File
Vinyl chloride

ESTABLISHING EXPOSURE TO VINYL CHLORIDE VAPOR BY BREATH ANALYSIS AND CONTINUOUS ENVIRONMENTAL SURVEILLANCE

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ABSTRACT

An environmental survey was conducted to determine the time-weighted average exposure (TWA) of a group of chemical plant workers to vinyl chloride (VCl) vapor. This survey featured continuous multipoiht air sampling and analysis using an infrared spectrophotometer. The inhalation exposure data were digitized and recorded on paper tape for subsequent computer analysis and derivation of daily TWA values for each worker. A breath sampling program was conducted concurrently with the environmental survey, and a series of breath decay curves relating post-exposure breath concentration to vapor exposure were derived from the data.

To validate the breath curves derived from on-the-job data, post-exposure breath curves were also constructed from breath data obtained following human exposures to controlled concentrations of VCl vapor. The close agreement between post-exposure breath concentrations at the corresponding TWA's obtained by each of the methods suggests that either method is valid for estimating the worker's individual daily exposure to VCl, and provides further evidence that breath analysis is a useful industrial hygiene technique for evaluating exposure to vinyl chloride vapor.

INTRODUCTION

The question that may arise following an environmental survey is whether the chemical vapor concentrations measured are truly representative of the exposure being experienced by the workmen. Evaluation of the ranges of atmospheric concentrations and estimates of time-weighted average concentration (TWA) are all too often based on a few spot samples obtained under conditions which are not representative of all phases of a given operation. Necessarily, a true picture of vapor exposure would have to be based upon continuous monitoring of air in the workman's breathing zone during his entire workshift. Obviously, even when possible, this task is made difficult and often impossible by the large number and variety of tasks performed by today's modern chemical plant worker.

Fortunately, improvements in automatic monitoring and data processing equipment have provided the means to a more satisfactory solution. Sequential samplers and automatic analyzers and recorders can now be used to monitor several locations or operations simultaneously, thus providing much more valid data on which to base estimates of chemical exposure. The application of computer technology to industrial hygiene provides a means of managing the large volume of data generated by continuous monitors.[1]

--Meanwhile, a supplementary technique of measuring inhalation exposure has been developed. The realization that the body burden of a volatile chemical that is excreted to some extent via the lungs is directly related to its concentration in expired air led to the development of techniques for collecting and analyzing breath samples to better personalize the exposure experience of individual workmen. Studies by Stewart, et al., showed that exposures could be characterized by measuring the concentration of vapor in the breath at various time intervals following exposure, and comparing these against breath decay curves already established. Thus, breath decay curves have been constructed for several common solvents for use in judging the severity of chronic or acute exposure to volatile organic chemicals.[2,3,4,5,6]

These breath decay curves were, for the most part, constructed from data obtained from controlled human exposures to relatively constant vapor concentrations. More recently, however, breath sampling programs have been used in the chemical plant and data obtained by analysis of the breath of workers following their workshifts were combined with data from an environmental survey to construct additional sets of breath decay curves.[7]

In this study of human exposure to vinyl chloride (VCl) vapor, breath decay curves obtained by each of the above methods, controlled human exposures and on-the-job breath sampling were for the first time compared in an attempt to judge their equivalence and to demonstrate whether:

(1) Either method can be used to establish useful breath decay curves;

(2) These curves provide a reliable index for evaluating the time-weighted average exposure of workers exposed to VCl vapors;

(3) Breath analysis, because of its usefulness in establishing TWA, might be useful as a rapid diagnostic tool, as a screening aid when used in conjunction with regular health inventory programs, or as a technique complementing the industrial hygiene survey in assessing exposure to VCl and other vapors.

ENVIRONMENTAL SURVEY AND BREATH SAMPLING FOLLOWING ON-THE-JOB EXPOSURE

Monitoring the Plant Atmosphere

The chemical installation surveyed was a closed structure housing several separate chemical processing operations. A job survey was first conducted for each of four job classifications to determine the work areas frequented by men in them and the time spent in each area. For each classification, five sampling probes

were then strategically placed in those areas which best represented the workman's exposure day. A sixth probe was placed outside the building and charcoal and silica gel filters were placed in the sampling line to assure a clean air reference. The sample probes consisted of 3/8-inch Saran tubing through which air samples were drawn by means of a vacuum pump to a centrally located infrared spectrophotometer. The sampling rate was adjusted to an air flow of 17.5 liters/min. The spectrophotometer was equipped with a 10-meter path-length gas cell and was capable of detecting 5 ppm VCl. By previous calibration, the VCl concentration was directly proportional to absorbance up to about 1,000 ppm at the measured wavelength, 10.63 μ.

A schematic diagram of the sampling system is shown in Figure 1. Sampling was executed sequentially with a set of six two-way solenoid valves controlled by a timer which advanced the sampling location every five minutes. A visual account of transmittance was recorded on a strip chart recorder. Meanwhile, the data were recorded in digital form on paper tape by a tape punch and digitizer programmed to record three equally spaced transmittances during the last half of each five-minute sampling p riod.

The transmittance data furnished by the spectrophotometer was converted to absorbance and reduced to concentration according to Beer's Law:

$$\text{Abs} = \text{Log}_{10} \left(\frac{X_1 - X_\infty}{X_i - X_\infty} \right)$$

Where: X_1 = base line response

X_∞ = response at total absorption

X_i = response at location i

i = 2, 3, 4, 5, 6.

Finally,

$$\text{Concentration} = K \text{ (Absorbance)}$$

Where K = a proportionality constant.

The taped data were processed by a Burroughs 5500 Computer at The Dow Chemical Company Computation Research Laboratory. The computer was used to calculate the mean and standard deviation of concentrations at each location for each eight-hour workshift. Finally, time-weighted average concentrations were calculated for ach job classification using the time-location data obtained from

from the job surveys. As described elsewhere[1], the weighted per cent of time during which concentrations exceeded several prechosen levels was also computed for use in establishing exposure profiles.

Figure 2 describes the exposure profiles (frequency distributions) for the four job classifications studied during this survey. These profiles show the percentage of time that concentrations exceeded the levels shown. They summarize several tends of thousands of individually measured concentrations and reduce them to single curves. Figure 3 shows the corrective trend brought about by actions undertaken to reduce the atmospheric concentration of VCl over the seven-month period during which the study was conducted. Only two job classifications warranted extensive study, but men in all four classifications were asked to participate in the breath sampling program.

Breath Sampling Programs

Three separate breath sampling programs were conducted concurrently with the environmental plant survey, as shown by the boxed portions in Figure 3. Each worker was asked to collect three breath samples daily, the first on his arrival home from work, the second 5-10 hours later and a final sample before returning to work the following day. The samples were collected by providing each man (on a daily basis) with three breath pipettes. The pipettes

were constructed from short lengths of 20 mm soft glass tubing to which had been welded at each end, the threaded portion of a 2-dram (8 ml) screw-cap glass vial (Figure 4). The overall length of the pipette was about 9-inches so it could be conveniently and inconspicuously transported to and from work in a lunch bucket.

