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PRODUCT FOCUS

CANTILEVER SHAFT DESIGN IMPROVES HYGIENE AND EASE OF OPERATION

KEK centrifugal sifters' advanced cantilever design improves sifting efficiency and features an easy to remove hygienic screen basket and paddle screw assembly, a hinged oversized end door and bolted flanges for dust-tight operation. The sifters also operate quietly without vibration.

Clean, simple, operator-friendly features require no tools for stripping down and cleaning. The units also contain easily removable sifter screens for inspection and cleaning. An oversized end door, which opens in seconds, provides easy access and zero leakage or contamination.

Available in white, red or blue, nylon sifting screens are built to handle arduous, heavy-duty applications where maintenance access is severely limited, such as toxic and radioactive processes. Optional screen protectors eject incoming extraneous objects, which could damage the sieving mesh. To further improve its hygienic capabilities, the units also can include CIP spray facilities, inlet section access door and additional inspection doors on the sifter body.

The design also is available on KEK models K300C, K650C, K800C and K1150C (the largest cantilevered sifter with capacities up to 80 tons per hour). View KEK centrifugal sifters in action.

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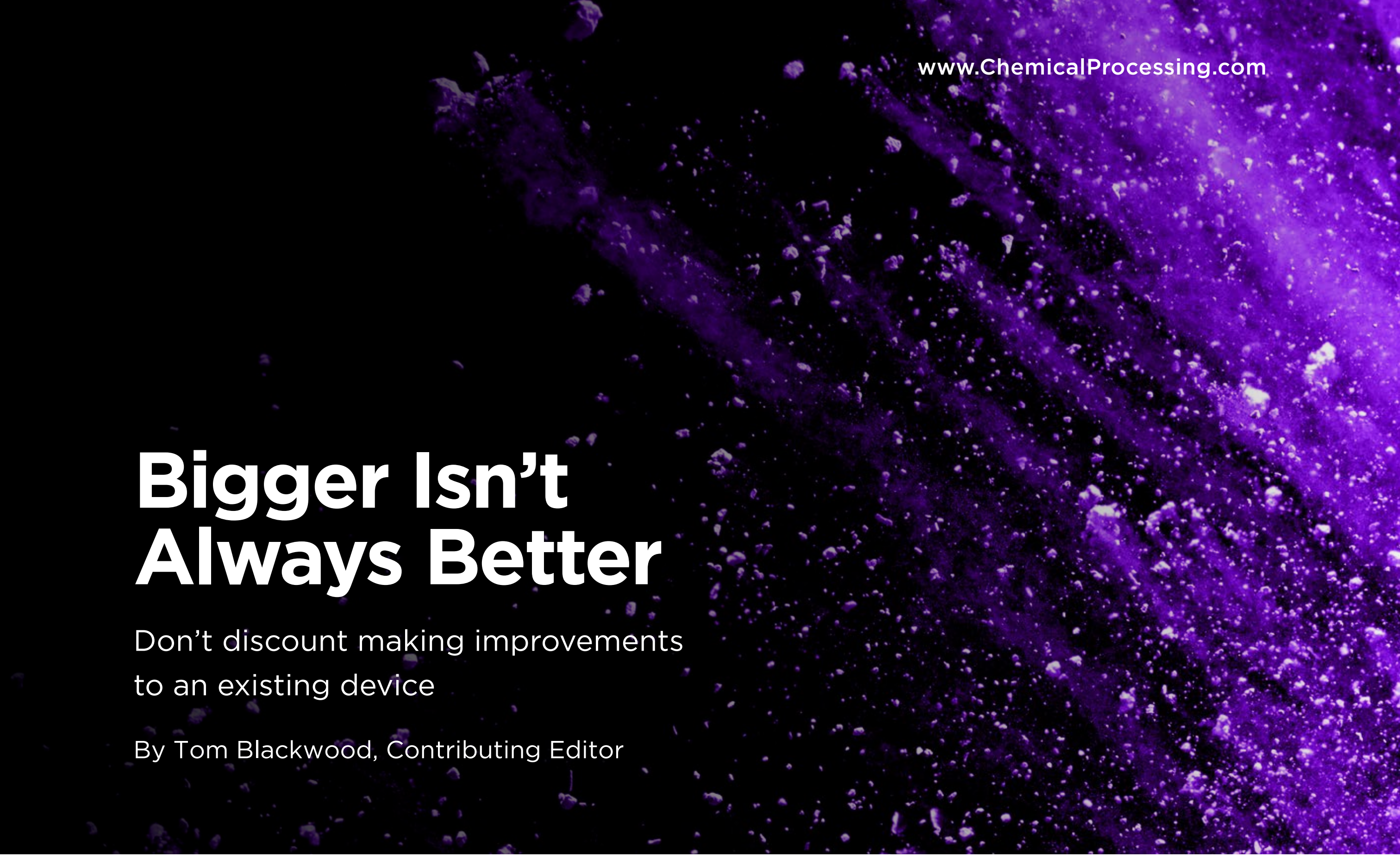


