CONVEYING IDEAS 3

- Tips for cleaning and sanitizing pneumatic conveying lines
- Mass flow meters measure flow rates the gravimetric way
- Validation of ozone as a sanitizing agent in pneumatic conveying pipelines

we make processes work

Tips for cleaning and sanitizing pneumatic conveying lines

To remove surface build-up and contamination from conveying lines, consider the piping system and cleaning methodologies.

Pneumatic conveying is an effective form of moving dry materials in the pet food industry and other food markets. However, the long lengths of conveying pipe present a challenge when it comes to addressing cleanliness and sanitation.

While the closed nature of pneumatic conveying systems protects material from outside contamination like debris, insects, etc., it is difficult to identify and protect against internal forms of contamination, such as build-up, microbial growth, etc. A plant HACCP or sanitation plan that does not address thousands of feet of pipe and dozens of elbows is incomplete and at risk for a recall.

At-risk materials

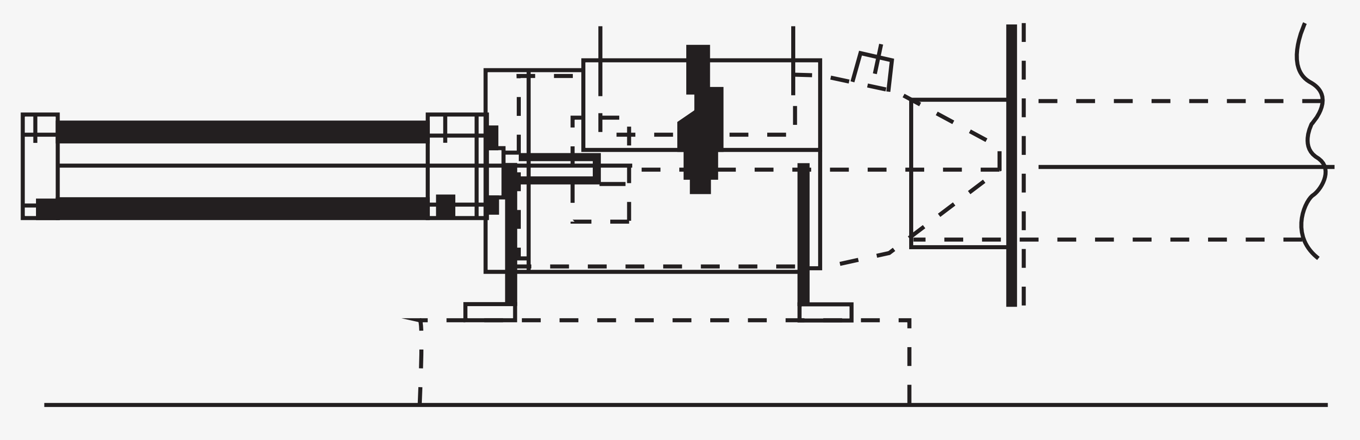
Deciding if a particular pneumatic conveying line should be cleaned at regular intervals involves identifying what materials pass through the pipeline, the inherent risk of contamination and where the conveying line is in the process. The analysis focuses on extrusion processes.

For conveying lines upstream from the extruder, assuming that a plant is using the proper kill step, the focus is on the worst offenders. Products that contain elevated moisture, exhibit cohesive properties or are known to carry pathogens from their origin can be considered at-risk materials. Because these conveying lines are upstream of the extruder, we are primarily concerned with material build-up that can form large quantities of a biological contaminant. In this case, periodic mechanical cleaning is sufficient to mitigate the problem. See the mechanical cleaning methods section for more information.

Downstream of the extruder, although the material itself can be considered safe, we are primarily concerned about recontamination. As ambient air invades processing areas, contaminants available in the environment at harmless concentrations can plant and multiply where conditions are favorable. Pipelines in these areas carrying finished foods will be more likely to be mechanically cleaned at regular intervals followed by a sanitation step. See the sanitation options section for more information.

Keeping piping systems clean can be a complex problem.

Ledgeless couplings eliminate gasket contact with the product stream.



Pig launcher

Conveying line variations

Piping used in a pneumatic conveying system can be comprised of piping components that vary by size and type. It is common to keep the pipe size and type constant across the length of a particular run. However, stepping, increasing the pipe size, is used to control the velocity of material in some cases. Couplings play a large role in how piping segments (straights or elbows) transition to one another.

