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Vacuum Conveying Fills a Void

Customization, automation and safety enhance its appeal

By Alan S. Brown, Contributing Editor

ASK A vacuum conveyor vendor what's new and the answer is likely to be both "not much" and "everything." After all, vacuum technology has changed little over the past decade but each conveying project presents a unique combination of processing issues, usually requiring some customization.

"There are not a lot of new things about vacuum conveying, but there are new applications every day," notes Doan Pendleton, vice president of marketing and sales for Vac-U-Max, Belleville, N.J.

"One of our strengths is that we have a standard line of equipment and also a custom metal shop. If you have an application where you have to discharge to a mixing tank next to a wall, we can take our standard vacuum receiver and reengineer it so it fits into that space," he says.

Piab, Hingham, Mass., boasts that its highly modular equipment provides flexibility. "We can customize anything based on a mix-and-match approach," explains Brian Wilson, who handles technical sales and support for the company's Material Handling Group. The firm makes a single vacuum pump housing but can alter vacuum capacity simply by adjusting the number of air ejector cartridges. "If an application changes and they need more capacity, we can swap out components and add air ejector cartridges, filters or a module for fluidization," he says.

"Customization is our forte. We're not trying to shove a single design or approach down a customer's throat," notes Ed Heller, president of Industrial Equipment & Design Co. (IEDCO), Turnersville, N.J.

Customer demands continue to evolve. Chemical manufacturers want new vacuum systems to increase throughput, protect worker health, and improve plant safety and efficiency. Yet, because their staffs are lean and overloaded with projects, they expect a lot more from vendors. Instead of looking for vacuum conveyors and receivers, facility managers want complete systems that they can plug into plants and forget about.

ENHANCED PROCESSING

Figure 1. Unit conveys 50 lb/hr of ingredient from dump station to a storage hamper. *Source: Hapman.*

This trend has been apparent for 10 or 15 years, but intensified since the recession in 2008. "Many customers rely on us far more than they had for preventative maintenance and also for advice on what spare parts they need to carry to keep their plant running optimally," says Nick Hayes, president of Volkmann,

Hainesport, N.J. Some companies, such as Hapman, Kalamazoo, Mich., also offer formal managed maintenance plans for their equipment.

FILLING A VOID

Plants opt for vacuum systems where screw conveyors, which are simpler and less expensive, simply won't work. "The number one thing people look at first is a screw conveyor," says Steve Grant, Hapman product manager. "But maybe the vertical distance is too high, or you have to work around existing equipment, or maybe you need to go around a couple of bends or through a wall… Or if you're involved in batching operations, it's more ergonomic to put a vacuum wand in a drum and empty it out than have someone carry that drum to the top of a hopper," he adds.

Unlike screw systems, vacuum conveyors can curve around reactors and deliver particles to an upper mezzanine with a 90° bend. While not as low cost as screw conveyors, they are relatively inexpensive and require little maintenance. Vacuum lines even purge themselves (with a vacuum, of course) when switching between products. They also simplify dust control, because any leak will suck in air rather than blow out powders.

Vacuum conveyors also have disadvantages, notes Joe Morris, vice president of sales and marketing for Cyclonaire, York, Neb. They are limited in length, generally to no more than 100 ft, and usually to moving material to a single point because switching destinations requires a vacuum receiver at each location as well as a complex system of valves.

Also, vacuum conveyors that rely on high airflow can pulverize fragile products. In such lean-phase systems air speed can exceed 1 mile per minute. This is fast enough to turn tablets into fine powders the first time they reach a 90° bend.

Use of lower air speed can solve this problem. Intermediate-phase systems, for example, provide just enough vacuum to entrain some powders while letting others drop to the bottom of the line. As these powders build up, they impede airflow. This increases suction and air speed at that point in the line, pulling the powders forward in gentle waves. The result is smooth and relatively gentle transport.

Figure 2. Vacuum conveyor wand eases unloading of a hazardous chemical. *Source: Volkmann.*

However, this approach doesn't work well with mixtures of fine and coarse particles. Dense-phase conveying solves this problem by ratcheting down air speeds further. This causes powders to build up until they plug the line. The vacuum eventually pulls the plug of material slowly through the line. "It moves so slowly you can convey very delicate products without damaging them," says Hayes.

BULK BENEFITS

Even the slowest vacuum conveyors can achieve large increases in productivity by enabling companies to switch to more flexible intermediate bulk contain-

ers (FIBCs), also known as bulk bags, from smaller packages such as 50-lb bags. The 1-ton bulk bags are simpler to handle and store. In addition, companies often can get substantial discounts for purchasing material in FIBCs.

More importantly, though, use of bulk bags simplifies process automation. Instead of manually handling 50-lb bags, say, to fill a hopper above a mixer, a vacuum line from the bulk bag can charge the material. Adding the vacuum system simplifies process flow and eliminates labor and the risk of injury from lifting.

"You can add sensors and it will automatically dose it, monitor the hopper, and send a message to the control room when it is time to get a new bag. It's cleaner and more convenient," says Morris. "We had people say they wanted to load up a weekend's worth of product. If something goes wrong, the system calls you on the phone. Otherwise, you come back in on Monday," he adds.

Even in low-volume applications, where bulk bags make little sense, vacuum systems can simplify process flow (Figure 1) and reduce the potential for injuries caused by lifting and unloading (Figure 2).

Many companies opt for vacuum systems to save labor, Heller notes. "If they can save a job here or there in terms of cleaning or maintenance, they want to do that, too," he adds.

Vacuum systems are relatively easy to maintain because they contain no moving parts. Over the years, vendors have solved many of the problems that once plagued the systems.

"I've worked in vacuum conveying for 17 years, and I can remember systems that workers had to whack to get product moving," recalls Piab's Wilson. "Now we have much better filtration systems and fluidizers to break up caked powders in hoppers. No one wants to have to babysit their system today."

Piab and other vendors also have made their systems easier to pull apart to service.

"Every aspect of our vacuum pump is modular, from the air shock housing to air ejectors. The average pump lasts seven years before it requires maintenance, and if something breaks or fails, you can replace just that component," notes Wilson. "It is designed so that even a small stature operator can take it apart. The parts are small and easy to lift. The only thing you need a tool for are three hex nuts," he says.

