

AUTOMATIC MONITORING SYSTEMS

Monitoring of exposure to various toxic materials is one of the most exciting and challenging areas in the field of industrial hygiene. As a result of toxicity studies we are being asked to measure and to control the work space and the ambient air at lower and lower levels of hazardous pollutants. We are no longer concerned with one or two jobs or tasks to monitor, we are asked to monitor hundreds of people and whole plants. We are being asked to maintain records for decades. These impossible-sounding problems are being overcome by automatic analyzers, data processors, extremely sensitive detectors.

Today I would like to discuss our vinyl chloride experiences with you, to talk about available technology, and to excite your imagination so that the next monitoring problem may be easier and results are obtained more quickly.

The objectives of monitoring and measurement work sometimes are obscured by semantics so for the record let's begin with the objectives:

1. Personal exposure is to be controlled.

Notice the absence of words monitor or measurement. We must determine the presence of a toxic material, measure its concentration and provide warning so that preventive action can be taken promptly whether it is putting on a respirator or fixing a leak.

2. Atmospheric emissions must be controlled.

In the case of the first objective, the atmosphere, the worker and the material are

regulated in the work space; thus, the problem of control is easier. The toxic material that moves over the plant fence into the community is a more difficult problem. Except for justifiable accidents the word control is more likely to be replaced by eliminated.

3. A personal exposure-health record must be maintained.

Previous toxicity studies along with epidemiology are simply too gross a tool to evaluate current health problems. We need to follow exposures and health from the cradle to the grave unless a better procedure is developed.

4. All industries and people must comply with governmental regulations.

Please notice objectives 1, 2, and 3 are separate from 4. I think governmental regulations are often political as well as scientific. We want to protect our employees and neighbors irrespective of government regulations. We also want to comply fully with the regulations, but not for the sake of compliance alone.

5. Cost of an operation is always a factor.

We want the most for the money expended; i.e., achieve an optimum balance between needs and resources.

Automatic analyzers have been in use for many years though speed and degree of sophistication has left much to be desired. From a safety-industrial hygiene standpoint the most widely used

monitoring device was the combustible gas detector. This found wide use in the vinyl chloride resin industry to provide alarms and to control corrective activities when vinyl chloride concentration became too high. An alarm at 20% of the L.E.L. (7,200 ppm) was usually used with evacuation at 40% of the L.E.L. (14,200 ppm). In 1969 there was a general recommendation from the MCA Epidemiological Study of Acroosteolysis that VCM exposures be limited to 50 ppm but methods of measurement at this level were not rugged enough for fieldwork. Companies equipped with combustible gas detector systems felt the level of safety was adequate. Essentially all injuries arose from fires and explosions. During this period, however, Dow was using infrared absorption and combustion conductivity for the monitoring studies they were doing on vinyl chloride. Neither of these instruments were available commercially and were considered research tools.

The parallel developments of the gas chromatograph and the electronic computer from the 1950's through to 1970 provided the basis for the automatic monitoring systems we have today. Assembly of these components by Union Carbide Corporation's Special Instrument Division starting approximately 1960 provided an excellent technological base from which to launch our automatic vinyl chloride monitoring systems when the need arose in 1974.

The announcement by B. F. Goodrich in January, 1974 that they had cases of angiosarcoma in their Louisville plant related to vinyl chloride exposure. This was followed by a temporary vinyl chloride standard emission limit of 25 ppm ceiling and a permanent standard of 1 ppm 8-hour TWA. Fortunately, there were four analytical systems available at that time which were useful.

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ANALYTICAL PROCEDURES

1. Organic Vapor Analyzer - Flame ionization detector
2. Chromatograph with flame ionization detector
3. Infrared absorption spectroscopy
4. Fourier transform infrared*

The organic vapor analyzer system was extensively reported by L. B. Crider of B. F. Goodrich in 1974 and marketed by Bendix (Bendix 8401 THA). It featured outstanding sensitivity (0.01 ppm), good linearity over wide range, and fast response (two minutes per sample point).

The chromatograph-flame ionization detector as designed by Union Carbide Corporation was sensitive to 0.1 ppm, was specific to vinyl chloride and had a fast response (two minutes per sample point). The Honeywell Model 100 was equivalent though faster (one minute per sample point).

The infrared absorption unit was marketed by Wilkes (Miran II.) Its sensitivity was approximately 1 ppm and provided one analysis per minute.

The Fourier transform infrared system was offered by EOCOM with a sensitivity of 0.05 ppm for vinyl chloride, was specific and had a very fast response (ten to thirty seconds per sample). It could monitor up to five individual gases simultaneously. It was very expensive (>\$100,000) and none were currently operating.

Since Union Carbide Corporation's Special Instrument Division could start immediate construction and delivery, five monitors were ordered and operating early in 1974. Four more were installed in 1975.

*The actual use of this system may be questionabl in 1974.

The purchase and installation of an automatic analyzer does not entitle you to say you have an automatic monitoring system. The items making up an automatic monitoring system are:

AUTOMATIC MONITORING SYSTEM

COMPONENTS

1. Objectives
2. Sampling
3. Analyzer
4. Output
5. Data Processing

Of all the components of a monitoring system the most important is a clear set of objectives which are compatible with the system capabilities and the resources to be committed to the system. The objectives stated earlier are a suitable guide. Except for vents requiring specific monitoring by EPA, the most efficient use of the system is via so-called area monitoring.

