IC 9089

Bureau of Mines Information Circular/1986

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UNITED STATES DEPARTMENT OF THE INTERIOR

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Donald Paul Hodel, Secretary

BUREAU OF MINES
Robert C. Horton, Director

Library of Congress Cataloging in Publication Data:

Cecala, Andrew B
Impact of background sources on dust exposure of bag machine operator.

(Information circular/Bureau of Mines; 9089)

Supt. of Docs. no.: I 28.27:9089.

1. Mineral industries – Hygienic aspects. 2. Bagging – Hygienic aspects. 3. Mineral dusts – Measurement. I. Thimons, Edward D. II. Title. III. Title: Dust exposure of bag machine operator. IV. Series: Information circular (United States. Bureau of Mines); 9089.

TN295.U4 [TH7697.M56] 622 s [622'.8] 86-600121

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

h	hour	mm	millimeter
h/d	hour per day	mg/m^3	milligram per cubic meter
lb	pound	min	minute
µm	micrometer	pct	percent

IMPACT OF BACKGROUND SOURCES ON DUST EXPOSURE OF BAG MACHINE OPERATOR

By Andrew B. Cecala[1] and Edward D. Thimons[2]

ABSTRACT

The Bureau of Mines has recorded a number of different background dust sources that significantly contaminated the air breathed by bag machine operators. These background sources, observed at five different plants over the past 2 years, can expose bag machine operators to more significant dust concentrations than the filling process itself. To keep bag operator exposure within acceptable dust levels established by the Mine Safety and Health Administration, U.S. Department of Labor, the significance of these background sources must be realized, and the sources must be identified and controlled. The purpose of this work is to identify common background dust sources and show the significant effects that they have on the bag operator's overall dust exposure.

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INTRODUCTION

The purpose of this report is to identify some common background dust sources in and around the bag-filling area. Although these background dust sources are often unrecognized, they can be more significant sources of contamination than the dust generated from the bagging process.

The bagging of mineral products into 50- and 100-lb paper bags is common throughout the entire mineral processing industry. Bagging is performed by a bag operator who sits in front of a two- or four-station fill machine. The bagger's function is to attach empty bags to the fill nozzles as filled bags are ejected from the machine. If the product being bagged is extremely fine (smaller than 200 mesh), the bag operator's dust exposure is usually one of the highest in the plant.

The bag operator is exposed to two primary dust sources. The first is product *blowback* during the bag-filling cycle. This occurs as excess pressure is released from around the fill nozzle during filling. As the excess air forces its way out of the bag, product is forced out with it. This blowback of product leaving the bag creates a considerable amount of dust. The second major source is the "rooster tail" of product thrown from the bag valve and fill nozzle as the bag is ejected from the fill machine. Since the bag is pressurized as it leaves the machine, product spews out of the valve for a few seconds.

These two known dust sources must be controlled to reduce the exposure of the bag operator. However, even when this is done, the operator's exposure often remains over the threshold limit value (TLV) established by the Mine Safety and Health Administration (MSHA). This is due to background dust sources that, in most cases, are not recognized by plant personnel. Gravimetric dust measurements, which are the standard dust measurements taken at most plants, only indicate the overall dust exposure of the worker averaged over an 8-h day. They do not identify the different sources or the magnitude of the exposure for specific periods during the workday. Since respirable dust is not visible to the unaided eye, many background dust sources are difficult to identify. To get an indication of the significance of each source, an instantaneous dust monitor must be used. Then, as different background-dust-producing events take place during the workday, increased dust concentrations and their related effects can be determined.

This report presents common plant occurrences that increase the bag operator's dust exposure over the standard baseline for dust generated at the fill station (blowback and rooster tail). These background sources were observed at five different plants.

