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Reducing Bag Operator's Dust Exposure in Mineral Processing Plants

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The Bureau of Mines has been investigating various techniques to reduce dust exposures of workers at mineral processing plants. A major problem has been the exposure of the bag operator who loads mineral product into 50- or 100-pound bags at a fill station. In many cases, this worker has the highest dust exposure of the entire plant. In the past few years, the Bureau has investigated several approaches that can significantly lower bag operator dust exposure. These include bag valve modification, dual bag nozzle system, overhead air supply island (OASIS), and control of background dust sources. Five commercially available bag-filling valves were evaluated to determine their dust reduction capabilities. An extended polyethylene valve was found to be the most effective, resulting in a 62 percent reduction in operator dust exposure as compared to the standard paper valve.

A dual bag nozzle system was developed that decreases product loss and significantly lowers the operator's exposure. With this system, one nozzle fills the bag, and the other nozzle exhausts excess air when filling is complete. An improved bag clamp reduces product blowback during filling, thus reducing product accumulation on the outside of the bag. The system reduces operator exposure up to 83 percent as well as significantly lowering the subsequent exposure of workers stacking the bags onto pallets.

The OASIS is placed over the operator's location at the fill station and delivers an envelope of clean air over the worker that has reduced workers' dust exposures 82 to 98 percent.

The number of background sources were observed to significantly contaminate the bag operator and could cause his exposure to exceed the permissible eight-hour limit in a short period of time. To keep this exposure below the permissible limit, these background sources must be identified and controlled. Cecala, A. B.; Volkwein, J. C.; Daniel, J. H.: *Reducing Bag Operator's Dust Exposure in Mineral Processing Plants*. *Appl. Ind. Hyg.* 3:23-27; 1988.

Introduction

The purpose of this paper is to summarize a number of different research projects performed over the last few years that deal directly with lowering the dust exposure of the bagger operating

fluidized air bag machines. Each of these projects investigated the possibility of using completely different methods and approaches. The first approach was to use a different type of bag valve. The next two approaches involved engineering controls which were implemented in and around the bag loading area. The last approach dealt with the control of dust sources from other areas of the plant or mill.

The bag operator's function is to place empty bags on the fill nozzles after filled bags are ejected from the machine. This is quite a common practice since most mineral processing plants bag at least some of their products. In many cases, especially when bagging extremely fine product, the bag operator's dust exposure is one of the highest for the entire plant.

In performing this job, the bag operator is exposed to two primary dust sources. The first is product blowback during the bag-filling cycle. As excess pressure is released from around the fill nozzle during filling, the excess air and product are forced out of the bag, creating a considerable amount of dust. The second major source is the sudden plume of product, commonly called a "rooster tail," thrown from the bag valve and fill nozzle as the pressurized bag is ejected from the machine.

Individuals wishing to lower the bag operator's dust exposure should be able to do so by using one or more of the techniques evaluated by the Bureau of Mines over the past few years and shown to lower operator dust exposure significantly.

Evaluation Techniques

In all cases, respirable dust concentrations in air at the bag operator's station were monitored by the same method. A 10-mm cyclone was attached either to the operator's lapel or near the breathing zone. The 10-mm cyclone is used in the United States for compliance sampling of respirable dust as established by the Mine Safety and Health Administration. Threshold limit values for metal/nonmetal operations are listed in the Federal Register (CFR) Part 30-56-5-5 which is based on a 1973 recommendation

Reference to specific manufacturers throughout does not imply endorsement by the Bureau of Mines.