The plastic caps were lined with six layers of Saran film identical to that used for the construction of Saran air sampling bags[8]. A 3/32-inch hole, predrilled through one of the caps provided a means of withdrawing samples. The Saran liners provided an effective gas barrier so that vapor losses were held to less than 10% for a holding period of about three days.

Samples were drawn from the pipettes with a 1 ml Hamilton gas-tight syringe and analyzed in an Aerograph A-600B gas chromatograph using N_2 carrier gas and a hydrogen flame detector. Separations were made with a 6-foot, 1/8-inch I.D. stainless steel column packed with Carbowax 20M alkaline on Chromosorb W 60/80 mesh acid washed.

When collecting a sample, the subject was asked to remove the caps, place the pipette to the lips, and breathe normally in through the nose and out through the pipette three times, then to expel the fourth breath completely through the tube, quickly capping the tube, thus trapping alveolar air of the lungs. The importance of writing the name, date, exact time of sampling, and the workshift most recently completed, on the label attached to each pipette, was stressed.

CONTROLLED HUMAN EXPOSURES

Exposure Chamber Operation

Three experimental human exposures to VCl were conducted at nominal concentrations of 50, 250, and 500 ppm. The exposure chamber was a room measuring 41-ft by 6-ft by 7 1/2-ft. The room had a continuous positive air supply and exhaust system capable of maintaining a slight negative pressure. Continuous distribution of the chamber air was achieved by recirculating the air with a squirrel cage fan through a series of inlet and outlet ducts spanning the length of the chamber. The VCl vapor was metered into the duct leading from the squirrel cage fan so that it entered the room atmosphere via the recirculation system at a rate sufficient to maintain the desired atmospheric concentration. VCl was introduced into the system from a pressurized cylinder through a coil made from 6-feet of 1/8-inch I.D. stainless steel tubing leading through a rotometer and finally through a short piece of rigid Saran tubing into the circulating air duct. A heating tape wrapped around the stainless steel tubing helped to prevent condensation and thus stabilize the flow of the vapor.

The concentration of VCl in the chamber was constantly monitored with a Perkin-Elmer Infrared Spectrophotometer equipped with a 10-meter path-length gas cell. A sampling probe, consisting of 3/8-inch Saran tubing was centrally located during the exposure

to represent the breathing zone of all subjects within the chamber. This probe was portable, however, and was used periodically to check and to prevent significant concentration gradients within the chamber. Breathing zone air samples were collected in breath pipettes and analyzed periodically as a check against the infrared monitor. Both the infrared spectrophotometer and gas chromatograph were calibrated before each experiment and at intervals throughout the exposure day.

Each 7 1/2-hour exposure day included a 1/2-hour lunch period in an uncontaminated area outside the exposure chamber midway between two 3 1/2-hour exposure periods. The TWA concentration was calculated on the basis of a 7 1/2-hour workshift to more closely agree with the plant work schedule.

Clinical and Laboratory Procedures

Each subject had been under careful medical surveillance by the medical department for a number of years and each was given a complete medical examination a few days prior to the VCl xposures. Included were complete (24-hour) urinalysis, including hippuric and mendalic acids, and urobilinogen, complete blood count, including sedimentation rate and reticulocyte count, SGOT, and SGPT.

Each subject received a repeat physical exam one hour before entering the exposure chamber. This examination included

temperature, blood pressure, pulse rate, neurological examination, breath and blood samples, and a questioning concerning any personal complaints (e.g., headache, nausea, sore throat).

After entering the chamber, total expired breath samples were collected every hour by having the subject breathe out through a Saran tube leading to a Saran plastic collection bag located outside the chamber. Tidal volume and total expiratory capacity were measured in the morning and again late in the afternoon exposure periods.

Subjective and neurological responses were measured upon entering the chamber at 15 minutes and at hour intervals thereafter. Flannagan Coordination and Crawford Manual Dexterity Tests were conducted in the mid-morning and afternoon hours. Breath sampling commenced immediately upon leaving the exposure chamber. A cumulative 24-hour urine sample was collected and a blood sample was drawn the following morning for SGPT, lactase dehydrogenase, alkaline phosphatase, blood urea nitrogen, creatinine and bilirubin.

Effects

From a subjective standpoint no significant untoward effects were noted at any of the exposure concentrations. The only complaints were those of two subjects who reported headache and some dryness of the eyes and nose during the 500 ppm exposure experiments.

No odor was detected by anyone entering the exposure chamber at 50 ppm. At 250 ppm all four subjects entering the chamber initially reported that they could detect a very slight odor of the chemical. Five of the seven subjects entering the exposure chamber at 500 ppm were able to detect the odor of VCl, however, even those five were unable to detect it even with forced inspiration 5 minutes after the onset of exposure. Three of four subjects reentering the chamber after lunch were able to detect a faint odor of VCl. One subject could detect a faint odor upon deep inspiration up to about 15 minutes after entering the exposure chamber.

The exposure had no noticeable effect on neurological responses or in the results of mental coordination or manual dexterity tests conducted during the exposure period. All clinical laboratory studies performed in the post-exposure period were normal and unchanged from pre-exposure values.

The concentration of VCl in the exhaled breath of subjects within the chamber was not significantly different from that concentration present in the exposure chamber at the time the measurements were made. From past experience it has been noted that xhaled breath concentrations are significantly lower than ambient concentrations when the subject vapor is either easily and rapidly metabolized by the body, e.g., benzene, styrene[5], alcohols, etc.,

or when it has a low vapor pressure and is extremely soluble in the blood fat and body tissue, e.g., carbon tetrachloride, chloroform, tetrachloroethylene. We assume from this observation that vinyl chloride rapidly comes to equilibrium with the blood and body tissues and probably is neither rapidly metabolized nor readily retained by the body tissues.

BREATH DATA ANALYSIS

The decay curves for the vinyl chloride concentrations in the breath were constructed by step-wise multiple regression using a digital computer. An empirical relationship of the form Conc = f (TWA, TIME) was selected from a choice of several terms, each based on TWA and/or TIME. The resulting regression equation best represents the ordered relationship between breath vinyl chloride concentration, time-weighted average exposures, and post-xposure time.

The breath decay curves each have an associated standard error of regression which can be used to compute the confidence band for any chosen level of significance. The 95% confidence band for the mean of a group of observations was chosen in this case to describe the statistical error associated with the breath data and the regression technique.