A properly installed ledgeless coupling will create a near seamless joint, while a poorly installed compression coupling can see large gaps between the pipe ends. The former will minimize contamination of stagnant material and facilitate mechanical cleaning. The latter promotes varying quantities of inactive product that can be difficult to remove by any means short of disassembly. Most piping systems experience variations from one of these extremes to the other throughout the line. However, a new piping system can be engineered to eliminate the risk of line contamination.

Finally, diverter valves and other ancillary piping components can have similar challenges. Although the primary flow of air and material may readily flow through the component, there may be recesses or dimensional changes that keep material from cleaning out completely. Non-uniform shapes also may limit the effectiveness of mechanical cleaning methods. Any existing piping system will need to be evaluated for consistency in piping diameter, quality of pipe joints and the potential effect of valves and piping components.

Mechanical cleaning methods

There are relatively few ways to gain access to the internal surface of a pipe to remove surface buildup and contamination, and each method has its challenges.

1) Remove and manually clean

For very short conveying lines with a few manageable pieces this option is probably the most straightforward path.

2) Scouring material

Running a secondary material through the conveying line, such as whole corn, salt, rice hulls, etc., to scour the inside surface of the pipe and remove contamination. Managing the quantity of scouring material required can be a challenge, unless it is used elsewhere in the process. It also is difficult to attack all surfaces because the material primarily follows the concentrated air path.

Pigging projectile sample

Conveying dry ice through the piping can remove build-up and deposits in the line.

3) Pigging

A surface-contacting projectile is sent down the conveying line multiple times to remove surface contamination. The projectile uses a seal with the pipe surface to clean and drag it through the conveying line. If the dimensions of the flow path change (coupling gap, non-concentric diverter valve etc.) the seal can be lost or the pig can become caught. The piping system should be engineered to properly process the pig. A launcher and retrieval system can optimize the pigging process.

4) Spray washing/CIP

The entire pipeline is filled with a cleaning solution or a sprayer is sent through the conveying line. The primary obstacle is the addition of a liquid which must be completely removed and dried before the conveying line can be used again. Add to that the logistics of storing and creating the spray and flow and then remediation of the contaminated liquid.

5) Dry ice conveying

Like the scouring material, dry ice is conveyed through the conveying line except that the extreme low temperature has a strong influence by cryogenically freezing deposits, making them brittle and changing pipe dimensions through shrinkage. In terms of ice remediation, much of the dry ice sublimates and leaves with the convey gas while the remainder can be collected and disposed. The ability to interact with the entire inside pipe surface is still questionable and significant condensation issues arise with the external pipe surface from the cool metal.

The above mechanical methods offer various advantages and obstacles depending on the attributes and condition of a conveying line. Fairly low-tech, pigging generally offers the greatest value if the piping system can effectively pass the projectile. A new piping system would be engineered to effectively pass the projectile and include features to easily launch or retrieve the units. The simplicity of pigging offers additional advantages compared to storing and disposing of intermediate material, such as scouring or dry ice or addressing the liquid contamination.

Sanitation options

In critical processes, for example, finished product handling a simple mechanical cleaning may not be sufficient to guarantee the removal of all biological contaminants. A sanitation step may be required to create the needed production break required by a comprehensive HACCP plan. An important aspect of the sanitation step is validating that the process being used kills the biological contaminants when operated under the correct conditions. Sanitation options for conveying lines are relatively limited. Below are some current offerings:

1) Antiseptic foam

A foaming agent is pumped down the conveying line. Validation would involve the number of injection points and pumping speed to guarantee surface coverage and the needed residence time. Foam residual removal is a concern so as not to affect the next batch of material.

2) Heat

Elevating the temperature of the pipe surface to unsustainable levels is another way to kill contaminants.

Piping used to pump ozone through lines.

This can be done with heat tracing or by pumping hot air through the system. In either case, this method will struggle with heat loss to the environment and heat gradients, or hotter and cooler areas of the pipe. Validation involves a heating process for a particular pipe run in a particular environment that will sufficiently heat the entire pipe and selection of a temperature/duration to guarantee a kill.