Hapman has made its filters easier to clean by shifting the filter door to the side of the housing from the top, where traditionally it's located. "It's safer because maintenance people don't have to get on top of a silo or hopper and remove the top cover with the filter attached. We can now put our filters right up to the ceiling," notes Grant.

IEDCO's Heller points out that many of these innovations — high reliability, easy maintainability, quick cleaning, and tight material containment — started in the pharmaceutical industry and spread to fine chemical and other manufacturers.

COST SAVINGS

Piab has introduced a less expensive system specifically for non-pharmaceutical manufacturers that don't require the corrosion resistance of Type 316L stainless steel. "It's for companies that make food, neutraceuticals, spices and fine chemicals. Its ability to have a full open bottom valve gives it very high throughput," explains Wilson.

The new piFlow system (Figure 3) costs 40% less than a similar 316L system, he says. Savings stem not just from switching materials but also from use of a more basic control system and the need for less extensive validation. In addition, the system boasts fewer optional features (such as fluidization).

Hapman and some other vendors argue that using electric blowers rather than plant air (from large compressed-air systems) saves money over the long term. "Plant air is very expensive to generate, and vacuum conveyors consume a lot of it. While both systems are similar in price initially, over the long run electric motors are cheaper to run than plant air systems," says Grant.

Hayes disagrees: "Vacuum systems only use plant air when actually conveying material. They do not run

LESS EXPENSIVE SYSTEM

Figure 3. Changes in material of construction and the control system lower costs. *Source: Piab.*

continuously. When you are refilling your hopper, you can't stop and start an electrical motor without ruining it, so what do you do? You leave the motor running and purge the air through a bypass system. So you're paying to pump air into atmosphere.

"With a plant air system, I take a 10-lb slug to the hopper, stop, and discharge. When I discharge, I cut the airflow. What that allows us to do is reverse-pulse the filter to clean it out. So I'm cleaning the filters when I'm not pulling a vacuum.

"People say it costs more money for compressed air, but when it stops it costs you nothing. When you're running a motor, you have to run it all the time and that costs money," says Hayes.

IEDCO's Heller also cites benefits of plant air. "IEDCO's mantra is: 'We don't mess around with things that go around… We try and design rotating machinery out of the equation. Compressed-air-driven vacuum pumps have no moving parts and are easier to maintain." However, the company isn't rigid about only using plant air. "So instead of pushing compressed air down our customers' throats, we also provide rotary claw, or bush, pumps. We've actually fallen in love with them. They have very flat vacuum performance and they can pull nearly as much vacuum as a compressed air system… By offering them, we can provide more flexibility in how we configure our lines."

Plant air systems also are much quieter than electric pumps and are intrinsically safe.

Hayes likes to talk about reducing the risk of explosions. He points to the 2008 explosion at an Imperial Sugar refinery, where a spark set off sugar dust that had accumulated in the rafters, killing 14 workers, injuring 40 others, and totaling the facility. (See: "Dust Gets Its Due," http://goo.gl/KPTImG.)

Vacuum systems not only reduce the likelihood of sparks, but also prevent product from leaking into the plant.

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We are Your Source for Pfizer Surplus Equipment

Match the Level Measurement System to the Job

Consider materials and work environment when choosing a device

By Jenny Nielson Christensen, BinMaster

INVENTORY MANAGEMENT is all about inventory and controlling its related costs. Your job is to determine how much material you have on hand and when you need more so that you don't run out. But these dusty powders are stored in large, dark, enclosed tanks. Without x-ray vision, you have no way to see what's actually in them.

Fortunately, devices are available to help make inventory more accurate and your job easier. To select the device that is best for a particular application, consider the material being measured, whether the material surface tends to be even or irregular, the regulatory environment and tank size, and whether you need to know when inventory has reached a certain level in the tank — which calls for a point level device — or you need continuous level measurement.

What can you expect from a level detection device? It will:

- Help you manage your inventory;
- Eliminate the need to climb tanks to check levels;
- Enhance safety in the workplace;
- Alert you when material reaches a particular level in the tank;
- Provide a single, repeatable measurement when there hasn't been any activity in the tank;
- Provide an accurate distance to product within a few inches; and,
- Measure headroom in the tank or the distance to the material to determine the remaining space in the tank.

What can't you expect? It's a common fallacy that a tank level will convert to mass or volume and then to pounds accurately. The nature of powders is that they will settle, shift and compact in the tank, often creating a topography reminiscent of a lunar surface. New, advanced devices can measure multiple points in the tank to account for surface variations. Adding strapping tables to account for compaction will improve inventory accuracy and compensate somewhat for the behavior of the material. However, a level measurement device is not a scale.

Let's explore some of the level sensor options and considerations when selecting a device, starting with simple sensors and building toward more complex, accurate continuous level technologies.

ROTARY DEVICE

Figure 1. For high-level detection in a tank, a rotary is mounted on top of the tank, and a custom-fabricated extension places the paddle at the desired level.

ROTARY LEVEL INDICATORS

Rotaries are familiar and common devices used for high- or low-level point level indication in bins, tanks, and silos. Rotaries can be used in most powders as long as the bulk density is at least 1 lb/ft^3. They are versatile enough to use in other materials such as granules, pellets, and coarse, lump materials with bulk densities up to 150 lb/ft^3.

The principle of operation for rotaries is simple: A rotary sends an alert via a control room, horn, light, or an alarm panel when material reaches or falls away from the rotary paddle. When material has reached a high level during filling, the paddle rotates continually until material reaches the paddle (Figure 1). When the paddle meets resistance from the material, it stops rotating and sends an alert. Conversely, as a low-level indicator, the paddle will begin turning when material drops below paddle level and will send an alert or can be wired to start up a process system.