BREATH DECAY CURVES

Controlled Exposures

A total of 13 men participated in the three controlled chamber exposures at nominal concentrations of 50, 250, and 500 ppm producing a total of 160 valid breath data points. Five of the six subjects exposed to 50 ppm were reexposed at 500 ppm two days later. There was no measurable residual vinyl chloride detected on the breaths of the subjects prior to the second exposure. Serial breath sampling was initiated immediately upon leaving the exposure chamber and continued up to 20 hours following the exposures.

Table I shows the analyzed concentration to which the subjects were exposed. Calculations of the mean and standard deviation of exposure concentration are based on chart readings from the infrared spectrophotometer taken at 5-minute intervals over the two 3 1/2-hour exposure periods. The TWA is for the total 7 1/2-hours which includes the 1/2-hour lunch period in an uncontaminated atmosphere.

The final breath decay curves intended for use as an index to VCl exposures were adjusted to TWA concentrations of 50, 250, and 500 ppm (Figure 5). A 100 ppm decay curve was interpolated from the available data using regression analysis. These curves are presented with the calculated 95% confidence bands for the mean of a group of observations.

Plant Survey

Ten workmen participated in the plant breath sampling program, producing a total of 91 usable sets of data. Ten per cent of the breath samples collected were discarded because of pipette leakage, faulty seals, and poor sampling techniques.

Absolute breath levels range from about 20 ppm in one sample taken less than one hour after an eight-hour TWA of 250 ppm to barely detectable levels (0.03 ppm) in samples taken after exposures at TWA's below 50 ppm.

The extremely broad day-to-day variation in the TWA's experienced by workmen during the period in which the breath sampling program was being conducted is demonstrated for three shifts of men bearing job classification "Coagulator Operator" in Figure 6. This illustration is presented to point out the fallacy of judging TWA's on the basis of spot sampling techniques. Even with continuous sampling, astute judgment and some educated guesswork may be required in estimating the degree of hazard encountered by a workman in the area.

The remarkable correlation between breath concentration and TWA made it possible to construct the series of breath decay curves shown in Figure 7, with confidence bands only slightly wider than those from controlled human experiments. The close similarity between these curves and those constructed from controlled exposure data are further illustrated in Figure 8.

CONCLUSIONS

The object of the environmental health survey is to identify the atmospheric contaminants, determine their concentration and to relate this to the health hazard, if any, which they present. If one is to judge hazard by concentration measurements then those measurements must accurately describe the exposure on a continuing personal basis. A carefully conducted survey combining continuous analysis of work room atmosphere with a comprehensive job study has certain benefits. For example, data useful in describing the exposure hazard, both chronic and acute, are obtained. Concurrently, information useful in establishing cycles or exposure trends may help to reveal operational inefficiencies and equipment malfunctions. Correcting these problems not only restores a healthful work environment, but often results in bonus savings by reducing raw material and product losses.

As a complementary technique, breath analysis has the advantage of personalizing each worker's integrated daily exposure; however, some basis of comparison is needed in order to establish an exposure level from breath decay data. A reliable index of exposure in the form of pre-established breath decay curves makes it possible to estimate the average daily exposure of workmen on the basis of a few breath samples taken serially in the post-exposure period. This information can be used to provide the same health and economic advantages already cited.

The decay curves presented by the authors are intended as an index of exposure for vinyl chloride and are based on an exposure duration of 7 1/2-hours for the controlled exposures and 8 hours for the on-the-job study. Similar indices in use, or in various stages of development, reflect the need for similar studies with others of the more widely used organic chemicals.

Certain vapors having extremely high solubility in the blood, fat and body tissue, and especially those which are not easily metabolized have a slight cumulative effect so that the increase in body burden may be detectable by a gradual upward shift in the breath decay curves following repeated daily exposures until a steady state is reached. In the case of vinyl chloride, the body burden is extremely low by the end of a normal 16-hour decay period so that breath decay curves on succeeding days of exposure are not noticeably affected.

There were no significant changes in either clinical or laboratory findings resulting from the controlled single human exposures lasting up to 7 1/2-hours to 50, 250, and 500 ppm VCl. Neither were there complaints nor changes in neurological responses which could be attributed to exposures at these concentrations. Odor was not detectable upon entering the exposure chamber at 50 ppm. Although a slight odor was detected by most subjects at 250 and 500 ppm, olfactory fatigue was quite rapid and the odor could no longer be preceived within five minutes following the onset of exposure.

Table I

CONTROLLED HUMAN EXPOSURE

TO VINYL CHLORIDE

Number Of Subjects	TWA 7.5 hrs (ppm)	Actual Chamber Conc. (ppm), 7 hrs Mean	±	Std Dev	Range Hi	Lo
6	48	59	±	2	65	53
4	248	261	±	8	289	243
4	459	493	±	7	518	471
7 (3.5 hrs)	491	491	±	5	525	475

REFERENCES

1. Peterson, J. E., Hoyle, H. R., Schneider, E. J.: "The Application of Computer Science to Industrial Hygiene," Am. Ind. Hyg. J., 27:180 (March) 1966.

2. Stewart, R. D., Gay, H. H., Erley, D. S., Hake, C. L., Schaffer, A. W.: "Human Exposure to Tetrachloroethylene Vapor: Relationship of Expired Air and Blood Concentrations to Exposure and Toxicity," Arch. Environmental Health, 2:516-522 (May) 1961.

3. Stewart, R. D., Gay, H. H., Erley, D. S., Hake, C. L., Peterson, J. E.: "Observations on the Concentration of Trichloroethylene in Blood and Expired Air Following Exposure of Humans," Amer. Ind. Hyg. Assoc. J., 23:167-170 (April) 1962.

4. Stewart, R. D., and Rowe, V. K.: "Quinze Ans D'Etudes Sur Le 1,1,1-Trichloroethane," Archives Des Maladies Professionnelles, 28:194-201, 1967.

