

Computers and video filming as aids in reducing exposure to air pollution

by Gunnar Rosen, MSc¹

Direct-reading instruments for measuring air pollution at workplaces are employed primarily as monitoring and alarm devices. Examples of such applications are leak detection with handheld detectors for processes in which high concentrations of toxic gases may occur. Stationary monitoring and alarm instruments which take readings at a number of different points and emit an alarm when necessary are other forms of application.

Exposure measurement with direct-reading instruments is sometimes made with small, personal monitors connected with a data logger (also carried by the subject). Data stored this way can be reported as mean values for the monitored period, and they can sometimes even supply information on variations in exposure. When large direct-reading instruments are employed, they are usually situated in a position near the subject with the sampler probe as close to the subject's breathing zone as possible. Readings can be recorded on a strip chart or a data logger. Their use provides more opportunities for the study of variations in exposure.

The spread of airborne pollutants in a room or from a pollution source is sometimes studied with spot checks at different points in a room or around the source. The results of these checks can be presented as numbers in a drawing of the room, but they usually serve as the basis of discussion on dissemination pathways.

A common feature of all these applications for direct-reading instruments is the fact that the ability of the equipment to display rapid variations in air pollution is often poorly utilized. This capability is indeed available if readings are recorded on a strip chart, but the cause of the variation usually remains obscure because of the dearth of information on events at the time the changes occurred.

The methods described in this article utilize computers and video filming for presenting measurement results with greater clarity.

The methods were developed as teaching aids for visualizing important relationships and causes of exposure variations and for determining the spread of pollution. Another important objective was to devise a procedure for facilitating scientific study of both the spread of air pollution and the variations in exposure.

Exposure variation — PIMEX

A new method, called PIMEX, was developed primarily for the purpose of studying variations in exposure to air pollution. The method utilizes direct-reading instruments plus video filming (1).

The simplest version of the method employs a measurement instrument and a video camera with a separate video recorder. The signal from the instrument and the video signal from the camera are fed into a video mixer. The video mixer amalgamates the camera image and instrument signal and displays the instrument signal as a bar at the edge of the image. The height of the bar designates the magnitude of the reading. The mixer can accept and display readings from two instruments.

The system was supplemented with telemetry equipment when the measurement instrument could be used as a personal sampler. The subject then carried the measurement instrument and the transmitter part of the telemetry equipment. The telemetry receiver was connected to the mixer. Figure 1 shows an example of the way the technique is employed for studies of exposure to solvents during spray painting.

The measurement instrument in the system must have an analogue output socket for a printer signal and must be relatively fast. A battery-powered instrument that can be carried without inconvenience by the subject is an advantage, as telemetry can then be em-

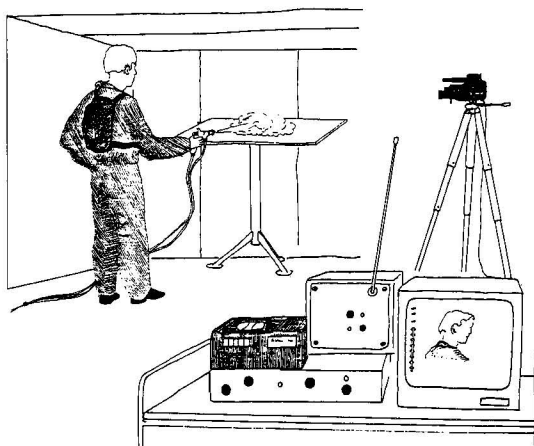


Figure 1. The PIMEX method used to study exposure to organic solvents during spray painting.

¹ Division of Chemical Industrial Hygiene, National Institute of Occupational Health, Solna, Sweden.

ployed. If subject transport is not possible, a tube is installed in the subject's breathing zone via a pump. This procedure obviously restricts the subject's movements to some extent, but experience has shown that this problem can be overcome in most cases. A fast instrument is needed because the reading is displayed in the image. Any significant delay causes an effect which makes interpretation harder. A second or two is regarded as an acceptable delay for the system.

Video filming equipment must offer access to the video signal between the camera and recorder. This requirement is sometimes impossible for camcorders. Otherwise, the demands on the video equipment are the same as for conventional applications. Having a monitor connected to the system during on-going studies is an advantage, as results can then be monitored directly and replayed immediately after being recorded.

The video mixer was especially developed for the system by the Swedish company IBC Ab in collaboration with the author. The initial mixer was designed for the television system used in Sweden and in many other parts of western Europe. The date, time, preset values, and an identification number can also be displayed in the picture, in addition to the reading, if so desired.

The PIMEX system has mainly been used at workplaces at which organic solvents and dust or smoke were the air pollutants. The direct-reading instrument employed for solvents was a photovac tip, a photo ionization device. The instrument is incapable of analyzing a specific solvent in a mixture of solvents. Therefore its readings represent a measure of total exposure to airborne solvents. This is no major obstacle, as the main purpose of the method is to show how exposure varies with work. Parallel measurements can be made with traditional methods for exposure determination when the investigator wishes to obtain some idea of the exposure represented by bar height.

