying gas, you’ll likely want to take special precautions to prevent the material or air from escaping into the atmosphere. Consider a vacuum conveying system because it’s less likely to leak.

Using a closed-loop conveying system also can help when conveying with an inert gas — such as for a combustible material — or to incorporate cooling or drying into your pneumatic conveying system to deal with temperature or moisture issues (as discussed in Part I). Using a closed-loop system allows you to reuse conditioned conveying air. For instance, in a pressure conveying system, the receiver bin dust collector usually exhausts the air to the atmosphere. By connecting an airline from the exhaust to the pressure air supply’s inlet, we’ve “closed the loop” so we can reuse the conditioned air. Similarly, in a vacuum conveying system can return the air mover’s exhaust to the conveying system’s feed point, again closing the loop.

Figure 2 shows a closed-loop conveying system. As you can see in the figure, properly using a closed-loop system requires adding several pieces of equipment. Let’s start with the blower: A cooler is typically added to the blower discharge to prevent the recycled air’s temperature from rising. Although the cooler may be required only to protect the air supply from overheating, it also may be required for the conveyed material. Ideally, the cooler is located after the blower because this is where the system’s volume is smallest, and the air temperature is highest.

If your system uses a rotary lobe air supply, a pressure relief valve connection is located after the cooler. The valve connects to the blower inlet. The valve is normally closed but opens when the differential pressure across the valve exceeds the blower’s design level.

Next is the conveying system’s material feed. A closed-loop system can use any type of feeding device, but with some feeder types, preventing loss of the conditioned conveying air is more difficult. For instance, air leaks out of a rotary feeder-airlock, resulting in some conveying air loss.

The conveying system should terminate in a small vessel that’s isolated from the storage silo. The vessel prevents unexplained pressure or volume surges caused by withdrawing material from the silo or by other process conditions. The material should be discharged from the vessel into the storage bin through an airlock.

The conveying air exits the receiver vessel through the primary filter units, which can be normal bag or cartridge filters. Because the receiver vessel might be the system’s weakest structural member, install a pressure relief valve on the unit.

As with a vacuum conveying system, use an in-line filter to protect any of the downstream equipment from material carryover.

If the conveying distance is long, you can install a return fan in the return piping. This fan doesn’t control the air volume (which is controlled by the blower) but only applies a pressure differential (or boost) to the return air.

If the conveying air contains moisture, install a dryer on a bypass loop. The dryer should handle a portion of the total air flow, because the air can be circulated a few minutes before conveying starts to dry the system. After this point, the only moisture the dryer must remove is that picked...
up from the conveyed material.
The last and probably most
important decision to make is at
what pressure (or vacuum) the
conveying system should operate.
If you want to protect the con-
veyed material from outside air or
are using nitrogen as the convey-
ing gas, then you want the system
to be slightly positive. Any leakage
would, thus, be outward, prevent-
ing oxygen from leaking into the
system. For this system, choose a
design pressure and then control
that pressure at the blower inlet,
which will be the lowest pressure
point in the entire loop.

If, on the other hand, you’re
conveying a toxic material and
don’t want the material or air to
leak out, then design the system to
operate below atmospheric pres-
sure. Select a design vacuum and
then control the blower discharge
to that level. The blower discharge
will be the highest pressure in the
system, and if you keep the dis-
charge slightly below atmospheric
pressure, then the pressure in the
entire loop will be negative.

As always, please feel free to send
any questions you may have.    PBE

References
1. NFPA, 1 Battery March Park, Quincy,
   nfpa.org.
2. www.powderbulk.com

For further reading
Find more information on this topic
in articles listed under “Pneumatic
conveying” in Powder and Bulk
Engineering’s article index in the
December 2018 issue or the Arti-
cle Archive at PBE’s website. (All
articles listed in the archive are
available for free download to reg-
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