Different types of rotaries warrant consideration depending on how critical the rotary's role is in the operation. What this means is what is the impact on an operation if a rotary should lose power or fail? This comes into play if a rotary is critical in starting, stopping, or controlling a process or in causing a work stoppage if a tank should become empty. Most standard rotaries are designed to provide protection from system power failure. Some feature a motor that "goes to sleep" or "de-energizes" to shut down automatically when material is present, which also serves to extend motor life. When it is crucial to confirm a rotary's continuous operation, the application calls for a fail-safe rotary that self-diagnoses continually and, in the event of a failure, sends an immediate warning and instantaneous corrective response. These models often have an LED light or other visual indicator on the unit to visually monitor the motor status.

Rotaries increasingly are applied in new and innovative ways. For high-level detection of a tank's interior, a vertical extension on a rotary can allow it to be extended up to 12 ft. down into the tank. This configuration is recommended for a center-fill tank when operation wants to allow a specific amount of headroom in the tank. Mounted on the top of the tank, a vertically extended rotary can alert when material is higher toward the center of the tank as opposed to simply detecting the level of material near the sidewall, which could be at a lower level when filling the tank (cone up) and at a higher level when emptying the tank (cone down). For thick tank walls, such as those in cement silos, a horizontal extension allows a rotary to be used to detect material levels through the sidewall. When a horizontal extension is combined with a collapsible paddle, the rotary can be installed through a 1¼- or 1½-in. NPT opening without entering the tank.

CAPACITANCE PROBES

Capacitance sensors are designed for an array of applications and can be customized with different type of probes, lengths or extensions. These sensors may be used for high-, mid-, and low-level detection in bins, silos, tanks, hoppers, chutes, and other types of vessels in which powders are stored, processed, flowing or discharged.

Capacitance sensors operate by detecting the presence or absence of material in contact with the probe by sensing a change in capacitance caused by the difference between the dielectric constant of the material in the tank and the air. These sensors detect very small changes in capacitance, typically one picofarad (pF). When selecting a capacitance probe, understanding the radio frequency (RF) range of the device and its impact on other equipment in the plant is important. According to the

Federal Communications Commission, signals in excess of 9 KHz are classified as “RF” and are prone to radiate.

Capacitance sensors that emit RF signals may interfere with nearby electronic plant equipment. Conversely, capacitance probe designs that use RF may be prone to interference from other RF devices, such as two-way radios. Some capacitance probe designs use electronic circuits incorporating frequency shift oscillators and balanced bridges and operate at frequencies between 100 KHz and 2 MHz in the RF range. Alternatively, other designs use a discharge time constant detector circuit that senses capacitance changes of less than one pF and operates at only 6 KHz, which is well below the RF level of most plant equipment. Since this type of capacitance sensor operates at such a low frequency, it will not interfere with nearby electronic plant equipment and is not susceptible to interference from other equipment.

For chemical processing applications in which the risk of contamination must be minimized, a shielded, Delrin-sleeved sanitary probe often is appropriate and will meet the regulatory requirements for the material application. A sanitary probe must be tested and proven to meet USDA or 3-A Sanitary Standards for hygienic equipment design to ensure the purity of material being measured is not compromised. A sanitary probe should be designed for quick disconnect from the device, so it may be removed from the tank easily for inspection and cleaning. Sanitary versions of capacitance probes also are designed so no exposed threads allow material to build up and become contaminated.

To guard against false readings from buildup on the probe or bridging between the sidewall and the probe, a portion of the probe should be shielded. The probe’s shielded portion emits a non-sensing signal that forces the active signal to examine a large area around the probe. This enables a capacitance probe to be used in tanks that store a variety of dusty, sticky or clinging powders without the risk of false alarms.

Figure 2. A bendable capacitance probe can be used to detect the level of powders in space-constrained tanks and mixers.

A time-delay feature can minimize false alarms in case of a sudden material shift caused by rapid filling or emptying of tanks or process activities. A time delay operates by “waiting” a set period of time before acknowledging the signal for a change in the presence or absence of material. A time delay can be set separately for “uncovered to covered”

or "covered to uncovered" conditions and may be adjusted for a delay of up to 30 seconds.

If continuous process operation is critical, look for a capacitance sensor that features fail-safe protection to eliminate process shutdowns, overfills, empty conditions or accidents. To prevent overfills or material shortages, a high/low selectable switch allows the sensor to be set for fail-safe high or fail-safe low.

An extended, flexible cable extension can be attached to the capacitance probe in instances when the sensor is mounted on top of the tank and will be used for high-, mid-, or low-level detection. The extension can be customized to the desired length depending on how far into the tank the material must be detected. A flexible extension is immune to the type of damage that may occur with a rigid probe.

A flush-mounted probe can be used in narrow or space-constrained areas or in applications in which material flow or bridging may damage a standard probe. This type of probe mounts flush on the tank wall, on a conveyor housing, or in a chute. When mounted in tanks with thick walls or angled hoppers, a tank wall adapter is used to mount the probe flush or slightly protruding on the inside of the vessel wall, which will help eliminate false signals resulting from excessive buildup on the probe surface.

When the tank is small or has internal obstructions, a bendable probe can be used to avoid such obstructions while still allowing adequate probe surface area to detect the presence or absence of material. A bendable probe can be used in places where other sensors won't fit, including smaller mixing tanks or storage vessels used in material processing applications (Figure 2).

If your facility has an explosion-proof requirement, you will need to specify a capacitance sensor designed and certified for hazardous location applications. This CSA certification ensures the sensor housing is tested and proven to provide explosion-proof protection in volatile process environments.

If the application is in a high-temperature environment or in an area with excessive vibration, it is appropriate to install a capacitance probe that houses the electronics and probe in separate enclosures. This remote configuration allows the sensor's electronics to be mounted safely in a location away from the sensing probe, which will protect the electronics from heat or vibration.

LEVEL SWITCH

Figure 3. A single-blade vibrating-type level switch can detect light, fluffy materials as well as heavy materials.

VIBRATING LEVEL SENSORS

The vibrating level sensor (Figure 3), or vibrating rod, is a piezoelectric-driven vibration-type level switch that can be used for level detection in bins, silos, and hoppers filled with powders and other dry bulk solid materials. A vibrating level sensor can detect fluffy materials as light as 1.25 lb./cu. ft.^{3}, such as powders and flakes, or can be used for heavy materials, such as granulars or pellets. These rugged sensors often are constructed of durable stainless steel and are almost wear- and maintenance-free. A vibrating level sensor can be used as a high-, mid-, or low-level alert and can be mounted on the top of the tank as a high-level detector or in the bottom cone of a tank to sense when the tank is almost empty.