TESTING SETUP

Bag operators were monitored to determine their dust exposure at the work station. The dust monitor used in all cases was a real-time aerosol monitor (RAM-1) developed by GCA Corp. under a Bureau of Mines contract. This instrument uses a light-scattering device to determine the dust concentration of a sample drawn in from the environment through a 10-mm cyclone. It is sensitive to changes in the dust content (size, shape, refractive index), but if calibrated to a specific dust, its accuracy is within plus or minus 10 pct of gravimetric samplers similarly equipped with the standard 10-mm cyclone.[3]

The 10-mm cyclone was used to sample the respirable fraction of dust. This cyclone is used in the United States for dust compliance sampling. The cyclone classifies "respirable" size particles

[3]Williams, K. L., and R. J. Timko. Performance Evaluation of a Real-Time Aerosol Monitor. BuMines IC 8968, 1984, 20 pp.

that reach the alveolar regions of the lungs, and are usually considered to have aerodynamic diameters (AED) of 10 µm or less.

The cyclone was attached to the bag operator's lapel to give an accurate indication of his dust exposure. The cyclone was connected to the dust monitor by tubing to allow the operator to work with minimal interference (fig. 1).

The signal from the RAM-1 dust monitor was fed into a strip-chart recorder, a continuous trace of the bag operator's dust exposure was recorded relative to time. The times of different dust-producing occurrences throughout the plant were noted. When an occurrence appeared to increase the operator's dust exposure, that time segment was analyzed using a planimeter to calculate the area under the curve for that time period, and an average concentration for that period was then calculated. The increase in the bag operator's exposure due to the background source was established by comparing the operator's baseline dust concentration with the increased exposure associated with the background source.

RESULTS

The first three cases involve increased exposure of bag operators due to their clothes becoming contaminated by product, which is emitted as they perform their work. Figure 2 shows a case in which the bag operator became soiled with product from a fill nozzle that did not shut off after the bag had ejected from the fill machine (case 1). The operator's recorded dust concentration before this happened was approximately 0.1 mg/m^3; this increased to 1.01 mg/m^3 after becoming soiled with product. Figure 3 shows a similar occurrence when the bag operator became contaminated with product when accidentally hitting the fill button while changing the saddle height (case 2). Since there was no bag on the nozzle, product flowed from the fill nozzle, soiling his clothes and increasing his dust exposure level from 0.07 mg/m^3 to 1.15 mg/m^3. In both cases, the background dust source was the operator's work clothes. Figure 4 shows an operator soiled with product. In a case such as this, clothes should be changed or cleaned using a vacuum system. Figure 5 shows a case where an operator finished bagging and cleaned his clothes using compressed air (case 3), which is not an acceptable cleaning technique. His dust exposure increased substantially, from 0.19 mg/m^3 to 0.45 mg/m^3 as he dusted off. In all three cases, the dust source was considered background because it was not being generated by the bag-filling operation. The operator was contaminated originally from the bag-filling process, but if the clothes were properly cleaned, his dust exposure would be minimized.

FIGURE 1.—Sampling setup to monitor a worker's dust exposure.

