Cost Effective Dust Control Technologies

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ABSTRACT

This paper will discuss techniques to control dust from material handling systems by reducing the creation of dust and in turn reducing the need for dust suppression and collection systems. The presentation will focus on engineered flow transfer chutes and conveyor belt “washboxes” to provide superior dust containment.

INTRODUCTION

As materials are loaded and carried on belt conveyors, fine particles are carried away as airborne dust. This dust is created by the fracture of lumps or larger particles of material, and carried away by the air currents created by the actions of loading and conveying.

This dust can create problems. The accumulations of dust are a maintenance headache. The piles of material increase the man-hours required for clean-up. The piles impair the movements of idler bearings and belt training devices to shorten the service life of idlers and other components. Dust presents a health hazard. This can be a short-term hazard, as accumulations pose a slip or trip hazard for personnel who must move around the facility. The dust can also be a long-term hazard to respiratory health of plant personnel. In addition, airborne dust is often a fire and explosion hazard.

Dust also creates environmental problems. Clouds of airborne dust respect no boundaries, and the clouds and the accumulations of fallout can create problems with plant neighbors and with regulatory *agencies.* Industries that thought they were immune to dust control restrictions now have to face the fact that neighbors are now more sensitized and alert to airborne pollution, and the laws are being enforced.

With these issues adding additional expenses and problems for a material-handling operation, dust control has turned from a convenience to a necessity in the past few years. Many techniques to prevent and control airborne dust have been developed and tried. But often the problem is not just how to control the dust, but how to achieve this control in a cost-effective manner.

The goal must be to provide effective control in a way that provides a quick and realistic payback, without requiring high overhead and continuous expenses.

Recent developments have provided effective solutions to help control dust, and as importantly, reduce the cost of controlling the dust. These technologies include engineered chutes, air-supported conveyors, and specialized belt cleaning systems.

These systems will require additional thought, engineering, and investment, but they will provide a payback in the form of reduced problems, extended component life, and improved operating results. These systems offer cost-effective solutions to the dust problems encountered in the conveying of bulk materials.

CONTROLLING DUST AT BELT LOADING WITH ENGINEERED CHUTES

Conveyor loading points are a common source for airborne dust. Fine particles are created by the impact of material onto the belt, or against the walls of the chutes, or from the collisions between the material particles themselves. These particles are picked up by the air that is moving through the chute and carried away from the load. To minimize dust, you must reduce the material impact and control the currents of air.

Engineered chutes are used to load the material on the receiving belt and accomplish both of these dust-reducing goals. These chutes apply the principles of fluid mechanics and the understanding of the particulate movement to the design of a transfer chute. The principle is to engineer a chute that uses inertial flow, so that the material goes into motion and stays in motion through the transfer chute. The material moves smoothly—like water through a faucet--rather than with the starts and stops, acceleration and deceleration, “billiard flow” that creates the problems in conventional conveyor transfer points.

The chute should be designed for minimal interference with the material’s natural trajectory as it exits the discharging conveyor. The direction of flow is steered through subtle changes using surfaces with known friction values. This allows the energy lost through friction to be calculable and accountable. This approach preserves material energy, reducing the power required to re-accelerate the load. It also minimizes impact in the load zone, reducing damage, and limiting the expulsion of air and the creation of airborne dust.

These inertial flow chutes achieve this by accurately positioning a hood to collect and concentrate the material at the top or discharging conveyor. This hood turns the material flow vertically, directing it downward in a coherent stream. At the bottom, a spoon receives the load and turns its vertical flow into the direction and speed of travel of the receiving conveyor. This reduces impact that can wear the belt and minimizes air expulsion that will drive dust into the air and minimizes buildups and plugging. **(FIGURE 1.)**

THE ENGINEERING PROCESS

These transfers are engineered using a parametric design procedure; that is, they rely on the information provided in a series of specifications to develop the chute design for a given transfer point. Some of this data can be determined from a site survey or (particularly for new facilities) from a review of the site plans and conveyor specifications. This data includes belt speed, belt width, trough angle, angle of incline/decline, actual and maximum flow rate, the material cross section area at the conveyor discharge, and the arrangement and length of conveyor transitions for both discharging and receiving conveyors.

