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Food-Grade Hoses Handle High-Static Applications

Hose design helps dissipate static charges to ground.

KURIYAMA OF America's new line of Tigerflex Voltbuster food-grade material-handling hoses have been designed for high-static applications such as the transfer of powders, pellets and other granular materials.

The hose's design helps dissipate static charges to ground, helping prevent static build-up and reducing the potential for dangerous electrostatic discharges. They have been constructed with static dissipative plastic materials, allowing for the free flow of static to the hose's embedded grounding wire. The light-weight design of the hoses can help reduce injuries related to heavier metal hoses.

The "Volt Series" hose-tube construction includes abrasion-resistant food-grade polyurethane to ensure the purity of transferred materials. In addition, the grounding wire has been encapsulated in a rigid PVC helix on the exterior of the hose, eliminating the risk of contaminating the transferred materials. The VLT-SD Series is constructed the same, but has an FDA polyester fabric reinforcement to handle both suction and higher pressure discharge applications. New 2- and 8-in. ID sizes have been recently added to this product line.





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DETERMINATION OF VOLATILE CONTENT OF COATINGS BY RAPID LOSS-ON-DRYING INSTRUMENTATION

| | | | |
|--------------|---------------------------|-----------------------|--------------------|
| | MAX® 4000XL (% Solids) | | Convection Oven |
| Coating 1 | 74.644 | Mean | 74.404 |
| | 0.111 | Standard Deviation | 0.400 |
| | 14:17 | Test time | 2 hours |

Table 1. Statistical Analysis of Clear Acrylic Resin

| | | | |
|--------------|---------------------------|-----------------------|--------------------|
| | MAX® 4000XL (% Solids) | | Convection Oven |
| Coating 2 | 48.429 | Mean | 48.198 |
| | 0.261 | Standard Deviation | 0.377 |
| | 10:01 | Test time | 2 hours |

Table 2. Statistical Analysis of Brown Acrylic Resin

| | | | |
|----------|---------------------------|-----------------------|--------------------|
| | MAX® 4000XL (% Solids) | | Convection Oven |
| Top Coat | 60.317 | Mean | 60.028 |
| | 0.111 | Standard Deviation | 0.035 |
| | 7:20 | Test time | 2 hours |

Table 3. Statistical Analysis of the Finish Coat with Additives

For testing paints and coatings, rapid loss-on-drying methods prove to be more desirable than traditional testing methods. Both testing methods were able to provide similar results, but the MAX® 4000XL was able to reduce testing times when compared to the convection oven, and gives a complete profile of the materials as they are being analyzed. This technology can be used to reduce manufacturing throughput times, and provide quality improvement with more information should formulation problems arise.

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Make the Most of Flow Additives

Optimization requires understanding their impact on overall powder behavior

By Brian Armstrong and Jamie Clayton, Freeman Technology

FINE POWDERS developed to meet certain product performance targets often suffer from inconsistent and unpredictable flow that can lead to caking and in-process blockages. Therefore, processors frequently include additives in a blend to enhance flow properties. Although typically incorporated to improve process efficiency, additives also can substantially influence final product quality.

When optimizing the use of flow additives, it's important to recognize their impact on behavior may extend beyond a simple improvement in flowability. Choosing the most-appropriate grade of flow additive for a particular blend and incorporating it at an optimal level for the application also are crucial. This article provides some guidance on the use of powder additives, outlining issues useful to assess as part of blend development. Experimental data illustrate how multifaceted powder characterization can help this development process.

USING FLOW ADDITIVES

Flow additives ease powder flow by physically lubricating interparticulate movement and by disrupting the cohesive bonds between particles within the powder. Reducing or breaking interparticulate forces, such as electrostatic or Van der Waals interactions, allows particles to move more easily with respect to one another, thereby enhancing flowability. A corresponding reduction in the adhesive forces between a powder and a material of construction can ease movement within process equipment and storage vessels. As a result, additives in certain circumstances simultaneously may serve both as lubricants and flow enhancers.

Used effectively, flow additives can substantially increase manufacturing efficiency by maintaining consistent flow through the process and preventing unplanned shutdowns due to machine blockages. They also can impart superior performance to a finished product, either directly, e.g., better flow properties for a fine milk



PROSPECTIVE FLOW ADDITIVES

| NAME | DESCRIPTION | POWDER CHARACTERISTICS |
|---------------------------------|--|--|
| Magnesium Stearate Monohydrate | NF/EP/JP Kosher Passover (Monohydrate) | 90th percentile: 35 μm max. 50th percentile: 10.5–16.5 μm |
| Magnesium Stearate Dihydrate NF | Dihydrate | 90th percentile: 55 μm max. 50th percentile: 16.0–30.0 μm |
| Magnesium Stearate Stear-o-Wet | Magnesium Stearate plus Sodium Dodecyl Sulfate | MgSt 90th percentile: 35 μm max. MgSt 50th percentile: 10.5–16.5 μm |

Table 1. Three commercially available magnesium stearate products underwent testing.

powder, or indirectly, such as consistent tablet weight resulting from a smoothly operating tableting press.

To select the most-appropriate flow additive, powder processors must consider a wide range of variables. In some applications, very specific end-product requirements may dictate choice. For instance, certain grades of hydrophobic silica aren't permitted in food applications — so, in such cases, choosing an appropriate additive relies on a detailed understanding of final product use and the regulatory framework that governs it.