3) Gaseous

Adding an antiseptic gas, such as ozone or chlorine dioxide to a carrying air stream. The high concentration gas is mixed to desired levels, pumped through the pipeline and then captured and remediated at the end. Validation involves demonstrating that the gas concentration is distributed throughout the pipe and identifying concentration/duration of exposures that guarantees a kill. Of the sanitation methods, gaseous appears to be the most advantageous selection because of the ability to easily inject the gas, reach all internal surfaces and remove the gas from the piping system via an air flush. Ozone (O_3) offers some unique advantages over other gas mediums because it can be generated from atmospheric oxygen and returned to the atmosphere.

Although ozone could be emitted outdoors to naturally break back down into oxygen over time, a highly concentrated stream can be broken down with a simple catalyst and return room air at levels below normal ambient conditions. Significant work also has been done to validate the concentration of O_3 and the required exposure time on pipelines, more so than other methodologies.

To execute an effective conveying line cleaning strategy, considerations for the characteristics of the convey piping system need to be accounted for as well as the features of the cleaning methodologies. For a best-in-class solution, an engineered piping system with ledgeless couplings or valves would be used with pigging and ozone for cleaning and sanitizing.

System for adding ozone to the conveying line

By Jonathan Thorn,
Executive Director, Process Technology

Mass flow meters measure flow rates the gravimetric way

A flow meter accurately measures high material flow rates, handles changes in material properties and fits into tight spaces.

What makes a good flow meter?
Accuracy and reliability, of course.
However, depending on your application, other factors can come into play, too. These include the meter's ability to handle a variety of material and flow conditions, as well as its mechanical simplicity, space requirements and capital and operating costs. A mass flow meter that uses the Coriolis force measuring principle is a simple, low-cost unit that can serve as a flow meter, a batcher or a continuous feeder. It can accurately measure high material flow rates, handle changes in material properties and fit into tight spaces.

The mass flow meter is used in many applications, including:

- Measuring flow rates and controlling feeding of dry powder and grain to food and pet food extrusion processes.
- Measuring powder and granule flow rates for loading storage bins and at loading and loadout stations, and measuring grain flow rates in mills.
- Measuring flow rates and controlling feeding of powder and granules in plastic compounding plants, in granulating lines or to continuous mixers in chemical plants.
- Measuring flow rates and controlling feeding of dust to metallurgical processes.

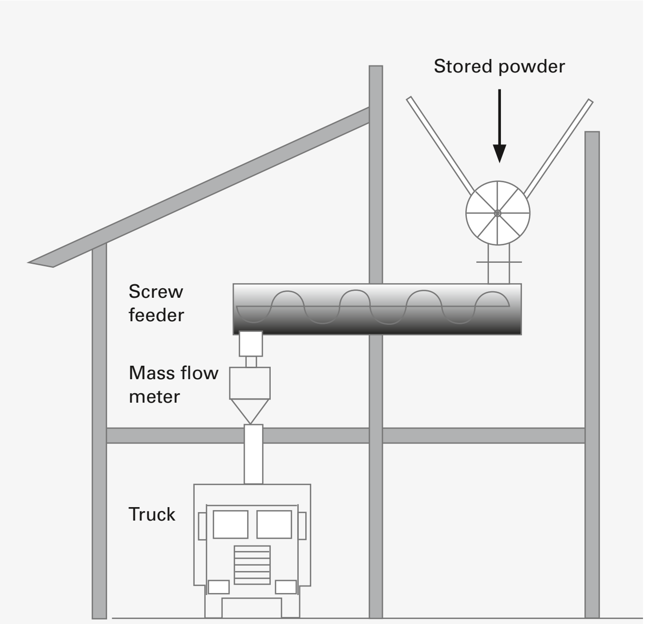


Figure 1: A mass flow meter measures powder flow rates from a screw feeder at a loadout station.

