



Advantages of Real-Time Data Acquisition for Exposure Assessment

Michael G. Gressel , William A. Heitbrink , James D. McGlothlin & Thomas J. Fischbach

To cite this article: Michael G. Gressel , William A. Heitbrink , James D. McGlothlin & Thomas J. Fischbach (1988) Advantages of Real-Time Data Acquisition for Exposure Assessment, Applied Industrial Hygiene, 3:11, 316-320, DOI: [10.1080/08828032.1988.10389864](https://doi.org/10.1080/08828032.1988.10389864)

To link to this article: <https://doi.org/10.1080/08828032.1988.10389864>



Published online: 25 Feb 2011.



[Submit your article to this journal](#)



Article views: 19



[View related articles](#)



Citing articles: 1 [View citing articles](#)

Advantages of Real-Time Data Acquisition for Exposure Assessment

Michael G. Gressel, William A. Heitbrink, James D. McGlothlin and Thomas J. Fischbach

National Institute for Occupational Safety and Health, Division of Physical Sciences and Engineering, Engineering Control Technology Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226

A computerized data acquisition system, utilizing real-time instrumentation and a video taping system, can provide the information necessary to identify the sources or activities which most affect worker exposure levels. Integrated workplace samplers, such as pumps with filters or charcoal tubes, may indicate a certain level of exposure. However, due to the complexity of the process or work cycle, an evaluation of activities affecting exposure patterns may be difficult. Such a system, utilizing a computer, real-time instrumentation, and video taping, has been used successfully in three different NIOSH studies. In the first, a study of manual weigh-out and transfer of powders, the data acquisition system identified the scooping operation as the component of the work cycle which most affected the worker dust exposures. Because of the short work cycle, typically 30 seconds or less, filter sampling could not isolate this work element as the major cause of worker dust exposure. In the second study, an evaluation of various control methods used during automotive brake servicing, several control devices were appraised; the work routines associated with each device also were assessed. The data acquisition system was used to identify the use of an air driven impact wrench as a significant contributor to dust exposures levels. The final study utilizing the data acquisition system was the characterization of emissions from an evaporative pattern-casting process. In this study, the real-time data, along with the integrated sampling, identified metal pouring and casting shakeout as the two activities requiring controls to contain contaminant emissions. The successful use of the computerized data acquisition system in these three studies shows that the system is very flexible and provides more detailed information than traditional integrated sampling alone. This system can pinpoint the hard-to-identify emission sources and activities so that controls can be modified or implemented. Gressel, M.G.; Heitbrink, W.A.; McGlothlin, J.D.; Fischbach, T.J.: *Advantages of Real-Time Data Acquisition for Exposure Assessment*. *Appl. Ind. Hyg.* 3:316-320; 1988.

Introduction

Determining an activity which causes a change in worker exposure can often be difficult, particularly if the activity lasts only a few seconds such as dust exposures during a repetitive manual

task. The duration of the activity may be too short to be detected with integrated sampling techniques. Real-time instrumentation (monitors that continually analyze for contaminants), along with some sort of a recording device, can be used to document the readings. Since the data are stored digitally, sophisticated data analysis can be performed either on a personal or mainframe computer. However, the success of the determination of the key activity causing the change in exposure depends upon an observer who must watch the operation while tracking the real-time instrument output. It is easy for an observer to miss the activities causing the changes since there is usually an instrument response delay due to transportation lags (the time necessary to transport the contaminant to the instrument) and instrument response time. Furthermore, it is difficult for an observer to anticipate the activities of a worker at two- or three-second intervals. A data acquisition system is needed that will document the activities while recording the real-time data. Such a system has been developed utilizing real-time instrumentation, computerized data logging, and video taping to aid in identifying activities that change exposure. This system has been used in three different studies: a study on manual weigh-out of powders in the rubber and plastics industry, a study on dust control during automotive brake servicing, and finally a study characterizing the emissions from the evaporative pattern-casting process. These studies show how the data acquisition system can identify emission sources and activities that traditional integrated sampling can not. In addition, several recent improvements have been made in the system. These improvements have resulted in a system that is much more compact and easier to use in the field.