However, a processor also should take many other factors into consideration. Indeed, making the optimum choice requires fully determining how an additive will affect the manufacturing process and influence critical quality attributes of the final product.

While most flow additives are selected on the basis of their ability to improve flow, the question remains as to what constitutes “improved flow” in a given process. Furthermore, an additive simultaneously and unintentionally may substantially affect a range of other powder properties that contribute to process performance. Compressibility, permeability, response to consolidation and, indeed, the ability to aerate, all may change with the inclusion of just small quantities of flow additive; these

potentially may impact, possibly detrimentally, many aspects of behavior in a process. Therefore, optimizing the use of flow additives requires a comprehensive understanding of exactly how the additive will influence both process performance and product quality.

MULTIVARIATE POWDER ANALYSIS

It is helpful to consider powders as multicomponent systems comprising solids (the particles), gases (air entrained between the particles) and water, often in the form of moisture. Powder behavior depends upon complex interactions between these components as well as external variables, such as the environmental conditions experienced during processing. (For specifics on the impact of moisture, see: “Optimize Humidity for Effective Powder Handling,” www.ChemicalProcessing.com/articles/2013/optimize-humidity-for-efficient-powder-handling/.) Individual processes subject powders to various stresses and flow regimes, making it important to identify the properties that dictate performance in any specific operation.

For example, the low-stress dynamic conditions that prevail in a fluidized bed differ dramatically from the high-stress static conditions imposed on a powder stored



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under its own weight in a hopper. Therefore, a unique set of powder properties will define performance in each case. Comprehensively defining how a flow additive will influence powder behavior consequently requires a multivariate approach to powder analysis.

Dynamic powder properties directly quantify flowability and have proven application in optimizing manufacturing practices. Dynamic measurement involves rotating a precision-engineered blade through an accurately controlled volume of powder along a prescribed path. Measuring the axial and rotational forces acting on the powder determine its resistance to the motion of the blade. The resulting data then are used to generate flow parameters such as basic flowability energy (BFE) and specific energy (SE). Dynamic properties can be measured for powders in consolidated, moderate-stress, aerated or even fluidized states, allowing the generation of data that directly relate to a specific process. Equally important, the repeatability, reproducibility and sensitivity of dynamic measurement enable the user to identify and quantify even subtle differences in powder behavior, making the technique a valuable tool for detailed flow additive studies.

Universal powder testers, such as the FT4 powder rheometer, complement dynamic powder testing with other valuable methods such as bulk property measurement and shear analysis. As a result, they can provide the multifaceted approach to powder characterization required for success with flow additives.

EFFECT ON SPECIFIC ENERGY

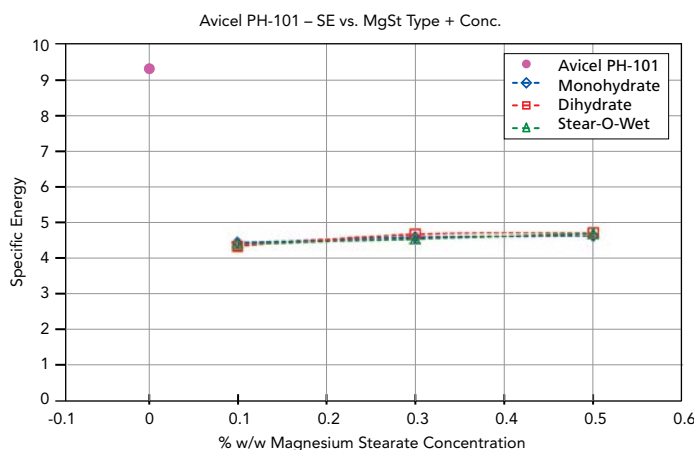


Figure 1. All three flow additives cut the microcrystalline cellulose's SE by more than half to a value that remains uniform across a range of low concentrations.

IMPACT ON AERATED ENERGY

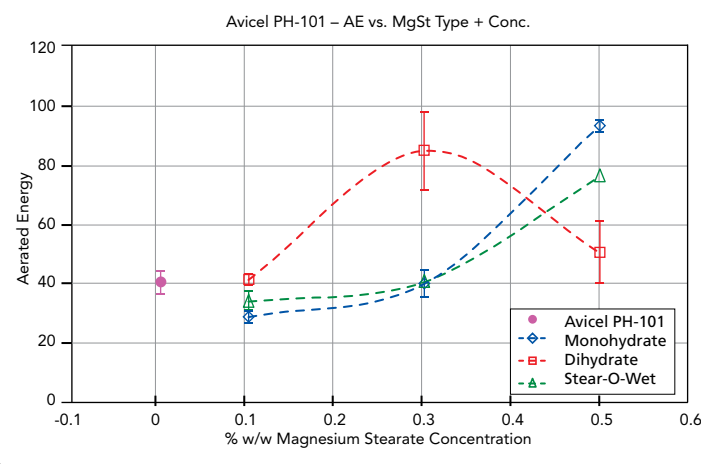


Figure 2. The AE of the cellulose depends upon the grade of MgSt employed and shows a nonlinear response with respect to concentration.