Bigger Isn't Always Better

Don't discount making improvements to an existing device

By Tom Blackwood, Contributing Editor

The phrase "a little goes a long way" often comes up when talking about additives to prevent scaling or fouling in chemical processes. However, another school of thought believes that more is better. After all, if a little reduces the scaling, then more could eliminate it. One example is the use of steam to decrease foaming in a crystallizer. More increases the evaporative load and productivity of the device but a little prevents carryover of fine droplets and fouling.

The more-is-better philosophy comes into play in equipment design as well. Not that long ago, engineers commonly added a significant safety factor when sizing equipment to allow for unknowns in the design. Many project managers have told me that every dollar put into the project yields a dollar of profit. An engineering director of a major company said that every piece of equipment he designed as a junior engineer could produce at a rate at least twice that of the original design. However, he added he would fire any engineer doing that now. In today's economy, bigger definitely is not better if you want to keep your job!

So, how do you get the best productivity with smaller devices? Let's look at a couple of real-world examples.

Boosting production in a fluid bed dryer. A company wanted to triple output but didn't have enough space to accommodate a bigger dryer along with all the other equipment necessary for the expansion. It looked like the firm would need a new building. This product was unique because the finished material could contain as much as 5% moisture — the more water in the material, the greater the profit margin. To avoid exceeding the 5% specification, most production was in the ≤2% moisture range. In addition, the dryer had several operating problems that often over-dried the product:

- Its filter bags plugged.
- These bags were located inside the dryer body and fine particles were being recirculated back to the bed, which caused the bed to collapse due to the excessive entrainment load.
- Not only did that over-dry these particles but the filter got overloaded.
- The amount of fluidization air was much more than required to suspend the solids. It had been increased to reduce bed collapse but just made the situation worse.

My first action was to get a drying curve and model the dryer. Samples taken from the dryer showed that the fine particles were instantly dried. Our initial step was modifying the filter to discharge the fines directly to the outlet of the dryer because they were virtually dry enough to meet the moisture specification. The dryer model suggested that raising inlet gas temperature, expanding the bed area by

20% and doubling the bed depth would increase production very close to the goal. The last step was adding an infrared moisture analyzer to verify moisture doesn't exceed 5%. Blending the dryer output and the dry fine particles would ensure meeting product quality goals. Later, the plant installed a dehumidifier to boost production during humid weather. The savings were enormous because the modifications fit inside the existing building.