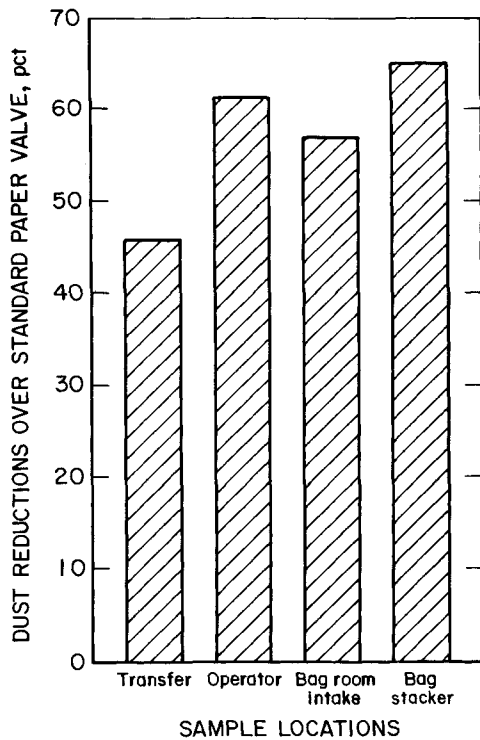


FIGURE 1. Airborne respirable dust reductions with extended polyethylene compared with that of standard paper valve.

from the American Conference of Governmental Industrial Hygienists.⁽¹⁾ The cyclone was connected to the dust monitor by Tygon tubing to allow the operator to perform the job function with minimal interference. The tubing length was minimized to reduce any losses associated with dust adhesion to the inner walls of the tubing, although a previous laboratory evaluation showed negligible effects with various tubing lengths that were within reason (1 to 3 meters). The same length of tubing was used in all cases for each analysis to further minimize any biases. The RAM-1 real-time aerosol dust monitor,* built by GCA Corp., was used for all monitoring.⁽²⁾ This device uses light scattering to determine the respirable dust concentration in an air sample drawn from the environment through the cyclone. This instrument was calibrated for respirable silica dust and was used to compare the relative change in the bag operator's respirable dust exposure determined before and after the implementation of each technique. The operator's exposure is a measure of the dust in the worker's breathing zone and not the actual dust breathed by the worker since most workers wear some type of respirator protection at these operations.

The Four Research Projects

Four research projects were conducted. These include 1) bag valve modification, 2) dual bag nozzle system, 3) overhead air supply island (OASIS), and 4) control background dust sources.

Bag Valve Modification

The bag valve design plays an important role in the degree of dust generated from blowback during the bag filling process, the rooster-tail as the bag is discharged from the fill station, and the later dust exposure of workers loading the bags onto pallets.

The effectiveness of five commercially available bag valves in reducing dust generated during bag filling, conveying, and the pallet loading process was evaluated. The five valves tested in-

cluded standard paper, polyethylene, extended polyethylene, double trap, and foam. Two factors appeared to determine valve effectiveness. The first was the valve length; the longer the valve, the more effective it was in reducing product blowback and bag-generated dust. The second factor was the valve material. Foam appears to be the most effective material for reducing dust generation, followed by polyethylene, and then standard paper. Considering both length and material, the extended polyethylene was the most effective valve tested and resulted in a 62 percent reduction in operator exposure.⁽³⁾ An additional benefit with this valve is the dust reductions achieved at various locations throughout the bag conveying and pallet loading process (Figure 1). The extended polyethylene valve was also one of the most cost-effective of those tested, with an increase in cost of approximately \$6.85 per thousand bags (0.7 cent per bag) over that of the standard paper valve (Table I).

TABLE I. Increase in Valve Cost Above the Cost of the Standard Paper Valve

Valve	Additional Cost per 1000 Bags (\$)	Additional Cost per Bag (¢)
Polyethylene	6.85	0.7
Extended polyethylene	6.85	0.7
Double trap	11.17	1.1
Foam	214.98	21.5

Dual Bag Nozzle System

A dual bag nozzle system was designed to reduce the major dust sources of the bag filling process. The inner nozzle is the normal fill nozzle; the outer nozzle serves as an exhaust nozzle (Figure 2). The exhaust system is operated after completion of the bag filling process to remove excess pressure from the bag. The exhaust is powered by an eductor, which uses a venturi effect to exhaust the bag at approximately 1.42 m³/min (50 ft³/min). The exhaust airstream goes into a bucket elevator, which recycles the exhausted product. A pinch valve opens and closes the exhaust outlet. An improved bag clamp which makes direct contact with about 80 percent of the nozzle reduces the amount of product blowback during bag filling.^(4,5)