Vibrating rod level sensors have a single rod-shaped vibrating element. The sensor's rod vibrates when no material covers the active rod. When the rod is covered with material, the vibration is dampened, and an electronic circuit causes a relay to switch and sends an alert. When the rod becomes uncovered, the vibration restarts, and the relay will switch back. Unlike a tuning fork that has two probes that can cause material to become lodged and give a false signal, a vibrating rod's single-probe design prevents material from bridging and giving a false signal.

Vibrating level sensors are reliable because the sensitivity is located at the tip of the sensor, and material built up on the vessel wall will not influence the sensor's function. In addition, the combination of low energy and tip sensitivity will reduce false alarms resulting from rat-holing around an active sensor. Because it is piezoelectric, the sensor can be used to overcome difficulties in some applications that may be associated with changes in dielectric constant, humidity, temperature or material density.

Figure 4. A top-mounted tilt switch is used for high-level detection, activating an alert when the material tilts the switch by 15°.

With advancements in product design, most vibrating rods do not require calibration and adjust easily to the desired sensitivity level. For process-critical applications, be sure to look for features such as a fail-safe alert that will provide notification when power is interrupted to the unit to avoid overfills and empty tank situations that could shut down operations. Other models may include features for high temperatures or with remote electronics. Depending on the manufacturer, some vibrating rods can be extended down into the tank

BOB SENSOR

Figure 5. A bob-style sensor works like an automated tape measure without the safety risks and hassle of climbing tanks.

if the vibrating sensor is to be used in a top-mounted application for high-level detection.

TILT SWITCH

A tilt switch is a high-level indicator designed to install easily and require no routine maintenance. A hanging tilt switch is installed by suspending it from a flexible cable within the tank or over a pile of material. As material rises below the switch, it will tilt and activate a microswitch when the tilt reaches 15° (Figure 4). A hanging tilt switch also can be used for plugged chute detection.

Alternatively, a fixed-mount tilt switch mounts from the outside on the top of the tank though a process connection. An angular motion transferred into linear motion activates an electrical microswitch that can be used for a direct input to a control system or to activate an external alarm. The switch is activated when material rises and tilts the switching mechanism 15°. A fixed-mount tilt switch can be custom-made in lengths from 1 to 8 ft. Depending on the distance from the top of the bin, an alert should be activated.

BOB-STYLE SENSORS

If minimal contact with the material in the tank is acceptable, a weight- and cable-based sensor (Figure 5) can be used for continuous level measurement. Weight- and cable-based, or bob-style, sensors are suitable for most powder applications as these sensors are not affected by dust, humidity, temperature, dielectric constant, or fumes that may be present in the tank. Because a stainless steel probe at the end of the cable makes minimal contact with the material, contamination risk is minimized. This type of sensor works in most material regardless of particle size or bulk density, including very light materials such as fine powders to heavy, dense materials. If multiple tanks containing different types of processing, packaging, or waste materials need to be monitored, bobs are a versatile technology that has been used for more than 20 years.

BIN VIEWING SOFTWARE

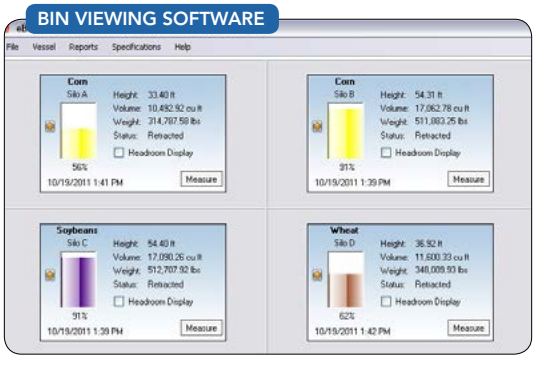

Figure 6. Windows-based software, available with bob-style systems, allows for viewing the levels of multiple tanks simultaneously.

A bob-style sensor can be used in tanks up to 180 ft. tall but are often used in smaller, active process tanks under 40 ft. tall. For the best accuracy, the sensor should be mounted on the roof about ⅙th of the way in from the outer perimeter of the tank, accounting for the angle of repose on a center-fill tank. Properly mounted on a center-fill, center-discharge tank, bob-style sensors will provide 5%–7% accuracy consistently. They work by releasing a cable with a weighted sensor probe that stops and retracts when the probe comes into contact with material. Redundant measurements are taken when the sensor probe is both descending and retracting to guarantee every measurement is precise.

Bob-style sensor networks can be integrated using a variety of communication options, such as a control console mounted at ground level that can report the data from one to more than 100 tanks and provide information such as distance to product (headroom), height of product, and percentage full. If the preference is to have tank data sent to a personal computer, several companies offer Windows-based software (Figure 6) to report detailed data for multiple tanks simultaneously and feature a visual report of tank levels. Other communications include the ability to send automated email alerts when tanks reach a predetermined level. Internet-based monitoring systems also are available that enable 24/7 access to inventory data from any device with a Web connection — including tablets and smartphones — and also allow for managing multiple sites from any remote location.

3D SCANNERS

A 3D scanner (Figure 7) is a noncontact, dust-penetrating tank-volume measurement system that uses acoustics-based technology to measure

Figure 7. A 3D scanner is a non-contact, dust-penetrating device that measures multiple points in the tank to provide better accuracy.

tank contents at multiple points within the tank. What makes a 3D scanner different is that unlike ultrasonic or radar devices that are measuring one point and determining a single distance, the 3D solids scanner takes measurements from multiple points within the tank and uses these points to help estimate the volume of material in the tank. Sampling measurements from multiple points when the material surface of the tank is uneven enables the scanner to calculate tank volume for powders with better precision.

