Tips for reducing dust from secondary sources during bagging

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You probably have an exhaust ventilation system to clean the air at your plant's bagging operation, but do you know that the bagging operators can still be exposed to unacceptable dust levels? This article addresses some of the less-recognized, secondary dust sources that can cause a bagging operator's exposure to exceed acceptable limits. Sections describe a US Bureau of Mines study and the secondary dust sources the study identified, and then explain how to monitor dust exposure and how to reduce dust from your bagging operation's secondary dust sources. Although the study described here was conducted in mineral processing plants, the information can be applied to bagging operations in plants handling other dry bulk materials.

A bagging operator is typically exposed to more dust than other workers in your plant, especially if your plant produces a powder of 120 mesh or finer. But with any powder, the operator is exposed to dust from the filling process itself and from several secondary sources. Keeping the operator's dust exposure within acceptable limits requires identifying both primary and secondary dust sources and developing ways to reduce dust.

During the bagging process, the bagging operator typically works at a two- or four-station filling machine, placing empty bags[1] (generally 50- or 100-pound capacity) on each of the machine's fill nozzles. When each bag is filled, either the filling machine mechanically ejects the bag onto a conveyor, or the operator manually removes the bag and places it on a conveyor or on a pallet for shipping.

During this process, primary dust sources are product blowback and rooster tails. *Product blowback* occurs during bag filling as excess pressure builds inside the bag and is relieved by air and product exiting the bag around the fill nozzle, which creates respirable dust. Then as the filling machine ejects the bag, a *rooster tail* of product is thrown from the bag valve and the machine's fill nozzle. The rooster tail occurs because the bag is pressurized as it leaves the machine, causing product to spew from the bag and fill nozzle briefly after the bag is ejected.

Controlling dust from these sources is important to keep the bagging operator's dust exposure within acceptable levels. Acceptable dust exposure levels (called permissible exposure limits) for hundreds of materials are established by the Occupational Safety and Health Administration, US Department of Labor. [***Editor's note:*** For more information, see the sidebar article, "Dust and fume inhalation standards," on page 41 in "Selecting a dust control system — Part I" by Thomas Godbey, *Powder and Bulk Engineering*, October 1989.] In addition, acceptable dust exposure levels (called threshold limit values) specifically for minerals are established by the Mine Safety and Health Administration, US Department of Labor.

Ways to control dust from the bagging operation's primary dust sources are well-known. The most common is to install an exhaust ventilation system. However, even with such a system in place, the bagging operator's dust exposure can still exceed acceptable levels due to dust from secondary sources.

Examples of secondary dust sources include the exhaust ventilation system's makeup air, bagging operator work practices, bagging operator work clothes, broken bags, hopper overflows, and floor sweeping. These secondary dust sources often aren't recognized, but they can significantly increase the bagging operator's dust exposure. In fact, secondary dust sources can be more significant sources than the bagging process itself, increasing the bagging operator's exposure in some cases to 10 times the normal level.

Secondary dust sources can be difficult to identify because respirable dust isn't visible to the naked eye. The sources can also be hard to find because most plants use a standard gravimetric dust measurement (in which a dust sample typically taken over a worker's 8-hour shift is collected on a filter and then weighed in a laboratory), which indicates only the bagging operator's overall dust exposure averaged over one work shift. This kind of measurement doesn't identify different dust sources or even a dust exposure level for a specific time period.

US Bureau of Mines study of secondary dust sources

A study conducted by the US Bureau of Mines[2] in five different plants identified secondary dust sources in and around the bagging area. In the study, researchers used a dust monitor (Figure 1) to evaluate each bagging operator's dust exposure. The dust monitor was a box-shaped, real-time aerosol unit[3] located near the bagging operator and linked by flexible tubing to a standard 10-millimeter cyclone attached to the bagging operator's lapel. The tubing ensured that the operator could work with minimal interference.