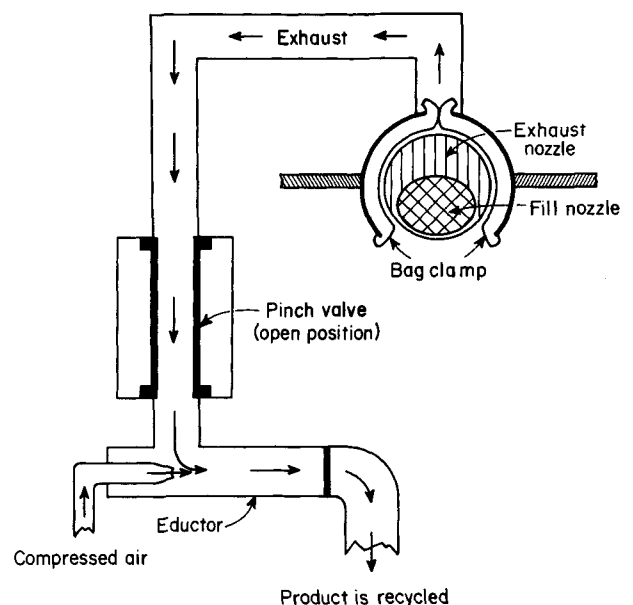


FIGURE 2. Dual bag nozzle system.

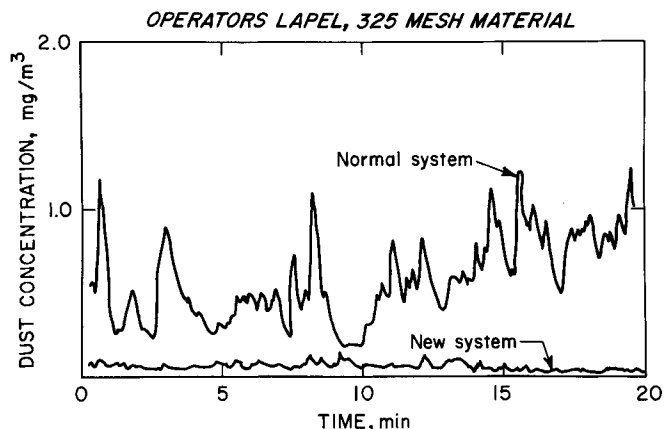


FIGURE 3. Operator's respirable dust exposure with normal system and dual nozzle system.

A field evaluation was performed on this dual bag nozzle system during the second week of a two-week test on a four-station bagging operation. During the first week, the conventional system was monitored to determine the amount of dust generated. Over the weekend, the new system was installed and the identical test was performed for the second week of testing. Figure 3 shows the bag operator's dust exposure with the conventional system and the new dual-nozzle system when bagging 325-mesh product. There was an 83 percent reduction in dust exposure with the dual bag nozzle system. There was a 90 percent reduction in respirable dust concentrations measured in the hopper below the fill station which determined the reduction in product blow-back during bag filling; this can result in tremendous product savings. A significant decrease in dust accumulation on the outside of the bag resulted in a 90 percent reduction in dust exposure of workers subsequently stacking the bags onto pallets in enclosed vehicles. This system is suggested only for operations in which the bag operator fills bags from three or four stations. The production rate would decrease substantially for a one or two station system since the bag operator would be waiting for each bag as the exhaust system is operating, and this would not be acceptable to most operations.