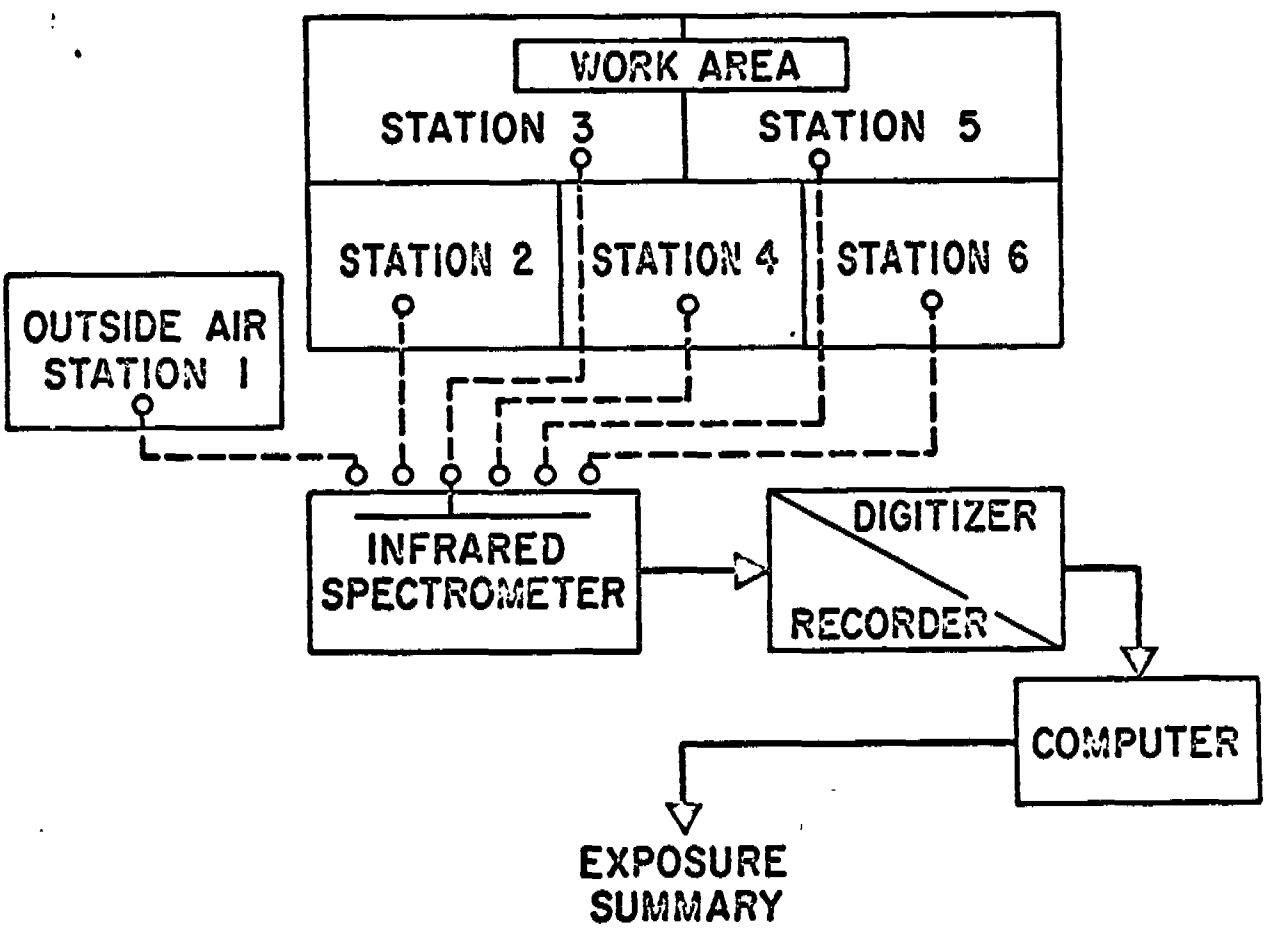
5. Stewart, R. D., Dodd, H. C., Baretta, E. D., Schaffer, A. W.: "Human Exposure to Styrene Vapor," Arch. Envir. Health (in press).

6. Stewart, R. D., Dodd, H. C., Baretta, E. D., Gay, H. H.: "Experimental Human Exposure to Tetrachloroethylene," presented at the National AIHA Conference, May 1-5, 1967, Chicago, Illinois (manuscript in preparation).

7. Stewart, R. D., Dodd, H. C., Baretta, E. D., Schaffer, A. W., Mutchler, J. E.: "Chronic Overexposure to Benzene Vapor," presented at the Sixth Annual Meeting of the Society of Toxicology, March 23-25, 1967, Atlanta, Georgia (manuscript in preparation).