FACTORS TO CONSIDER

While the need for a flow additive may be clear, the right additive isn't always immediately evident. Incorporating a flow additive requires careful consideration of a number of factors, including:

- which additive to use, including its specification and grade;
- the amount of additive necessary for optimal effect; and
- whether the resulting blend will perform as needed under specific process conditions.

Considering each of these points in turn helps provide guidance for the development of an optimal blend.

Selecting the type and grade of additive.

Many commercially available flow additives come in different chemical forms or in various grades. At a minimum, there's usually a choice of suppliers. Therefore, it's important to assess whether all available versions of the chosen additive deliver identical performance. Table 1 provides details of three commercially available magnesium stearate (MgSt) products that can serve as flow additives.

Figure 1 shows the impact of each type of MgSt on the SE of a commercially available microcrystalline cellulose (Avicel PH-101). SE measures the ease with which a powder flows in an unconfined low-stress state. The three grades all have a similar impact, decreasing the SE of Avicel PH-101 by over 50%, from approximately 9.4 to 4.5 mJ/g.

However, the three grades differently affect the aerated energy (AE) of Avicel PH-101

INFLUENCE ON WALL FRICTION ANGLE

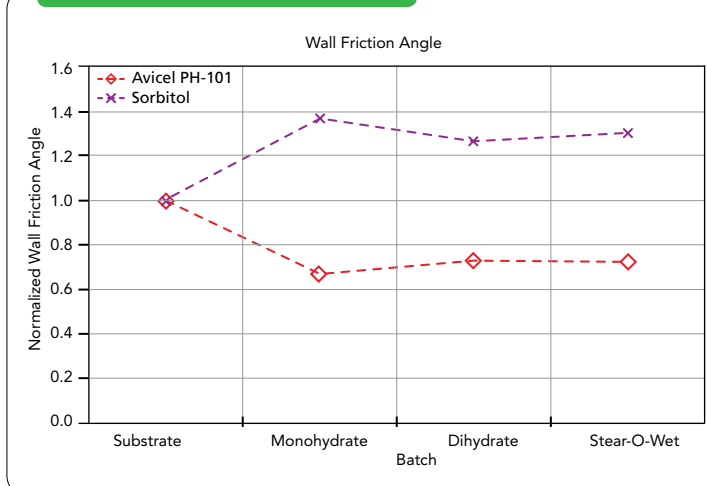


Figure 3. MgSt, regardless of grade, increases the WFA of sorbitol but decreases the WFA of the microcrystalline cellulose.

DIFFERENT SUBSTRATE RESPONSE

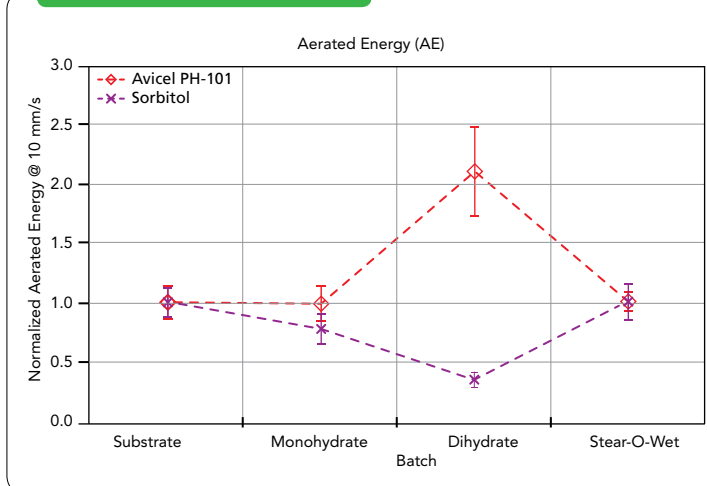


Figure 4. The MgSt raises the AE of the cellulose but lowers the AE of the sorbitol, with dihydrate inducing a more pronounced change than other grades.

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(Figure 2). The AE of a powder quantifies the flow energy as air flows through the sample and is a reliable indicator of the absolute levels of cohesion in the powder. Figure 2 shows the dihydrate grade results in very different performance compared with the monohydrate and Stear-o-Wet.

In general, flow additives consist of very fine particles that coat the relatively larger particles of the substrate in a blend, lubricating interparticulate movement in a manner analogous to ball bearings. SE primarily depends upon interparticulate friction and mechanical interlocking, which typically is a consequence of rough or irregularly shaped particles. The results presented here suggest all three grades comparably impact these two aspects of flowability.

In contrast, AE provides a measure of the strength of the cohesive bonds between particles of the powder. While the additive lubricates physical interactions between substrate particles, it simultaneously might increase cohesive bond strength if the agglomerates of Avicel/MgSt themselves are attracted to one another in low-stress conditions. The AE results suggest these different grades generate agglomerates of varying cohesive strength, which in turn may reflect their intrinsic cohesivity.

Establishing the optimal concentration of additive. Flow additives often impart functionality at relatively low concentrations. While many people assume that

more flow additive will equate to better flow properties, this assumption frequently is wrong — making it important to assess thoroughly how the performance of a blend varies with flow additive concentration. The data shown in Figure 1 indicate that with this system SE effectively is independent of MgSt concentration and grade at low levels. The amount of additive used, above the threshold value applied in these tests of 0.1% w/w, has no appreciable effect. However, Figure 2 indicates AE clearly depends upon additive concentration. The AE of the Avicel PH-101 blended with monohydrate or Stear-O-Wet rises steadily with concentration while the analogous curve for the dihydrate grade passes through a maximum.