System Characteristics

The data acquisition system consists of three components. The first is an appropriate real-time monitor. Its response time should be shorter than the process or work elements so that accurate data can be obtained. Use of instruments with a long response time will result in data with a low level of resolution. In fact, if the activity of interest is of a short enough duration, the ability

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

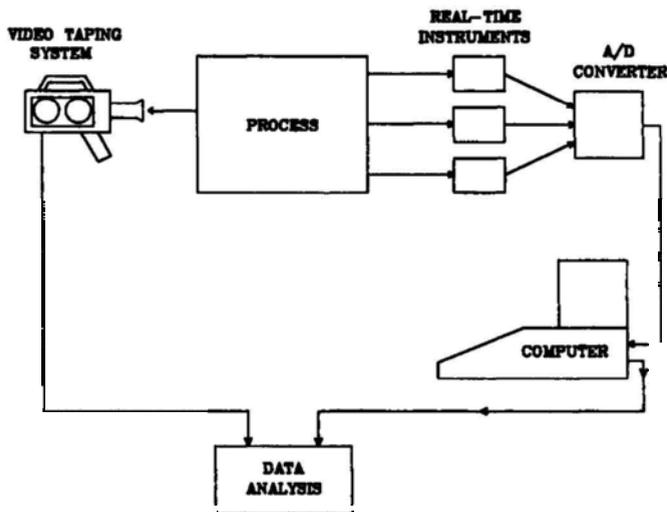


FIGURE 1. Schematic drawing of data acquisition system.

of a slow response instrument to detect an exposure change may be limited. For maximum utility, the preferred instrument should be a portable, personal type monitor. The monitor also should have either an analog output or internal data logging capabilities with a real-time clock. In the absence of built-in data logging capabilities, the analog output of the instrument is connected to the second component of the system, the data logging element. The analog signal from the monitor can be recorded in two ways: either into a data logger which can then be downloaded to a personal computer or directly into the personal computer via an analog to digital converter board installed in the personal computer. The computer or data logger serves as an electronic strip chart recorder with a sampling rate as high as 100,000 sample per second, depending upon the equipment selected. The computer or data logger should have an on-board clock and be programmable so that a time reading can be recorded with the value of the instrument reading. The final component of the data acquisition system, the video taping system, documents the activities of the work cycle or process. The camera should have an on-screen clock or timer that can be synchronized with the real-time clock of the computer or data logger. The on-screen clock permits the matching of an exposure with an associated activity. The video tape of the work cycle or process can be reviewed while tracking the worker's exposure from a printout or plot of the real-time data. From the video tape, activities can be keyed into the data file for further data analysis, or the data can be plotted with the activities associated with any peaks documented.

The method of data analysis can be varied and is up to the discretion of the investigator. Figure 1 shows a schematic representation of the data acquisition system.

Data Acquisition Studies

Several studies have been conducted utilizing this computerized data acquisition system. The three examples to be shown here—manual weigh-out and transfer of powders, dust control during automotive brake servicing, and characterization of an evaporative pattern-casting process—indicate the utility and the versatility of the system. The information for each example is presented only to indicate the relevance of the data acquisition system and is not intended as comprehensive report of the results of these studies.

Manual Weigh-Out and Transfer of Powders

A study of manual weigh-out and transfer of powdered materials was conducted to evaluate the effects of dusty clothing, depth of powder in the weigh-out drum, and work practices on the dust exposures of the workers performing this task.⁽¹⁾ In performing this operation, a worker would scoop powder from a drum, weigh 1.18 kg (2.6 lb) into a paper bag, close the bag, and then place it in a bin behind him. A previous study has indicated that in spite of the presence of many controls, such as ventilated booths, rubber and plastics industry workers performing these activities have had high dust exposures as measured by gravimetric filter sampling.⁽²⁾ The filter sampling could not indicate which specific job elements were causing these high exposures. Therefore, an acquisition system was developed, utilizing real-time instrumentation, computerized data recording, and video taping. A hand-held aerosol monitor (ppm, Inc., Knoxville, TN) was fastened to the worker. An umbilical line was connected from the hand-held aerosol monitor to an Apple II-plus computer equipped with an AI13 analog to digital converter (Interactive Structures, Inc., Bala Cynwyd, PA). Because a worker performing the weigh-out activity did not have to leave his work station during a sampling run (25 min or less), the umbilical did not interfere with his performance of the job. The computer was programmed to take a reading every two seconds and digitally store the data. Data were collected while the worker weighed out the powder from an initially full drum until it was empty.