A 3D scanner is unique because it can map the topography of the tank and create a computerized profile of the tank contents. This allows for greater accuracy as it detects cone up, cone down, bridging, and sidewall buildup and then accounts for these variations when it provides the volume estimate. The 3D scanner comes equipped with

software that displays the tank data in an easy-to-read format. The measurements are sent to a main display screen and includes data such as average, minimum, and maximum distances; level; temperature inside the tank; and volume percentage. The 3D mapping software depicts surface irregularities in a visual representation of the tank contents (Figure 8).

A 3D scanner can perform in tanks up to 200 ft tall and in materials with bulk densities greater than 12 lb/ ft^3. Facilities that install 3D technology are seeking improved inventory accuracy; a 3D scanner can deliver 0.5%–3% volume accuracy when mounted in the proper location and used in a tank that is less than 45 ft in diameter. For tanks greater than 45 ft in diameter, a multiple scanner system can record measurement data from multiple devices and then combine the data to report volume to a personal computer and provide a single graphical representation of the tank contents.

A 3D scanner is desirable when highly accurate volume inventories are needed to help in optimizing purchasing, delivery logistics, production planning and financial management. Mapping the contents provides a realistic view of inventory levels, helps managers track inventory more closely, and reduces production shutdowns. By detecting buildup, a 3D scanner allows the maintenance crew to perform timely preventive maintenance and cleaning, which over the long term can protect the tank from potentially damaging structural stress.

ULTRASONIC AND RADAR DEVICES

These types of measurement devices eliminate the risk of contamination or interference with the internal tank structure because the device does not come into contact with the tank material.

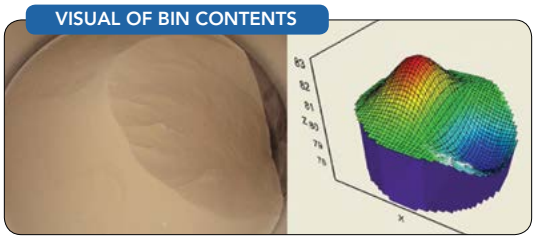

Figure 8. The 3D scanner can provide a visual representation of bin contents depicting high and low levels in the tank. The visual on the left is the tank contents, and the 3D representation is on the right.

Ultrasonic and radar-based technologies are single-point, continuous measurement devices used for ongoing level measuring and monitoring of tanks up to 100-ft tall. An ultrasonic device generates an ultrasonic pulse that is sent to the surface of the material in the tank. The pulse reflects off the product and returns to the sensor in the form of an echo. The amount of time the echo takes to return to the sensor determines the distance to the material. Radar-based devices generate an electromagnetic wave that travels to the material surface being monitored then bounces off the surface back to the sensor. The calculated distance is based on the length of time it takes the wave to return from the surface.

Many ultrasonic and radar devices offer broad processor capabilities that provide remote display options on a dedicated display panel or have PC software that allows tanks to be monitored from an office. Many manufacturers offer system designs intended to simplify system implementation and maintenance and offer communication technology that can be integrated with an existing plant infrastructure. Both ultrasonic and radar-based devices can be programmed to send a 4-20 mA analog output signal to an existing control system or send

data to a PC running a calibration/data logging program using RS-485 communications.

Ultrasonic and radar generally are not the best choices for powders because high-dust environments can cause their signals to become "confused" and provide inaccurate measurements or no data at all. Because these devices measure only a single point in the tank, accuracy may be compromised in materials such as powders that are more prone to bridge or have an irregular surface area. They also need intensive maintenance in powder applications, requiring frequent cleaning or an air purge to keep the sensor working properly. However, they can be suitable and highly accurate for liquid applications, as liquid levels are even across the tank.

If these sensors are used in hygienic applications or applications sensitive to cross-contamination, special consideration should be made for sanitary fittings such as stainless steel, Teflon, or Delrin-insulated components that will not contaminate material.

A pulse radar device with an aluminum housing and Teflon (PTFE) antenna can be used for level measurement applications with the demanding regulatory requirements of the chemical industry. When selecting an ultrasonic or radar device, look for one that is self-calibrating or easy to calibrate because of the variability of materials that may be measured. Be sure to match the device capabilities with the desired communications options, whether they are 4-20 mA, RS-232, or RS-485 or PLC-based.

MAKING THE RIGHT CHOICE

When it comes to managing inventory in any tank in your operation, the first consideration is what type of information you need. Are you seeking level, volume, or weight? If you simply need to know whether a tank is empty or full, choose a point level device. If you need to know the tank's level, such as percentage full, headroom, or distance to product on an ongoing basis, consider a continuous inventory management system such as a bob-style, ultrasonic, radar, or 3D device. A non-contact device may be desired if the regulatory environment demands it. Keep in mind that some non-contact devices perform inconsistently or unreliably in dusty environments. Finally, check to ensure the necessary certifications apply if the device is being used in a volatile environment.

Tank size, the number of tanks, and whether they need to be networked also will influence the type of system you select. If you are seeking convenience, look for a system that offers wireless installation as well as software or consoles that centralize the location of your data and can generate the types of reports you need. The precision of inventory accuracy can vary from one operation or even one tank to the next. Getting an accurate measurement for a single point in the tank can be accomplished easily, but it might not give you the overall volume accuracy you need. For uneven material surfaces, tanks with multiple fill and discharge points, or very large tanks, expect the system to be more complex and more expensive.

And remember, when it comes to level controls, you can find a robust selection of technologies at prices ranging from a few hundred to a few thousand dollars. Level measurement is not a one-size-fits-all product. It is a puzzle with many pieces that when put together right will give you a better picture of your inventory.

JENNY CHRISTENSEN, MBA, is vice president of marketing for BinMaster. She can be reached at jchristensen@garnerindustries.com.

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Vibrating Rod	Vibration stops when material reaches its level to alert to silo status	Dry solid materials with bulk density as low as 1.25 lb./cu. ft.	Unique sword-shaped probe resists buildup and prevents false alarms. Rigid and flexible extensions for top mounting. Self-cleaning with no moving parts
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Remove Solvent Vapors in Diverse Applications

Dry and liquid ring vacuum pumps are alternatives to oil-sealed pumps

By Phil Vilbert, Tuthill Vacuum & Blower Systems

IN MANY chemical and pharmaceutical applications vacuum systems are used to pump solvent vapors whenever excess solvents must be removed. Such processes involve drying, distilling, chemical reactions, synthesis of compounds, separation and purification, and cleaning. Many organic solvents need to be recovered because of their toxicity, flammability, or environmental impact. Among the vacuum pumps used to handle solvents are liquid ring and dry pumps.