As far as AE is concerned, it's likely that cohesivity in the overall system is affected by two factors: the relative strength of substrate-additive and additive-additive cohesivity; and the extent to which the additive distributes over the substrate as concentration increases. It's impossible to quantify the individual impact and the combined effects of these factors but the data clearly support the previous observation that increasing flow additive content doesn't necessarily improve all flow properties. If a process heavily depends upon the aeration properties of a blend, then these data suggest the introduction of a flow additive isn't always beneficial or the results easily predicted.



Ensuring the formulated blend is well suited to processing conditions. While the preceding issues focus very much on the flow additive — grade and concentration — it's important to recognize that each blend for each application presents a unique optimization task. Changes induced by an additive will depend upon the substrate to which it is being added. Furthermore, the additive may alter a number of aspects of powder behavior, not just flowability. Understanding all possible effects is crucial.

The data shown in Figures 3 and 4 for wall friction angle (WFA) and AE, respectively, illustrate this point well. These tests used a fixed concentration of MgSt, 0.3 % w/w, on two commonly used excipients, Avicel PH-101 (which has a nominal particle size of 50 µm) and C*Sorbindex (sorbitol with a nominal particle size of 190–200 µm).

The shear property WFA routinely is measured to support hopper design activities. However, more generally, it indicates how easily a powder moves across a given surface. In this case, WFA was measured using a type-316L stainless steel test coupon with a surface finish of 1.2 µm R_a ; so the results show to what extent the MgSt changes interactions between the individual substrates and the grade of stainless steel.

The first conclusion that can be drawn from the WFA results (Figure 3) is that all three additive grades appear to influence each substrate in a similar way. All three increase the WFA of sorbitol and decrease the WFA of Avicel PH-101. A rise in WFA indicates greater resistance between the substrate and equipment surface. This means that inclusion of MgSt detrimentally impacts sorbitol if the aim is to ease movement across a stainless steel surface. In contrast, MgSt lowers the WFA for Avicel PH-101, suggesting it might successfully serve as a lubricant, for example, in a tableting process. This result is interesting because it not only shows the effects of MgSt aren't consistent for each substrate but also that the additive doesn't deliver the expected lubrication for the sorbitol/stainless-steel combination.

The results for AE (Figure 4) show a very different

response. The inclusion of 0.3% MgSt raises the AE of the Avicel PH-101 but lowers the AE of the sorbitol. The two substrates again respond differently to the inclusion of the additives. However, in this case, the changes observed aren't uniform for all grades of MgSt. The dihydrate more significantly affects the flow properties of both substrates than the other grades, halving the AE of sorbitol and doubling that of the Avicel PH-101.

The parameters presented here — WFA and AE — reflect behavior in different processing environments. Therefore, the contrasting results demonstrate the importance of measuring properties that accurately reflect a specific aspect of a process or application. MgSt used with Avicel PH-101 should ease flow at certain concentrations and provide lubrication in stainless steel equipment. However, there's also a risk of increasing overall cohesivity in the bulk, which could have implications, for example, in filling applications. In contrast, MgSt isn't necessarily an ideal lubricant for sorbitol contacting stainless steel but can reduce overall cohesivity within the bulk powder.

OPTIMIZE ADDITIVE USE

Choosing the most-appropriate flow additive to resolve a processing issue and incorporating it at an optimal level require a comprehensive approach to powder analysis. Testing must accurately reflect the impact of the additive on the specific substrate being used and represent conditions that directly relate to the manufacturing process or final application. Dynamic powder testing, in combination with shear and bulk property measurements, is a proven approach to addressing this type of complex powder-handling challenge. The experimental data presented here demonstrate the capability of such powder characterization tools in optimizing the application of flow additives. ●

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Improve the Performance of Your Gravimetric Feeder

Use these tips to avoid poor accuracy and frequent downtime

By Todd D. Messmer, Schenck Process

HOW CAN I improve my screw feeder's gravimetric performance? As applications engineers, we get asked this question quite often. In answering, the first thing you need to tell us is the material you are feeding. Gravimetric feeder performance is most always affected by how well the material feeds volumetrically. The closer you can fill the flights of the feed screw volumetrically to 100%, the better the feeder will perform gravimetrically. In order to get the material to feed better volumetrically, the material's bulk characteristics must be analyzed first. Let's look at some of the most common material characteristics that affect volumetric feeder performance:

- **Free flowing:** Plastic pellets are generally freeflowing materials. They feed under gravity without the need for special design considerations or flow enhancements.
- **Adhesive:** Some materials like to stick to everything. Pigments are notorious for adhering to all types of contact surfaces. Often, we need to clean feed screws and tubes just to keep the material from building up on them. Avoid feeders with internal agitation systems. We may need to look at different coatings such as fluoropolymers or more polished contact surfaces. Systems to self-clean the inside of the feed tube should be considered.
- **Cohesive:** These materials like to pack like a snowball and are typically associated with a high angle of repose. They need flow aids such as internal agitation, air sweeps, or air pads to create movement or external vibration to break up the clumps. Adding cross wires on the end of the feed tube to get the material to "pack" better into the flights of the feed screw can help.
- **Aeratable /floodable:** These materials are typically associated with a low angle of repose. They behave like a fluid when aerated and will easily flush out of a feed screw if it is not designed properly. A feed screw with a center rod vs. an open flight often is needed with these materials. I would recommend doing smaller refills

more frequently with these types of materials versus a larger refill, which can often aerate the material in the feeder causing it to flood out.