Figure 1

Test setup

The dust monitor is sensitive to changes in the dust characteristics (size, shape, or refractive index). When calibrated to a specific dust, the unit can achieve accuracy ±10 percent that of a gravimetric unit equipped with the same 10-millimeter cyclone.[4] The cyclone is used to classify respirable dust when evaluating compliance with dust control standards.

In operation, the cyclone drew an air sample from the environment and classified the respirable particles (usually defined as having 10-micron or smaller *aerodynamic diameters*) that can be deposited in the lungs. The dust monitor used a light-scattering device to determine the respirable particles' dust concentration and produced a signal that fed to a strip-chart recorder. The recorder provided a continuous trace of the dust concentration — and, hence, the bagging operator's dust exposure — over time. This trace established the operator's baseline dust exposure.

The researchers recorded times during each test at which dust-producing incidents (secondary dust sources) occurred in the plant. When an incident appeared to increase the bagging operator's dust exposure, the researchers analyzed the time segment, calculated the area under the strip-chart's trace for that time segment, and then calculated the average dust concentration for that time segment. Next, by comparing the operator's baseline dust exposure with the increased dust exposure, the researchers established the dust exposure increase caused by the secondary dust source.

Several secondary dust sources observed during the study can significantly contaminate the air breathed by the bagging operator. Three of the secondary dust sources were the exhaust ventilation system makeup air, the operator work practices, and the operator work clothes. The following sections describe what the researchers discovered about these secondary dust sources during the study.

Exhaust ventilation system makeup air

Most bagging operations use an exhaust ventilation system to draw the dust generated by the bagging process away from the bagging operator and back into the filling machine or into the hopper used to recycle product. The makeup air pulled into the system can be contaminated with dust, making the air a secondary dust source.

At one plant, the researchers observed that the makeup air was drawn directly from the bulk-loading area outside the plant. When no bulk loading was occurring, the bagging operator's average dust exposure was 0.22 mg/m^3. But during bulk loading, the dust generated by the loading moved through an open door into the plant and past the operator into the exhaust ventilation system, increasing the operator's average dust exposure to 0.42 mg/m³ (Figure 2).

Bagging operator work practices

The dust exposures recorded for various bagging operators were substantially different during a part of the study that evaluated dust control systems at one plant. The researchers identified some of the work practices that increased a bagging operator's dust exposure by comparing exposures for two operators (called A and B in this article).

One work practice, which affects the amount of dust from the rooster tail, involves how long the filled bag stays on the fill nozzle. The researchers observed that bagging operator A immediately removed the filled bag from the fill nozzle, producing a large rooster tail that spewed from the bag valve and fill nozzle. But bagging operator B let the bag stay on the fill nozzle for a few seconds after it was filled, generating less dust from the rooster tail. This practice didn't reduce the production rate as long as the operator maintained a consistent rotation that kept the bag on the fill nozzle for a few seconds.

Another work practice affects the amount of dust escaping from the bag during and after the bagging operator manually loads the bag onto the conveyor. The practice involves how well the operator seals the bag valve. The researchers observed that bagging operator A grasped the bag at any of various points when removing the bag from the fill nozzle and turning to place it on the conveyor, which caused product to spew from the bag and produced dust. Some product also leaked from the bag as it traveled the first few feet on the conveyor, which created more dust. Bagging operator B grasped the bag at the valve and crimped the valve closed (Figure 3) while turning and placing the bag on the conveyor, causing less product to spew and leak from the bag and reducing the operator's dust exposure.

A related work practice affecting dust exposure during bag loading onto the conveyor is the bagging operator's handling manner. The researchers observed that bagging operator A removed the bag from the fill nozzle and placed it on the conveyor in a choppy, rough manner, generating much dust. Bagging operator B used a more continuous, careful manner, which generated less dust.

Figure 4 plots the relative dust exposures recorded for bagging operators A and B during testing of four dust control systems installed at the plant. Regardless of the dust control system in use, bagging operator B's good work practices reduced dust exposure each time and reduced the operator's overall dust exposure by about 70 percent from that of bagging operator A.