Unlike oil-sealed pumps such as rotary vane or piston pumps, neither the liquid ring nor the dry pump requires internal lubrication. This allows solvent vapors to be sucked through the pumps without jeopardizing their lubrication. The liquid ring pump has external grease-packed bearings that are isolated from the process fluid by mechanical seals. The dry pump has external bearings that are either oil-lubricated or grease-packed and separated from the process by mechanical seals. The dry pump also has oil-lubricated timing gears to maintain the two parallel shafts rotating in the correct phase to avoid contact.

LIQUID RING PUMP

This type of pump requires a liquid sealant to seal the clearances and cool the heat load, which is composed of the pump's brake horsepower (bhp) and any latent heat of condensation. The most common sealant is water, but other process fluids can be used if they are compatible with the process and allow for recovery and return to the process to minimize waste. In some cases, water is used as the sealant when the process solvent being handled is immiscible or only slightly miscible with water and can be decanted in an oversized separator tank.

Figure 1. A liquid ring pump relies on handling the process fluids as a vapor at inlet and condensing them to the liquid phase while passing through the pump.

The liquid ring pump (Figure 1) usually relies on handling the process fluids as a vapor at inlet and condensing them to the liquid phase while passing through the pump. If the condensing process occurs at inlet while contacting the lower temperature sealant, the pumping capacity will

DRY VACUUM PUMP

Figure 2. The dry pump keeps high-vapor pressure solvents such as methylene chloride, acetone, and methyl ethyl ketone in the vapor phase while passing through the pump.

be increased. If it occurs later before discharging, because of the pressure increase, the capacity will not be increased, but the heat load still will require handling as a result of the latent heat of condensation. If it is large enough, it will increase the sealant ΔT. Because the liquid ring operates with a liquid sealant, it can accommodate a continuous liquid carryover from the process or from the condensate stream from an upstream condenser.

DRY PUMP

This type of pump does not use a liquid sealant and relies on small clearances between rotors and housing and higher rotational speed to reduce gas slippage. The lack of a liquid sealant also causes the discharge temperatures to be higher, which assists in maintaining the "dry" feature of the pump by helping to keep the process vapors in the vapor phase from inlet to discharge. The dry pump does not benefit from condensing effects but does benefit by keeping high-vapor pressure solvents such as methylene chloride, acetone, and methyl ethyl ketone in the vapor phase while passing through the pump (Figure 2).

Some dry pumps can accommodate a small amount of process liquid carryover, but if this occurs continuously, the pump will not maintain its "dry" characteristics, and performance also

CONTAMINATE-FREE SYSTEM

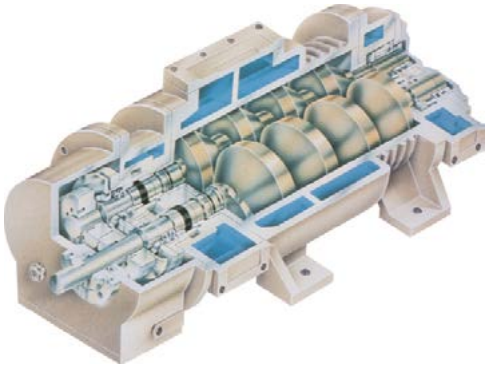

Figure 3. Solvent vapors are passed through the dry vacuum system and then usually are condensed at the exhaust, which provides a closed loop for containment and recovery with no contamination.

LIQUID RING VACUUM PUMP

Advantages	Disadvantages
Can perform as both vacuum pump and direct contact condenser	Normally higher operating cost than a dry pump
Lower purchase price	Higher power and cooling water consumption
Simplicity of rotating parts improves reliability	Larger footprint
Lower maintenance	Pump performance is limited by vapor pressure of sealant
Pump simplicity enables disassembly and reassembly onsite by end user	Requires a supply of liquid sealant for makeup or change out
Lower operating temperature for thermal-sensitive or polymerizable process material	Operation normally results in larger amount of hazardous waste
Liquid sealant allows for handling higher temperature inlet gases and vapors	
Can ingest liquid from process or condensate from upstream condenser	
Less sensitive to process particulate because of larger clearances	
Liquid within pump may act as quench to reduce chance of ignition from sparking	

Table 1. Liquid ring vacuum pumps boast numerous advantages.

DRY VACUUM PUMP

Advantages	Disadvantages
Lower ultimate pressure and higher capacity at low-pressure for single-stage pump	Higher purchase price
Lower power consumption	Higher complexity affects reliability
Lower cooling water usage	More difficult to disassemble onsite by end user
More compact footprint	Solvent handling limited by solvent's auto-ignition temperature
Can pump high-vapor pressure solvents	Limited liquid ingestion
Environmentally friendly with less pollution	

Table 2. Dry vacuum pumps can be very energy efficient.

will become limited by the vapor pressure of the liquid. In cases of process liquid carryover from upsets, knock-out traps normally are used to trap the liquid ahead of the dry pump. In many cases, dual traps are used in parallel so that one trap can be valved off and emptied while the other is placed online. In some cases, a valved bypass around the trap is used to allow the dry pump to stay online while the isolated trap is emptied. If an upstream condenser is used ahead of the dry pump, the condensate is collected in a separate condensate tank. Because the dry pump maintains the process vapors in the vapor phase passing through the pump, an aftercondenser normally is used for collection.

CORROSIVE PROCESS FLUIDS

When handling corrosive process fluids, the liquid ring pump can use a corrosion-resistant material of construction such as 316 SST and a nonaqueous sealant, while the dry pump relies on a corrosion-resistant coating such as Teflon and the fluid in the vapor phase to minimize the corrosion potential.

