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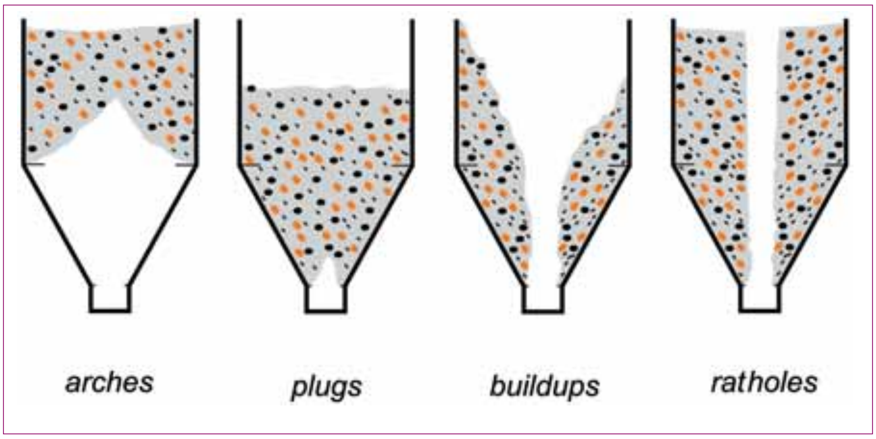
Keep the flow going: preventing accumulation in cement processing



Efficient material flow is a critical element of dry-process cement manufacturing, and accumulation or blockages can put a choke hold on a plant's profitability, *writes Brad Pronschinske, Global Director of Air Cannons Business Group/Martin Engineering*. Hang-ups in storage systems and build-up in process vessels can impede material movement, causing bottlenecks that interfere with equipment performance and reduce process efficiency. Poor material flow also raises maintenance expenses, diverting manpower from core activities and in some cases introducing safety risks for personnel.

Most systems suffer from some amount of accumulation on vessel walls, which can rob plant owners of the storage systems in which they have invested. These build-ups reduce material flow, decreasing the 'live' capacity of the vessel and the efficiency of the bulk handling system. The accumulations tend to take one of several forms: arches, plugs, build-ups or 'ratholes'.

If they become severe enough, flow problems can bring production to a complete stop. Although many plants still use manual techniques to remove build-up, the cost of labour and periodic shutdowns has led some producers to investigate more effective methods for dealing with this common production issue.

Build-up vs. throughput

Even well-designed processes can experience accumulations that have a significant impact. Changes in process conditions, raw materials or weather can all have an effect on material flow, and even small amounts of accumulation can quickly grow into a serious blockage.

Build-up can occur in many places, and in several forms. For example, it can be found as dry material that clings to the walls of pre-heater towers, or as ash that adheres to boiler tubes, SCR units and vessels. Accumulation often appears in riser ducts, feed pipes, cyclones, transfer chutes and storage bins, as well as kilns and coolers. The accumulation can be particularly severe when fuels with high sulphur or chloride content are used, such as petcoke. In extreme cases, massive build-ups can suddenly break loose and suffocate the process, potentially causing significant damage to equipment.

Lost production is probably the most conspicuous cost of these flow problems, but the expense can become apparent in a variety of other ways. Shutdowns to clear the restricted flow cost valuable process time and maintenance hours, while wasting energy during re-start. Refractory walls can be worn or damaged by tools or cleaning techniques. When access is difficult, removing material blockages may also introduce safety risks for personnel. Scaffolds or ladders might be needed to reach access points, and staff can risk exposure to hot debris, dust or gases when chunks of material are released.

Many of the most common problem areas for accumulation are classified as confined spaces, requiring a special permit for workers to enter and perform work. The consequences of untrained or inexperienced staff entering a silo or hopper can be disastrous, including physical injury, burial and asphyxiation. Disrupted material adhered to the sides of the vessel can suddenly break loose and fall on a worker. If the discharge door is in the open position, cargo can suddenly evacuate, causing unsecured workers to get caught in the flow. Cleaning vessels containing combustible dust — without proper testing, ventilation and safety measures — could even result in a deadly explosion with as little as a spark from a tool.

What is confined space entry?