To analyze the real-time data, the data files were transferred from the Apple II-plus computer to a mainframe computer via modem. Time series analysis was performed on the data to develop a model to predict the workers dust exposure at a given powder depth in the drum. The SAS procedure AUTOREG was

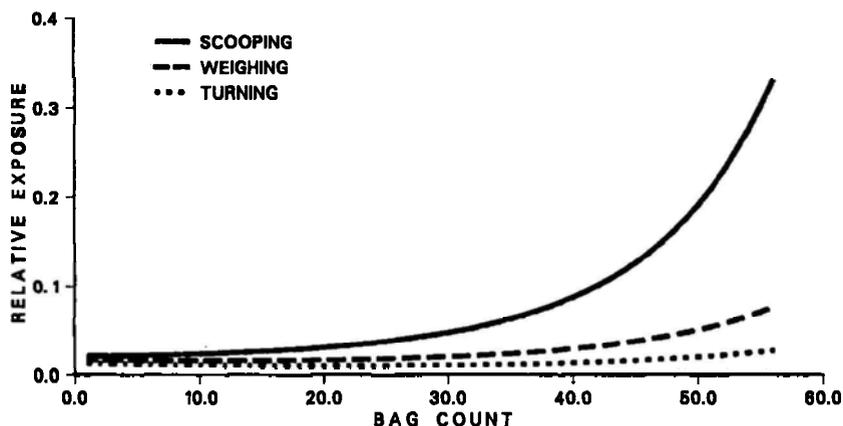


FIGURE 2. Plot of relative dust exposure versus bag count for scooping, weighing, and turning of manual weigh-out of powders.⁽¹⁾

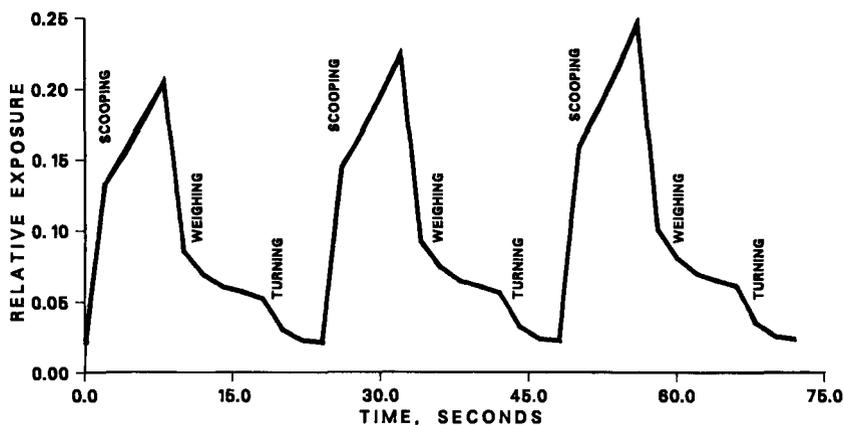


FIGURE 3. Plot of relative dust exposure versus time for three bags during manual weigh-out of powders.⁽¹⁾

used for this analysis.^(3,4) The model used bag count (the number of bags weighed out by the worker) as the measure of the depth of powder in the drum. The process divided into three basic elements for use in the model: scooping, weighing, and turning (including closing the bag, placing it in the bin, and opening a new bag). The weigh-out process typically took 20 to 30 seconds to complete. The model was plotted assuming each element (scooping, weighing, and turning) took 8 seconds for a total process time of 24 seconds. Figure 2 shows a plot of predicted relative exposure versus depth of powder in the drum, given as bag count, with separate curves predicting the exposure for scooping, weighing, and turning.⁽¹⁾ Figure 3 is a plot of predicted relative exposure versus time for the weigh-out of three bags. The plot takes the form of a single peak for each bag weighed, with exposure increasing during scooping and decreasing during weighing and turning.