- **Hygroscopic:** These materials retain moisture very easily. Often we hear customers say that they left material in the feeder and when they came back the next morning it had solidified because it had collected moisture from the environment. Blanketing the material with clean, dry air or nitrogen can help keep moisture out of the feeder.
- **Pressure sensitive:** These materials are prone to packing if used in large-volume hopper extensions. Again, frequent smaller refills may help keep the material from packing. Feeders that utilize external paddle agitation with flexible-walled hoppers require close attention to the level of frequency with which the paddles are agitating the hopper walls. Higher frequency agitation



Figure 1. Cohesive materials like to pack like a snowball and need flow aids such as internal agitation, air sweeps, or air pads to create movement or external vibration to break up the clumps.

REDUCE MOVEMENT



Figure 2. Any electrical, plumbing, or other connections to the gravimetric feeder must be made with flexible conduit, piping or tubing to have minimal effect on the movement of the gravimetric scale.

or vibration can often pack these materials.

- **Low melt temp:** These materials tend to break down, melt, or caramelize when excess friction/energy is used on them. I would recommend using a larger-diameter feed screw turning at a lower rpm than a smaller-diameter feed screw running at a higher rpm with these types of materials.

If all else fails, inquire about the testing capabilities of your material-handling equipment supplier. Often, they have had experience feeding the material and can suggest ways of improving performance. Material testing is usually free of charge and can be witnessed firsthand.

Now, after taking steps to improve material feeding volumetrically, let's take a look at several factors that will

affect the gravimetric performance of the feeder.

Vibration. Because of the sensitivity of the scale, vibration is detrimental to the operation of the gravimetric system; special provisions must be taken to eliminate any vibration of the scale. Some possible ways to minimize vibration are to isolate the decking that the weighing system rests on; reinforce the decking around the weighing equipment so the decking flexes minimally; mount the weighing equipment on a high-mass pedestal (i.e., concrete-block table); mount the weighing equipment on vibration isolators; or mount the weighing equipment on structural members, not on the decking itself.

Heating, air conditioning, and ventilation ducts. These cause air disturbances, which could translate into false scale

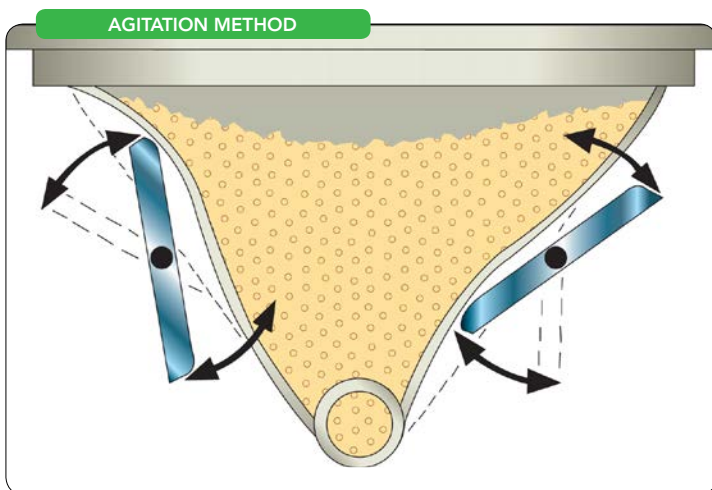


Figure 3. Pressure-sensitive materials are prone to pack if used on large-volume hopper extensions. Sometimes external paddles, as shown above, are used to agitate flexible-walled hoppers to mitigate this problem.

movements and changing scale weights. These ducts may need to be relocated away from the gravimetric system, especially for those systems with small load-cell capacities required for very accurate measurements.

Open windows and doors. Like the ventilation ducts, open windows and doors can create air disturbances that affect the gravimetric system. Special precautions may need to be taken to make sure that doors and windows, especially to the outside, remain closed.

Ambient temperature. The air temperature where the gravimetric system — the scale, controller and feeder — is going to be placed must not exceed the temperature limit in the scale systems specifications, because load cells are temperature compensated.

Hazardous areas. Provisions for the class, division and group of hazardous areas must be taken into consideration. These areas typically require the need for intrinsic barriers

within the feeding system, which will degrade the raw signal of the load cell due to the voltage drop across the barrier.

Electrical power. The controller of the gravimetric system requires “clean power” much as a computer requires a clean line. This line should be free from any large inductive or capacitive loads. If uncertain about the condition of supply power, an isolation transformer or UPS (uninterruptible power supply) is recommended.

Large inductive and/or capacitive equipment. The scale and the scale cables (excitation and signal) must be separated from large inductive and/or capacitive loads, such as arc welders, large motors, etc.

AC voltage power wiring. All cables associated with the gravimetric system should be run in separate conduit from all high-voltage AC signals.

Radio-frequency equipment. The scale and the scale cables must be isolated from RF-generating equipment.

Support systems. The floor, balcony, mezzanine, etc., on which the gravimetric system is mounted must have a rigid construction to provide a solid platform, as mentioned earlier.