The Occupational Safety and Health Administration (OSHA) defines 'confined space' as an area not designed for continuous employee occupancy and large enough for an employee to enter and perform assigned work, but with limited or restricted means for entry or exit.[1] 'Permit-required confined space' means a confined space that has one or more of the following characteristics:

- The vessel contains or has the potential of containing a hazardous atmosphere such as exposure to explosive dust, flammable gas, vapour, or mist in excess of 10 percent of its lower flammable limit (LFL). Atmospheric oxygen concentration below 19.5% or above 23.5%;
- There is the potential for material to engulf, entrap or asphyxiate an entrant by inwardly converging walls or by a door which slopes downward and tapers to a smaller cross-section; or
- Contains any other recognized serious safety or health hazards.

Permit-required confined space entry entails cumbersome and costly — but necessary — safety procedures, including special personnel training, safety harness and rigging, extensive preparation and added personnel for a 'buddy system.'

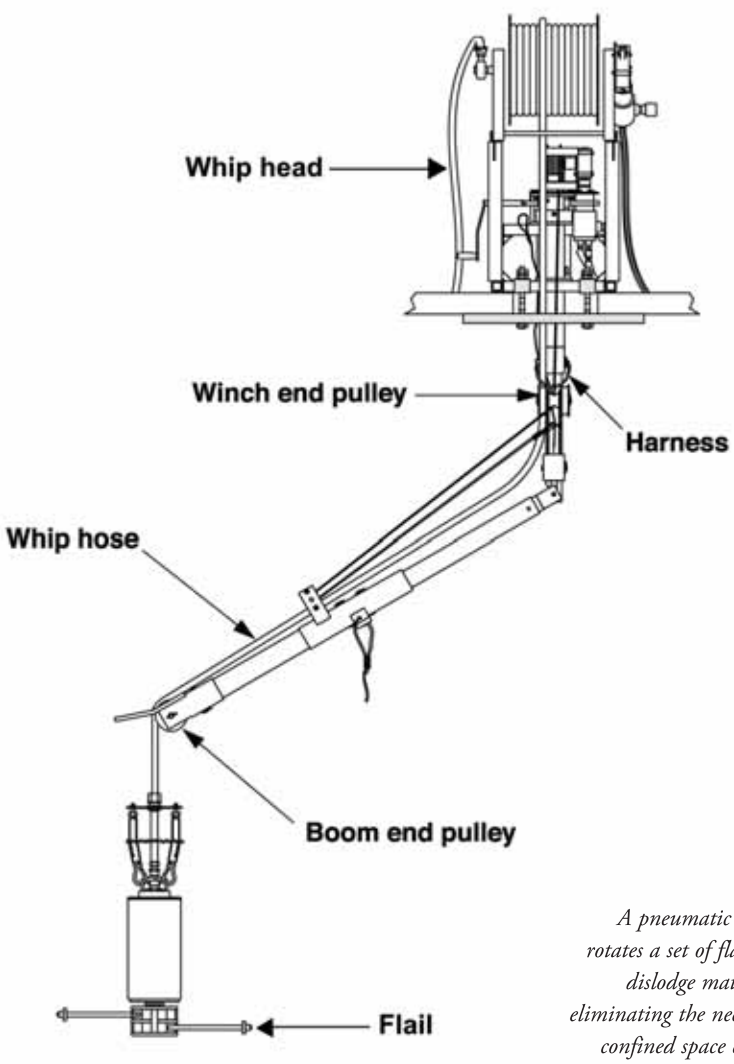
Getting professional help

While some large facilities choose to make the capital investment to purchase their own cleaning equipment to clear process equipment and storage vessels — as well as train personnel — others are finding it more sensible to schedule regular cleanings by specially-trained contractors. Given the costs of labour, lost time and potential risk to employees, this can often be accomplished for less than the total investment of in-house cleanouts.

At one plant, for example, a cleaning crew cleared a silo in two weeks that had been out of use literally for years, adding 3,500 tonnes of 'live' storage capacity. At another plant, the cleaning crew was able to remove enough 'lost' material — which had been written off as a loss over the years — that the value of the recovered material actually paid for the cost of the cleaning. In short, the cleaning of storage capacity can quickly turn into an economic

[1] Dougherty, Dorothy, "Permit-Required Confined Spaces," Occupational Safety and Health Administration, Department of Labor, Dec. 12, 2011.
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9797&p_table=STANDARDS

Safe, effective cleaning requires tools that work inside the silo from the top, controlled by personnel outside.



A pneumatic whip rotates a set of flails to dislodge material, eliminating the need for confined space entry.

benefit — not an expense, but rather an investment with a measurable ROI.