Dust and smoke are measured with a portable miniram instrument, which operates on the aerosol photometry principle. This instrument is also incapable of measuring any particular substance in dust but records the total amount of respirable particles in dust or smoke. It was also roughly calibrated by parallel measurements with a conventional method.

The telemetry system described can therefore be used on the aforementioned airborne contaminants, as the measurement equipment is small and portable. Another advantage of the instruments is the fact that they are very rapid. The response of the entire system to a change in exposure is less than a second.

The system utilized a tube from the subject's respiratory zone to the measurement device. Nitrous oxide, measured with the infrared instrument, and carbon monoxide, measured with the electrochemical cell, are the substances that have been tested to date.

The PIMEX method has been used in measures to eliminate exposure to solvent at individual workplaces and in the production of training films.

At individual workplaces, the PIMEX method is utilized as follows: the subject (eg, a spray painter) is first studied for a few minutes. The resulting film is then shown to him and the cause of any exposure peaks discussed. Any simple changes suggested are then tested, and their effect is evaluated immediately.

The training films cover paint manufacturing, screen printing, and surface treatment at wood processing factories. The PIMEX method was utilized in the films (each about 20 min long) to illustrate the situations in which heavy exposure may occur and the steps which can be taken to avoid these situations. The effects of technical elimination methods are also considered. The films have been shown to involved staff and supervisors. After each showing, the message of the film is discussed in relation to the condition of the actual company. Thus the film on screen printing has been shown to more than 100 printing companies in Stockholm.

Spread of air pollutants — Grid map

"Grid map" is the name of the method employed in studying and visualizing the spread of air pollutants in a room. The method involves measurement of the concentration of a particular substance with a fast, direct-reading instrument at different points. The procedure involves shifting the instrument along lines in a grid network and taking readings at a given number of points on each line. A total of 16 points may be involved when readings only concern conditions around a single emission source. Up to 148 points have been used in the case of an entire factory room. Readings at all points are made as rapidly as possible. With a fast, direct-reading instrument, more than 100 readings can be made in only a few minutes.

Readings are processed by a computer which assumes that the concentrations between the measurement points are continuous, rising or falling. The concentrations between the measurement points are therefore obtained by interpolation. Interpolation is not linear, as it would result in unrealistically abrupt changes in the concentration profile. To avoid such changes, spline functions are employed for the interpolations. Spline functions consist of a series of equations of the third degree with a continuous derivative.

The result is a dense grid map containing information on the pollutant concentration at a desired number of points. These values are graphically displayed (figure 2) as a grid whose elevation above the base plane at a given point indicates the concentration at that point. The grid map is superimposed on an image of the room. With the aid of three dimensional graphics, the grid can be displayed as it would look to an observer standing at any given point. The image of the

room may consist of a simple drawing, a photograph, or a video frame.

Amalgamation with a video film is achieved through connecting a video camera, via a gen-lock, to the computer used. The gen-lock can be employed to replace the background screen color of the computer monitor with a camera image. The camera image of the relevant area of a room and the computer-generated grid pattern for that area are superimposed in a composite image illustrating, eg, the effects of technical elimination measures and the impact of these measures on air pollution. However, continuous acquisition of readings from all measurement points is necessary for the system to work as described. Work on the development and testing of the method is currently in progress.

The grid map method has been used in various projects to illustrate the points of heavy pollution in a room. The frames have been shown to and discussed with the affected staff at workplaces. The aim is to trace and remedy the biggest sources of pollution. The results of corrective action have been evaluated with new readings and new grid maps.

Concluding remarks

The two described methods, PIMEX and grid map, are two examples of the way in which computers and video filming can be used to enhance the excellent ability of direct-reading instruments to deliver rapid readings. The most important feature of both methods is their ability to display measurement results in a highly comprehensible form and therefore make it easier for lay persons to understand causal relationships. This process is, in turn, one of the most impor-

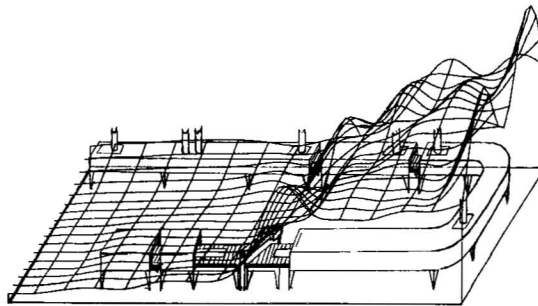


Figure 2. Example of a grid map. The figure shows the distribution of solvent concentrations in a room for the surface treatment of wood.

tant prerequisites for the successful elimination of air pollutants. The methods also serve as aids in evaluating the effect of technical elimination methods.

The methods have proved to be excellent teaching aids. Displaying someone doing familiar work and simultaneously showing the way exposure varies triggers new ideas about ways of reducing exposure.

The work on the development of new methods for combining direct-reading instruments, video filming, and computers is continuing. One area of development involves the utilization of experience from situations in which other environmental factors (such as physical load factors and ergonomic overloading) are involved instead of air pollution.

Reference

1. Rosén G, Lundström S. Concurrent video filming and measuring for visualization of exposure. *Am Ind Hyg Assoc J* 48 1987 688—692