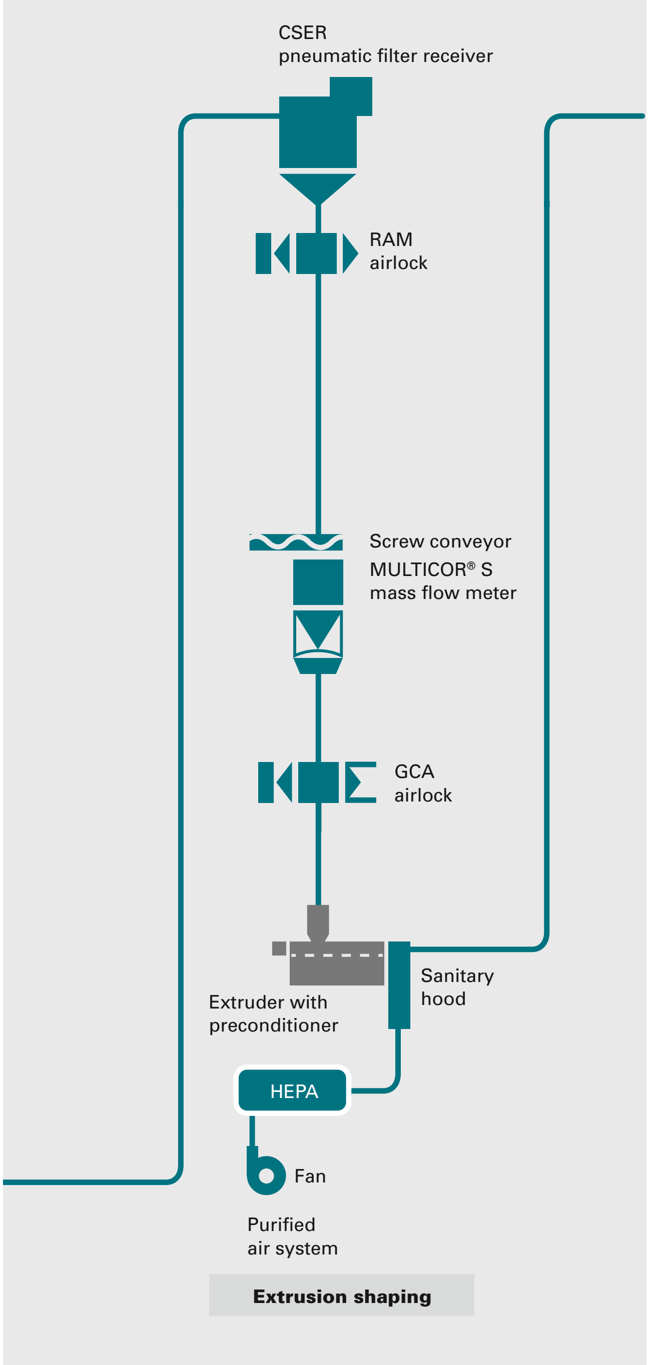


Figure 2: An example of a mass flow meter installed in a pet food extrusion shaping process.

Figures 1 and 2 illustrate some common installation options for a mass flow meter. Figure 1 shows a mass flow meter measuring powder flow rates from a screw feeder at a loadout station.

Figure 2 shows a mass flow meter installed in a pet food extrusion shaping process. The mass-flow meter receives raw ingredients from a screw conveyor and accurately meters them to the extruder.

How a mass flow meter works

A mass flow meter consists of a rotating measuring wheel with several guide vanes surrounding a central deflection cone, as shown in Figure 3. The wheel is mounted on a drive shaft, which extends upward from the deflection cone. The wheel is inside a dust-tight enclosure with an off-center feed inlet above one side of the wheel and a central outlet below the wheel. The drive shaft is driven by a swivel-mounted electric motor located above and outside the enclosure.