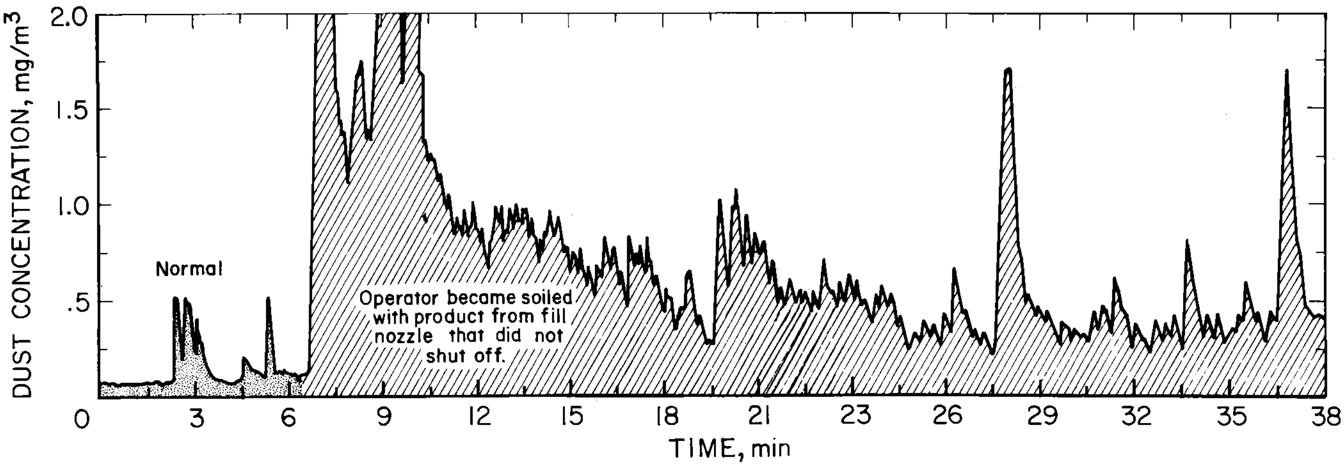

FIGURE 2.—Case 1: Operator's exposure after becoming soiled with product from fill nozzle that did not shut off.

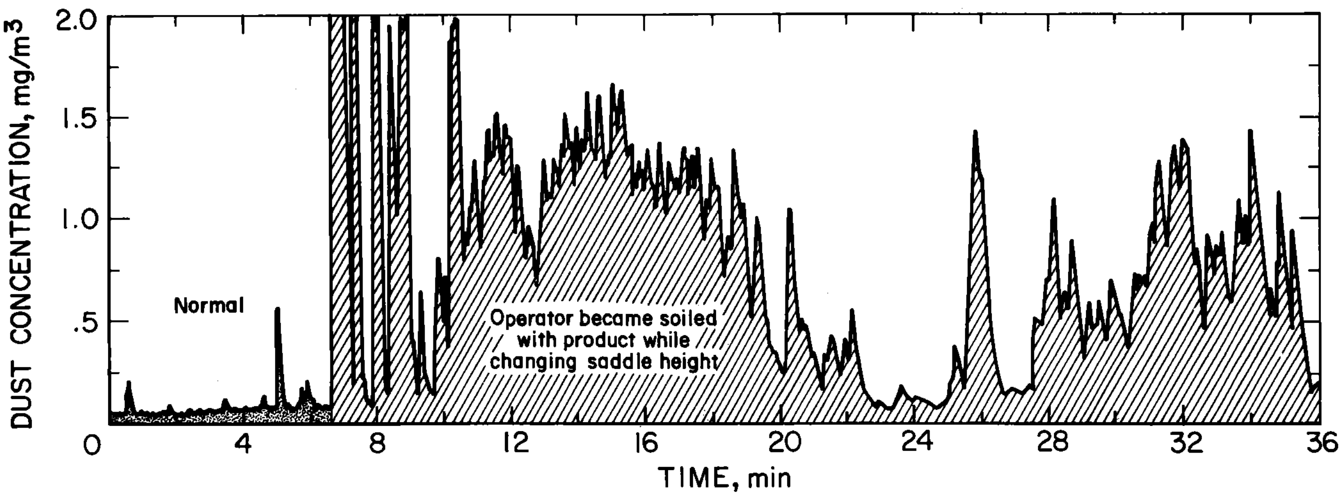

FIGURE 3.—Case 2: Operator's exposure after becoming soiled with product while changing saddle height.

These next three cases deal with increased dust exposure from broken bags of product material, two cases of a broken bag at the fill station, and one of a broken bag during the conveying process. In most cases, bags break because of flawed bags delivered from the manufacturer and not due to ripping by the operator or the conveyor. Figure 6 (panels *A* and *B*) shows cases 4 and 5, in which the bag operator's exposure was from a broken bag at the fill station. In case 4, dust exposure was increased from 0.07 mg/m^3 to 0.40 mg/m^3 immediately following the bag breaking; in case 5, the operator's exposure went from 0.11 mg/m^3 to 0.35 mg/m^3 immediately following the break. In figure 7, the bag operator's dust exposure was from a broken bag during the conveying process (case 6). Dust exposure increased from 0.07 mg/m^3 before to 0.48 mg/m^3 after the bag broke. In this case, even though the bag broke during conveying, dust contaminated the air in the mill substantially, then flowed into the bagging room where the operator is located. This occurs because the exhaust ventilation system in the bag loading area creates a negative pressure that draws background air in from the mill.