Testing of material samples provides other important data. Information analyzed includes material composition and physical properties, moisture content, lump size range, and fines size. Testing will determine the range of material characteristics—what are its levels of cohesion and adhesion, what are the extremes of particle sizes, what are the angles of repose given various characteristics. By testing at the full range of parameters (from absolutely dry to soaking wet slurry) the system can be engineered to accommodate all conditions—even worst case “saturated” material.

FIGURE 1
Engineered Flow Chutes Typically Include a “Hood” (Top) to Direct the Material Flow and a “Spoon” (Bottom) to Place the Material on the Receiving Belt

. After the various conveyor and material parameters are spelled out, the material discharge trajectory can be determined. In combination with the established parameters, the trajectory is the basis for the development of the chutes. These accurate and detailed parameters are used in developing a computer-generated 3D model of the chute system. This is an iterative procedure, which means over and over making small movements or adjustments, one at a time. The flow and chute design are modeled inch by inch, or, if you prefer, 25 mm at a time.

With the computer-based system, changes can be quickly made to compare performance with various changes in the system characteristics. One can see the effect of changes easily—how a change in belt speed, pulley diameter, or lump size will alter the material's trajectory and fall. The model can be used as a guard against the design limitations and to check for conflict between the proposed design and existing equipment. The 3D computer model is used to produce the fabrication and installation drawings.

The use of computer-based modeling techniques allows the quick and efficient development of the design for an engineered chute to meet specific requirements. Here is one example.

CASE HISTORY: ENGINEERED CHUTES IN COAL HANDLING

Located in the central United States, the Ameren Meramec plant is a four-unit coal-fired power plant producing 865 MW of power. Its coal handling system was designed to operate at 1000 tons/hr. But feed chutes choked, cutting the flow of coal to nearly half the system's design rate and requiring simultaneous operation of both sides of the twin bunker feed conveyors**.** Engineers wanted to improve the flow rate, without adding to the plant's problems with dust from the friable Powder River Basin coal used as fuel.

After evaluating a number of proposals for chute engineering and construction, Ameren turned to the inertial flow engineered transfer chute system available from Martin Engineering. (**FIGURE 2.)** One of the reasons they selected this system was a guaranteed reduction in dust, despite the increase in material flow.

The new chutes have eliminated the bottleneck and greatly reduced spillage and dusting, allowing the plant's production material handling rate to climb nearly 50% and achieve the design capacity of 1000 tons per hour. (**FIGURE 3.)** As shown by detailed testing, dust and spillage have been reduced more than 98%.

DUST CONTROL PERFORMANCE TESTING

To evaluate the success of the engineered chutes, the power plant arranged a testing program. By carefully collecting and weighing the material, plant officials could assess the amount of material lost from the coal handling system before and after the installation of the engineered chutes.

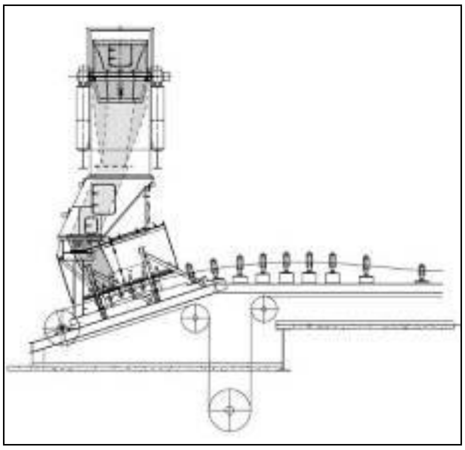

FIGURE 2
Plan for Engineered Chutes at Ameren Meramec Power Plant

FIGURE 3
Engineered Chutes as Installed on the Bunker Feed Conveyors at Meramec Power Plant.