8. Saran bags. Supplied by R. E. Allen, Inc., 233 West Ohio Street, Kenton, Ohio.

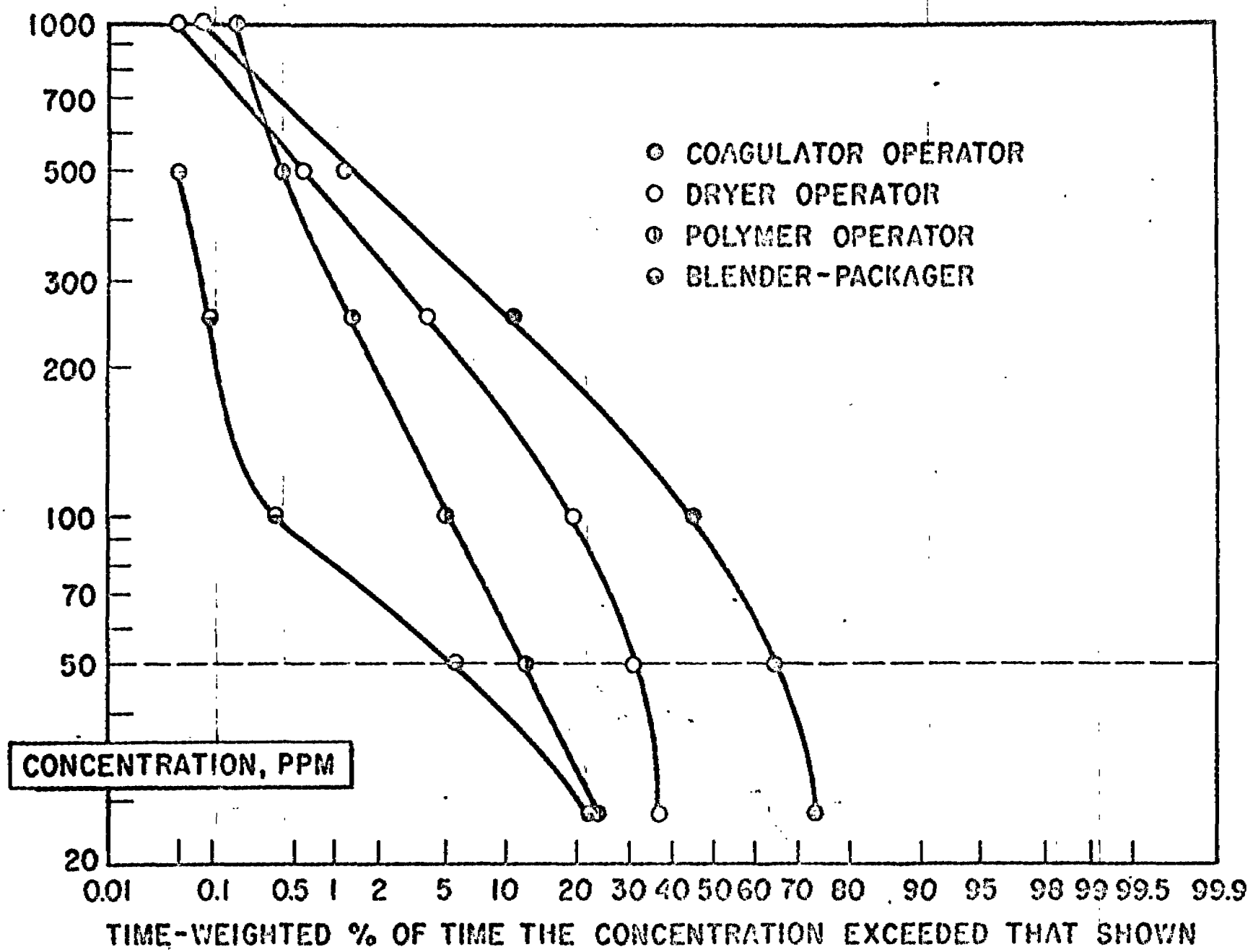
SCHEMATIC DIAGRAM OF THE INFRARED MONITORING SYSTEM



$$\text{TIME-WEIGHTED MEAN EXPOSURE} = 0.01 \sum_{i=2}^{6} \bar{C}_i P_i$$

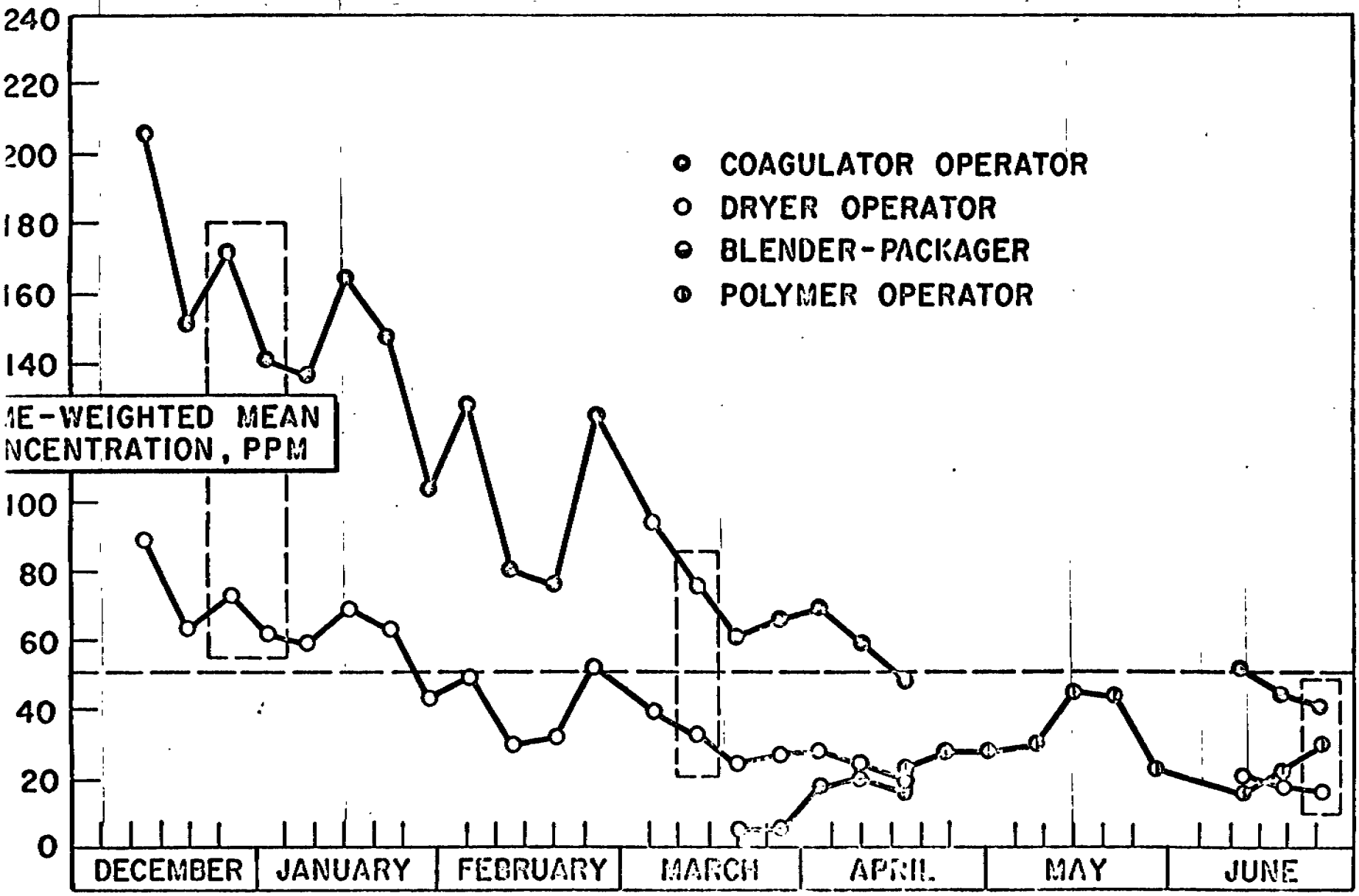
Where $\bar{C}_i$ = mean concentration at Station i