Figure 2

Increase in bagging operator's dust exposure due to contaminated makeup air

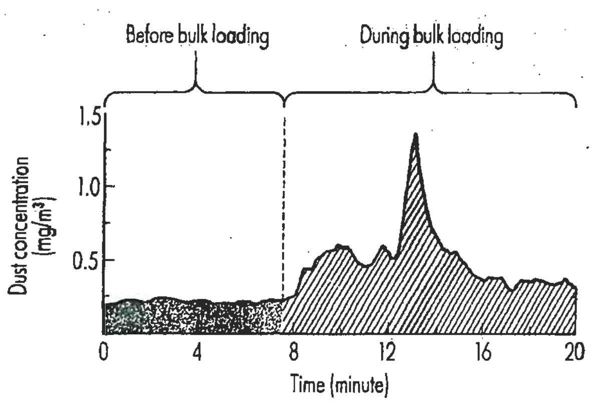


Figure 3

Bagging operator crimping the bag valve shut

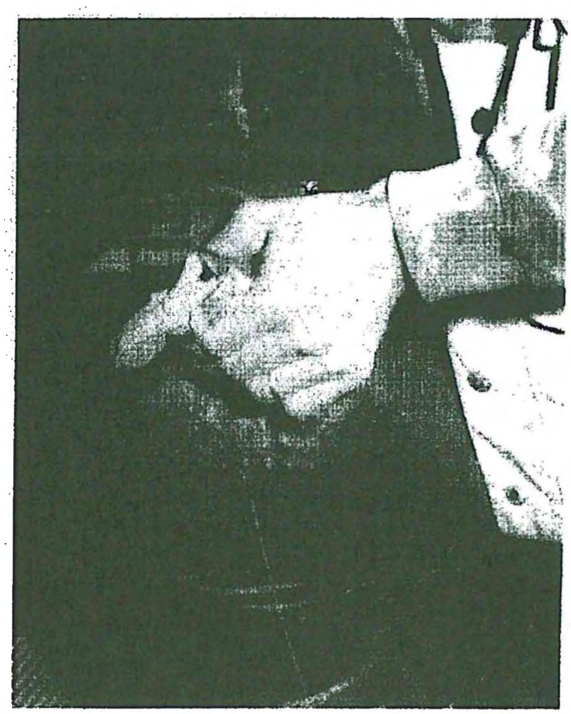
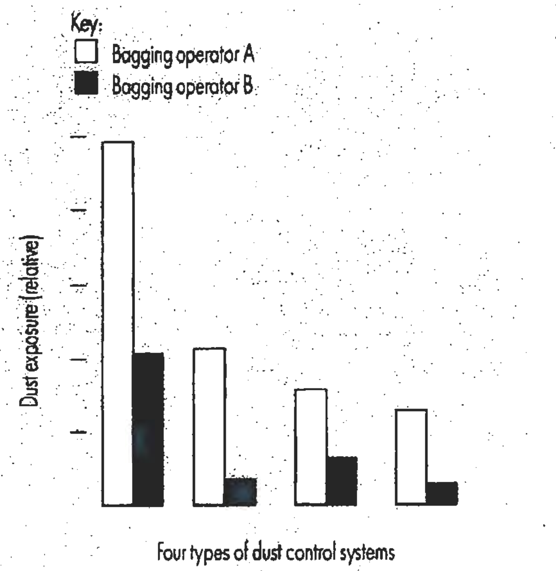


Figure 4

Differences in dust exposures due to different work practices of bagging operators A and B



Bagging operator work clothes

The researchers noticed that dust-covered work clothes increased the bagging operator's dust exposure during a part of the study at a ground silica sand operation. In one case, the fill nozzle failed to shut off after the bag was ejected from the filling machine. Before the failure, the bagging operator's average dust exposure was 0.1 mg/m³. After the failure, dust covered the operator's clothes and the operator's average dust exposure was 1.0 mg/m³, a 10-fold increase (Figure 5). This increase would cause the operator to be out of compliance with the Mine Safety and Health Administration silica standards in about 1½ hours.