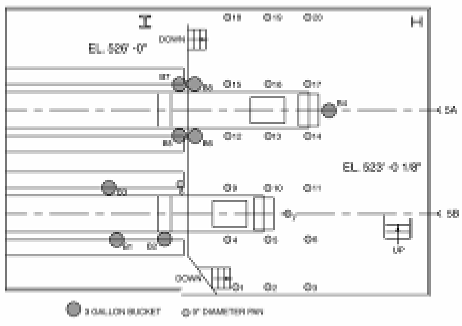

Figure 4
Collection Pan Placement Plan for Dust Control Performance Tests

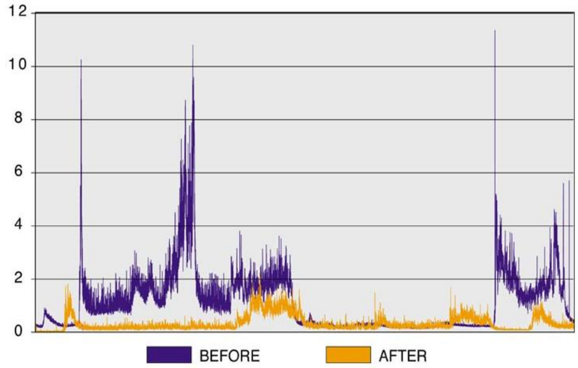

Figure 5:
Results from Dust Collection Performance Tests at the Ameren Meramec Power Plant

The first step was to establish a baseline for evaluation of the performance of the new system. Before the new system was installed, dust is collected over a three-day**,** 24-hour-per-day period. Pans and buckets were used to collect spillage and heavy dust over a three-day**,** 24-hour-per-day period. (**FIGURE 4.)** This is the method approved for testing to achieve Best Available Control Technology (BACT) status. Pans are placed around the perimeter of the installation--alongside the conveyor and around the exterior walls (inside the building) to collect spilled coal and heavy dust.

A similar three-day test was conducted after the new chutes were installed. The collecting pans were placed in the same locations, and the samples were gathered and weighed on a daily basis. (**FIGURE 5.)** These results show that during average daily run, the two transfer points would lose over 7614.637 grams (16.75 pounds). This represents an average loss of 1.810 grams per ton conveyed. Following the installation of the engineered chutes, the testing shows the loss of material was reduced to 0.022 grams per ton. This is a reduction of 98.77% in the amount of material lost per ton.

ANALYSIS OF RESULTS

This improved dust control has allowed the plant to increase its flow rate by more than 70 percent, from 550 to 950 tons per hour without requiring the installation of dust collection systems. (At present, the plant operates without any "baghouse" dust collection system and plant officials hope to keep it that way.)

In addition, the plant has been able to reduce its use of a dust suppression system. With the new chutes doing a better job controlling the coal flow and minimizing the dust creation, the plant has reduced its dust suppression chemical use by 54%, from 1.72 gallons per ton to 0.79 gallons per ton. This reduced consumption of suppressant chemicals at the plant in half, providing an annual savings of roughly $75,000 in chemical costs.

In a presentation to a utility conference in the US, the company's project engineer summarized the results of the installation as follows:

- 98.77% Reduction in Spillage and Dusting. (Annual Savings ~ $50,000).
- 54% Reduction in Suppression Chemicals. (Annual Savings ~$75,000).
- Reduced Housekeeping Expense. (Annual Savings ~$25,000).

As the engineer noted in his summary, these savings were accomplished despite an increase of more than 70% in the overall volume of material handled.

FIGURE 6
Air-Supported Belt Conveyors Use a Layer of Air
Released Under the Belt to Eliminate the Need for Idlers.

CONTROLLING DUST WITH AIR-SUPPORTED CONVEYORS

Dust can be carried off a conveyor belt along the conveyor's run. It can be lifted off the belt by the high speed air currents as the load emerges from the transfer point enclosure—"the dog house"--as it is sometimes called in the US, or it can be dispersed by environmental wind currents, or even the roller coaster action of the conveyor belt as it passes up and over the idlers spaced along its carrying side.