P_i = per cent of time spent at location i during normal work activity

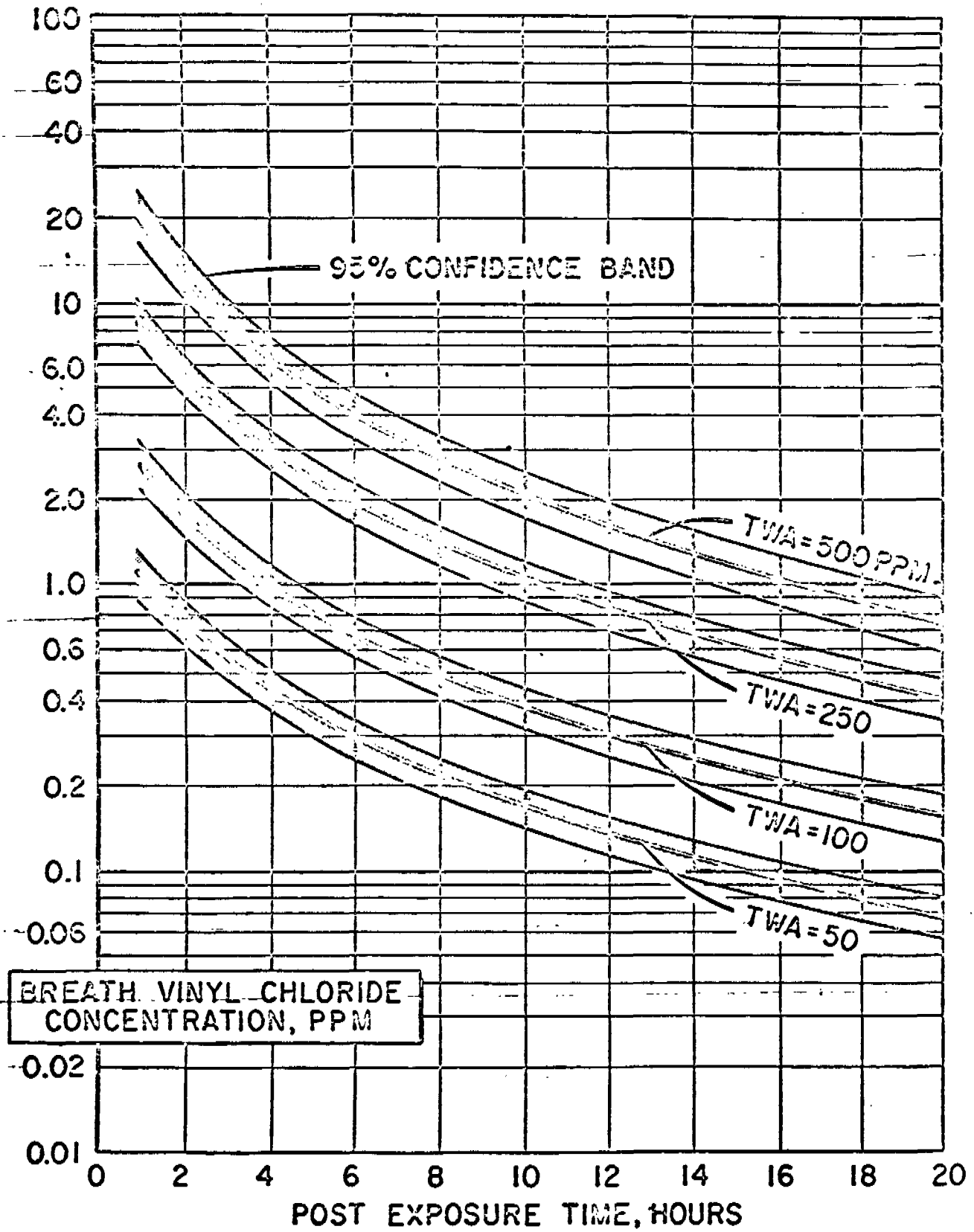

1000
700
500
300
200
100
70
50
20
CONCENTRATION, PPM
COAGULATOR OPERATOR
DRYER OPERATOR
POLYMER OPERATOR
BLENDER-PACKAGER
0.01
0.1
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.5
99.9
TIME-WEIGHTED % OF TIME THE CONCENTRATION EXCEEDED THAT SHOWN