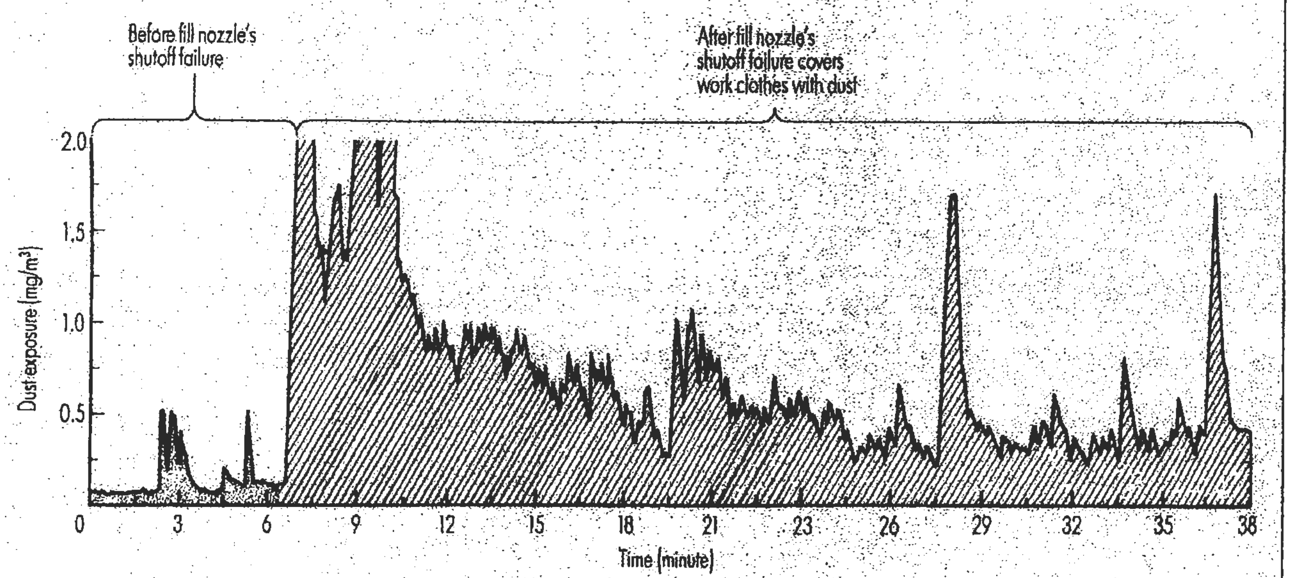
Two factors that can increase dust exposure from dust-covered work clothes are the season and the fabric type. Problems with contaminated work clothes can be significant in some operations during the winter when the bagging operator wears a heavy coat. The operator may only occasionally clean the coat during the season, which can make the coat a significant secondary dust source. A coat fabric with a high percentage of cotton or wool, common in outer wear, also absorbs more dust than a synthetic or polyethylene fabric and can increase the operator's dust exposure.

Other secondary dust sources

Other secondary dust sources that can significantly increase the bagging operator's dust exposure are broken bags during loading or conveying, hopper overflows, and floor sweeping (even at some distance from the bagging operation). [***Editor's note:*** For research data on these secondary dust sources, see the additional source listed at the article's end.]

Figure 5

Increase in bagging operator's dust exposure after fill nozzle's shutoff failure covers work clothes with dust



How to monitor bagging operator dust exposure

To sample and measure the secondary dust your bagging operator is exposed to and ensure the dust level is in compliance with established dust control standards, you can use a dust monitor and cyclone as in the study described here or use similar methods. For help selecting a specific method, consult an industrial hygiene specialist.