The next three cases are all somewhat different, except that in each case the bag operator was totally unaware of the additional activity or background source

FIGURE 4.—Bag operator after becoming soiled with product.

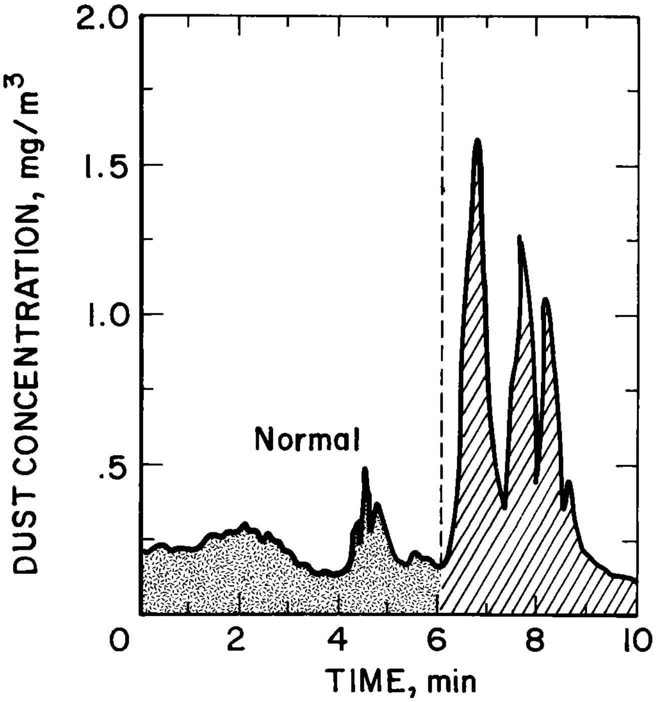

FIGURE 5.—Case 3: Operator's exposure from blowing clothes with compressed air.

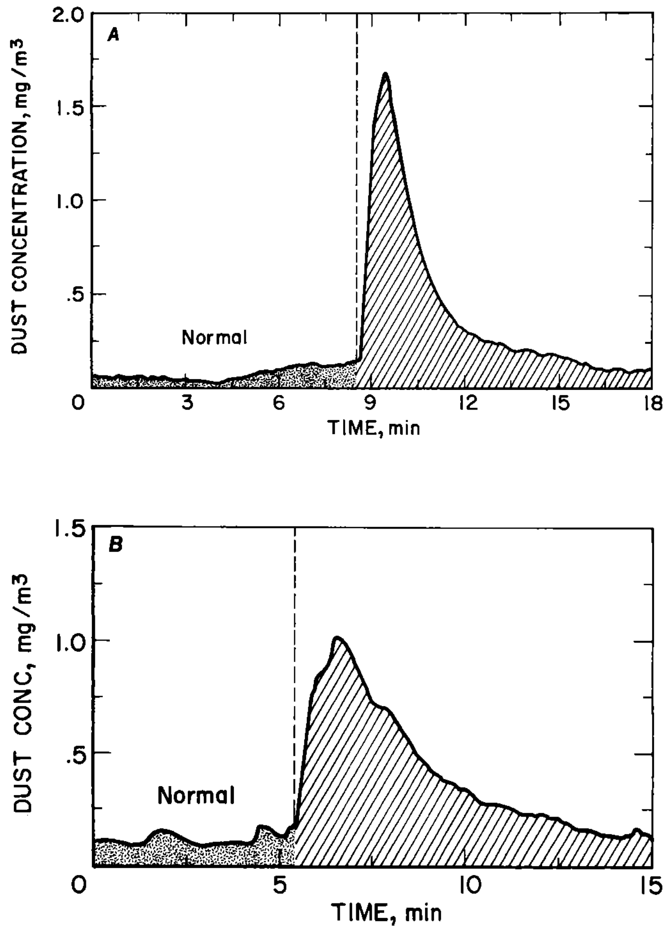

FIGURE 6.—Operator's exposure from broken bag at fill station. *A*, Case 4; *B*, case 5.