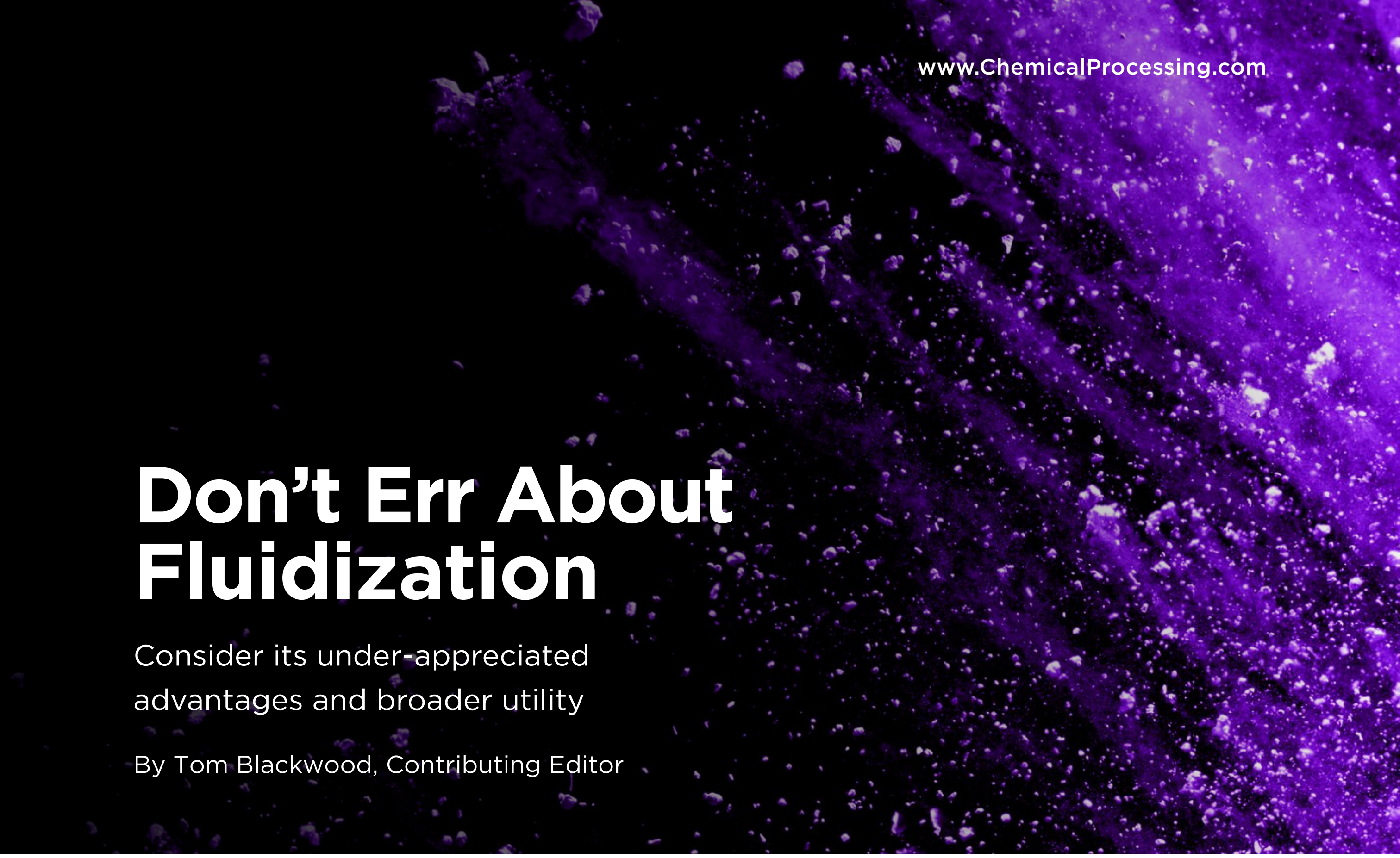
Dealing with a conical dryer that was a process bottleneck. The plant had available another conical dryer that was twice the size of the original one. So, manufacturing shifted production to that unit — with disappointing results. The larger dryer yielded a lumpy product that varied in moisture content and required more cleaning at the end of a batch. Reaching the desired moisture content necessitated an increase in batch time; the extra cleaning requirements meant the net production rate wasn't any higher.

A drying test showed that the critical moisture content was very low, so only heat transfer should limit drying. However, the gas in the dryer was saturated with moisture. The overall heat transfer coefficient was very low, indicating not enough mass transfer of the moisture.

The original conical dryer had a bottom nozzle that was used for cleaning. Feeding a small amount of gas through that nozzle to carry off the moisture decreased drying time by a factor of three. The dryer had more than enough heating capacity but the moisture couldn't get out of the dryer without the extra gas, giving us yet another example of a little goes a long way and bigger is not always better. ●