Distance from the feeder and scale to the controller. For distances greater than 25 feet, contact the manufacturer for cabling recommendations.

Electrical ground. A solid electrical ground must be available for both the feeder and the electrical controller.

Scale/feeder mounting. The mounting table or mounting base for the scale must be solid and preferably afford some vibration isolation between the scale and the floor.

Outdoor installations. If any gravimetric equipment is to be installed outdoors, extreme temperature variations should be noted and avoided if at all possible. Cabinet heaters may be required to keep the controller and the load cells at a nominal temperature.

Flexible connections. Any electrical, plumbing, or other connections to the gravimetric feeder must be made with

PREVENTIVE MAINTENANCE



Figure 4. Preventative-maintenance programs are offered by some material-handling equipment suppliers. These should include a feeder audit and recommendations by a field-service engineer for improving feeder performance.

flexible conduit, piping or tubing to have minimal effect on the movement of the gravimetric scale. Use factory-recommended flexible connectors for feeder inlet and discharge ends when the scale system is part of a gravimetric feeder.

Maintenance access. Consideration should be given to allow maintenance personnel access to maintain the scale, gravimetric feeder and controller.

Corrosive atmospheres. Any corrosive vapors, dust, etc., should be noted and recommendations should be given on how to prevent corrosion by using resistant materials.

Refill mechanism. The mechanism used to automatically refill gravimetric feeders must be tight-closing so the material can't enter the feeder's extension hopper other than during the refill time. In addition, the refill device must be sized to refill the required amount of material so the feeder doesn't starve out.

Refill venting. Rapid introduction of dry material into a feeder hopper extension during a refill causes pressure to build up inside the hopper extension equivalent to the volume of air displaced by the volume of dry material. This pressure must be relieved, either by leaving the refill gate open so the displaced air can move into the refill hopper or by providing a vent in the feeder hopper extension.

Vacuum systems. Vacuum or pressure systems, either at the infeed or discharge of a feeder, may affect the gravimetric system by causing adverse suction or pressure on the system. These ancillary systems must be properly vented to prevent these conditions.

Contact your material handling equipment supplier to see if they offer a preventative-maintenance program that includes a feeder audit and recommendations by a field-service engineer for improving feeder performance. There typically is a small fee associated with this service, but when weighed against the alternatives of poor accuracy and frequent downtime, the feeder evaluation is worth the expense. ●

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Protect Against Combustible Dust Explosion

Economical approaches exist to protect spray dryer processes and solutions

By Dr. Johannes Lottermann, REMBE

MUCH HAS been written and will continue to be written about the risks of combustible dust in a manufacturing facility, if for no other reason, than because people are injured and die every year from combustible dust-related explosions.¹

From a manufacturer's perspective, the costs involved in not protecting a facility are prohibitive: should an incident occur, an operation may be out of business for weeks or months and its customers will go elsewhere. The community outcry will be enormous and damage to an organization's reputation will result. The costs for startup, fines, compensation to the injured, etc. are very high. It just isn't worth the risk.²

Unfortunately, the costs of protecting a facility also can be very high, so every manufacturing facility must work closely with its "consultants" — manufacturers' representatives, engineers, risk consultants, insurance consultants and others — to develop the best, most cost-effective working solution for their particular manufacturing process. Therefore, plant process hazard analyses and dust testing should be an integral part of the total safety concept per NFPA standards, OSHA requirements and as a practical matter.³

One process that has received limited attention with respect to protection against combustible dust risks to date is the spray drying process. The risks are great as are the potential costs for protection following conventional design standards.

New basic interpretations, however, in accordance with the VDI 2263 Data Sheet 7 guideline, "Dust Fires and Dust Explosions for spray dryers — Hazards, Assessment and Protective Measures," have recently been released which specifically address fire and explosion protection in spray-drying facilities.^{4,5} These interpretations will be discussed as an alternative cost-effective method of protecting spray dryer processes as they specify the partial volume approach

for the sizing of explosion relief devices described in NFPA 68 and FM Global Loss Prevention Data Sheet 7-76.

Adopting this method should be discussed in detail with Authorities Having Jurisdiction (AHJ) in the interest of improved compliance leading to increased safety in addressing the combustible dust hazard.

COMBUSTIBLE DUST

Any airborne organic dust that can burn could lead to an explosive atmosphere.⁶ If there is a combination of such dusts with a sufficient ignition source, explosions can occur. OSHA requires in its general duty clause that employers provide a "...place of employment which are free from recognized hazards..."⁷, so measures must be taken to avoid or reduce the damage caused by such explosions.

NFPA REQUIREMENT

| Field | Value | Unit |
|---------------------------------|-------|---------|
| Volume (V) | 200.0 | m³ |
| Length / Diameter (L/De) | 1.30 | |
| Resistance (overpressure) (P) | 0.40 | bar |
| Explosion overpressure (Pmax) | 9.0 | bar |
| Product-spec. constant (Kmax) | 200 | m/bar/s |
| Activation overpressure (Pstat) | 0.10 | bar |
| Vent area (geometric) (Aq) | 6.85 | m² |
| Vent area (Aq) | 6.85 | m² |
| Vent area (IA) | | m |
| Vessel / Standard | | |

Figure 1. NFPA 68 requires the venting area be 6.85 m² for a 200-m³ spray dryer.