A technique for preventing the loss of dust from the material load on the conveyor is the use of fully enclosed air-supported conveyors. These systems use a stream of air passing through openings in the belt support trough to eliminate the need for conventional idlers. Applied to the belt's bottom surface, this film of air supplies almost frictionless support for the loaded belt. **(FIGURE 6.)**

Air-supported belt conveying systems offer a number of benefits over conventional troughed-idler conveyors. These advantages include a reduction in friction which results in reduced energy expense and increased belt life. As the air-supported conveyor requires no carrying-side idlers, there is no idler lubrication required. With air-supported conveyors, the belt path is smooth and even, minimizing the "roller coaster ride" that creates dust and spillage on conventional idler-supported conveyors. In addition, the air-supported conveyor is fully enclosed; it forms its own plenum so any airborne dust returns to the belt without escaping to the environment.

With its low-friction operation and a stable belt path, the air-supported conveyor will reduce wear, noise, dust-generation, energy consumption, and maintenance costs.

CASE HISTORY: COAL HANDLING ON AN AIR-SUPPORTED CONVEYOR

The Martin Drake Plant of Colorado Springs Utilities operates three coal-fired units with a total capacity of 262 mw. To optimize performance and minimize dust pollution, the plant elected to add a second coal supply, that in turn required the plant's coal yard to add a second reclaim system complete with a belt scale. This new system would feed this new Powder River Basin (PRB) coal supply onto a new conveyor to be metered into the local coal carried on an existing conveyor.

But the plant's location in downtown Colorado Springs meant the operation needed to be particularly conscious of environmental impact. Realizing the need for effective dust control from this friable coal, the plant and its engineering firm Roberts & Schaefer selected a fully-enclosed air-supported belt conveyor—the S-CLASS™ Air Supported Belt Conveyor as supplied by Martin Engineering--for this project.

To carry the PRB coal from the new stockpile and place it on the existing conveyor, the Martin Drake plant installed a new 80-foot (24.4 meters) long, 35° trough conveyor. The first 60 feet (18.3 meters) are air-supported conveyor plenum; for the final 20 feet (6.1 m) the conveyor changes to idler support to allow use of a belt scale. **(FIGURE 7.)** Fed by a McClanahan drag chain feeder, the 30-inch (~762 mm) wide belt conveyor carries 120 tons per hour from the new stockpile's reclaim into a transfer structure where the material is loaded onto a previously-existing conveyor to be moved to the crusher house.

FIGURE 7
An Air-Supported Belt Conveyor was Added to the Martin Drake Plant Coal Yard to Blend Coal from a New Stockpile to the Existing System.

Installation of the system was completed in November 2002 and the initial unloaded runs performed. The new reclaim system with the air-supported conveyor was put into daily operation in December 2002 and has operated successfully and without incident—even in the snow and cold weather conditions of Colorado--since installation.

Plant officials are pleased with the results of this installation. They noted, “The air-supported conveyor fit well within the overall scope of this major project and achieved our expectations for both coal handling and for dust control.”

CASE HISTORY: CLINKER HANDLING ON AIR SUPPORTED CONVEYORS

Another example of the use of the air-supported conveyor system to contain airborne dust is the installation at a cement plant in Guatemala. Here, Cementos Progreso’s Planta San Miguel was looking to improve its ability to transport clinker from silos into its grinding operation. Looking for the best option to control spillage and dust from this conveyor, the company chose an air-supported belt conveyor supplied by Martin Engineering..

At the Cementos Progreso facility, the air-supported conveyor was retrofit onto an existing (but idle) conveyor as the facility expanded its production capacity. The air-supported conveyor features a patented modular design that retrofits onto CEMA-standard conveyor structures to allow the upgrade of portions of existing belt conveyors. The 30- inch (762 mm) air-supported conveyor carries clinker at a rate of 340 tons per hour at 225 fpm (1.1 m/sec). Supported on its return side by conventional rollers, the conveyor is loaded by three feeder belts pulling material from storage hoppers.