TOM BLACKWOOD, Contributing Editor

TBlackwood@putman.net



Don’t Err About Fluidization

Consider its under-appreciated advantages and broader utility

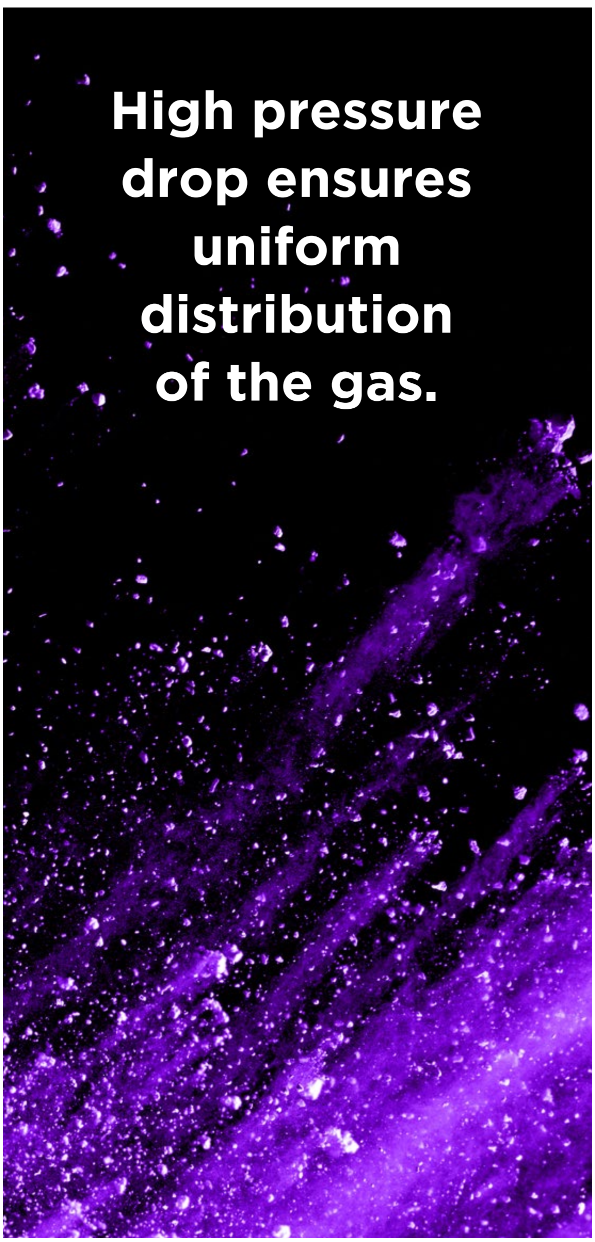
By Tom Blackwood, Contributing Editor

Anyone who knows me will say: “He’s crazy about fluidization.” That’s the absolute truth. The heat transfer is greater, the mixing can be better if you’re careful, and fluidization often provides the lowest cost option for processing. One of our plant’s operators observed that the only thing his product didn’t stick to was air, so he became a fan of fluidized beds. Not all products are well-suited for this type of operation, though. Attrition and segregation of the product may pose concerns. However, you can design around these limitations or even turn them to your advantage. Here are some examples:

- A granular product having some fine particles was being loaded into drums, which was an easily contained operation. However, when the lid was removed, the excess fines created a dust and handling problem. Fluidizing the product as it was loaded enabled stripping off the fine particles, eliminating the problem.
- Coal fed to a calciner produced an emission of fine particles that would be very expensive to collect at 2,000°F. Rather than install emission controls, the site added a fluidized bed that removed the coal fines before the calciner. This worked well because larger coal particles have less inorganic chemicals than the fines.
- Fine crystals that form in solution often are more reactive than grown crystals that are ground down to the desired size — and thus frequently command

a much higher price. So, eliminating the grinding operation, using a fluidized bed and segregating the finer particles during the drying process can boost profits.

Attrition often is cited as a reason not to use a fluid bed. However, particle-particle impact is much more damaging than impact between a particle and a gas or even a particle and a wall. In one study of a cyclone, we found most attrition occurred when the cyclone was removed and the solids discharged directly into the bin. One of the major concerns of designers of fluid beds is maintaining adequate fluidization of the bed; so they use too high a velocity, which can impact attrition. To compensate, they don't provide enough pressure drop at the fluidization grid to prevent larger solids from settling on the grid, which in a dryer can cause fires or burn the product. Note I said pressure drop, not velocity. High pressure drop ensures uniform distribution of the gas, whereas high velocity may increase particle-particle impact and attrition.