The different components of this system can be fabricated by the mineral processing operations themselves or can be purchased from Foster-Miller, Inc., Waltham, Massachusetts, in which case the price would be dependent on the actual components necessary in each situation.⁽³⁾

Overhead Air Supply Island (OASIS)

The OASIS is an air cleaning device that is suspended over the bag operator and provides a flow of filtered air over the work station. It operates independently of the product processing equipment used. Mill air is drawn into the system and passed through a primary cartridge filter. This primary filter is self-cleaning, automatically using the reverse pulse technique when excessive filter restriction is sensed. The air can then pass through a heating or cooling chamber (optional), depending on the air temperature, and from there into a distribution manifold, which also serves as a secondary filter (Figure 4). The resulting filtered air flows down over the operator at an average velocity of 1.9 m/s (375 fpm), which restricts mill air from entering the clean air core.⁽⁶⁾

The OASIS was evaluated at two different operations by monitoring the bag operator's dust exposure with the device turned on and off. Figure 5 is a segment of strip chart that shows the operator's dust exposure during actual testing at the first operation. The dust reductions for these two operations were 98 percent and 82 percent, respectively. The primary reason for the difference between these two values were the lower background levels, or off concentrations, at the second plant. At both plants, the dust concentration with the OASIS operating remained under 0.04 mg/m³. An additional benefit with this system is the overall reduction in dust levels in the mill building as a result of the OASIS's cleaning action which averaged approximately 12 percent.

This system is commercially available from Donaldson Company, Inc., from Minneapolis, Minnesota, at an approximate cost of \$10,000 for a basic 6,000-cfm version; heating and air conditioning requirements are optional. The unit can also be fabricated in 3,000-cfm increments.

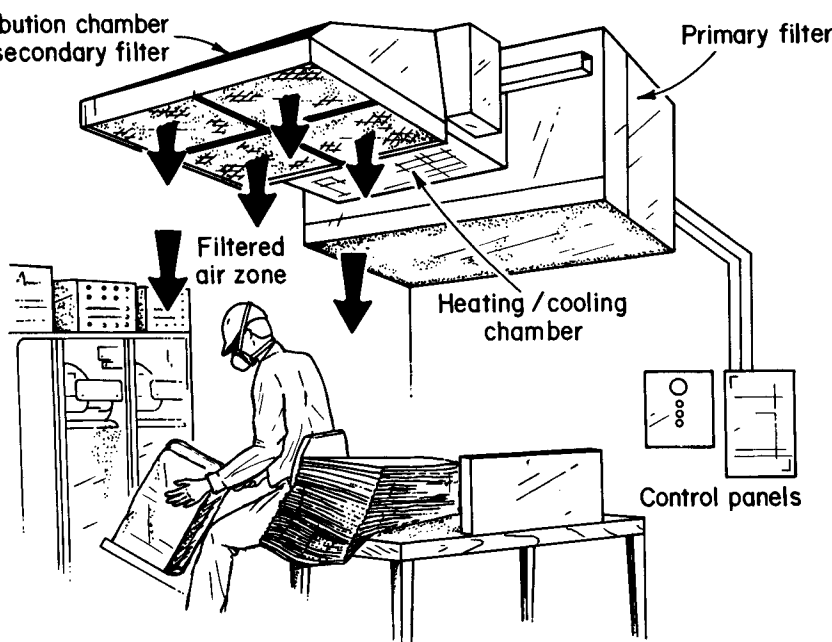


FIGURE 4. Overhead air supply island (OASIS).