that was increasing his dust exposure. In case 7, a truck was being bulk loaded outside the mill where bagging was being performed. The dust generated from this bulk-loading process traveled through an open door into the mill, contaminating the bag operator (fig. 8). The bag operator's dust exposure of 0.17 mg/m^3 before bulk loading began outside and increased to 0.42 mg/m^3. Over the period of the day, there can be a substantial number of trucks bulk loaded at this position, depending upon customer orders. In the second instance, the bag hopper feeding the bag machine overflowed with product (case 8). As the product fell to the floor, a substantial amount of dust was dispersed (fig. 9). The operator's exposure was increased from 0.06 mg/m^3 to 0.73 mg/m^3 after the hopper overflowed. In the last case, a coworker in the mill was sweeping the floor one level below with a push broom, and the operator's exposure increased from 0.03 mg/m^3 to 0.17 mg/m^3 (fig. 10). Sweeping is an

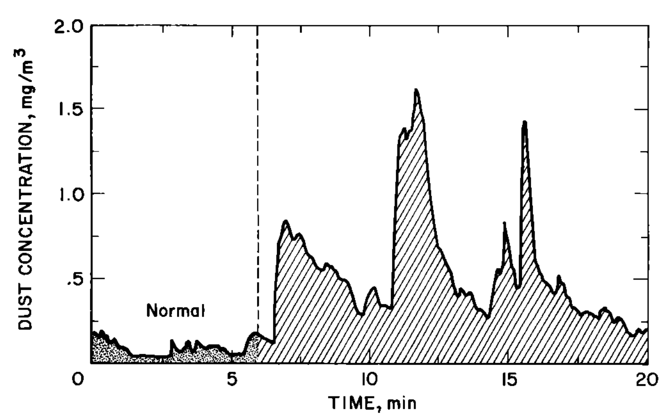

FIGURE 7.—Case 6: Operator's exposure from broken bag during conveying process.

unacceptable method of cleaning the floor because of the dust it generates. Washing the floor with water, or vacuuming are the only two acceptable methods.

DISCUSSION

The results showed that a number of different background sources can significantly increase the bag operator's dust exposure. For bag operator exposure to remain within acceptable dust levels as established by MSHA, dust from the bagging process and background dust sources must be controlled.

The TLV for respirable dusts containing quartz (silica) is calculated by the following equation:

$$\frac{10}{\text{pct silica} + 2} = \text{mg/m}^3.$$

In practice, personal samplers are attached to worker's breathing zone for a normal 8-h workday. The respirable particles are collected on a filter and weighed to determine the average 8-h exposure. This quantity is then compared with the TLV calculated from the above equation. The percent silica is determined by testing the material retained on the filter, generally by X-ray defraction. A sample having 100 pct silica on the filter will establish a TLV for the operator of 0.1 mg/m^3. Many times at silica sand operations, although pure ground silica is being bagged, the silica content of the respirable dust is in the 50- to 80-pct range; thus, the TLV for these plants is in the 0.20- to 0.12-mg/m^3 range. With these low TLV dust requirements, every effort must be made to eliminate the background dust sources.

Table 1 shows the bag operator's exposure for each case showing the before and after dust concentration with reference to the background event, and the amount of increase over previous concentrations (before), which show as increase factor. The TLV exposure time represents the length of time necessary for the operator to exceed his 8-h TLV standard when exposed to the background dust source at the measured dust level. This is assuming a 50-pct silica content, which corresponds to a 0.2 mg/m^3 standard. The method used to calculate this TLV exposure time is presented in the appendix.