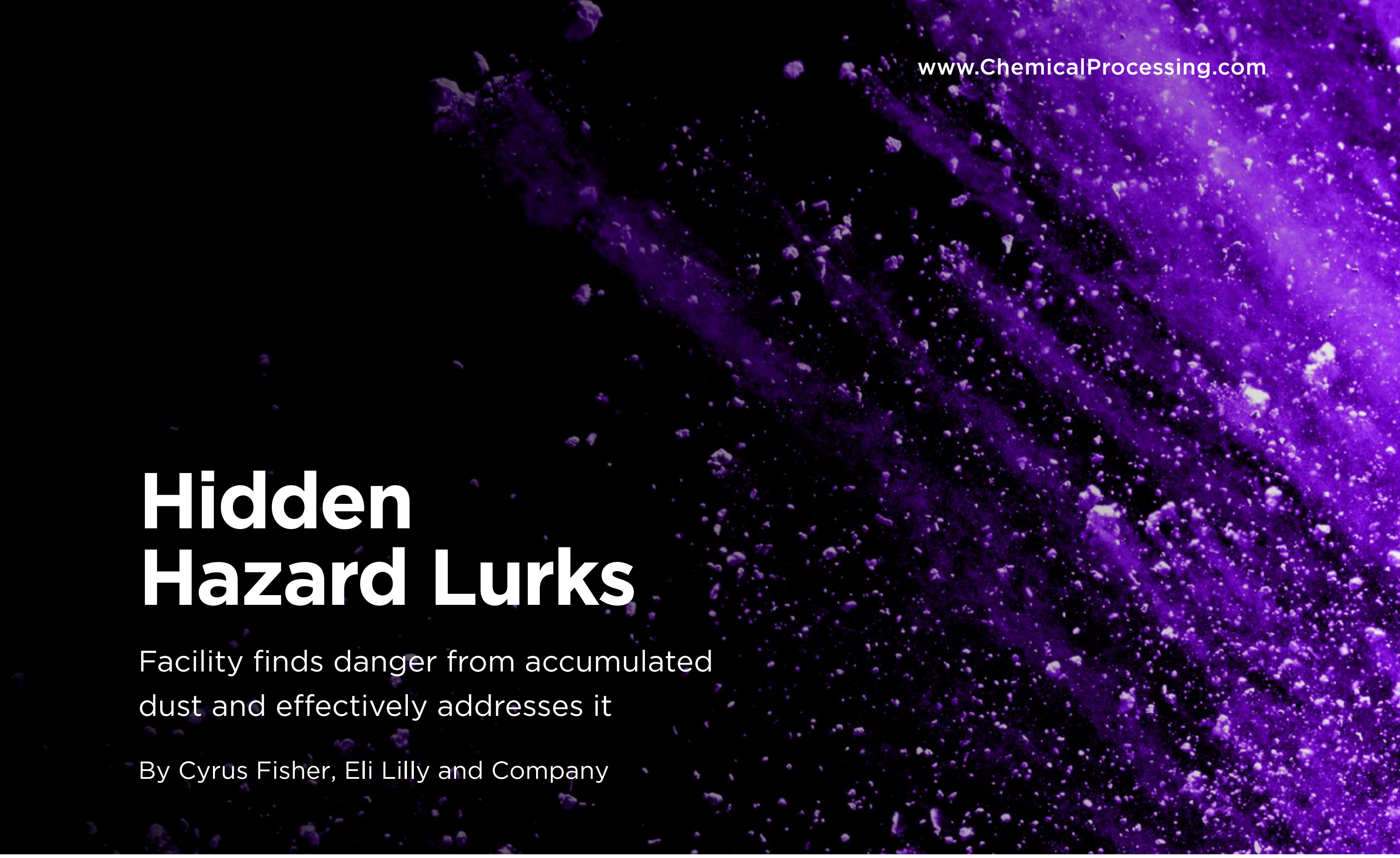


Pneumatic conveying systems, including so-called dense-phase ones, count on fluidization to transport particulate solids. Clearly, dilute-phase systems rely on fluidization — most of their operational problems stem from not maintaining fluidization all along the line. In these systems, we not only are fluidizing the particles but also are accelerating them to some velocity below the gas velocity. Gas velocity is increased at the feed point to help in this process but the effort is wasted if the travel distance before an elbow or diverter isn't sufficient. Also, we know that putting two elbows close together is a well-known recipe for defluidization, which increases the solids/air ratio and pressure drop. In dense-phase systems, fluidization is less obvious with the typical dune or even plug flow. Some particulate solids need some sort of gas bypass to refluidize and maintain motion down the pipe.

Have you ever tried to coat a large particle with a fine powder? Mechanical devices frequently fail because of the clumping of the fine powder or lack of uniform coverage on the larger particles. The fluid bed coater often is a better option. It exposes the full surface of the larger particle to the gas that contains the fine particle. Any excess fines can be scrubbed off in the bed and returned for coating.

One of the more important aspects of fluidization is heat transfer. Not only is more surface area available but also convection is more effective than conduction. In addition, fouling of heat transfer surfaces is less of an issue, even when in-bed heat transfer surfaces are involved. By the way, in-bed heat transfer is an often-overlooked technology for high-solvent particulate. It allows use of much lower inlet gas temperatures, which can be especially valuable with heat-sensitive products. So the next time you want to move, dry or dedust a product, get a fluidizing device. ●

TOM BLACKWOOD is a contributing editor for *Chemical Processing*. Contact him at TBlackwood@putman.net.



Hidden Hazard Lurks

Facility finds danger from accumulated dust and effectively addresses it

By Cyrus Fisher, Eli Lilly and Company

Combustible dust can pose a hidden hazard when accumulation occurs in unseen locations such as in mechanical spaces, above false ceiling, ventilation systems and dust collection systems. Such hazards may be particularly well hidden in certain pharmaceutical manufacturing facilities where use of clean rooms with surrounding mechanical areas are common and the scale of the equipment and facility is relatively modest. Even small quantities of combustible dust may result in a dust cloud flash fire or an explosion capable of significant damage in a plant environment. Although events of this magnitude may not make headline news, the potential impact on an individual present during a flash fire could be life changing.

So, here, I share an example that occurred at Eli Lilly and Company to show how combustible dust may become "hidden" within a dust collection system, and to describe a methodology for safe combustible-dust removal, as well as actions that can prevent future problems.