The results of the real-time data analysis indicated that performing the weigh-out operation with a nearly empty drum causes higher worker dust exposure than performing the same operation with a full drum.⁽¹⁾ Short-term air filter sampling performed in this study showed the same results. However, the filter sampling did not show specifically that scooping increased the exposure while exposures decreased during weighing and turning. By video taping the operation and then keying activities to the data, an analysis was performed to model the worker's dust exposure. This analysis would not have been possible without the video documentation of the operation. Further, the short-term filter sampling took several days to obtain sufficient replicate data, whereas the real-time data was collected in just 20 minutes.

Dust Control During Automotive Brake Servicing

Dust control during automotive brake servicing was evaluated to determine which control schemes work best. Control of brake dust may be important since most brake shoes and pads contain asbestos, and servicing brakes may result in asbestos exposure. The two methods of control that were evaluated were vacuum enclosures and wet methods. The vacuum enclosure surrounded the brake assembly, and all cleaning work was performed inside the enclosure. For the wet methods, the brake drum was removed from the brake assembly, and all the parts were washed with a cleaning solution. The effectiveness of these devices are detailed elsewhere.⁽⁵⁾ The utility of the data acquisition system, rather than the study results, will be presented here.

In this study, a hand-held aerosol monitor was placed on the worker along with two filter cassettes and pumps. A second hand-held aerosol monitor was placed under the axle of the vehicle

being serviced. This second monitor served as a measure of the dust escaping from the rear of the drum. These dust monitors gave a measure of total dust, not just asbestos fibers. Other air filter samples taken included area, background, and outdoor samples. The Apple II-plus computer sampled the data at a rate of one reading every three seconds. The entire brake servicing operation was video taped with the camera clock being synchronized with the clock of the computer.

Analysis of the brake dust data was simple and straight forward. The data were transferred from the Apple computer to an IBM AT computer via modem. The data were imported into a spreadsheet program, then plotted and printed out. With a hard copy of the data in hand, the video tapes were reviewed. For every peak on the plot, the activity occurring at the exact same time as the peak was found on the tape. In this manner, most activities causing short-term changes in worker dust exposure could be documented. Figure 4 shows a portion of the real-time data from one brake job. This plot shows two large concentration peaks, one at the beginning of the brake job and one at the end. From reviewing the video tape of this job, it was determined that the two large concentration peaks were caused by the mechanic using an air driven impact wrench to remove the vehicle's lug nuts. While the filter samples did show some level of exposure, they were not able to identify the existence of large peaks.

Emission Characterization of an Evaporative Pattern-Casting Process

The third study utilizing this data acquisition system characterized emissions from an evaporative pattern-casting process, a process used in the foundry industry. In this process, a polystyrene foam facsimile of the part to be cast is fabricated. With the foam facsimile packed in dry unbonded sand, the molten metal is poured on top of the foam, causing it to evaporate. A high quality casting is produced, a casting requiring little cleaning because sand is not bonded to the surface. Since the evaporative pattern-casting process is claimed to be a lower cost method of producing castings in both aluminum and gray iron, the process may become widely used in the years to come. However, though much work had been done on developing the process, little is known about the nature and composition of the emissions. This study attempted to identify and quantify the contaminants produced by the process and to compare the emissions to those generated by the green sand process, a conventional casting technique.⁽⁶⁾

In order to eliminate variations inherent in production facilities, all testing was done in a pilot foundry. A hood was con-

