



## Continuing Education: Real-Time Data Evaluation at a Bag-Emptying Operation: A Case Study

Thomas C. Cooper & Michael G. Gressel

To cite this article: Thomas C. Cooper & Michael G. Gressel (1992) Continuing Education: Real-Time Data Evaluation at a Bag-Emptying Operation: A Case Study, Applied Occupational and Environmental Hygiene, 7:4, 227-230, DOI: [10.1080/1047322X.1992.10389765](https://doi.org/10.1080/1047322X.1992.10389765)

To link to this article: <http://dx.doi.org/10.1080/1047322X.1992.10389765>



Published online: 24 Feb 2011.



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# Real-Time Data Evaluation at a Bag-Emptying Operation: A Case Study

Thomas C. Cooper and Michael G. Gressel

U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Division of Physical Sciences and Engineering, 4676 Columbia Parkway, Mailstop R5, Cincinnati, Ohio 45226

A variety of tasks are performed during the brief time required to open and empty a bag of powdered material. Each task creates a potential source of dust exposure for the workers performing these tasks. In this study, 50-pound bags of powdered lead chromate were emptied at a ventilated bag-dumping station. Continuous, real-time measurements of dust exposure were recorded, and the worker's actions were videotaped while emptying 65 bags in a 24-minute period. Using a computer program, a representation of the instantaneous dust exposure was overlaid onto the videotape of the worker's actions. Study of this videotape identified seven specific tasks and the relative contribution of each to the worker's overall dust exposure. It was found that pushing empty bags into barrels for subsequent disposal was the major dust source; cutting open bags and lifting them to the emptying shelf of the dump station were lesser but significant dust sources. It was also observed that the bag disposal unit within the dump station control system was awkward for the worker to use; therefore, workers disposed the empty bags in barrels outside the control system. It is estimated that redesign of the disposal system and modification of work practices can reduce worker exposure by about 35 percent. The videotape with the overlay of the dust exposure information can also be used as a training aid for improving work practices. Workers viewing this tape can observe which tasks cause the greatest exposures and understand the need to modify these activities. Cooper, T.C.; Gressel, M.G.: *Real-Time Data Evaluation at a Bag-Emptying Operation: A Case Study*. *Appl. Occup. Environ. Hyg.* 7(4):227-230; 1992.

## Introduction

Most labor-intensive operations that expose workers to hazardous dust concentrations are made up of a variety of repetitive tasks, each task usually requiring only a few seconds to complete. Upon closer examination of the individual tasks, it may be found that only one or two of these tasks are the major sources contributing to the total dust exposure. However, time-weighted average dust measurement methods used to determine normal 8-hour workday concentrations are not designed to isolate dust contributions during each brief individual task. Real-time data collection makes it possible to isolate the dust con-

tributions, even for individual tasks of very short duration. The ability to simultaneously view the worker's activity and the resultant exposures is a useful tool in showing the worker which work practices cause the greatest exposure and need to be modified. For the engineer designing the ventilation system, these real-time data can point out areas in the dust control system that are ineffective or incompatible with work practices. By modifying work practices that exceed the criteria and revising ineffective engineering controls, the worker's average exposure to the toxic material being handled can be significantly reduced. A combination of real-time instruments (monitors that continually analyze for contaminants) to measure personal exposures, data loggers to record and store the data, a video camera to tape the entire operation, and a computer to analyze the data have been used to identify and quantify dust exposures at repetitive tasks.<sup>(1,2)</sup> In this case study, real-time techniques were used to identify and quantify dust sources during a bag-emptying operation, to identify tasks and work practices that contribute significantly to the dust exposures, and to evaluate the efficiency of the existing engineered dust controls.<sup>(3)</sup>

## Methodology

A real-time data collection system consists of four basic components: a dust monitor, which provides a continuous measurement or average measurements over short time intervals; a data logger; a portable computer; and video recorder. For this study, a Hand-Held Aerosol Monitor (HAM) (ppm, Inc., Knoxville, Tennessee) was used to measure respirable dust. The HAM is a light-scattering device that responds to the optical characteristics of the dust being measured. However, it does not differentiate between types of dust. For this reason, it provides only relative dust con-

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**TABLE I.** Summary of the Real-Time Results

Task: Emptying 65 Bags in 24 Minutes	Relative Dust Conc.*	Average Time (sec)	% of Total Time	% of Total Exposure	Exposure Index (%Ex/%Ti)
1. Moving bag on pallet	0.3	2.4	12	9	0.8
2. Cutting bag open	0.4	1.3	7	6	0.9
3. Lift bag to hood	0.4	2.0	10	9	0.9
4. Empty bag	0.2	7.8	40	24	0.6
5. Drop bag into barrel	0.1	0.2	1	<1	0.3
6. Push bag into barrel	1.0	3.3	17	41	2.4
7. Other	0.3	2.6	13	10	0.8
Total		19.6	100	100	

\*Dust concentrations relative to the task having the highest dust concentration normalized to 1.0.

centrations, giving estimates of the actual dust concentration based on the factory calibration. Dust samples collected on filters over a period of several hours are needed to determine actual time-weighted average (TWA) concentrations of the dust of interest; in this case, lead chromate.