VACUUM SYSTEMS

While both liquid ring and dry vacuum pumping systems can be used as alternatives to oil-sealed pumps, dry vacuum pumping systems provide a green vehicle for removing excess solvents (Figure 3). Dry vacuum systems have no internal sealing liquid that could be contaminated by incoming solvents or contaminate the outgoing solvents that need to be recovered. The solvent vapors are passed through the dry vacuum system and then usually are condensed at the exhaust, which provides a closed loop for containment and recovery with no contamination.

A typical system consists of a dry vacuum pump with a shell and tube condenser at the exhaust. If higher capacities are required, a booster/dry pump combination can be used. Dry vacuum systems offer the advantages of reduced power consumption, decreased coolant usage (lower bhp/acfm and cooling water flow), a smaller footprint, and better control in maintaining the solvent as a vapor while passing through the pump so that condensing occurs where desired. Dry pumps also are more easily controlled by using variable frequency drives (VFD) for process pressure control compared to liquid ring pumps in which the minimum rpm is determined by the fluid ring's collapsing. Dry vacuum systems also can handle volatile organic solvents such as methylene chloride, acetone, or methanol in which the higher vapor pressures could cause problems for a liquid ring pump (see Tables 1 and 2 for pros and cons }of each system).

A dry vacuum system more easily handles and maintains a leak-tight system that prevents the entrance of air to avoid flammable mixtures or the leaking of process fluid to the environment. Because of the elevated discharge temperatures of the dry vacuum pump, the solvent's auto-ignition temperature always should be greater than the dry pump's maximum discharge temperature, which normally occurs at the lower inlet pressure range.

PHIL VILBERT is senior applications engineer for Tuthill Vacuum & Blower Systems. He can be reached at pvibert@tuthill.com.

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Meet Combustible Dust Compliance

Facility tackles combustible dust with portable central vacuum system

By Doan Pendleton, Vac-U-Max

WHEN MISSY Morrison, plant manager at Star Milling, Perris, Calif., says, "We want to avoid injury at all costs," she's not regurgitating a safety slogan but stating a legitimate objective. Morrison and Keith Williams, maintenance manager, attend several safety seminars throughout the year and devote a significant amount of time staying abreast of the Occupational Safety and Health Administration (OSHA) news. "We are in a high-risk industry," says Williams. "Many people don't understand that grain milling is high risk. It's an extremely flammable industry."

Star Milling (Figure 1) began as a means to produce quality feed for the family egg farm. The mill brings in raw grains and other ingredients to produce feed for a variety of animals. In addition to producing its feed labels Integrity, Kelley's, Ace Hi, and Ultra Balance, the company also provides private-label services and delivers its feed in bulk tankers to farms. Functioning on the same principles for more than 40 years, the feed mill still is family-owned and operated and is the largest feed mill in Southern California.

Figure 1. Star Milling's facility includes a variety of equipment that produces tons of feed per day, generating large amounts of dust. *Source: Air Cleaning Technology*

Producing tons of feed per day, the large facility includes an extruder, two pellet mills, a grain cleaner, roller mills for making rolled barley grains, a mixer for pigeon and wild bird feed, a fully automated bagging system that uses a robot to palletize sacks, and a small bagging line for small-packaging flexibility. To stay ahead of the growth, new electrical and computer systems facilitate increased automation in the facility.

With increasing production, manual cleaning methods were becoming cumbersome. "As plant manager, the vision for me is a clean mill. I want to look up high and not see any webs or dust," says Morrison. "I feel that a clean environment makes it easier to be at work, and that creates a happier, more productive team."

Knowing that combustible dust is one of OSHA's increasingly hot topics, "especially with feed mills," says Williams, he and Morrison began researching alternatives to manual cleaning methods of sweeping and using compressed air. "Compressed air is the biggest thing to get away from right now," says Williams. "It just blows the dust around into hard-to-reach areas."

Although vacuum cleaners are the preferred method of removing fugitive combustible dust, the mill previously had used an agricultural vacuum that Williams says "is great on the farm, but not for an application like ours. We tried to use it for years, but it just wasn't working."

The other alternative was a central vacuum system that Williams says "would be expensive to set up and require more piping, which would increase the areas where dust could settle. Also, this is a big facility, and

getting a vacuum that can pull from one end to the other would require something huge, and the cost would be crazy. So we had to figure out how to combat an expensive problem cost-effectively."

CENTRAL VACUUM SYSTEMS

Traditionally central vacuum systems require a bag house with either a chemical suppression system or an explosion venting system to meet National Fire Protection Association (NFPA) and OSHA standards.

Both Williams and Morrison remembered reading an article about a Vac-U-Max breakaway central vacuum system that met OSHA's requirements for a combustible dust vacuum, so they researched companies that had product lines that fit those requirements.

Belleville, N.J.-based Vac-U-Max has been around for 60 years. Its heavy-duty industrial vacuum cleaning systems are designed for production lines and other dust-intensive areas.

After researching available options, Morrison set up meetings with a European industrial vacuum cleaner company, as well as Air Cleaning Technology (ACT), which represents Vac-U-Max locally.

In the air cleaning business for 37 years, Santa Ana, Calif.-based ACT is a full-service pollution control company providing consulting, design, engineering, equipment, installation, routine maintenance, and around-the-clock service.

During the initial discussion between ACT's Randy O'Halloran, sales engineer, and Star Milling, the option of dust collection equipment was considered. However, during the walk-through when O'Halloran witnessed the problem areas the feed mill wanted to handle such as rafters, beams, and pits, coupled with mill's desire to clean spills quickly (Figure 2), O'Halloran says, "When it comes to that type of application, it isn't just collecting fine dust; they're collecting a little bit of everything, and it naturally led itself to be a vacuum cleaning application."

SPILLAGE CLEANUP

Figure 2. Breakaway central vacuum cleaners can help clean spillage from railway cars. *Source: Air Cleaning Technology*

SUCTION POWER

After receiving quotes from both companies, Williams created spreadsheets to ensure he and Morrison were comparing apples to apples, laying out every type of hose and connection. The price points were pretty close.