A special challenge of engineering the air-supported conveyor for the Cementos Progreso plant was the need to include a vertical curve in the center of the conveyor. **(FIGURE 8.)** The first one-third of the conveyor’s 156-foot (47.4 m) length is flat where the belt runs under the belt feeders that pull material from three clinker silos. The middle section is curved to reach a height of roughly seven feet (2.1 m). The final one third of the belt is inclined, to the raise the conveyor to its nearly 26 feet (7.9 m) discharge height. The unique design of the air-supported conveyor allowed the modular sections of the conveyor to be mitered to form a smooth arc. **(FIGURE 9.)**

Plant officials are pleased with the performance of the air-supported conveyor and its potential for improving the amount of dust released in the plant. In fact, a second air-supported conveyor system has been delivered and installed in the plant.

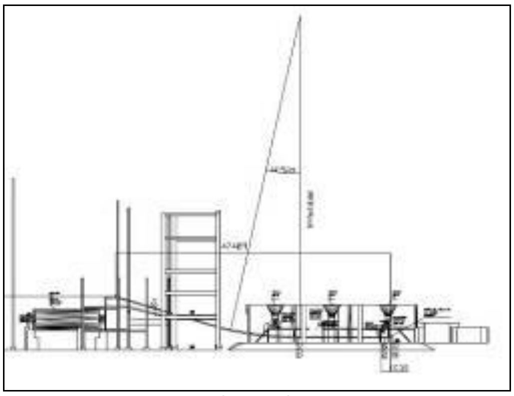

FIGURE 8
The Air-Supported Conveyor at the Cementos Progreso's Plant Raises Clinker from Storage to Grinding.

FIGURE 9
Modular Sections of the Conveyor were Mitered to Accommodate the Vertical Curve.

CONTROLLING DUST WITH EFFECTIVE BELT CLEANING

Of course, a multiple cleaning system is an important and cost-effective way to reduce the escape of material along the belt line.

There are many commercial belt cleaning systems available. I would like to make the point that there are a variety of systems available and that one size—or one design--does NOT fit all. To achieve optimum results may require special things, like the use of special or customized engineering, a commitment to continuing maintenance, or an additional initial investment. The following are examples where the need to control fugitive material provided the incentive to make this extra commitment to developing systems that provided a cost effective solution.

The cleaning of overland conveyors or in-pit belts presents special problems. In opencast mining, the conveyors are usually wide, high speed, and heavily loaded. The belts are often worn and damaged from this severe duty. The conveyors' transfer points are subject to abuse from large rocks and frequent plugging. The belts often run 24 hours a day, seven days a week, with little time for planned maintenance.

To withstand these abusive conditions, belt cleaners must be robust in construction, require minimal maintenance, and have an extended blade life. Cleaning efficiency is important, but it is not as important as these other criteria. The cleaning efficiency needs to be sufficient to meet the mine's routine clean up interval because spillage and carry back are inevitable in mining. To achieve these high levels of cleaning efficiency usually means a more precise and hence more expensive cleaning system than necessary.

We have worked together with mines to develop solutions that meet their needs. Usually the requirements include the criteria listed above—robust construction, low maintenance, long life--as well as a significant return on the investment. One example of such a project was the development of the Super Heavy-Duty (SHD) Belt Cleaner in cooperation with Rheinbraun.

CASE HISTORY: BELT CLEANING ON LIGNITE CONVEYORS

Rheinbraun is a large open-pit lignite mining company in Germany. In their operations, belts range up to 2.8 meters wide and run at speeds up to 7.5 m/sec. On the belts used to move overburden away from the bucketwheel excavators, Rheinbraun had used a cleaning system designed by the supplier of the conveyors, composed of a slab of rubber mounted on a beam that was pivoted into the head pulley. These rubber slab cleaners had to be adjusted on a weekly basis, and needed replacement every second week. The blades were inexpensive—only 200 euros per blade-- but maintenance labor was not. Like most mining companies Rheinbraun was forced by competitive pressure to reduce costs and increase production. Management saw the cost of belt cleaning as an opportunity for cost reduction.