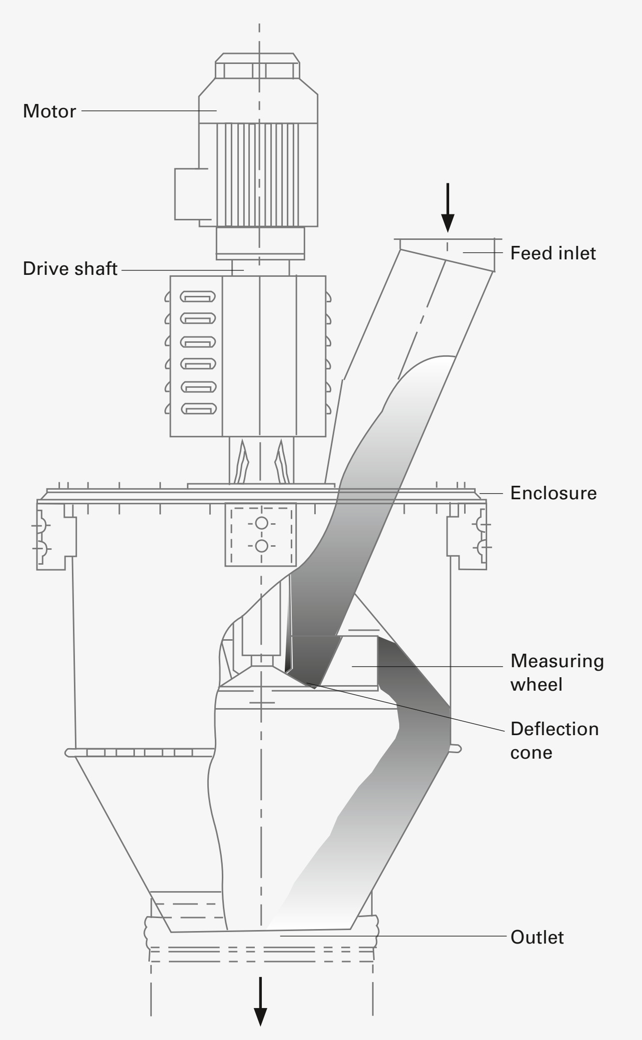


Figure 3: A mass flow meter consists of a rotating measuring wheel with several guide vanes surrounding a central deflection cone.

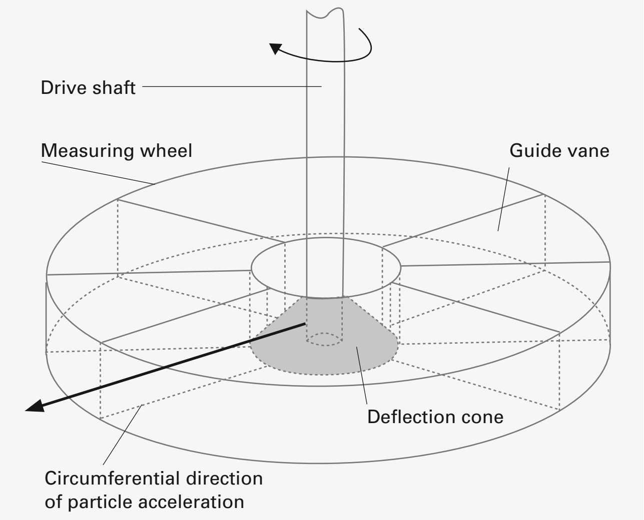


Figure 4a: Particle acceleartion inside measuring wheel

A microprocessor-based controller is located near the mass flow meter and is linked to a load cell and digital speed transducer. In turn, the load cell and associated hardware are linked to the motor and serve as a gravimetric torque-measuring system. The digital speed transducer is linked to the area between the drive shaft and gearbox to measure the wheel's rotation speed.

How material flows through the meter

In operation, the motor drives the shaft, causing the measuring wheel to rotate at a constant angular velocity. Material flows downward through the inlet into the wheel's top, and the deflection cone deflects the particles outward in the radial direction.

As shown in Figure 4a, the guide vanes catch the particles and accelerate them in a circumferential direction. And as shown in Figure 4b, the measuring wheel's rotation causes three forces – centrifugal (F_z), frictional (F_r), and Coriolis (F_c) – to act on the particles as they move along the guide vanes:

- The centrifugal force acts in the radial direction.
- The frictional force acts in the opposite direction, reducing centrifugal force.
- The Coriolis force acts in the tangential direction and produces a measurable reaction torque in the measuring wheel's rotation that is directly proportional to mass flow.

The material discharges from the measuring wheel's outer diameter, where the particles come together as they impact the enclosure's inner surface area before dropping through the outlet. The motor's exterior location keeps the motor cool when the meter handles hot material or operates in