Mechanical collection of the sample is generally via a network of initial sample tubes, pumps and filters. Our preference is to purge a single tube prior to sampling; thus, suitable alarms can be provided for nonfunction. Sample lines up to 200 feet can be handled by the sample pump at the analyzer. Longer sample lines are possible with booster pumps.

The type of sampling in Figure IV depends on the objectives, whether the area is open or enclosed and the sampling program. This is largely dependent upon the equipment capability and the sophistication of the user since sampling is now computer controlled.

Initially the sample pattern was controlled by a mechanical turret valve system, but this was difficult to maintain and could not make use of statistically controlled sample patterns. One company installs a capacity tank on each sample line to approximate the fifteen-minute sample required by OSHA.

The various types of analyzers available have been discussed previously but these factors are also important.

- A. Reliability of the system to the point of redundancy is important. EPA has generally stated that failure of controls is cause for a plant shutdown. Hazardous operations or men in respirators must be covered continually under OSHA. These requirements are in addition to the desire to provide maximum protection for personnel.
- B. Calibration of control instruments is a daily requirement under EPA. This is also an excellent check on system operation. Calibration samples must also be approved by EPA.

Analyzer data output is often a point where redundancy pays. The analyzer output is immediately recorded on a vertical strip chart which also acts as the alarm activator. This recorder system has little value except as a check of the downstream components and breakdown uses. The data is also transmitted to the processing unit.

The nature and sophistication of the data processing unit determines the overall control of the monitoring system and determines the extent to which figures are converted to facts. Automatic analyzers produce tremendous amounts of raw data. A single Union Carbide Corporation monitor produces 26,600 analyses in 24 hours.

There were two in each resin producing unit. Converting 53,000 pieces of data each day into a useful fact or two is difficult manually. When this mass of data is to be correlated with external input such as who is working, where he is working and how long he is near each point of analysis several human intellects have been fully utilized. This fortunately did not happen all at once.

The first analyzer system simply provided eight-hour averages for six points with maximum peak levels and the time and duration of VCM concentrations over the maximum allowable limits.

The second generation system calculated eight hour, twenty-four hour and month averages arithmetically, standard deviations, estimated exposures against a job time study, listed the number of times the allowable limit was exceeded and calculated the probability of exposure in excess of maximum limit.

The third generation data processing unit calculated log normal means and log normal standard deviations, calculated probability of employee exposure in excess of the limit, controlled sampling points to identify the leak area, executed random sweep sampling, did time trend analysis and printed out plant and job exposure data to comply with OSHA requirements.

The fourth generation monitor is still undergoing development. This system will analyze and record employee and job data for thirty years and generate all necessary OSHA notice and reports. This fourth generation data processing unit will be operational at South Charleston in the first half of 1977.

For those who are interested in some of the principles involved the following are offered:

Figure V shows the relationship between a single point sample versus an area sample. This is the area requiring a skilled industrial hygienist. He must take the available sample points and secure the best representation of the area to be monitored. This can vary between a combination of single points, manifolded points and combinations of points. All these must be made compatible with the analytical system in use.

Figure VI shows the relationship between time-volume samples and instantaneous samples. Notice the difference in the curves between arithmetic and geometric means.

Figure VII shows the three items of input:

- A. The man's identification, his job, the time worked and his protection.
- B. The job description in terms of time at each sample point, the variance in the monitor and the variance in time spent at each point from the mean job time allocation.
- C. The analysis of each sample point and the calculated standard deviation.

The input data is calculated monthly to yield the following.

Figure VIII is the roster required by OSHA for a regulated area.

Figure IX is the man's personal exposure monthly along with pertinent job data.

Figure X is the analysis of the job exposure.

The automatic monitoring systems and their technology are expanding more rapidly than our ability to conceive and utilize

them; i.e., their utility and their ability is largely limited by our human ability to secure their maximum utilization. Examples of monitoring systems used in vinyl chloride are:

1. Manual Grab Sample Monitoring

This was practiced in the Dispersion Resin Unit for a number of months. The results indicated an average VCM concentration of 10.24 ppm with 95% under 46. The total number of grab samples was 29 per survey. The first month of automatic monitoring showed an average concentration of 16.3 ppm with 95% under 68.7ppm.

2. Organic vapor analysis was practiced by B. F. Goodrich in their Avon Lake Plant in 1974. They analyzed six points every two minutes. These were first generation monitors.

3. Chromatograph - Flame Ionization detector analyzers were installed early in 1974 in all major Union Carbide Corporation operations with more added in 1975. All these were aided by mini computer and digital print outs for data processing. A representative output sheet is shown. These were second generation monitors.

4. The Fourier Transform Infrared system was installed by Pantasote in their New Jersey plant by EOCOM. This has been widely advertised and is acceptable by OSHA for monitoring as required by the VCM Standard.

5. The fourth generation of monitor is in process of development. In concept, it will be a gas chromatograph system with a thirty-second cycle. Job roster and exposure data

will be input via electronic systems such as magnetic card readers and all necessary alarms, notices and records generated daily. This system is not built or working but it is there when the need arises.

Figure XI shows an indexed comparison of monitoring procedures in general use today. It is offered without comment except that only the automatic systems can meet the objectives listed at the beginning of this discussion.

Figure XII shows a comparison of a job monitored by automatic monitor versus OSHA prescribed procedure. OSHA requires nine eight-hour samples yielding an average of 2.06 ppm. The automatic monitor uses 6,696 samples and analyses to characterize an exposure of 2.10 ppm. Which system would make you feel more secure?