The costs of cleaning

Most cleaning projects are bid on a 'time and materials' basis. It's difficult to give a firm estimate, because the length of time can vary significantly depending on the amount and characteristics of the material in the vessel. And some of those details cannot be determined until the cleaning has actually begun.

There are several types of equipment that can be used for this purpose. One operates like an industrial-strength 'weed whip', rotating a set of flails against the material in the vessel. Abrasion-resistant steel chain is best suited for most applications, with non-sparking brass chain for combustible materials. Urethane flails can also be employed to protect lined vessels that could be susceptible to damage from metal tools. This approach eliminates the need for confined space entry and hazardous cleaning techniques such as CO_2 blasting, water and air lancing, typically allowing the material to be recaptured and returned to the process stream.

The whip can be set up quickly outside the vessel, and it's portable enough to move easily around various bin sizes and shapes. Typically lowered into the vessel from the top and then working from the bottom up to safely dislodge accumulation, the pneumatic cutting head delivers powerful cleaning action to remove buildup from walls and chutes without damaging refractory linings. Technicians lower the device all the way down through the restricted opening, starting at the bottom of the buildup and working their way up, undercutting the wall accumulation until it falls by its own weight. In extreme cases, a 'bin drill' can be used to clear a 12-inch (30.5cm) pathway as deep as 150 feet (45 metres).

In general, an efficient silo cleaning crew can clean the walls in a 30 x 60 foot (9 x 18m) vessel — removing up to 150 tonnes of material — in a day of working time, excluding travel and setup. It may be possible to reduce the mobilization charges for bringing a vessel cleaning contractor to a plant by scheduling a cleaning project in conjunction with other facilities nearby that also use large bulk storage vessels. If the cleaning is scheduled before accumulation becomes too severe, plants may be able to hold down costs even further by allowing the cleaning service the option to schedule the cleaning at its convenience and/or during scheduled downtime.

Flow aids

Regular cleaning is one approach to keeping materials flowing freely by removing buildups from silo walls, but there are other flow aids which may reduce the need for cleaning or even eliminate it. One method is through industrial vibrators designed for bin and chute applications.

Electric vibrators are generally the most efficient, delivering the longest life, low maintenance and low noise. The initial cost for an electric vibrator is higher than for pneumatic designs, but the operating cost is lower. Turbine vibrators are the most efficient and quietest of the pneumatic designs, making them well suited to applications in which low noise, high efficiency and low initial cost are desired.

Air cannons are another approach to maintaining good material flow, particularly in larger vessels. Also known as an air

Industrial vibrators for bin & chute applications can reduce or eliminate the need for cleaning.

blaster, the air cannon is a flow aid device that can be found in cement manufacturing, coal handling and many other industries. Applications vary widely, from emptying stagnant bulk material storage vessels to purging boiler ash to cleaning high-temperature gas ducts.

In the cement industry, air cannons are frequently specified to eliminate build-ups in preheater towers, often at points such as the riser ducts, feed pipes, kiln inlets and cyclones. They can also be found in extensive use on clinker coolers, in material transfer chutes and in storage bunkers.