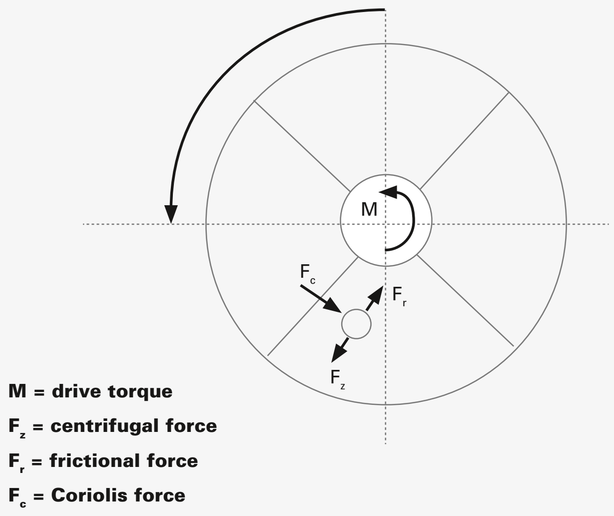


Figure 4b: Forces acting on the particles

The guide vanes catch the particles and accelerate them in circumferential direction. The measuring wheel's rotation causes three forces – centrifugal (F_z), frictional (F_r), and Coriolis (F_c) – to act on the particles as they move along the guide vanes.

warm environments, as well as prevents dust from getting into the motor.

How the meter measures mass flow

The motor's drive torque compensates for the measuring wheel's reaction torque, so measuring either torque provides an accurate mass flow measurement. As the wheel rotates, the torque-measuring system measures the wheel's reaction to torque. The motor's swivel mounting prevents frictional forces from influencing this measurement.

As shown in Figure 5, the digital speed transducer monitors the rotation speed and inputs it to a controller with the amplified signal from the torque-measuring load cell to determine the actual material flow rate. The controller determines the material flow total by integrating the flow rate with the total feeding time.

A look at the equations behind the operation

Examining the equations the controller uses to calculate mass flow rate will help you understand how the mass flow meter depends on the Coriolis force.

The drive input into the drive shaft is equal to the energy imparted to the material as it passes over the guide vanes:

$$E = \int M \times \omega \times dt = \int dE$$

where E is the energy imparted to the material, M is the drive torque, ω is the angular velocity, dt is time, and dE is the change in energy.

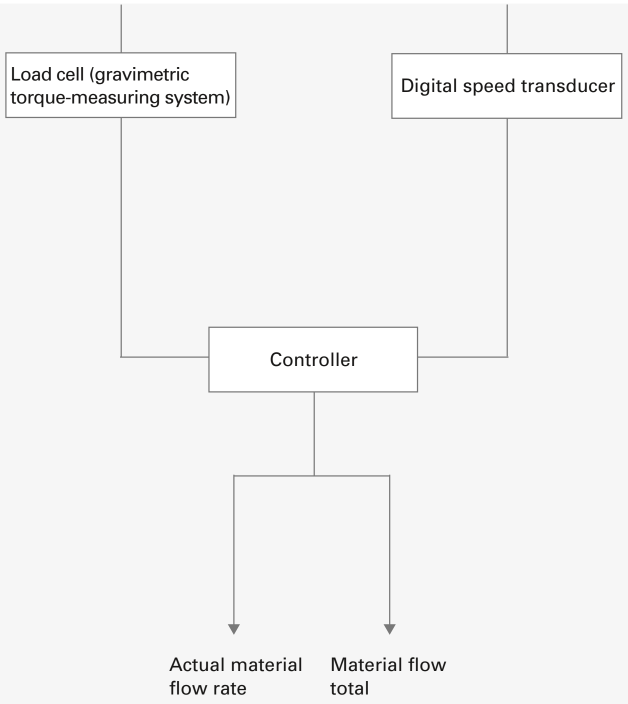


Figure 5: The digital speed transducer monitors the rotation speed and inputs it to a controller with the amplified signal from the torque-measuring load cell to determine the actual material flow rate.

The energy required to move a particle with the mass (dm) out of the measuring wheel is:

$$dE = dm \times \omega^2 \times Ra^2$$

where Ra is the measuring wheel's radius.

From these equations it follows that the drive torque (M) can be measured as:

$$M = m \times \omega \times Ra^2$$

where m is the mass flow.

As the equations show, M, which depends on the Coriolis force, is directly proportional to the mass flow (m). Thus by measuring drive torque, the mass flow meter accurately measures the mass flow rate.

This measuring technique prevents frictional forces between the particles and the measuring wheel or between different material layers from affecting the flow rate measurement. The meter can accurately measure flow rates as low as 1 t/h (25 ft^3/h). The material's physical properties (such as the friction coefficient, impact coefficient, density, or humidity) and the flow path's characteristics (such as drop height) also don't influence the meter's sensitivity.