When asked what the tipping factor was in choosing the system, Williams said it was difficult to recall all the points that sold him given that 8 months had passed; however there were two points that did come to him. "The Vac-U-Max 1020 has much higher suction, and that made me happy, and the European brand was metric, and I prefer to keep everything in the shop standard if I can."

The cause for the higher suction on the U.S. model is a result of the positive displacement (PD) pump vacuum producer. PD pumps can generate high vacuum and excellent airflow and can pull massive amounts of material over distances. The 15-hp model

HIGH SUCTION POWER

Figure 3. This 15-hp model can move 10,000 lbs of powder in an hour from 30 ft away. *Source: Air Cleaning Technology*

that the feed mill uses can move 10,000 lb of powder in an hour from 30 ft away if needed (Figure 3).

Some manufacturers use regenerative blowers as a vacuum source in central vacuum systems. They have the airflow but not the simultaneous vacuum. Regenerative blowers look appealing because they show a lot of airflow for a given horsepower, but they do not generate enough vacuum to move material over distances in tubing; when vacuum pressure goes up, meaning when the job gets harder, performance is lost.

Williams says, "I like the ability to do whatever I want with one vacuum. It is a dual-purpose machine that maximizes ROI. It is a cost-effective alternative to what could have been very expensive."

TUBING NETWORK

The machine can function as a breakaway vacuum system with several smaller tubing networks (Figure 4). For instance if a user is working in a 100×200-sq.-ft. area and there are two more areas in another building, individual tubing networks are created, and the 1020 is used to break away from one tubing network, rolling to the next network, and so on.

A typical stationary central vacuum system to suit Star Milling's plant layout would have been much larger and would have required an explosion protection system. The larger size and explosion protection probably would have led to an outdoor installation, which brings other challenges such as air permits and construction permits. The breakaway system avoids those costs and delays, providing the convenience of a multi-inlet central vac, with the energy efficiency and flexibility of a portable vacuum.

Star Milling installed several fixed tubing networks itself. "I have two fabricators, on-staff electricians, and programmers — we only bring in contractors for very large jobs. Randy from ACT told me how to do it, sent me diagrams, and told me where to get the pipe and that was that," explains Williams.

Once the system was in place, a training program was set up to teach supervisors and operators how to use the machine. "It's pretty much plug-and-play right

TUBING NETWORK

Figure 4. This vacuum system uses individual tubing networks to quickly and easily move from one tubing network to the next, providing the convenience of a multi-inlet central vac, with the energy efficiency and flexibility of a portable vacuum. *Source: Air Cleaning Technology*

away, but the suction is powerful, and we wanted to be sure everyone was using the vacuum safely," says Williams.

Vax-U-Max sells drums, but because Star Milling had many drums on-site, the mill decided to use one it already had, and Williams just had to find the right one.

"We did have a bit of a learning curve with the intercept drum before we got it to the mill," he says. "We kept collapsing drums and turning them into perfect triangles. I had to call ACT to make sure we were using the system correctly and find out why it was out-performing what we talked about." Intercept drums need to be a minimum of 16-ga. steel with a rolled-top rim, two reinforcing chines, and no dents or dings.

CLEANING THE FACILITY

Cleaning the upper area of the pellet mill was one of Morrison's first projects. "Before we purchased the vacuum, we used to clean that area every three months, and it took one person all day to clean it," she says. The area was difficult to clean because it's elevated and tough to reach everything. The job was messy, requiring knocking everything to ground level and then cleaning from there, which "of course, created dust, and it landed where it landed," she says.

"With the vacuum all the dust and cobwebs are getting sucked into the vacuum system and not spreading anywhere," says Morrison. "Now we are working on a detailed cleaning of the entire facility, which, if you can imagine, would be like cleaning every inch of a large wooden roller coaster. There are lots of high rafters, pipes, ledges, beams, and equipment."

Currently the mill uses a crew of three workers for 8 hours during the weekend for this task. "After we get there, we'll have a better understanding if we'll need someone full-time to vacuum or if the operators can do it during their shift rotating days for different areas," says Morrison.

One of the biggest benefits and quickest cost reductions came with cleaning the confined spaces of the elevator pits. Dust tends to accumulate in the pits "because it's hidden, and you have to go looking for it," she says. "Now that we have the vacuum, we use extension tubes, and they give us the ability to get into the confined space without anyone actually having to enter the confined space, which is a big deal for us because every time you have to enter the confined space, you need to have a three-person team monitor the air," says Morrison. According to Williams, the extensions don't reduce the vacuum's suction.

Before Morrison and Williams had a chance to set up a schedule to clean the pits, the operators in the area began doing it on their own — getting the vacuum from the shop and bringing it to their area. The unit is designed for one-person maneuverability with 14-in.-dia. wheels, but Star Milling chooses to move the vacuum from area to area with a forklift.

Because the 1020 filter separator and collector are less than 8 ft^3., an explosion vent is not needed to use it in Class II, Div 1 & 2 areas, per NFPA standards and OSHA regulations. Even so, Williams has set up the tubing network so the machine operates in a non-dusty environment. "I just prefer it that way," he says.

DOAN PENDLETON, vice president at Vac-U-Max, is an expert in vacuum technology with more than 20 years of experience designing and engineering vacuum conveying systems and industrial vacuum cleaners. He can be reached at doanpendleton@vac-u-max.net.

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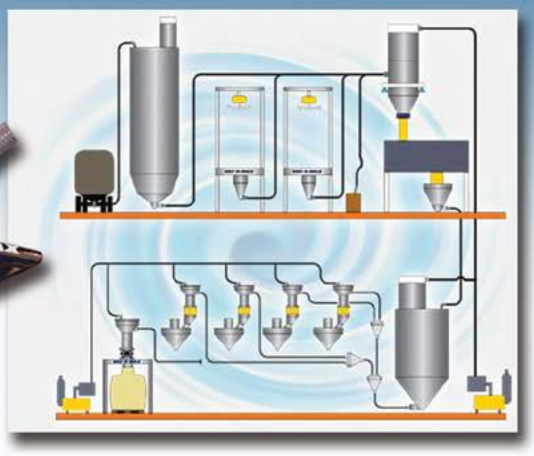

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