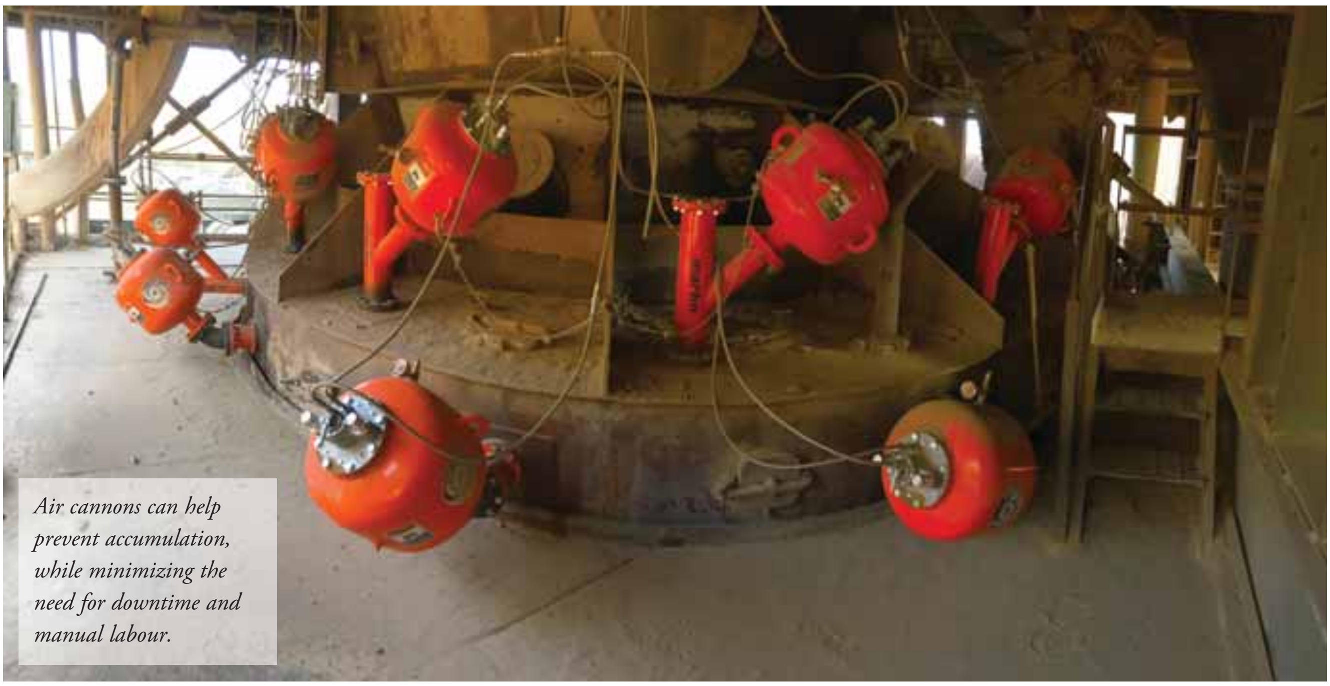
Air cannon technology has a long history of service in cement manufacturing, helping to improve material flow and reduce maintenance. The timed discharge of a directed air blast can prevent accumulation or blockages that reduce process efficiency and raise maintenance expenses. By facilitating flow and minimizing build-up, air cannons help companies minimize the need for process interruptions and manual labour.

The two basic components of an air cannon are a fast-acting, high-flow valve and a pressure vessel (tank). The device performs work when compressed air (or some other inert gas) in the tank is suddenly released by the valve and directed through a nozzle, which is strategically positioned in the tower, duct, cyclone or other location. Often installed in a series and precisely sequenced for maximum effect, the network can be timed to best suit individual process conditions or material characteristics.

In many applications, an engineered firing sequence will relieve the build-up problems. The air blasts help break down material accumulations and clear blocked pathways, allowing solids and/or gases to resume normal flow. In order to customize the air cannon installation to the service environment, specific air blast characteristics can be achieved by manipulating the operating pressure, tank volume, valve design and nozzle shape.

In the past, when material accumulation problems became an issue, processors would have to either limp along until the next scheduled shutdown or endure expensive downtime to install an air cannon network. That could cost a business hundreds of thousands of dollars per day in lost production. But a new technology has been developed by Martin Engineering for installing air cannons without a processing shutdown, allowing specially-trained technicians to mount the units on furnaces, preheaters, clinker coolers and in other high-temperature locations while production continues uninterrupted.

The patent-pending technology is designed to dramatically reduce expensive downtime associated with traditional installation methods, which require that high-heat processes be halted to allow core drilling and mounting of the cannons. This new approach allows specially-trained technicians to add air cannons and nozzles to an operation while it's in full swing, without disrupting the process. It's been proven in dozens of installations to date, helping high-temperature processes maintain effective material flow and minimize shutdowns, improving efficiency