Thus, the meter can measure material flow rates with accuracies better than ±0.5 percent of the actual flow rate without additional equipment, such as a loss-in-weight feeder's refill hopper. The Coriolis force also eliminates any effect from the flow rate on the mass flow meter's measuring accuracy, which ensures the meter's measuring results are repeatable.

The mass flow meter requires no calibration based on your material. The unit can be preadjusted for accurate measurement in a specific application by entering characteristic values into the controller based on the meter's mechanical design data. For instance, you can enter the measuring wheel's radius, such as 7.2 inches, on the vanes' angular velocity, such as 600 rpm, so that the meter can base the flow rate measurement on these variables. For high-accuracy applications, the preadjustment can be verified by running measurement checks with your material.

System configurations, benefits for different applications

Depending on where or how you install the mass flow meter in your handling or processing system, you can apply the device as a meter that provides flow rate measurement and totalization, a batcher that provides batch control, filling or loading, or a mass flow feeder that continuously controls the feed rate.

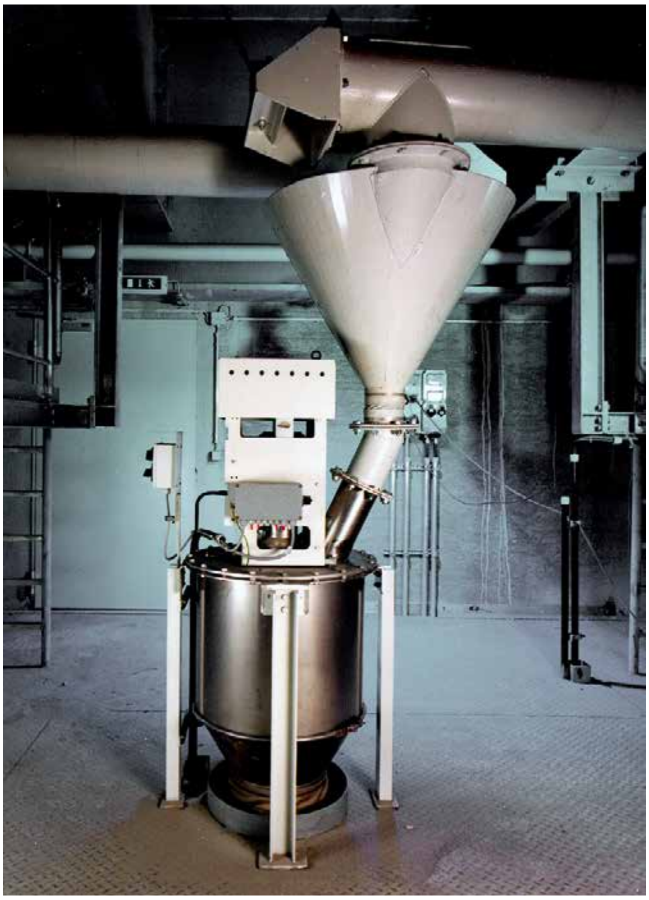
Regardless of how you apply the mass flow meter, take steps at installation to control airflow through the unit. This will prevent airflow from disturbing the material flow through the meter and affecting measurement accuracy. If you install the mass flow meter in a pneumatic conveying system, isolate the meter from the conveying air by a rotary valve airlock or other device.

Meter for flow rate measurement and totalization

To measure and totalize material flow rates, you can install the mass flow meter in the material flow path, such as between a storage hopper's outlet and vessel's inlet. The meter's controller continuously indicates the flow rate, triggers alarms (for instance, to indicate minimum and maximum flow rates or deviation from setpoint), and displays the meter flow total. By linking the controller to additive feeders, you can slave the additive feed rates to the rate measured by the meter.

Batcher for batch control, filling, or unloading

To provide batch control, filling, or unloading, you can install the mass flow meter after a cut-off device, such as a prefeeder or slide gate. Enter the desired batch setpoint into the meter's controller, and the meter measures the material flow rate and flow total until the total reaches the batch setpoint. At this point, the controller activates the cut-off device, stopping the flow.



The mass flow meter measures high material flow rates, fits into tight spaces and can serve as a flow meter, a batcher, or a continuous feeder.

Feeder for continuous mass flow feed rate control.