FIGURE 10
Developed For Applications in Open Pit Lignite Mines, the Super Heavy-Duty Belt Cleaner Features Massive Blades on a Steel I-Beam Frame

Because of a proven track record of success on many of the company's other conveyors--the smaller belts used for handling the lignite-Martin Engineering was invited to make a proposal for cleaning these larger overburden belts. Martin Engineering offered to develop a cleaner specifically for the application. After consulting with Rheinbraun engineers and operators, a "wish list" for the design was created. The two key requirements were the ability to retrofit to the existing cleaner support structure and a blade life of 10 months without maintenance.

To achieve these requirements, a Super Heavy-Duty Pre-Cleaner with special geometry based upon the existing Rheinbraun cleaner support steel was developed. After trials of two generations of prototypes, the design was finalized and the SHD Belt Cleaner produced. **(FIGURE 10.)**

This new cleaner provided an average blade life in excess of the 10-month requirement. Cleaner adjustment is only needed once during the life of the blade. The system mounts on the existing beam of the original cleaner. When a blade change is necessary it requires only two hours of downtime. Cleaning efficiency is sufficient and at a consistent level.

Instead of emphasizing the opportunity to drive down the price of the rubber slab cleaning blades by 10 Euros, to save a total of 250 Euros per conveyor per year, Rheinbraun focused on the big picture and realized significant savings. By extending the service life and reducing the labor cost, the net savings to Rheinbraun is 6000 Euros per transfer point per year. When all transfer points were retrofitted the maintenance savings proved in excess of one million Euros per year. The return on investment is over 80% for each installation.

As a result of this success, this "Super Heavy-Duty" Cleaner has become the standard of the lignite industry across Europe. It has also adopted in many other severe-duty, "bucketwheel-grade" applications around the world. This is a case where a commitment to working with a reputable supplier yielded a solution that proved useful and cost effective.

CASE HISTORY: BELT WASHING SYSTEM ON A MOLYBDENUM ORE CONVEYOR

Another example of how it is important to match the belt cleaning system to the application is the sophisticated belt washing system developed for Climax Molybdenum Company's Henderson Operations. This operation—a division of Phelps Dodge--faces a number of challenges in removing carryback from the 10.5-mile (16.7-km) -long overland conveyor that carries the crushed molybdenum ore from the mine across the continental divide to the process plant. These challenges include:

- High altitude location (with resulting cold weather and low humidity conditions).
- Viscous, clay-like material that hardens like concrete.
- High-speed (6 m/sec (1,200 fpm), high-capacity (2.27 kt/h (2,500 stph) conveyor.
- Limited available space in the transfer house for cleaner installation.
- Limited water supply.
- Conveyor availability requirements restricting maintenance outages.

It is a core value at the Henderson Operation to be proactive in maintaining minimal impact on the real estate the operation sits on or, in the case of the conveyors, travels over. After the startup of the conveyor system, it became apparent that the operation needed more effective methods to control dust and carryback on the conveyors.

After determining that a dust collection system in the conveyor transfer house would be both massive and expensive, the Henderson team began working with belt cleaning specialists from Martin Engineering. The goal was to develop a belt cleaning system that would provide good performance while allowing the testing of methods to achieve one of Phelps Dodge's key management objectives of continuous improvement.

WASHBOX DESIGN

The result was a system composed of a custom belt washing station, vibrating chute, high-pressure pump, sludge tank, sludge tank pump and air compressor. This system is in addition to the dual pre-cleaner, dual secondary cleaner system already positioned on the conveyor's head pulley. Housed in the belt washing station are components including (from belt entry to exit):

- Two water sprays—the first supplying mist, the second applying high-pressure spray.
- An electrically-powered rotating brush cleaner with polypropylene bristles.
- Three Heavy-Duty In-Line secondary cleaners.
- Two air knife assemblies.

The water sprays moisten the belt-borne material to lubricate belt and scrapers. Recognizing that water quantities were limited, the designers elected to use a high-pressure spray only in the second spray bar. The rotating brush provides a scrubbing action to make sure the entire belt surface is wet for scraping by the three In-Line cleaners. The secondary cleaners were selected because their "slide-out/slide-in" design allows fast and simple blade replacement, reducing conveyor downtime; and their narrow profile allows the three cleaner assemblies to be installed in a space only 43 inches (1090 mm) -wide. Removed material falls through the open bottom of the washing station into a collection box. This slurry is then pumped to a point where it is returned to the main material stream.