The risk of combustible dust explosions often is underestimated: For example, we use powdered milk in food we eat and handle such powder in our kitchens, living rooms, coffee shops and even airplanes. When stored at home in small amounts or even in big bags at warehouses, milk powder is considered a harmless product — as long as fine dust particles are not airborne, dispersed and in contact with a source of ignition such as a mechanically created spark, a spark created by discharging static electricity, a hot surface or an open fire.

As a “Checklist for an Explosion,” the following elements have to be in place to create an explosion:

- combustible dust,
- a confined area,
- oxygen,
- an ignition source, and
- perfect dispersion of dust particles.

COMBUSTIBLE DUST RISKS IN THE SPRAY DRYING PROCESS

Spray dryers are primarily deployed in the chemical and food industry, for processes such as powdered milk, detergent powder or infant formula production. The liquids (slurries) are atomized in a drying tower by means of pressure nozzles or rotating discs. The powdery commodity is dried through hot current or counter-current gas.⁵

These processes are extremely explosive, as all above mentioned “elements” for a dust explosion are “naturally” in place.^{5,6}

- combustible dust → the dried product
- a confined area → the drying chamber
- oxygen → by the warm air
- an ignition source → embers, mechanically sparks created by broken atomizing discs etc.
- perfect dispersion of dust particles → the drying process requires a dispersion

Unfortunately, these conditions are present in other elements of typical spray-drying installations (cyclones, bag

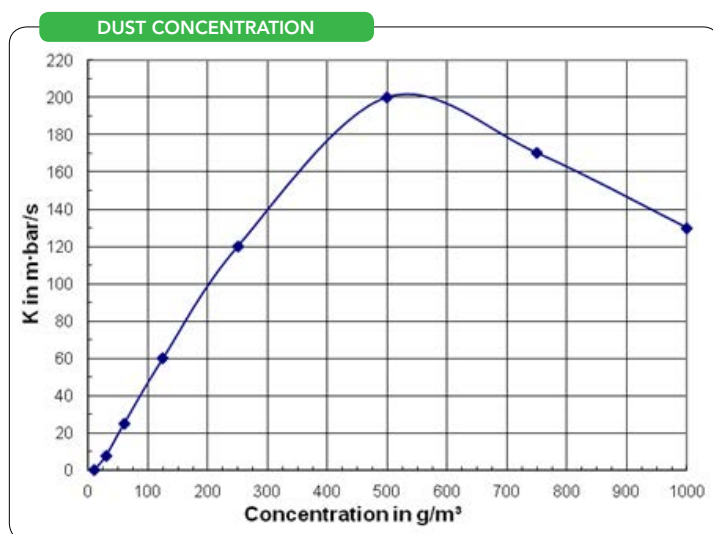


Figure 2. Concentrations in spray dryers are much lower, typically around 500–600 g/m³, and the VDI approach takes this into account.

| Parameter | Value | Unit |
|--|-------------------|---------|
| Vessel Volume (V) | 72.0 | m³ |
| Length / Diameter (L/D) | 1.30 | |
| Resistance (overpressure) (P) | 0.40 | bar |
| Explosion overpressure (P _{max}) | 7.0 | bar |
| Product-spec. constant (K _{max}) | 120 | m-bar/s |
| Activation overpressure (P _{stat}) | 0.10 | bar |
| Vent area (geometric) (A _g) | 1.40 | m² |
| Vent duct Length (L _A) | | m |
| Addenda | Vessel / Standard | |

Figure 3. Using the VDI approach, a 200 m³ spray drier that would require 6.85 m² per NFPA 68 would realistically only need 1.48 m².



filters, fluid bed driers, screens) as well — so wherever the explosion starts it could propagate to all interconnected vessels.

For this reason, it is necessary to equip the spray-drying process with appropriate protective measures.

APPROPRIATE PROTECTION FOR THE SPRAY DRYER PROCESS

Per NFPA 68, the conventional approach to protecting a spray dryer would be to apply so-called explosion relief devices that offer a certain venting area taking into account the entire chamber volume, the strength of the vessel and the so-called K_{st} -value (pressure rise normalized to a 1 m³ - chamber), although the process conditions inside a spray dryer are quite different from the vessels that the NFPA 68 committee had in mind when publishing the standard. The NFPA conventional approach for protection of spray dryers, from the prospective of explosion safety experts, is much too conservative and leads to an over-engineered result.⁸

The following example of a 200-m³ spray drier where the required venting area following the NFPA 68 would be 6.85 m² shall demonstrate this in comparison to the VDI approach (Figure 1).

VDI APPROACH

The new VDI approach⁹, described in the European Guideline VDI 2263-7, takes into account, for example, that the temperature (resulting in dust temperatures of 176°F/80°C within the drying tower) influences the maximum explosion pressure P_{max} . In addition, under certain conditions *only one-third of the tower volume is needed for the calculation*, since the product located in the upper area of the dryer is still moist and, thus, the atmosphere not explosive.

The K_{st} value is significantly influenced by the dust concentration.¹⁰ Because the concentrations in spray dryers are much lower (maximum: 250 g/m³) than the “perfect explosive mixture,” typically around 500–600 g/m³ (Figure 2),



Figure 4. Explosion flame temperatures that reach up to 1,500°C (2,732°F) are efficiently cooled down through an energy transfer taking place in the unique stainless steel mesh filter basket.

the VDI approach only takes the pressure rise of the realistic dust concentration into account and reduces the required vent area in a next step to an appropriate level of protection.