This example comes from a pharmaceutical blending operation located in a typical clean room. Technicians are preparing to blend 110 kg of dried pharmaceutical powder. All surfaces within the room are dust free and the polished stainless steel blender has just been cleaned. The technicians connect a small 2-in. ventilation trunk between the blender and a port on the clean room wall labeled "to dust collector." The technicians then open the access cover of the blender and press a button to start the dust collector, which is located elsewhere. Seven bags, each containing 16 kg of dried powder, are charged to the blender through the opening. The technicians are wearing personal protective equipment (PPE) to prevent inhalation of the dust but no dust is observed outside the opening. When the product charge is completed, technicians turn off the dust collector and disconnect the 2-in. ventilation trunk. The trunk is visually clean. The self-contained blending operation completes normally. All equipment and the room itself then are cleaned in preparation for the next batch. Lastly, the technicians leave the clean room to check for accumulation of material in a small drum under the dust collector; the drum is empty as always. The technicians know the routine well; they have completed these tasks at least once a week for the last ten years.

By their training, the technicians understand the powder they are handling is a combustible dust. They know the minimum ignition energy (MIE) has been tested at approximately 200 mJ with an average particle size of 27 microns, which means the risk of ignition from an electrostatic discharge from personnel is greatly reduced, and personnel grounding isn't required [1]. The electrical outlets and switches in the clean room look different from others in the area, and signs hang on the doors indicating the room is electrically classified as Class II, Division II for combustible dust. If technicians observe a dust cloud for any reason (e.g., a dropped product bag), they are to immediately leave the area until the cloud settles. In general, technicians believe little if any dusting occurs during loading of product to the blender — a belief supported by the lack of dusting seen during blender loading and emptying the dust collector discharge drum.

The technicians and technical support personnel assumed that because no dust is coming out of the dust collector, no dust is going in. The assumption was widely believed to be true and even documented in a previously completed formal hazard review. The idea that dust accumulation might be possible simply did not occur to those supporting the blending operation.

A TELLING INSPECTION

In 2012, the facility initiated a hazard review process for all solids handled at the site. This included looking specifically at the dust accumulation risk for each operation. One recommendation stemming from this activity was for engineering to perform an internal inspection of the blending operation dust collector.

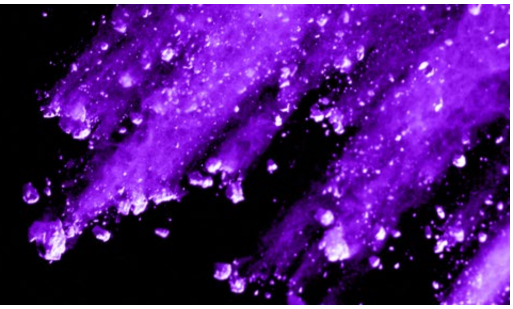
Prior to the inspection, the team reviewed available design information for the dust collector and field-verified all ductwork. The system was designed for an airflow of 500 ft^3/min to ensure sufficient capture velocity at the blender opening during

ACCUMULATED DUST
Figure 1. Inspection revealed that interior of dust collector contained an accumulation ½- to 1-in. thick.

loading. The ductwork in the field begins at the clean room wall, where the duct diameter increases from 2 in. to 4 in. and then transitions to a diameter of 6 in. immediately prior to a 15-ft vertical riser. The duct then travels horizontally several hundred feet through multiple mechanical rooms before reaching the dust collector inlet plenum. Portions of this ductwork run above false ceilings. At the inlet plenum, the 6-in. duct expands to a 1-ft × 3-ft rectangle at which point it enters the dust collector. That unit, which is 1 ft in diameter and 3 ft in length, contains four cartridge filters. The dust collector is equipped with a differential-pressure pulsation system to clear the filters under conditions of high pressure drop. At the bottom of the dust collector, a manual slide gate valve leads to the aforementioned drum for dust disposal.

During the engineering inspection, the four cartridge filters were removed and found to be heavily loaded with dust. Internal inspection of the dust collector revealed ½-in.+ layers of dust settled on all horizontal surfaces including the inlet plenum (Figure 1). Samples were taken and submitted for particle-size and MIE testing. The average particle size of the material in the dust collector was 12 microns, half the size of the bulk powder loaded to the blender. That in itself isn't surprising because the dust collector air stream primarily captures fines churned up during blender loading. The MIE for the material in the dust collector was approximately 25 mJ — an order of

The hazard review team focused on two specific areas for risk reduction.