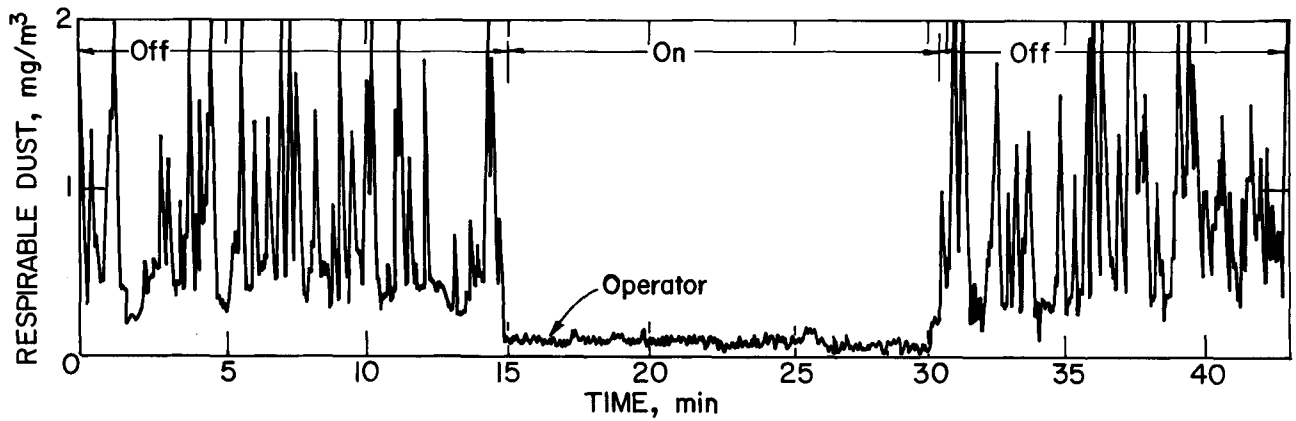


FIGURE 5. Operator's respirable dust exposure during bagging without and with OASIS.

Control of Background Dust Sources

In addition to dust at the bagging station, a number of common background dust sources were identified in and around the bag filling area. These background dust sources, which are often unrecognized, can cause more contamination than the bagging process itself.

Bag operators were monitored at their work station to determine different background contamination sources over the period of a workday. A number of different dust sources were observed to increase the bag operator's exposure substantially, in many cases as much as 5 to 10 times above the job function.⁽⁷⁾ These background sources include work clothes soiled with product material, blowing work clothes off with compressed air, bag breakage during loading and conveying, bulk loading outside, bag hopper overflow, and sweeping with brooms. Figure 6 shows a case in which the bag operator became soiled with product from a fill nozzle that did not shut off after the bag ejected from the fill machine. The bag operator's respirable dust exposure before this occurred was approximately 0.1 mg/m³; this increased to 1.0 mg/m³ after the operator became soiled with product. Another example occurred while a truck was being bulk-loaded outside a mill where the bagging was performed. The dust generated from this bulk-loading process traveled through an open door into the mill, increasing the bag operator's exposure from 0.17 mg/m³ before bulk loading began to 0.42 mg/m³ (Figure 7). Over the period of the day, a substantial number of trucks may be bulk-loaded at this position, depending on customer orders.

Thus, events not directly related to the bagging operation can be more significant sources of dust exposure to the bag operator than the bagging process itself. To effectively keep the operator exposure at acceptable dust levels, these background dust sources must be identified and controlled.

Discussion

The OASIS and dual bag nozzle system are available commercially. The dual bag nozzle system can also be fabricated at the plant, using the basic technology provided. Both of these engineering control techniques can lower the bag operator's dust exposure from 82 to 98 percent. The OASIS can also restrict dust from other sources from penetrating into the filtered envelope of air that flows down over the operator. Over a period of time, it also acts as a general air cleaner. The dual bag nozzle system significantly reduces the amount of product blowback during bag filling, which can also account for substantial product savings when lost product is not recycled. Since the system depressurizes the bag, much less product accumulates on the outside of the bag, thus substantially reducing dust generated during the conveyor and pallet loading processes. A 90 percent reduction in the dust exposure of workers stacking the bags into enclosed vehicles was also measured.

The extended polyethylene bag valve is commercially available at an additional cost of 0.7 cent per bag, or \$3.36 per standard truck load of 480 bags. It is a cost effective way to reduce workers' dust exposure.