When you link the mass flow meter with the setpoint controller of a variable-speed prefeeder, which provides consistent material flow with no pulsing, such as a screw feeder, vibratory feeder, or rotary valve, the meter can measure the flow rate and send the measurement signal to the prefeeder's setpoint controller. The meter's flow rate measurement is the process variable for the controller, which compares the actual material flow rate with the setpoint and continuously adjusts the prefeeder. The controller continuously displays and outputs the flow rate, any alarms, and material flow total.

Using the mass flow meter to provide continuous feed rate control with a variable-speed prefeeder has several advantages over standard gravimetric feeders for high-capacity applications. A loss-in-weight feeder or weighbelt feeder is typically not dust-tight, has large headroom requirements (such as for the loss-in-weight feeder's refill device), and can be mechanically complex. In addition to handling flow rates over 220 t/h (5,500 ft^3/h), the mass flow meter is totally enclosed, is compact, and has one moving part – the measuring wheel – that requires little maintenance. In a continuous feeding application, the mass flow meter also requires no auxiliary equipment, such as a dust collector or refill device, and can be purged easily with inert gas to prevent the flowing material from reacting with oxygen.

The benefits of dust-tight operation, compact size, and low maintenance requirements also are true for the flow rate measurement, totalization and batcher applications. In any applications, the mass flow meter also has low capital, installation and operating costs.

A few tips to remember

To select a mass flow meter for your application, first evaluate your flow rate and material characteristics. Make sure your material is free-flowing: a cohesive material such as cake mix can stick to the meter's measuring wheel. Also determine your accuracy requirements. For instance, if a ±2 percent metering accuracy is acceptable for your application, you may want to choose another type of flow meter. Also consider your plant's available space. If headroom is tight, the mass flow meter can be an ideal solution.

Once you know your requirements, have your material tested at the mass flow meter manufacturer's lab. The test staff will review your requirements and duplicate your operating conditions in several material tests. The test results can help you select the meter's mechanical design factors, such as radius and angular velocity, that will ensure optimum performance in your plant.

By Todd D. Messmer,
Applications Engineering Manager

Validation of ozone as a sanitizing agent in pneumatic conveying pipelines

Pet food forum exclusive presentation on ozone as a sanitizing agent in pneumatic conveying pipelines

Ozone gas (O_3) is a strong oxidizing agent and used in various industries to provide sanitation. Pneumatic conveying pipelines are very common in food and pet food processing plants but are hardly addressed in cleaning or plant HACCP plans. Liquid CIP (Continuous Improvement Process) systems offer a way to address wet processes, but the use of CIP on dry processing presents the difficulty of liquid removal and residuals. A gas, on the other hand, can be introduced to typical air-tight conveying lines. Gas can be removed without a trace, if it can be shown to be effective as a sanitizing medium. It is known that O_3 is a highly unstable compound and will easily give up its extra oxygen atom to other matter (oxidation). When contacting live organic matter, the oxidation will destroy the cell wall and in the case of pathogens render them inert. A project was initiated to validate O_3 gas as a sanitizing agent on piping components and to address the logistics of O_3 generation, introduction and destruction.

The validation of such a process involves several steps crucial to demonstrating that ozone gas can effectively be used to remediate pathogen contamination from the inner pipe surfaces:

- Developing a method to effectively introduce O_3 gas to the piping system
- Establishing O_3 concentrations effective for remediation
- Establishing exposure times effective for remediation
- Demonstrating the O_3 gas is distributed throughout the pipeline
- Demonstrating the destruction of various pathogens by O_3 exposure
- Establishing a surrogate microbe that can be safely tested in the field

Although the testing process does not allow each variable to be tested exhaustively, the establishment of a set of parameters was found to effectively remediate substantial concentrations of salmonella, E.coli and listeria monocytogenes. A surrogate was also identified and tested in parallel, yielding similar results and paving the way for field testing.

For more information on this presentation, contact:

Jonathan Thorn,
Executive Director, Process Technology

j.thorn@schenckprocess.com.

schenck process

Schenck Process LLC
7901 NW 107th Terrace
Kansas City, MO 64153 USA
T 816-891-9300
mktg@schenckprocess.com
www.schenckprocess.com

Schenck Process Europe GmbH
Pallaswiesenstr. 100
64293 Darmstadt, Germany
T +49 61 51-15 31 0
sales@schenckprocess.com
www.schenckprocess.com

BV-A1057EN