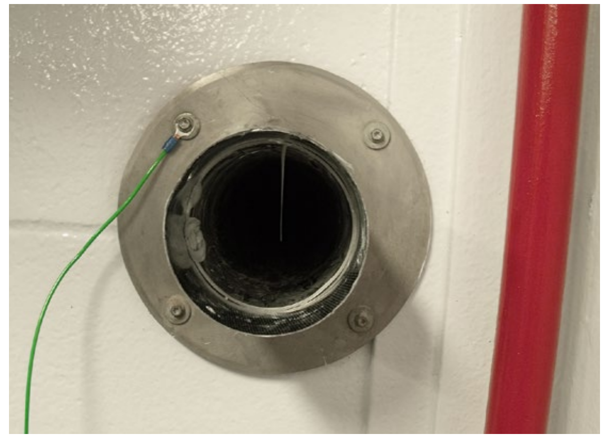
magnitude less than that of the bulk powder loaded into the blender! With an MIE as low as 25 mJ, the risk of ignition from electrostatic discharges becomes a greater hazard, necessitating enhanced safeguards including personnel grounding [1].

Upon discovery of this fine collected dust, planning commenced for its removal. Engineering personnel led the effort and got assistance from maintenance and operations. The cleaning scope included both the main body of the dust collector and all impacted ductwork. Engineering developed a written cleaning plan. A hazard review team then performed a risk analysis of the proposal. Hazard review teams are routine at this facility due to the significant quantities of solvents utilized. However, site personnel were relatively inexperienced with combustible dust remediation. To ensure a robust review, corporate combustible-dust subject matter experts and the contractors selected to perform the cleaning joined site engineering, operations, maintenance and health/safety personnel to perform a what-if risk analysis of the written cleaning plan.

Using photographs from the field, engineering went over the entire dust collection system with the review team. The MIE data obtained for the dust then were used to list types of ignition sources that would have sufficient energy to ignite a dust cloud if one formed during the cleaning operation. The hazard review team next focused on two specific areas for risk reduction: 1) identifying safeguards that would prevent/minimize/contain disruption of the dust to prevent formation of a combustible dust cloud during cleaning; and 2) identifying safeguards to minimize all possible ignition sources in the event a combustible dust cloud inadvertently was created.

To minimize the risk of creating a dust cloud, the cleaning plan incorporated multiple recommendations from the hazard review team. First, the order of line breaks and cleaning activities were specified so as to remove dust from easy-to-access areas prior to performing higher-risk line breaks. The goal was to remove as much fuel from the system as possible before performing overhead work with reduced egress options. This included removal of the filter elements and cleaning of the dust collector prior to disassembling overhead ductwork. Second, extra ductwork supports were installed. Adding these supports ensured the ductwork couldn't accidently fall as it was disassembled, disturbing settled dust and potentially forming an ignitable dust cloud. Third, plastic sheeting and glove bags (similar to those used for asbestos remediation) isolated rooms and line breaks. These actions ensured that any dust disturbed wouldn't be able to travel outside the boundaries of the work area, where measures to enhance protection against ignition also were being put in place.

Potential ignition sources were categorized, e.g., charge on metal surfaces (scaffolding, ductwork, etc.), charge on personnel, charge on tools, the vacuum to be used for cleaning, and surrounding electrical equipment. Again, the cleaning plan incorporated multiple recommendations from the hazard review team. Grounding wires were installed in multiple predefined locations including the ductwork (Figure 2), dust collector, scaffolding and any other potentially isolated metal surface. Engineering inspected the contractor air-powered HEPA vacuum equipment. Prior to the cleaning, which took place in August 2013, all operating equipment in the work area was shut down, and an extensive lock-out/tag-out was performed for all electrically powered equipment. Lock out of electrical equipment was accomplished remotely in motor control centers or at electric breaker panels away from the work area. Equipment locked out included motors, heaters, power outlets and control panels. Immediately prior to performing work, engineering met with contractors and maintenance personnel to review the cleaning plan, PPE requirements, and combustible dust hazards. All personnel were instructed to leave the area in the event of a dust cloud. "Danger" tape isolated the entire area; technicians posted at all entrances kept personnel out of the cleaning area.



GROUNDED DUCT
Figure 2. Ground wire was installed to prevent isolation of metal during cleaning of 4-in. duct.

The planning and coordination for the cleaning activity took several weeks but the cleaning itself required less than six hours. Approximately 10 kg of combustible dust were removed from the system and collected as a wet paste in the bottom of the contractor's vacuum equipment. After cleaning, engineering inspected all ductwork, which was in like-new condition.

PREVENTING FUTURE PROBLEMS

Engineering initiated a root cause investigation into why dust had accumulated and what needed to be implemented to stop accumulation from occurring in the future. The root cause investigation identified two causal factors.

First, designers had inaccurate/incomplete process safety information when the dust collection system was installed over a decade prior to this event. Preliminary design documentation erroneously indicated the product wasn't combustible. As a result, the dust collector system design didn't incorporate standards applicable to combustible dust (isolation/suppression systems, housekeeping program, etc.).