OLI 1675

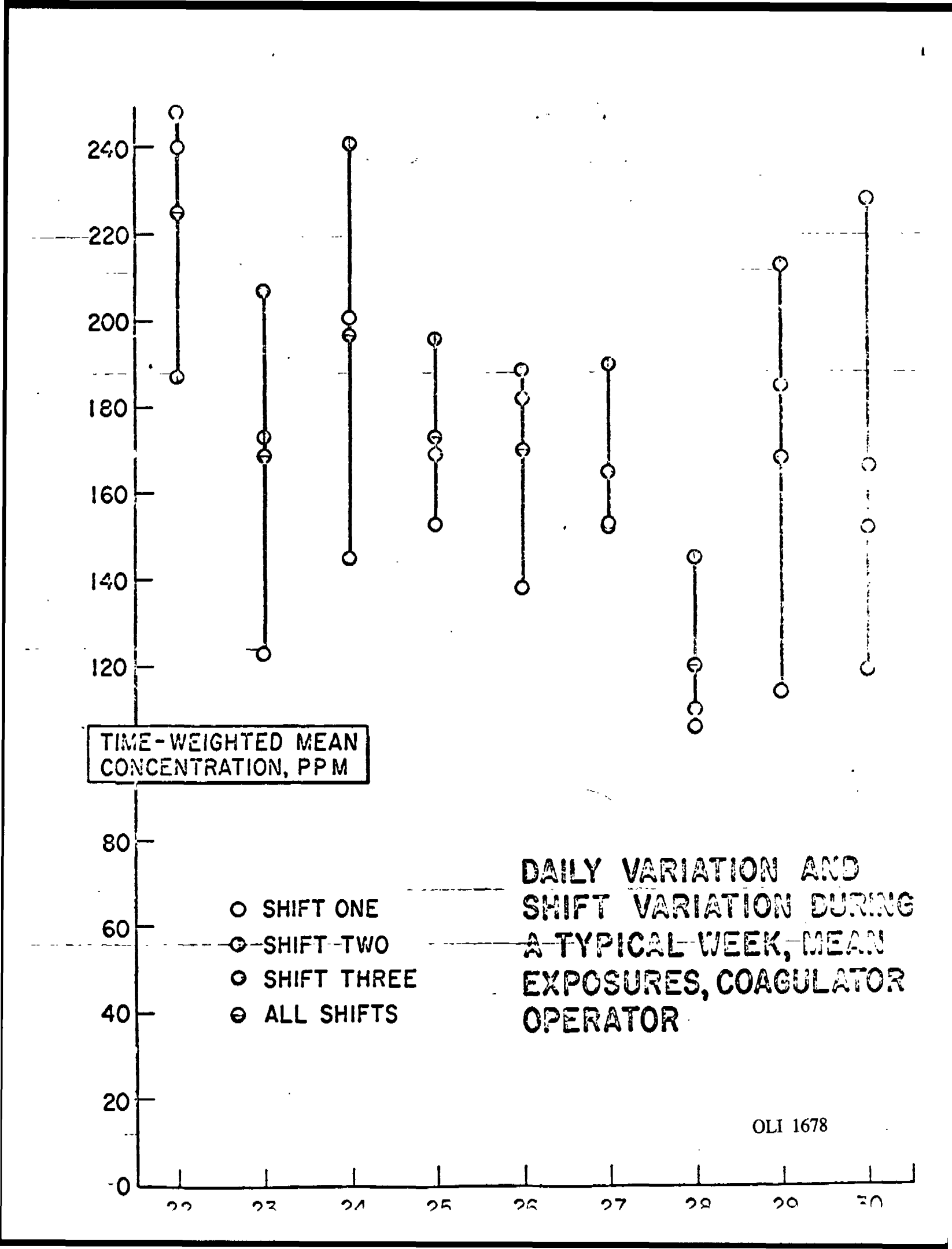
WEEKLY MEAN EXPOSURE LEVELS MEASURED DURING SURVEY

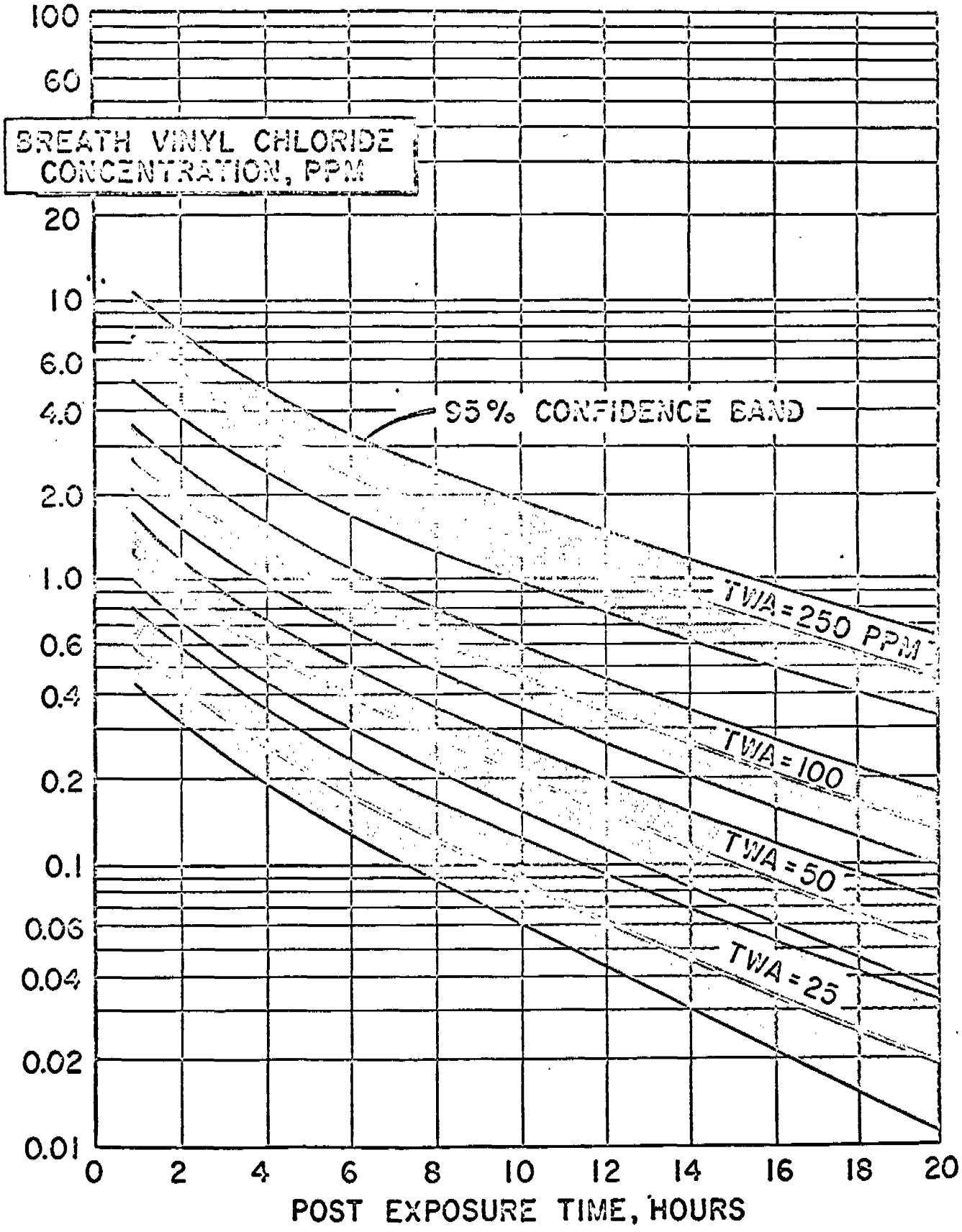


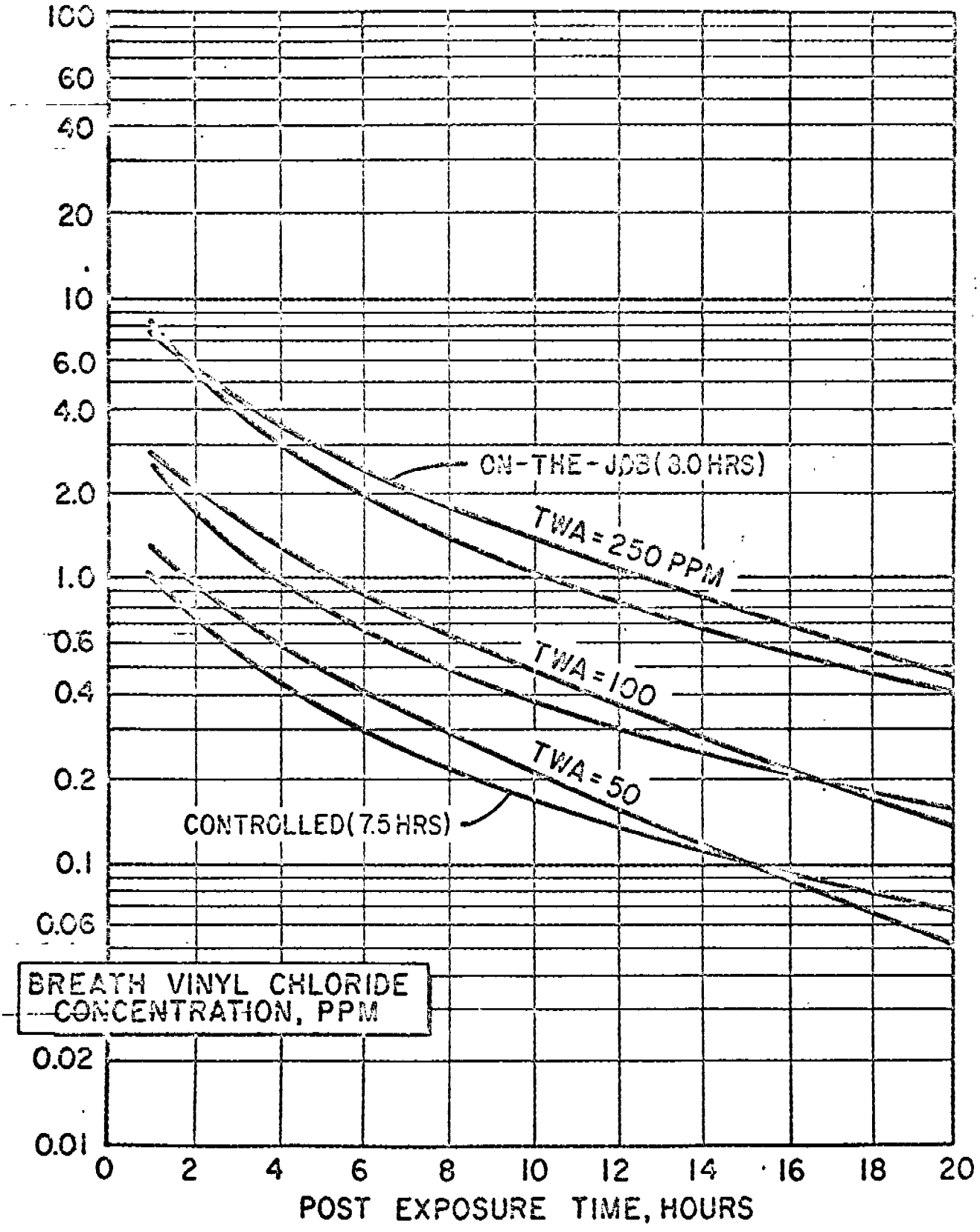
OLI 1676


100
60
40
20
10
6.0
4.0
2.0
1.0
0.6
0.4
0.2
0.1
0.06
0.02
0.01
95% CONFIDENCE BAND
TWA = 500 PPM
TWA = 250
TWA = 100
TWA = 50
BREATH VINYL CHLORIDE CONCENTRATION, PPM
0
2
4
6
8
10
12
14
16
18
20
POST EXPOSURE TIME, HOURS

