REDUCING BAG OPERATOR'S DUST EXPOSURE IN MINERAL PROCESSING PLANTS

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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 as 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 significantly lower operator dust exposure.

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 from the American Conference of Government 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

The following four research projects were conducted.

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 included 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% 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).

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

Table I
Increase in Valve Cost Above the Cost of the Standard Paper Valve

Valve	Additional cost per 1000 bags, $	Additional cost per bag, cents
Polyethylene..............	6.85	0.7
Extended polyethylene.....	6.85	0.7
Double trap...............	11.17	1.1
Foam......................	214.98	21.5

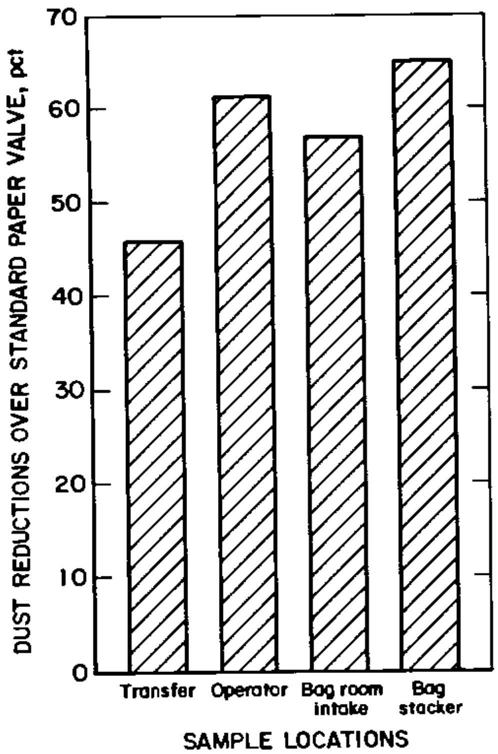

Figure 1. Airborne respirable dust reductions with extended polyethylene compared with that of standard paper valve.

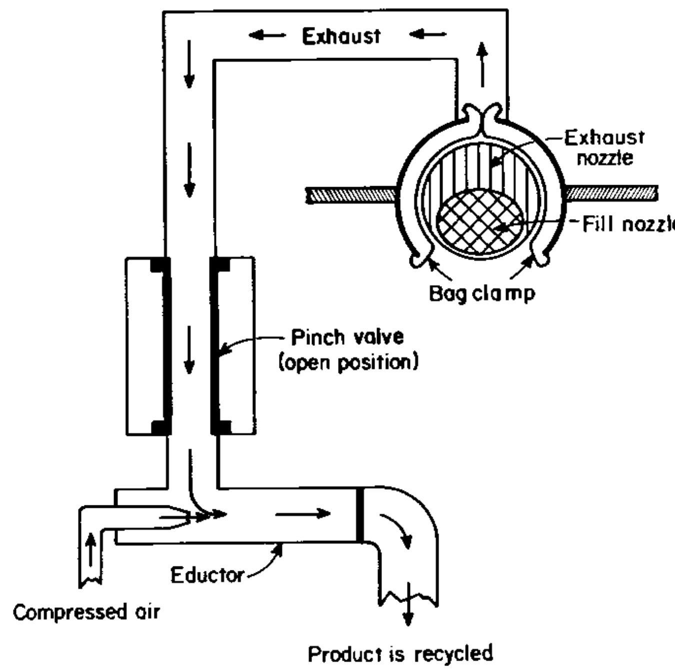

Figure 2. Dual bag nozzle system.

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 m^3/min (50 ft^3/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% of the nozzle reduces the amount of product blowback during bag filling.[4,5] A field evaluation was performed on this dual bag nozzle system during the second week of a 2-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% reduction in dust exposure with the dual bag nozzle system. There was a 90% reduction in respirable dust concentrations measured in the hopper below the fill station which determined the reduction in product blowback 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% 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 on each bag as the exhaust system is operating, and thus 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.*

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% and 82%, 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/m^3. 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%. 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.*

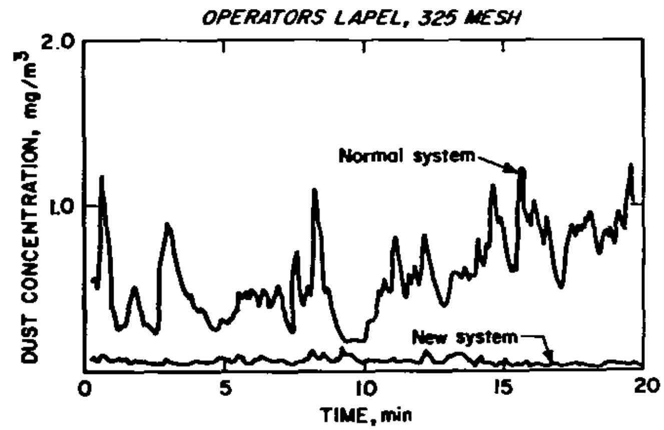

Figure 3. Operator's respirable dust exposure with normal system and dual nozzle system.