The analog output of the dust monitor was recorded and stored in a data logger (Rustrak Ranger, Gulton, Inc., East Greenwich, Rhode Island). The logger had a built-in clock recording at less than 1-second increments. When the data collection was completed, the data logger was downloaded by connecting it with a cable to the serial port on the portable computer and downloading the data file for analysis. The data were imported into a spreadsheet program (Lotus 1-2-3, Lotus Development Corp., Cambridge, Massachusetts) to plot the real-time information in a graphical display of the relative dust concentrations during the worker's activities.

The video recorder had an on-screen clock displaying hours, minutes, and seconds. Before starting to collect data, the clocks on the video recorder and the data logger were synchronized and the dust monitor was zeroed.

In most plants, lighting for good videography is inadequate and additional lighting is needed. To improve the effectiveness of the video as a teaching tool, it is recommended that a light source be placed behind the potential dust source to increase the visibility of any dust escaping during the various tasks.

## Results and Discussion

The individual tasks were identified and coded, and dust contributions for each task were calculated from the video recording of the operation and a printout of the data. An operator emptied 65 fifty-pound bags of lead chromate pigment into a ventilated dump station in a 24-minute period. The bag-emptying operation consisted of seven tasks:

1. Positioning the bag on the pallet.
2. Cutting the bag open.
3. Lifting the bag to the dump shelf of the station.
4. Emptying the bag into hopper.
5. Dropping the empty bag into a barrel for disposal.
6. Manually compacting the bags by pushing the bag into the barrel.
7. Other activities: infrequent activities such as removing the stretch wrap from pallet and placing it in a barrel, using the forklift to raise the pallet load to waist height, and replacing a filled bag disposal barrel with an empty barrel.

Individually, the first six tasks required less than 1 second to 8 seconds to complete and were repeated over 100 times in an hour.

The data from the spreadsheet containing the real-time measurements are summarized in Table I. The relative dust concentration created by each task during the emptying

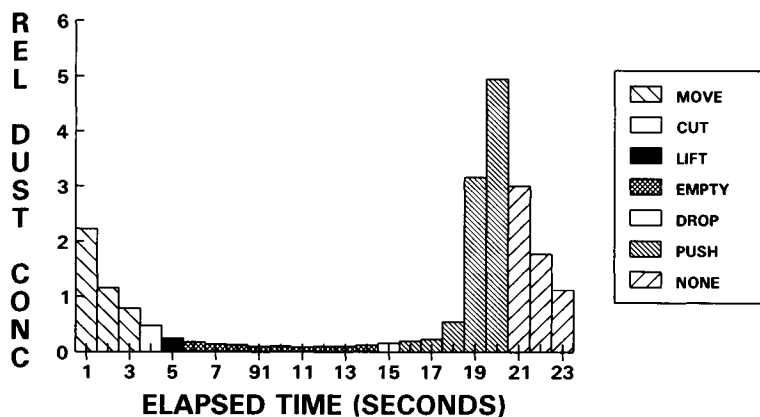
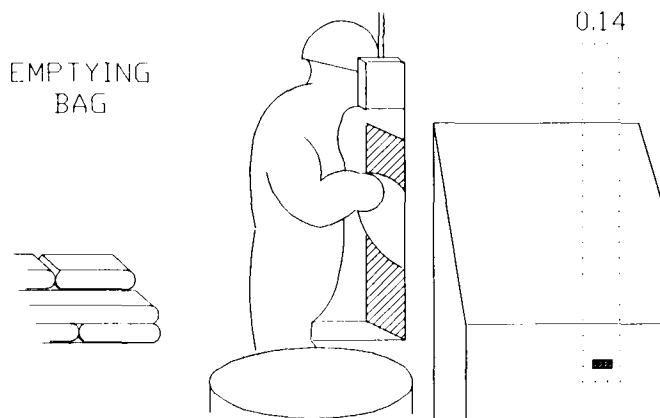


FIGURE 1. Bar graph of worker's exposure during one bag-emptying cycle.