OLI 1677


240
220
200
180
160
140
120
80
60
40
20
0
TIME-WEIGHTED MEAN CONCENTRATION, PPM
SHIFT ONE
SHIFT TWO
SHIFT THREE
ALL SHIFTS
DAILY VARIATION AND SHIFT VARIATION DURING A TYPICAL WEEK, MEAN EXPOSURES, COAGULATOR OPERATOR
OLI 1678


100
60
BREATH VINYL CHLORIDE CONCENTRATION, PPM
20
10
6.0
4.0
2.0
1.0
0.6
0.4
0.2
0.1
0.06
0.04
0.02
0.01
95% CONFIDENCE BAND
TWA = 250 PPM
TWA = 100
TWA = 50
TWA = 25
0
2
4
6
8
10
12
14
16
18
20
POST EXPOSURE TIME, HOURS


100
60
40
20
10
6.0
4.0
2.0
1.0
0.6
0.4
0.2
0.1
0.06
0.02
0.01
ON-THE-JOB(8.0 HRS)
TWA=250 PPM
TWA=100
TWA=50
CONTROLLED(7.5 HRS)
BREATH VINYL CHLORIDE CONCENTRATION, PPM
0
2
4
6
8
10
12
14
16
18
20
POST EXPOSURE TIME, HOURS

OLI 1680

Instructi ns f r Using
BREATH SAMPLING PIPETTE

1. FLUSH THE PIPETTE

a. Remove the screw caps from each end

b. Place one of the open ends of the pipette in your mouth & hold one of the caps in your free hand

c. Flush the pipette by exhaling through it three times

2. CAP THE FAR END

a. At the very end of the fourth expiration cap the outlet (open) end of the pipette

3. CAP THE NEAR END

a. Remove the pipette from your mouth and immediately seal the open end with an index finger or thumb

b. Screw the remaining cap in place

4. SEAL & LABEL THE PIPETTE

a. Tighten both caps securely so that the special saran cap liners will seal

b. Label the pipette as illustrated:

Name John Doe

Date 4-2-65

Time 5:20 P.M.

Exposure to Benzene

Date 4-2-65 From 8:00 A.M. To 4:30 P.M.

OLI 1681

—SEE INSTRUCTIONS REVERSE SIDE

INSTRUCTIONS FOR THE USE OF THE BREATH SAMPLING PIPETTE

EACH STYROFOAM PACKET CONTAINS THREE BREATH SAMPLING PIPETTES. UNTIL THEY ARE USED THE PIPETTES SHOULD BE STORED IN AN AREA WHICH IS NOT CONTAMINATED WITH THE GAS OR VAPOR FOR WHICH ANALYSIS IS DESIRED.

THE TIME OF THE BREATH COLLECTION FOLLOWING AN EXPOSURE IS CRITICAL AND VARIES WITH THE MAGNITUDE OF EXPOSURE AND THE BIOLOGIC HALF LIFE OF THE COMPOUND IN QUESTION. IF YOU ARE NOT OTHERWISE INSTRUCTED, COLLECT THE FIRST SAMPLE IN AN UNCONTAMINATED AREA 15 MINUTES FOLLOWING THE EXPOSURE. COLLECT A SECOND BREATH SAMPLE 4 TO 6 HOURS LATER, AND A THIRD BREATH SAMPLE 12 TO 24 HOURS LATER.

TO INSURE ACCURACY IN THE INTERPRETATION OF THE RESULTS A CONTROL BREATH SAMPLE SHOULD BE OBTAINED FROM A PREVIOUSLY UNEXPOSED SUBJECT IN THE SAME UNCONTAMINATED AREA WHERE YOU COLLECT YOUR SAMPLE.

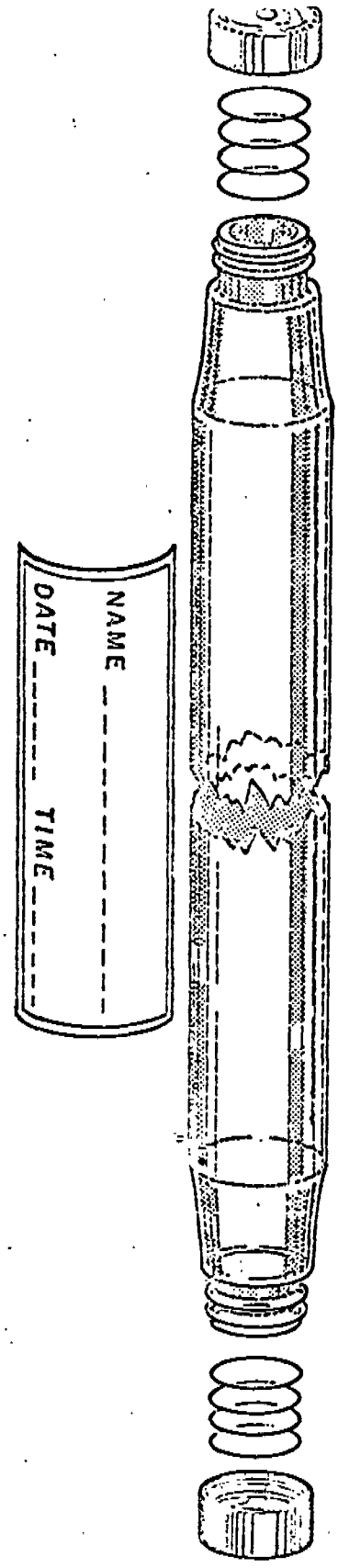
MAILING INSTRUCTIONS

REPLACE THE PIPETTES IN THE CONTAINER AND RETURN IT VIA AIR MAIL WHEN YOU HAVE COMPLETED THE COLLECTIONS.

PLEASE RETURN TO:

MEDICAL RESEARCH LABORATORY
THE DOW CHEMICAL COMPANY
BUILDING 607
P. O. BOX 612
MIDLAND, MICHIGAN

See Instructions Reverse Side



OLI 1683