To accurately determine the bagging operator's dust exposure, it would be ideal to locate the cyclone at the operator's breathing zone, but this isn't possible. Federal regulatory agencies consider the breathing zone to be a 2-foot sphere around the operator's mouth and nose. Try to locate the cyclone on the bagging operator's lapel or collar or as close as possible to the breathing zone.

With many workers, the dust concentration from one area of the 2-foot zone to another doesn't change significantly. But with others, including a bagging operator, the concentration can change greatly from one area to another. For instance, during the US Bureau of Mines study, the researchers noticed a visible difference in the respirable dust concentration created by the exhaust ventilation system at the filling machine. Blowback from the fill nozzles and different air currents around the exhaust ventilation system overpowered the system, which then recirculated rather than removed the dust. The dust drifted upward from the floor toward the bagging operator. Thus, as the researchers moved the cyclone from the upper area of the operator's breathing zone toward the floor, the dust concentration increased, which could have a major — though misleading — effect on the operator's measured dust exposure.

The researchers then located cyclones near the operator's collar and about 6 inches lower, on the operator's chest. The respirable dust concentration measured at the chest location was about 80 percent higher than that measured at the collar location. However, the operator breathed from the collar location, and the 80 percent increase at the chest location wasn't truly representative of the operator's dust exposure. So to achieve accurate measurements, be sure to sample the air as close as possible to the bagging operator's mouth and nose.

How to reduce dust from your bagging operation's secondary dust sources

To reduce dust from the exhaust ventilation system's makeup air, make sure the makeup air is drawn from a location where the air isn't contaminated with dust — for instance, away from bulk-loading areas or other dust-producing plant operations. Also consider the exhaust ventilation system itself: Properly size the system for your operation and operate the system at the optimum exhaust volume to ensure it effectively controls dust. Also properly maintain the system for airtight operation because air leaks can reduce the system's effectiveness and increase the required exhaust volume and operating cost.

To reduce dust created by the bagging operator's work practices, evaluate dust exposure results for different bagging operators to identify consistent trends or differences. If one operator has a consistently higher dust exposure than others who perform the same function, the operator's work practices are probably the cause. In this case, train the operator to use techniques that minimize dust exposure: for instance, letting the filled bag stay on the fill nozzle a few seconds before moving it, crimping the bag valve closed while moving it to the conveyor, and using a continuous, careful motion to handle the filled bag.

To reduce dust on the bagging operator's work clothes after a dust-producing incident, such as a bag break, have the bagging operator immediately use a vacuum system to clean the work clothes (a 1- to 2-minute procedure). If the bagging operator wears a heavy coat during the winter, the operator can clean the coat before coming to work, or the company can provide clean outer overalls for the operator. The company can also provide work clothes or disposable coveralls made from a nonstick, nonabsorbent fabric such as a synthetic or polyethylene.

You can use several methods to reduce dust from other secondary sources near the bagging operation. To prevent broken bags, use better quality bags (for instance, bags constructed with stress kraft or additional plies). To prevent a hopper overflow, evaluate past overflows to correct the cause (typically operator error), and also consider using mechanical or electronic methods to monitor the hopper's product level. To prevent dust from floor sweeping, have workers wash or vacuum floors rather than sweep them with a push broom, even with floors at long distances from the bagging operation. PBE

Endnotes

1. This article concentrates on operations using valve bags, which typically handle finer powders.
2. Study conducted by the Dust Control and Ventilation Division, US Bureau of Mines, Pittsburgh, Pa.
3. RAM-1, developed by MIE, Inc. (formerly GCA Corp.), Billerica, Mass., under a US Bureau of Mines contract.
4. K.L. Williams and R.J. Timko, "Performance evaluation of a real-time aerosol monitor," US Bureau of Mines Information Circular 8968, 1984.

Additional source

Andrew B. Cecala and Edward D. Thimons, "Impact of background sources on dust exposure of bag machine operators," US Bureau of Mines Information Circular 9089, 1986.

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