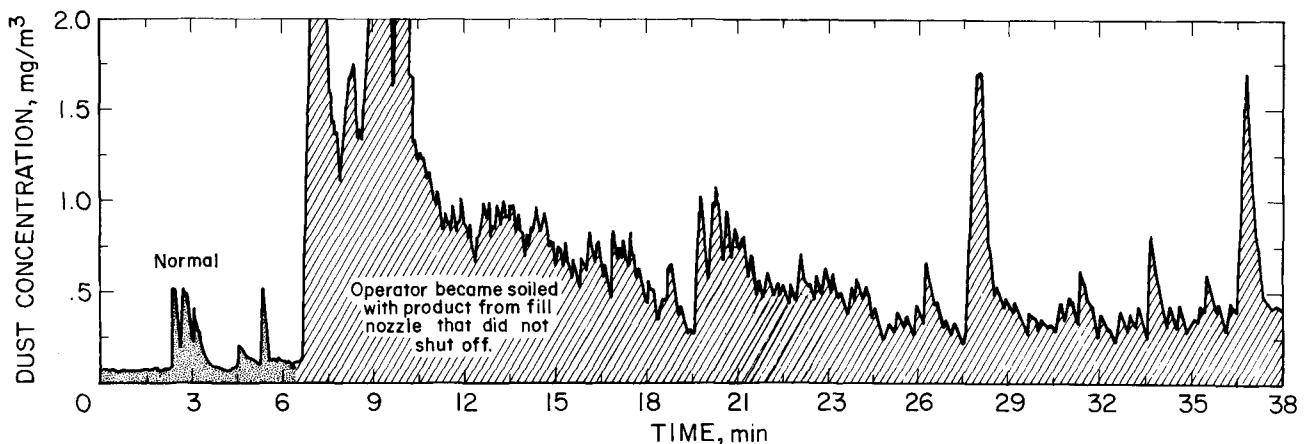


FIGURE 6. Operator's respirable dust exposure after becoming soiled with product from fill nozzle that did not shut off.

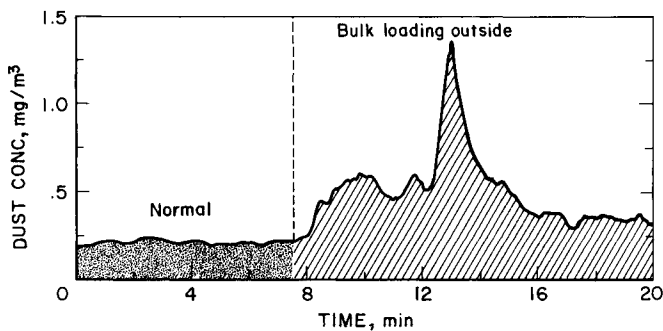


FIGURE 7. Bag operator's exposure from bulk loading outside.

There are basically two types of background sources. The first is operator-induced dust; the second involves dust from external sources being drawn over the bag operator. Operator-induced dust sources include soiled work clothes, blowing clothes off with compressed air, and bag breakage on the fill station due to improper pressure settings. Soiled work clothes can be an especially significant factor in winter, when heavy coats may be worn for long periods without cleaning.

Dust from the second type of source occurs when the exhaust ventilation system captures dust generated from other areas of the plant. This is applicable in those cases where an exhaust ventilation system is located below the bag operator to capture any machine and bag-generated dust at the fill station. This creates a negative pressure which can draw dust from the mill over the bag operator unless a clean makeup air source is supplied. This was the case when bags were broken during conveying, during bulk loading outside, and when the bag hopper overflowed.

Recommendations

For mineral processing plants to keep bag machine operators' dust exposure at acceptable levels, plant operators' must be aware

of the different dust sources and methods to reduce these sources. Recent Bureau of Mines research has shown ways in which operator exposure can be reduced 62 to 98 percent. This information can be useful to any facility that packages product material into 50- to 100-pound bags. Comparison of various techniques in the actual working environment allows plant and mill operators to select methods best suited to their needs. Two of these techniques involve engineering controls that can be purchased commercially or fabricated at the plant. One technique involves simply acquiring a more efficient bag valve. The substantial effect of a number of different background dust sources on the bag operator's exposure must be recognized, and these dust sources must be identified and controlled.

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