The same 200-m³ spray drier that would require 6.85 m² per NFPA 68 would realistically only need 1.48 m² (Figure 3), since the pressure rise (K_{st} value) may be reduced from 200 to 120 per Figure 2. Furthermore, the volume taken into account would only be the cone volume — the alignment of the maximum explosions pressure to the process conditions is the final step of this engineered approach.

Critical readers might think that it is all well and good that a European guideline exists, but such a guideline wouldn't be allowed in the U.S. Also, these critical readers might prefer the additional “safety margin” of the over-engineered approach, which might give rise to a more “comfortable feeling”.



Figure 5. The first explosion test (top) uses explosion panels and produces a visible flame. The same test is performed again using the Q-Rohr-3 flameless venting system (bottom).

These same readers should know that NFPA always gives a performance-based design option as an alternative, which simply means that other approaches also are allowed. And, let's remember, purchasers also have the right to have a "comfortable feeling" that will result in improved compliance with regard to the non-specific partial volume approach. This innovative calculation method allows for effective explosion protection with venting at an affordable, competitive price. Since most spray-dryer installations are indoors, indoor flameless venting is worth consideration.

INDOOR FLAMELESS EXPLOSION VENTING

With indoor venting systems, such as the REMBE Q-Rohr-311,

explosion flame temperatures that reach up to 1,500°C (2,732°F) are efficiently and effectively cooled down through an energy transfer taking place in the unique stainless steel mesh filter basket developed by REMBE (Figure 4). This transfer fully extinguishes the flames (Figure 5). Additionally, the pressure rise and increased noise level associated with free vented explosions are massively reduced to negligible, harmless levels. The specially developed filter ensures that no burnt or unburnt dust particles are discharged. After an event, simply clean and replace the bursting disc and the flameless vent is immediately ready for operation once again.

With indoor venting systems, installation is uncomplicated and cost-intensive venting ducts are eliminated.



REFERENCES

1. Incidence numbers vary and the near misses are not accounted for. See, for example: Peetz, Ben, CFPS, Combustible Dust Fires and Explosions, www.fireengineering.com/articles/print/volume-165/issue-3/features/combustible-dust-fires-and-explosions.html "According to OSHA, since 1980, almost 150 workers have been killed and more than 850 injured in combustible dust explosions.
2. See, for example, Febo, Jr, Henry, Processes for Drying Powders – Hazards and Solutions www.aidic.it/lp2013/webpapers/15febo.pdf
3. OSHA on Combustible Dust: www.osha.gov/Publications/3371combustible-dust.html; Every NFPA Standard relating to Combustible dust. NFPA: see, for example, NFPA 69, 2014 section 4.2.3.
4. European Guideline VDI 2263-7, Dust Fires and Dust Explosions-Hazards, Evaluation and Protection Measures, 3/2013.
5. Febo, Jr, Henry, Processes for Drying Powders – Hazards and Solutions www.aidic.it/lp2013/webpapers/15febo.pdf p.4
6. For more information on Combustible dust, see, Mayer, Gerd, Ph.D, Mitigate Explosions with Indoor Flameless Venting, Chemical Processing e-handbook 1302 v2 page 24: www.chemicalprocessing.com/assets/wp_downloads/pdf/powder-e-handbook-1302-v2.pdf
7. OSHA General Duty Clause: www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=3359&p_table=oshact
8. Febo, Jr, Henry, Processes for Drying Powders – Hazards and Solutions www.aidic.it/lp2013/webpapers/15febo.pdf p.5 . NFPA 68 Standard on Explosion Protection by Deflagration Venting, 2013
9. See also, Febo, Jr, Henry, Processes for Drying Powders – Hazards and Solutions www.aidic.it/lp2013/webpapers/15febo.pdf p.5 . NFPA 68 Standard on Explosion Protection by Deflagration Venting, 2013
10. Combustible Dust defined: www.osha.gov/Publications/3371combustible-dust.html; Vahid Ebidat, Ph.D, Dust Explosion Hazard Assessment, 2009 presentation: www.aiha.org/LocalSections/html/Metro%20NY/Combustible%20Dust%20-%20Dr.%20Ebadat,%20Chilworth.pdf
11. The Q-Rohr-3 indoor explosion venting system is licensed/compliant with all currently relevant guidelines, e.g. NFPA 68, VDI 3673, EN 16009 or EN 14797. For more information see www.rembe.us/products/explosion-protection/indoor-outdoor-flameless-venting-systems/

Procedure-optimized installation within the immediate vicinity of people and machines also is an advantage, as is visual inspection without high-priced maintenance costs. All of these features add up to additional savings.

REALISTIC COMBUSTIBLE DUST EXPLOSION PROTECTION

A modern explosion protection system must be safe and economically reasonable. In this way, the level of protection, and thus occupational safety, is ensured.

The VDI approach for protecting spray dryers is just one

example of a method to potentially reduce an operator's cost to protect. Realistically evaluating risks is another approach that may result in less equipment or less costly equipment being used. Whatever the approach, spray dryer processes must be evaluated for their combustible dust risk and protected accordingly.

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