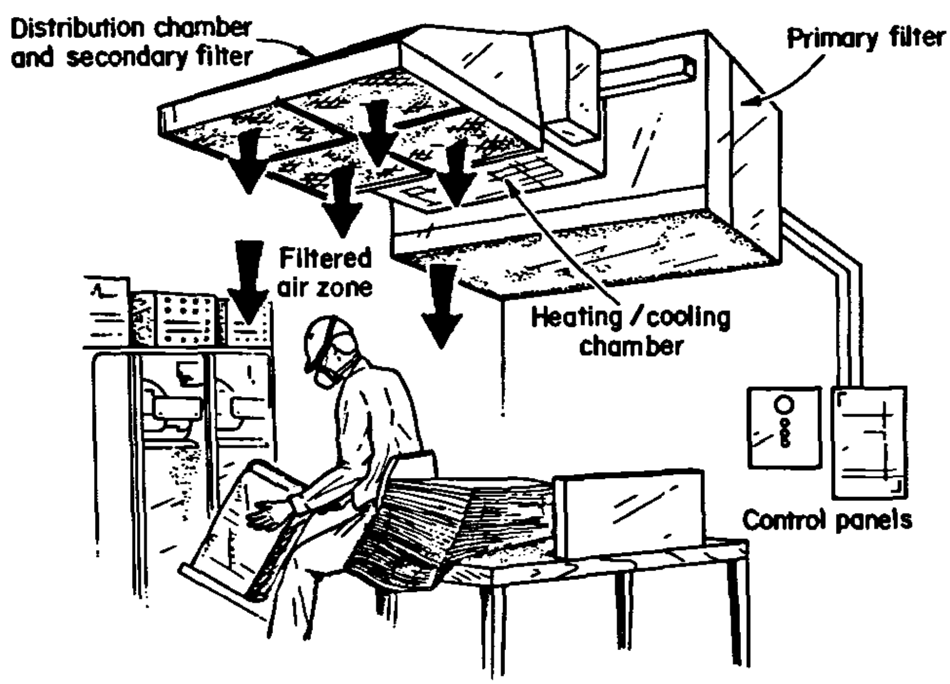

Figure 4. Overhead air supply island (OASIS).

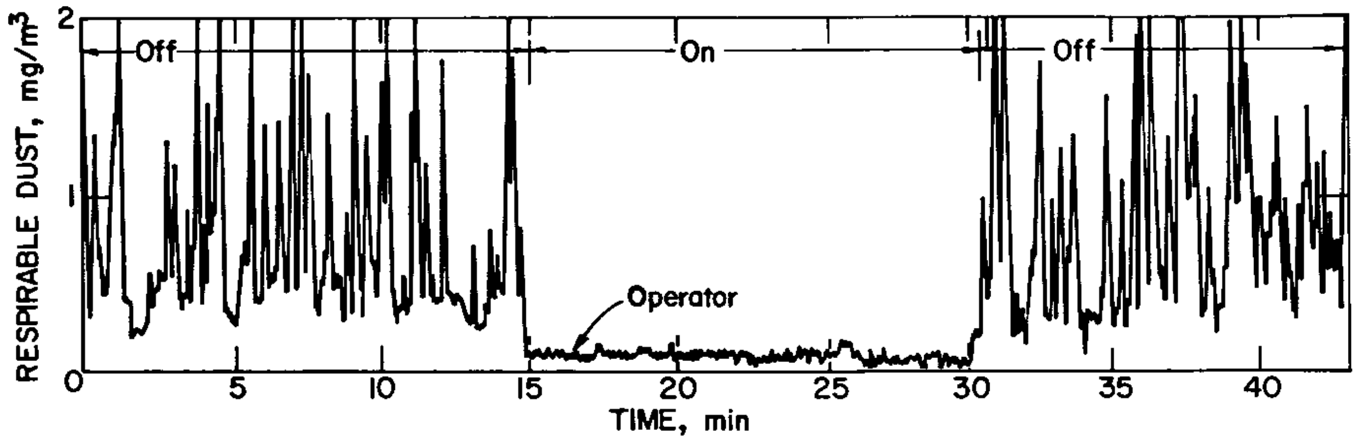

Figure 5. Operator's respirable dust exposure during bagging without and with OASIS.