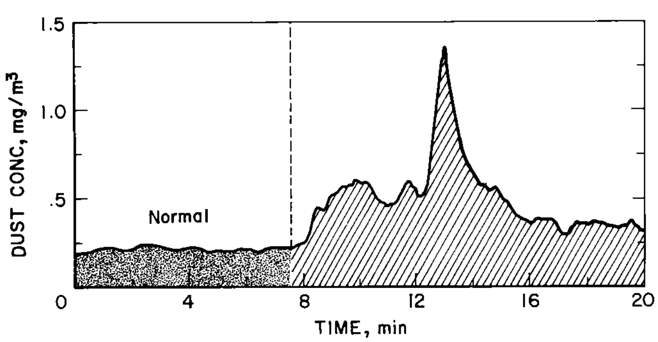

FIGURE 8.—Case 7: Operator's exposure from bulk loading outside.

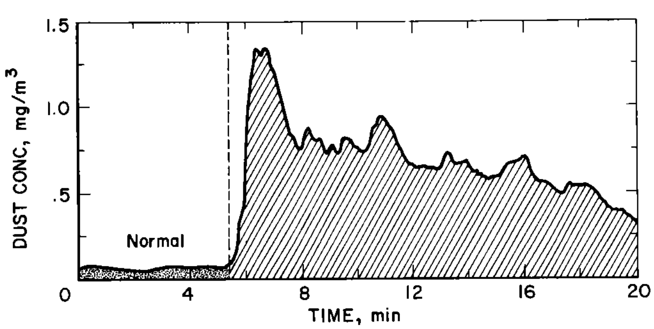

FIGURE 9.—Case 8: Operator's exposure from bag hopper overflowing.

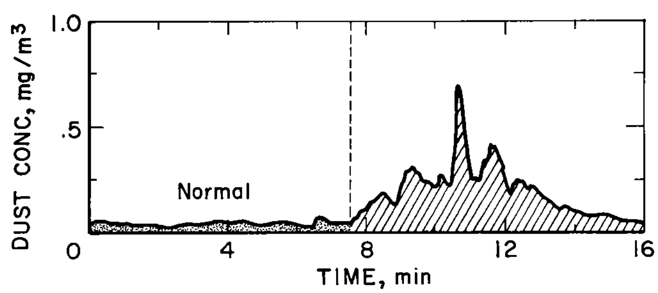

FIGURE 10.—Case 9: Operator's exposure from coworker sweeping floor one level down.

TABLE 1. - Nine cases of background dust exposure to bag operator

Case	Description	Dust conc, mg/m^3		Increase factor	TLV exposure time using 0.2-mg/m^3 std
		Before	After		
1...	Malfunctioning fill nozzle	0.10	1.01	10.1	1 h 35 min
2...	Start button hit..........	.07	1.15	16.4	1 h 23 min
3...	Blowing clothes...........	.19	.45	2.4	3 h 33 min
4...	Broken bag-fill station...	.11	.35	3.2	4 h 34 min
5...	...do.....................	.07	.40	5.7	4 h 0 min
6...	Broken bag-conveying......	.07	.48	6.9	3 h 20 min
7...	Bulk loading outside......	.17	.42	2.5	3 h 48 min
8...	Bag hopper overflowing....	.06	.73	12.2	2 h 11 min
9...	Sweeping floor............	.03	.17	5.7	9 h 24 min

What must be considered with this TLV exposure time is the duration of each occurrence. In case 3, when the operator is blowing dust from his clothes with compressed air, the dust exposure duration would be relatively short, since it is unrealistic that an operator would blow dust from his clothes for 3.5 h/d. On the other hand, there are examples where one occurrence can overexpose an operator (cases 1 and 2) where his clothes have become contaminated with product. The bag operator's dust exposure in both cases remain at significant concentrations 30 min after becoming contaminated. If the operator decided to finish loading the truck, or to wait until break time to clean his clothes, he would be overexposed in 1.5 h, which emphasizes the importance of not wearing previously soiled clothes. This would be especially relevant in cold weather when workers are wearing jackets that may not be cleaned for long periods of time.