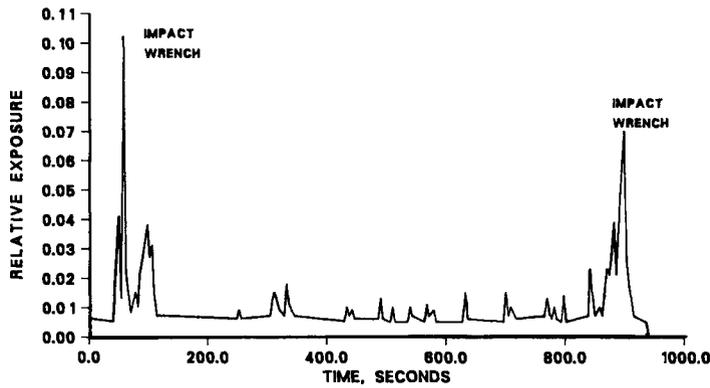


FIGURE 4. Plot of relative dust exposure during automotive brake servicing.⁽⁵⁾

structed to contain all the emissions, including those given off during the pouring of the metal. From the capture hood, a sampling stack led to a total aerosol mass filter and a high volume blower. Both real-time instrumentation and integrated sampling were used in this study. The real-time instrumentation continuously monitored aerosol mass, organic vapors, and carbon monoxide. Integrated sampling methods were used to identify and quantify the organic compounds present (charcoal tubes), measure the total aerosol mass (high volume filters), and screen for polynuclear aromatic hydrocarbon concentrations (sorber tubes and filters). In the case of the aerosol mass, the integrated sampling also was used to calibrate the real-time instrumentation. The output from all of the instruments was uploaded to the Apple II-plus computer at a rate of one sample every three seconds. Two video taping systems were employed. The first system was used to monitor the rate of the metal pour, while the other system monitored the casting flask for events such as lightoff. The clocks from both video systems and the clock of the computer were synchronized allowing the events of the experiment to be matched with the emission data. The results and conclusions based upon one contaminant, carbon monoxide, demonstrate the value of the data acquisition system to the study. More detailed information about other contaminants are reported elsewhere.⁽⁶⁾

Figure 5 shows a real-time plot of carbon monoxide emissions during the casting of gray iron. This plot shows the emissions for both the evaporative pattern-casting process and the green sand process. It was important to know not only the total amount of carbon monoxide given off, but also when it was given off. The real-time data indicated that both of these casting systems emitted most of the carbon monoxide during the beginning of

the pouring and shakeout phases. Green sand castings, however, emitted significantly higher concentrations than the evaporative pattern-casting process. These results are significant because carbon monoxide is typically used as a measure of control in green sand foundries (i.e., when the carbon monoxide is controlled to low levels, other contaminants are assumed to be reduced to relatively low levels as well). However, based upon the other sampling results, contaminants such as benzene are present at more critical concentrations than carbon monoxide in the evaporative pattern-casting process. Therefore, the use of carbon monoxide as a measure of control in an evaporative pattern-casting foundry may result in overexposure to other contaminants. This study was unique in the way that the real-time instrumentation and the integrated sampling worked closely together. The real-time instrumentation could not identify the specific contaminants such as benzene, while the integrated sampling could not identify casting pouring as an activity which resulted in high concentrations of carbon monoxide.

System Improvements

Several improvements in the data acquisition system have been made since these studies were performed. While the Apple II-plus computer performed well, it was cumbersome to take into the field. In most current studies utilizing the data acquisition system, Rustrak Ranger data loggers with Pronto software (Gulton Industries, Inc., East Greenwich, RI), are being used to log the real-time data. In the other studies, a Compaq Portable II computer (Compaq Computer Corporation, Houston, TX) with a Dash-16 analog to digital converter (MetraByte Corporation, Taunton,