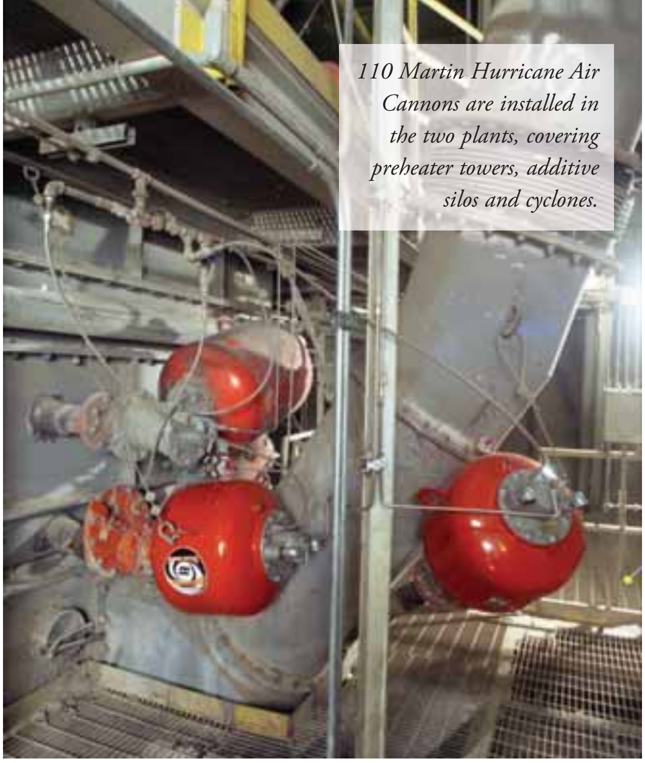


Air cannons can help prevent accumulation, while minimizing the need for downtime and manual labour.

while reducing lost production time.

Case study

One of the world's leading manufacturers of cement, concrete and aggregates has specified a total of 110 air cannons to facilitate material flow in two new plants in Brazil. Starting in the early design stages of the project, Votorantim Cimentos has maintained an intense focus on efficient material flow, with engineers carefully researching the latest technologies to maximize efficiency and reduce maintenance expenses. Company officials anticipated that the cannons and their high-efficiency valves would prevent blockages that could slow production, while minimizing air consumption.



110 Martin Hurricane Air Cannons are installed in the two plants, covering preheater towers, additive silos and cyclones.

The two new plants were part of a massive R$2 billion investment to enhance production throughout Brazil, producing approximately 8,500 tonnes of clinker per day between them. In designing the processes, Votorantim engineers wanted to take all reasonable measures to prevent accumulations in vessels and storage systems. They contacted Martin Engineering to conduct an audit of the two processes, and a joint effort was developed to determine the optimum solution, including air cannon design, nozzle selection and specific locations to maintain high throughput.

One of the primary reasons Votorantim officials selected Martin Engineering for the air cannon work is the low operating cost of the company's equipment. Compared to other sources of energy, compressed air is relatively expensive. As energy costs continue to rise, so does the value of cannon technologies that can reduce compressed air consumption.

The new cannon designs optimize compressed air use by employing advanced valve technology, with more efficient valves mounted on smaller tanks able to deliver higher discharge forces than less efficient valves mounted on larger tanks. The work is performed more effectively by the high-efficiency design, and the compressed air savings is equal to the difference in tank volumes.

Because larger tanks deliver longer blast durations from the greater air volume being discharged, there's a temptation to assume that the larger tanks perform more work. In reality, peak force is generated only during the first few thousandths of a second following the valve opening, so in applications requiring high output force to move material, the duration of useful energy is extremely short. The subsequent discharge of compressed air is actually wasted.

The new family of positive-action valves from Martin Engineering produces about twice the blast force output of the valve generation introduced just a decade ago, while using about half the compressed air volume. If the two designs were set to deliver the same discharge force, the new valve would operate at about half the pressure of the preceding design. Firing only in response to a positive surge of air, the specially-designed valve allows the control solenoid to be positioned as far as 200 feet (60 metres) from the tank, keeping critical components away from harsh service environments.

The units fire a powerful discharge of compressed air in a prescribed pattern to remove material that sticks to vessel walls and ductwork. In the Cuiabá plant, 56 cannons are being installed, with 54 being placed at Rio Branco. The benefits of specifying the new technology for air cannon networks include reduced energy costs, improved system performance and increased uptime, with greater availability of compressed air for other processes within the plant.

Conclusion

Material accumulation issues in bins, hoppers and silos are common, and a number of factors can contribute, including a high level of friction between the material and the bin wall and high cohesive strength within the material. Wall friction is dependent upon the wall angle, wall material, smoothness, temperature, moisture, corrosion, abrasive wear and the time the material remains at rest in the cone where the blockage is located.

New technology allows air cannons to be installed and serviced without a process shutdown.

Material flow problems can exist for many reasons, and eliminating them can be difficult. But silo cleanings using professional equipment and services can resolve blockages, and routine scheduling can help prevent emergency charges. Flow aids such as bin vibrators and air cannons can help maintain adequate flow in between cleanings, and in some applications can be installed to resolve accumulation issues without a system shutdown. DCi