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Ask Joe! Column

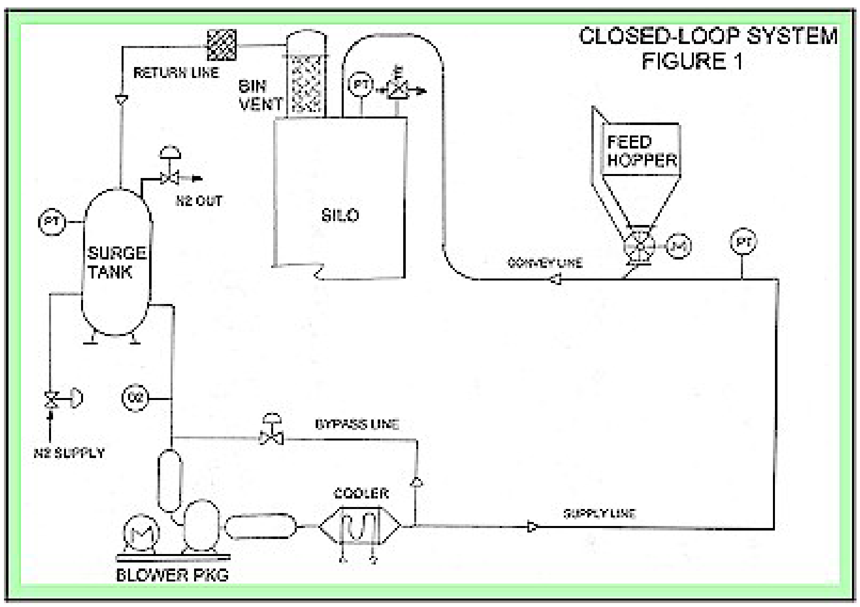
Solving Closed-Loop Pneumatic Conveying System Problems

Guest article by Tim Singer of Pneu Solutions

Without a doubt, the closed-loop system is the most problematic type of pneumatic conveying system in existence. The majority of these systems are dilute-phase pressure, but vacuum and dense phase systems are also run in closed loop as well.

Closed-loop pneumatic conveying systems are commonly used in conjunction with an inert gas as the conveying medium. Nitrogen is the most commonly used inert gas. The closed system provides a means to recycle and conserve the inert gas transport medium. The inert gas serves several purposes. It can be used to dry a material, to keep a hygroscopic material dry, or to provide an atmosphere around the material in which to inhibit potential explosions of the dust clouds produced by that material. Figure 1 is a simplified diagram of a closed-loop system.

Figure 1: Closed-Loop System Diagram



Many conveyed materials are highly explosive in specific concentrations. Three things must be present to cause any type of explosion: an ignitable energy source, oxygen, and a spark or flame. Pneumatic conveying provides an easy means to transport explosive materials because it can economically eliminate two of the items that are necessary to generate a dust explosion. The air, or oxygen, in the system is displaced by the inert gas medium and the equipment and piping are positively grounded to prevent any possibility of a spark caused by the release of a static electricity charge.

When a closed-loop pneumatic conveying system is not functioning properly, it often exhibits wide pressure and vacuum fluctuations. This situation can lead to upset conditions that release potentially explosive concentrations of material outside the system or let oxygen into the system. The typical place for material to be released and oxygen to enter the system is on top of the receiving silo through the pressure/vacuum release safety valve. When this upset situation occurs, the safety conditions of the system have been breeched. It is time to correct the system immediately because all three factors necessary to fuel an explosion may be present.

The key to proper design of a closed pneumatic conveying system is in the details. Even if all the necessary equipment is in place, an improperly set switch can throw the system out of balance and into upset conditions. A thorough understanding of how the closed system is designed to operate is the key to safe operation. What are the most common problems plaguing these systems? The following four items are most common key points missed during the design stage that cause most of the problems.

Filter and Silo Design

The receiving filter and silo must be designed to withstand a higher than normal internal pressure.

The normal internal design pressure of a silo in an open-type pneumatic conveying system is usually about 0.5 PSIG. This is enough to withstand the differential pressure of a bin vent filter in an upset condition. In a closed-loop system, the design pressure of the receiving filter and silo will usually be a minimum of 3 PSIG. Within the closed system, there is no longer a condition of atmospheric pressure after the silo filter. There exists a return line between the silo and the blower inlet. A positive internal pressure is always maintained in this section of piping with the lowest gage pressure in this section occurring at the blower inlet flange. This must be the situation to avoid the possibility of a vacuum leak that may let in unwanted oxygen from the atmosphere.

When the system is in operation with a gas flow, there will be a differential pressure in the return line associated with the piping and other equipment within this section. The differential pressure is produced by: a blower inlet silencer (0.3 PSI), blower inline protective filter (0.3 PSI), a bin vent or receiver filter (0.2 PSI), and return line piping and elbows (0.3 PSI or more). The unknown factor is still the return line piping and elbow losses. The equipment layout between the receiving silo and blower must be determined prior to determining the final design pressure ratings of the silo and filter.