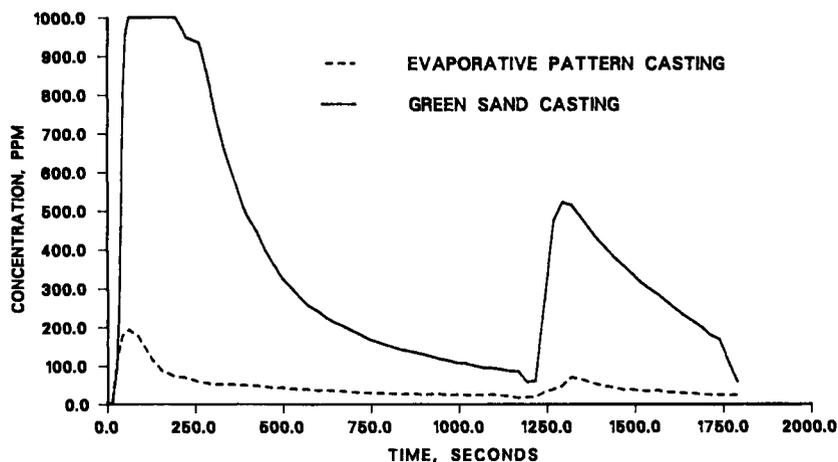


FIGURE 5. Plot of carbon monoxide emissions from the evaporative pattern-casting and green sand processes.⁽⁶⁾

MA) and Labtech Notebook software (Laboratory Technologies Corporation, Wilmington, MA) are being used to record the real-time data. The computer is used when the data loggers will not provide sufficient data resolution or the data needs to be displayed while collection is taking place. When using the computer with analog to digital converter, the data can be sent from the worker-mounted instrument to the computer via an umbilical or a telemetry system. The telemetry system should be used if eliminating the umbilical is necessary due to the work process or cycle. The use of the portable computers and the data loggers drastically reduces the amount of equipment that needs to be taken into the field as well as allowing simple graphical display of the data in a spreadsheet program such as Lotus 1-2-3®.

Another area in which the amount of equipment can be reduced is the video taping system. In the three studies discussed, a VHS camera with separate recorder was used. The use of a camcorder, such as many of the 8-mm systems available, will reduce the volume of equipment necessary to assemble this system. It is important, however, that any camera used have an on-screen clock or timer that will display hours, minutes, and seconds.

Finally, combining the graphic display of the computer with the signal of the video recorder is one area that needs further development. This could prove to be useful in worker training programs. A worker could be shown how his exposure changes depending upon the activities of the job. It could serve as reinforcement for changes in a work cycle since the workers could see which activities cause high exposures. With the development of some display software, combining the two output signals will be possible with the use of professional quality video equipment.

Conclusions and Recommendations

As shown by the three studies, the computerized data acquisition system utilizing real-time instrumentation, video taping, and elec-

tronic data logging is extremely versatile. It serves well in identifying activities that change worker exposures by allowing a repeated detailed review of the work cycle or process while tracking worker exposures. Though not always able to replace integrated sampling, the data acquisition system can be a good complement to traditional sampling methods using filters and charcoal tubes, as was the case with the evaporative casting study. It also can stand alone, as it did in the manual weigh-out and brake studies. The computerized data acquisition system can save time since sampling can be performed and analyzed in as quickly as a few minutes. With recent improvements, this system is portable and easy to operate. And finally, with the modifications currently being developed, the data acquisition system will also be a useful training tool. With all of these advantages, a computerized data acquisition system is a useful tool for identifying work cycle or process elements causing changes in occupational exposures.

References

1. Gressel, M.; Heitbrink, W.; McGlothlin, J.; Fischbach T.: In-Depth Survey Report: Control Technology for Manual Transfer of Chemical Powders at the B. F. Goodrich Company, Marietta, Ohio. NTIS Pub. No. PB-87-107579. National Technical Information Service, Springfield, VA (1986).
2. McKinnery, W.; Heitbrink, W.: Control of Air Contaminants in Tire Manufacturing. DHHS (NIOSH) Pub. No. 84-111. NIOSH, Cincinnati, OH (1984).
3. SAS Institute: SAS/ETS User's Guide. Cary, NC (1982).
4. SAS Institute: SAS User's Guide: Statistics. Cary, NC (1982).
5. Sheehy, J.; Todd, W.; Cooper, T.; Van Wagenen, H.: In-Depth Survey Report: Control Technology for Brake Drum Service Operations at Cincinnati Bell Maintenance Facility, Fairfax, Ohio. NTIS Publication (in press).
6. Gressel, M.; O'Brien, D.; Tenaglia, R.: Emissions from the Evaporative Casting Process. Applied Industrial Hygiene (in press).

Received 12/4/87; review/decision 5/2/88; revision 6/6/88; accepted 6/21/88