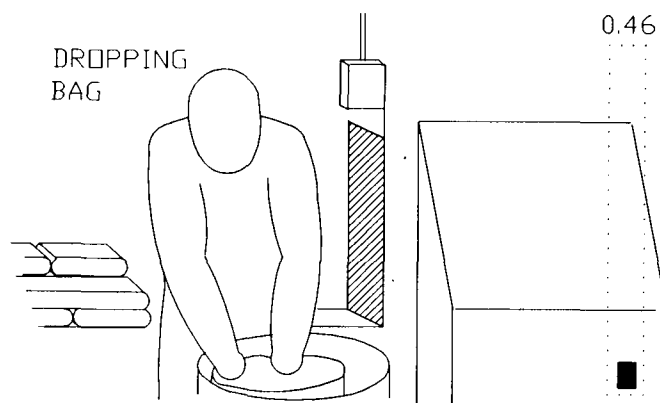
**FIGURE 2.** Low dust exposure. Emptying bag into hopper. (Dust exposures are represented by the vertical bar on the right side of each picture and illustration. The number in the upper right-hand corner of each illustration is the measured relative dust exposure at that moment. The illustrations are used to emphasize the worker's activity in the picture.)

of one bag is depicted in Figure 1. Of the seven tasks, three were noted to result in higher dust levels: Task 2 (cutting open the bag), Task 3 (lifting the opened bag), and Task 6 (pushing the emptied bag into the barrel). The greatest potential exposure (Exposure Index of 2.4) occurred when pushing the bag into the barrel; this accounted for 41 percent of the total exposure. Cutting and lifting the bag accounted for 15 percent of the total exposure. By controlling these three activities to a dust level similar to the other activities, the worker's average exposure could be reduced by 30 to 40 percent. (*Note:* In this case study, this reduction would not be sufficient to bring this operation into compliance with Occupational Safety and Health Administration standards.)

To provide a visual representation of the real-time dust exposure data, a fluctuating bar was overlaid onto the work activity video.<sup>(4)</sup> (The method for overlaying the data onto the video is described in the Appendix.) The length of the

bar increases or decreases in proportion to the worker's dust exposure. Figures 2, 3, and 4 illustrate this for three of the tasks performed. (Because of the poor reproduction of the videotape, a sketch above each photo highlights the worker and exposure bar. The number in the upper right-hand corner of the sketch is the numerical value of the relative concentration represented by the height of the bar.)

The video permits one to view the activity and the relative dust exposure due to the activity simultaneously. The worker can see which activities result in the higher exposures. The design engineer can see that a bag disposal device designed into the booth was not used. With feedback from the worker, it may be possible to redesign the built-in bag disposal to be more user-friendly and effective. Also, work practices can be observed which, if altered, may lower the average exposure for the operation. For example, if Tasks 2 and 3 were reversed so that the bag was first lifted to the dump shelf and then cut open, the exposure for these two tasks may be lowered. Real-time measurements can be used to determine any reduction in dust exposure due to the change.



**FIGURE 3.** Low dust exposure. Dropping bag into barrel.



**FIGURE 4.** High dust exposure. Pushed bag into barrel and turned to retrieve next bag to be opened.

### Conclusions/Recommendations

As shown in this study, a computerized data acquisition system using a continuous aerosol monitor, a data logger to record and store the data, and a video recorder to record the operation is a valuable tool. Individual tasks were identified and their contribution to the worker's average exposure were determined. This information can be used to set priorities and to develop the most cost effective way to control exposure by focusing on those tasks with the highest exposure indices for corrective action. By overlaying the worker's exposure in the form of a bar onto the video, this video could be used as a training aid. The worker can see the relative exposure resulting from each activity, pointing out which work practices result in higher exposures. The engineer can use the information to redesign those portions of the dust control system that are less effective or incompatible with the worker in an effort to improve the overall effectiveness of the system. Another benefit of the video may be that ergonomic studies of the operation can be performed in an effort to reduce the

potential for cumulative trauma disorders and physical injuries.

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Received 8/15/90; review decision 9/18/90; revision 10/11/91; accepted 11/13/91

### APPENDIX

A computer-based graphics overlay system superimposed a graphical representation of the worker's exposure on the work activity video signal. The overlay system consisted of an Enhanced Graphics Adapter (EGA) card and a video overlay card called Video Charley (Progressive Image Technology, Folsom, California). Video Charley piggybacked the EGA card and interfaced the graphics card's Feature Connector. With the Video Charley installed, the EGA card's two RCA ports became video-in and video-out. The work activity video recording was played back into the video-in port, and the signal sent to the video-out port was the work activity overlaid with computer graphics.

The bar-generating program read the data from a specially formatted ASCII file containing the exposure data. This file contained three columns: minutes, seconds (the time the exposure measurement was made), and the exposure measurement. Formatting of the data set was done in a spreadsheet. The spreadsheet data set was then exported to the ASCII file.

To superimpose the worker exposure measurements onto the work activity video recording, the bar-generating program was first configured. The program determined the time of the first reading in the data set. The work activity video recording was played back through the video-in port. When the time on the video recording reached the time of the first reading in the real-time data file, the bar-generating program was started. The signal from the video-out port contained the work activity overlaid with the exposure bar. This signal was displayed on a television monitor and recorded on a video recorder. The result was a video recording of a worker's activity and the simultaneous relative exposure shown directly on the video screen.

The bar-generating computer program was written by Michael G. Gressel and Gregory J. Deye (Division of Physical Sciences and Engineering) of NIOSH in Cincinnati, Ohio, and is available upon written request and submission of a blank diskette with mailer.