Second, multiple opportunities to identify the risk of accumulating material were missed even after the material was confirmed to be combustible. One opportunity came after several years of service when an initial combustible-dust hazard assessment was completed on the blending operation/dust collector. At the time, the facility had minimal organizational knowledge regarding combustible dust hazards. Technicians interviewed then stated that little dusting occurred during loading of the blender and no dust ever was discharged from the dust collector. These types of observations prompted the review team to conclude that no dust was being pulled into the dust collector system. The root cause investigation found these observations/conclusions to be inaccurate. The lack of dusting at the blender was due to the successful operation of the dust collector (i.e., dust is pulled away from the operator as intended). The failure to discharge material from the dust collector was traced to a mechanical problem with the internal pulsation system, which likely never had functioned following initial installation. This explained the heavy loading seen on the filters.

Another opportunity to recognize that dust was accumulating arose during completion of routine airflow testing. The investigation found that a 50% drop in airflow was documented in the work history of the dust collector but not flagged as a potential dust-collector operations issue. The reduced airflow rate of 250 ft^3/min sufficed to maintain operator protection from an industrial hygiene perspective, so no actions were taken to restore the airflow to the original design requirement of 500 ft^3/min. The reduced flow and, thus, duct velocity accelerated accumulation. Generally, preventing the settling of materials similar to this product requires a minimum airflow rate of 2,500 ft/min [2]. At 250 ft^3/min, the dust collector system was operating well below this minimum velocity in the 6-in.-diameter line that accounted for the majority of the ductwork in the system. In some cases, nearly 50% of the duct cross-sectional area was found to be plugged, particularly near the bottom of vertical risers where dust settling was prevalent.

Recommendations from the root cause investigation included: upgrading the system design to be suitable for combustible dust service; implementing routine internal inspections; establishing pass/fail criteria for duct velocity measurements; modifying duct sizing to increase airflow velocity; and setting up a program for regular internal cleaning.

The key takeaways from our experience are:

- Accurate material properties are essential for making informed risk-based decisions whenever handling combustible dust. The properties of a specific combustible dust material can vary greatly with changes in particle size. In our case, a 50% reduction in particle size resulted in an order-of-magnitude decrease in MIE and, thus, a far greater risk of a combustible dust flash-fire/explosion. Failure to understand this reduction in MIE might have resulted in less-stringent safeguards during development of the cleaning plan.
- Having all affected parties and subject matter experts take part in performing a thorough hazard analysis is invaluable in confirming that a written plan provides the safest possible path forward for executing a non-routine activity.
- An effective prework safety meeting ensures work is completed in the manner intended by the hazard review team and also provides a final opportunity to address concerns of those performing the work.

In the end, a significant amount of resources went into the uneventful cleaning of a small quantity of accumulated material. The results of the cleaning activity and subsequent investigation were communicated in multiple forums across the organization. Many committed team members actively participated in completing this work. Hopefully, this simple example results in positive outcomes for others vigilantly working to reduce combustible dust risk.

CYRUS FISHER is a consultant engineer for Eli Lilly and Company, Indianapolis. E-mail him at fisher_cyrus_a@lilly.com.

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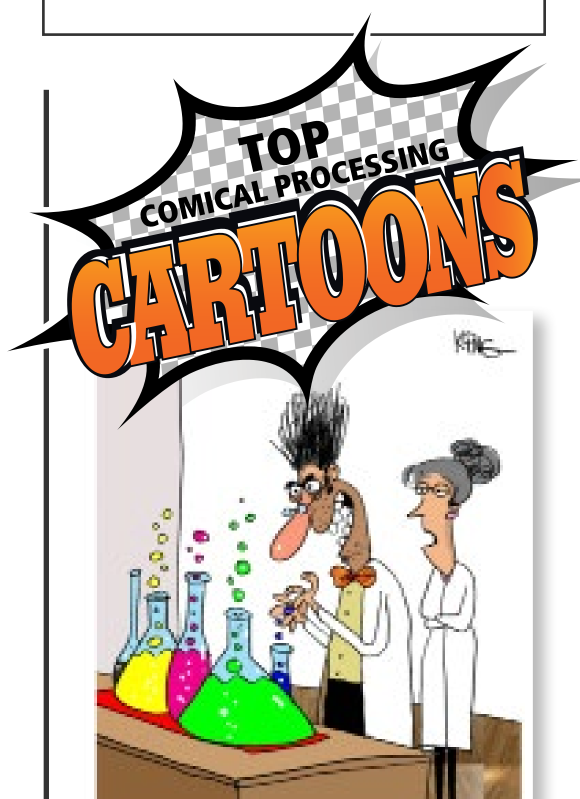

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