Once the physical relationship between the silo and blower are set and the pipe routing is complete, the final pneumatic calculation can be performed to determine total pipeline pressure losses. Starting with a slight positive pressure at the blower, this quickly puts the normal operating pressure inside a silo at 1.5 PSIG or higher. In order to minimize the silo internal design pressure rating and minimize project costs, it is advisable to minimize the pipe losses by locating the blower package as close to the receiving silo as possible.

Make-up Gas and Overpressure System

There must be a gas make-up and a gas overpressure system installed.

No closed system is truly perfect and there is going to be times that the system will require rebalancing of gas volume. The gas can exit the system through airlocks, slide gate valves, and pipeline leaks.

A system can become “off balance” during start-up as material enters the system and displaces [compresses] the gas that was at rest in the system before start-up. The material entering the system will offset some of the volume of the compressed gas, but a net loss of gas volume [actual cubic feet] is usually the result. A gas make-up valve needs to be incorporated and sized accordingly.

Conversely, as the system is shut-down and the gas decompresses, there may be too much gas in the system and the need to safely expel some gas may be required.

A typical example of this is during the unloading of a pressurized bulk truck similar to the one shown in the photograph, Figure 2. These trucks hold approximately 1,000 cubic feet of material. When they are near empty of material and filled with compressed gas at 15 PSIG, they can hold 2,000 cubic feet of gas. Where does the additional gas go upon shutdown? The gas volume will produce a net increase in pressure when the system is at rest. The need for a gas overpressure valve will release the excess gas volume and solve this problem.

Figure 2: Pressurized Bulk Truck

Proper system design and equipment selection can minimize the adverse effects of these conditions and conserve the net gas loss.

Blower Design

A system requiring a positive displacement blower producing approximately 1000 CFM or more of gas will require a bypass line around the blower.

A positive displacement blower is the typical gas flow device used for these systems. The blower will reach full flow condition in a matter of a few seconds as the motor reaches full speed. The blower must pull in as much gas as it pushes out.

Is the return line capable of allowing this to happen without drawing some amount of vacuum at the blower inlet? With a surge tank in front of the blower, a small blower may not have a problem. As the blower increases in volume and size, some amount of vacuum at the inlet is not possible to avoid without an aid. The addition of a bypass pipe and control valve from the blower discharge side to the blower inlet side will allow the blower to start and recirculate the gas under a no-load condition and without disturbing the pressure conditions of the system. The bypass line control valve can be slowly closed and the gas will start its way through the main piping loop in a controlled manner.

The gas pressure will remain nearly constant at the inlet of the blower and the internal pressure at the blower inlet can be set at just a few inches of water column. Without the bypass line, the return line pressure must typically be set at 1 to 2 PSIG in order to absorb the vacuum surge at start-up. Remember the problem above? If the internal pressure is at 2 PSIG at the blower inlet, than the pressure is 3 to 4 PSIG at the receiving silo. This situation results in higher silo costs. Also, the conveying pressure is higher than necessary and conveying capacity may be reduced as a result.

Baghouse Design

A top-loading pulse-jet, baghouse design is highly recommended for closed systems that convey materials with very small particle size or having many fines.

A top-loading filter design will increase the initial capital cost of the project, but will absolutely pay for itself down the road in maintenance costs.

Anyone who has had responsibility for the operation of a closed-loop system conveying a fine powder with bottom-loaded filter bags has an experience to share of the maintenance nightmares they experienced. The fine material has a tendency to migrate through the area at the top of these filter bags and into the clean side of the filter and return line. This situation will eventually lead to a high differential pressure in the blower protective filter and will add an unnecessary pressure drop to the return line.

The result is increased operating pressure in the receiving silo. The problem is easily avoided with a properly designed top-loading filter unit. The sealing arrangement is improved and filter bag replacement is simplified. The photo [below right] shows a typical top-loaded filter bag where the bag cage and venturi arrangement are loaded from the top of the filter tube sheet.

Other filter arrangements may be possible from a new design or retrofit perspective. Another possibility is a pleated filter installation. Most baghouse equipment suppliers can provide details of the different filter arrangements along with the installation procedures.

Summary

The key to safe and proper operation and maintenance of these systems lay in the knowledge of how the components and controls function together to maintain a balanced system. A pneumatic conveying system operating with material spillage is a potential human and environmental hazard in need of immediate attention. The addition of the above mentioned design considerations to a pressure dilute, closed-loop pneumatic conveying system will increase plant safety and provide a safe work environment for you and your co-workers.

About our author:

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Welcome to Ask Joe!, a monthly column by our resident materials handling guru, Joe Marinelli of Solids Handling Technologies. Joe addresses the issues that bug you the most. And Joe knows!! Formerly with Jenike & Johanson, Solids Flow and Peabody TecTank, Joe is an expert on materials handling.

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