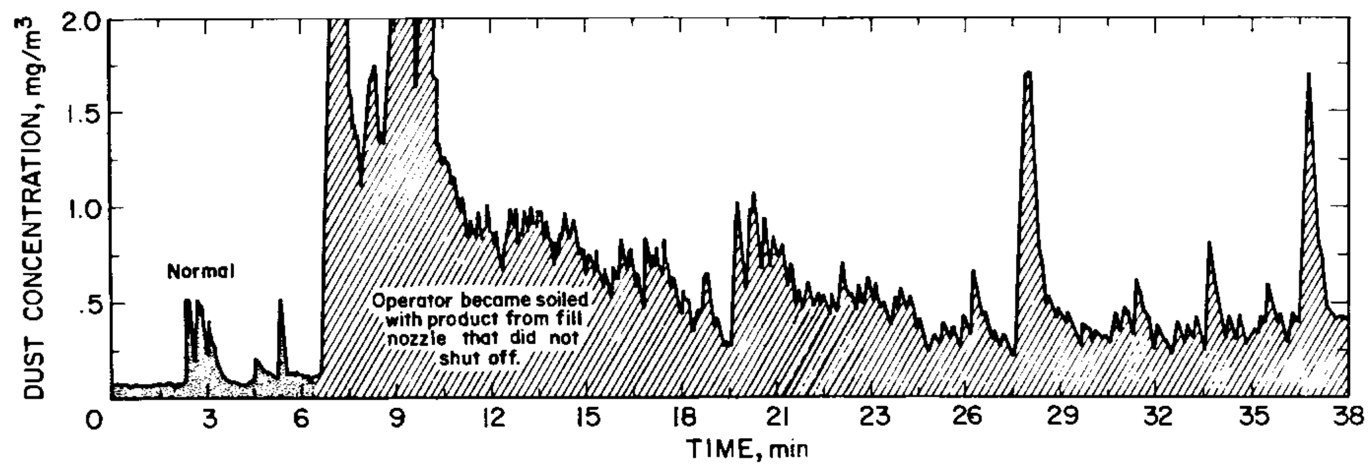

Figure 6. Operator's respirable dust exposure after becoming soiled with product from fill nozzle that did not shut off.

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 substantially increase the bag operator's exposure, 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/m^3; this increased to 1.01 mg/m^3 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/m^3 before bulk loading began to 0.42 mg/m^3 (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.

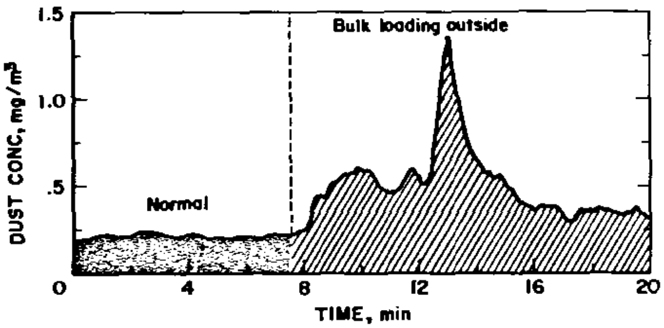

Figure 7. Bag operator's exposure from bulk loading outside.

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 82-98%. 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% 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. 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%. 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.

REFERENCES

1. *Threshold Limit Values for Chemical Substances in the Work Environment Adopted by ACGIH.* ISBN 0-936712-45-7, American Conference of Governmental Industrial Hygienists, 6500 Glenway Ave., Cincinnati, OH 45211, 1973.
2. Williams, K. L., and R. J. Timko: *Performance Evaluation of Real-Time Aerosol Monitor.* Bureau of Mines IC 8968 (1984).
3. Cecala, A.B., Covelli, A., Thimons, E.D.: *Dust Reduction Capabilities of Five Commercially Available Bag Valves.* Bureau of Mines IC 9068 (1986).
4. Cecala, A.B., Volkwein, J.C., Thimons, E.D.: *New Bag Nozzle To Reduce Dust From Fluidized Air Bag Machines.* Bureau of Mines RI 8886 (1984).
5. Muldoon, T.L., Valentine, J.W., Burnett, M.: *Bag Machine Dust Controls and Bag Sealing.* USBM Contract Report H0318013, NTIS PB86-153558 (1986).
6. Volkwein, J.C., Engel, M.R., Raether, T.D.: *Get Away From the Dust With Clean Air From an Overhead Air Supply Island (OASIS).* Rock Products, July 1986.
7. Cecala, A.B., Thimons, E.D.: *Impact of Background Sources on Dust Exposure of Bag Machine Operator.* Bureau of Mines IC 9089 (1986).

*Reference to a specific manufacturer does not imply endorsement by the Bureau of Mines.

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