Another factor in the TLV exposure time is the amount of air that is contaminated by the background source. This is most obvious with the three cases involving broken bags. When the bags broke at the fill station (cases 4 and 5), the product fell through a wire mesh conveyor into a hopper to recycle the product. The exposure time ranged between 5 and 15 min. When the bag broke on the conveyor, the significant exposure time was much longer because the breakage contaminated a greater volume of air. All the product either remained on the belt or fell to the floor, generating a substantial amount of dust and contaminating a large volume of air. Because of this, the exposure time doubled from that of the bag breakage at the fill machine.

It must be realized that the bag operator can be overexposed when a very small number of these background sources occur. The following are a few common background sources observed and an estimate of the number of occurrences necessary for the operator to be overexposed:

	Number of occurrences
Soiled clothing............	1
Bag breakage:	
During loading............	14-18
During conveying..........	6-10
Bulk loading outside........	3- 4
Bag hopper overflow.........	3- 4

It must be remembered that these dust sources are site related. A significant background source at one plant might be insignificant at another.

It is evident from table 1 that each of the background dust sources had significant effect on the bag operator's dust exposure and the importance of controlling these sources is clear. In each of these cases, the background dust exposure could be eliminated or reduced. An operator who becomes soiled with product should immediately vacuum or change his clothes. He should not blow dust off them with compressed air (case 3). If broken bags are a problem, the answer might be to go to a better bag, for example, a bag using stress kraft paper or possibly a bag with additional plies. A solution for contaminated mill air might be to draw the air into the bag room from a location away from the loading activity, or to filter the air using a canopy air curtain device.[4] Contaminated air from outside the mill should never be permitted to flow into a building and to contaminate workers as in case 7 where bulk loading was being performed. Also, sweeping should not be performed.

These case studies are designed to show the extent and seriousness of background dust sources in terms of the bag operator's overall dust exposure. A number of dust control techniques are available to deal with these background sources.[5]

CONCLUSION

The bagging of mineral products into paper bags is common throughout the mineral processing industry. The bag operator's dust exposure at these plants is usually one of the highest recorded for the plant, especially when the product being bagged is very fine (smaller than 200 mesh). Frequently, events not directly related to the bagging operation may be more significant sources of contamination than the bagging process itself, sometimes increasing the operator's exposure 10 times normal. In cases where the operator's TLV is low because of high silica content, these background sources have been shown to overexpose an operator in less than 2 h. To effectively keep bag operator exposure at acceptable dust levels, these background dust sources must be controlled.

[4]U.S. Bureau of Mines. Dust Free Work Station for Minerals Processing. Technol. News, No. 230, Oct. 1985, 35 pp.

[5]National Industrial Sand Association. Guidance and Solutions to Reducing Dust Levels in the Bagging of Whole Grain Silica Product. Silver Spring, MD, 1977, 35 pp.

APPENDIX.--CALCULATIONS TO DETERMINE TLV EXPOSURE TIME

To calculate the workers' TLV exposure level, the following equation is used:

$$\frac{10}{\text{pct silica} + 2} = \text{mg/m}^3.$$

1. Assume 50 pct respirable silica content, which calculates to be a TLV value of 0.192 mg/m^3. For convenience, this value will be rounded off to 0.2 mg/m^3.

2. This means that the workers' average dust exposure over the 8-h day, must not exceed 0.2 mg/m^3.

$$8 \text{ h} \times 60 \text{ min} = 480 \text{ min}$$

$$480 \text{ min} \times 0.20 \text{ mg/m}^3 = 96 \text{ mg min/m}^3.$$

3. By knowing the dust concentration for a particular occurrence, for example the 1.01 mg/m^3 in case 1, and by dividing this 1.01 value into 96, the TLV exposure time can be determined.

$$96 \text{ mg min/m}^3 \div 1.01 \text{ mg/m}^3$$

$$= 95 \text{ min, or 1 h 35 min.}$$

4. This means that at a dust concentration of 1.01 mg/m^3, in 1 h and 35 min, the worker will reach his TLV level.

U.S. GOVERNMENT PRINTING OFFICE: 1986—605-017/40.064

INT.-BU.OF MINES,PGH.,PA. 28320