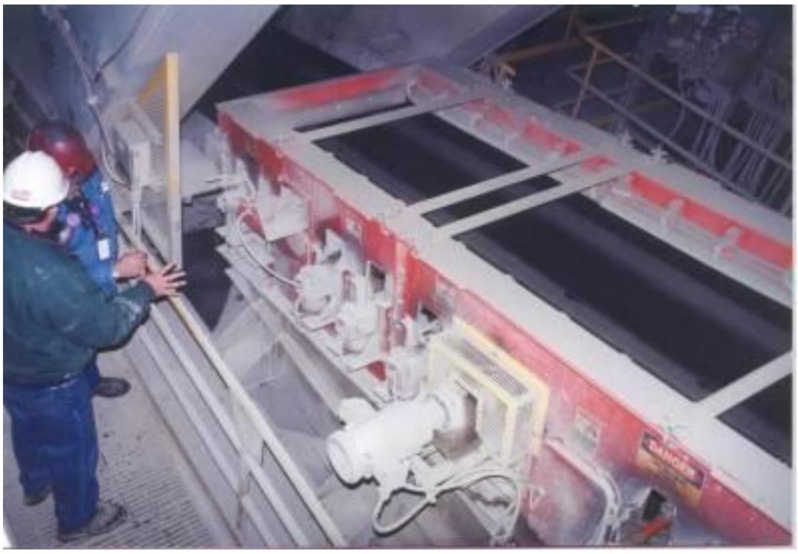

FIGURE 11

An Engineered Belt Washing System was Installed to Remove Carryback from an Overland Conveyor at Henderson Mine.

The “washbox” is controlled with a sophisticated PLC system that allows the cleaners to be moved away from the belt when material is not present, thus reducing wear on both belt and cleaner. The controls also automatically shut off the water supply to the spray bars when material is not present to reduce water consumption**.**

PERFORMANCE OF THE WASHBOX

This system was engineered to allow modifications—changes in blade-to-belt pressures, use of cleaning blades made from various materials, changes in spray pressure —for a continuous upgrading of cleaning performance. Now, after more than three years in service, Henderson Mine continues to work with Martin Engineering to fine tune the entire PC2 belt cleaning system, seeking the best combination of cleaning technologies**.**

Working with a capable supplier, Climax Molybdenum’s Henderson Operation has made an investment in a sophisticated belt washing station to match its state-of-the-art conveyors. This investment is paying off in improved belt cleaning performance and a reduction in fugitive material, allowing the Henderson Mine to achieve its goals of continuously improving performance.

CONCLUSION:

There are cost-effective methods to control dust in material handling operations. The key is to review the operation, investigate the options, and consider all solutions. It is entirely possible that dust can be engineered out of your solution, in a way that does not present an annuity to the dust collector manufacturer or the supplier of dust suppression chemicals.

. The first step is to consider the source of your dust. Do what you can to minimize it at the source by reducing the impact of material against material and against the chute walls and belting. Then contain the material flow as effectively as possible to allow most airborne dust to settle out of the system on its own. Finally, prevent the release of dust at the loading zone and along the conveyor run and return.

Analyze your problem and match your solution to your application, and you will find a cost-effective solution that will improve your operation.

Author Information

R. Todd Swinderman is Chief Executive Officer and Chief Technology Officer of Martin Engineering, Neponset, Illinois, USA. Swinderman joined Martin Engineering in 1979 as a product engineer and served the company as President from 1984 until 2004. He is the lead author of Martin Engineering’s series of *FOUNDATIONS* books on improving conveyor performance by controlling fugitive materials. As chair of the book committee of the Conveyor Equipment Manufacturer’s Association, Swinderman was also the driving force behind the newly published sixth edition of “the CEMA book” *Belt Conveyors for Bulk Materials.*

Martin Engineering is a world leader in the development of systems to make the handling of bulk materials cleaner, safer, and more productive.

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