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UNION CARBIDE INTERNAL CORRESPONDENCE

CHEMICALS AND PLASTICS • P. O. BOX 8361, SOUTH CHARLESTON, WEST VIRGINIA 25303

See Attached Distribution List

Date: October 29, 1975

Originating Dept: Engineering

Subject: Technical Report TEC-75-27, Automatic Monitoring Systems for Vinyl Chloride

Gentlemen:

Attached is Technical Report TEC-75-27, Automatic Monitoring Systems for Vinyl Chloride, written by Mr. G. L. Baker. This compendium describes the hardware brought together to form a completely automatic analytical system capable of: measuring a specific compound at a level of 0.1 ppm, self analyses for adequate sample flow and proper calibration, data acquisition and processing, and annunciation of conditions exceeding the preset permissable operating limits.

This project, involving installations at two C&P plants and a Jennat plant, was in part a "develop as you go" program due to compliance deadlines and varying opinions on what the data format should be. After numerous skull sessions and several modifications, an acceptable course of action was defined. The end result appears to be quite satisfactory.

Although this project is being "wrapped up" and those individuals who worked diligently to satisfy the goals and meet the deadlines are now engrossed in other activities, one cannot help ponder if we have only seen the tip of the iceberg. Which process will be the next to require equally sophisticated monitoring?

For additional information on this project, address you queries to Mr. Baker at ext. 4482, Mr. Reiter at ext. 4978, or me at ext. 5333.

Sincerely yours,

Jay H. Brubaker

J. H. Brubaker
Measurement and Control Technology
CHEMICALS AND PLASTICS

JHB:sgm
Attachment

UCC 095577

TEC-75-27

Technical Report

ENGINEERING DEPARTMENT
CHEMICALS AND PLASTICS
UNION CARBIDE CORPORATION
SOUTH CHARLESTON, WEST VIRGINIA

SUBJECT: Automatic Monitoring Systems for Vinyl Chloride

WRITTEN BY: G. L. Baker DATE: October 22, 1975

REVIEWED BY: J. H. Brubaker

SUMMARY:

Since the Occupational Safety and Health Administration (OSHA) published an Emergency Temporary Standard for Exposure to Vinyl Chloride in April, 1974, Union Carbide has fabricated ten vinyl chloride (VC) monitoring systems for installation in UCC vinyl resins units. Nine of these systems are in operation, and the tenth is scheduled for start-up before the end of 1975.

Each system includes a UCC Model 1200 chromatograph, a twenty point stream selector, a stream switching station, a sample pump, a strip chart recorder, and a data acquisition system which includes a UCC Model 2800 microcomputer and a General Electric Terminet 300 printer. Each system is capable of measuring 0-25 ppm VC on twenty sample points, at two minutes per point.

Each data acquisition system prints out the VC concentration for every sample point, shift summaries, daily summaries, month-to-date summaries, and monthly summaries. It also performs various alarm checks to determine the validity of the data.

The monitoring systems have performed very well. They provide permanent records of the VC concentrations at various vinyl resins units, and they also are useful in rapidly detecting high VC concentrations so that immediate corrective action can be taken. Reliability has been good, although periodic maintenance is required.

INTRODUCTION:

Early in 1974, evidence was found indicating that prolonged exposure to high concentrations of vinyl chloride (VC) may be harmful. OSHA immediately published an Emergency Temporary Standard for Exposure to Vinyl Chloride in the April 5, 1974 Federal Register which reduced the 8-hour average allowable exposure of workers to VC from 500 ppm to 50 ppm. Also, intensive investigation of the health effects from exposure to VC was begun.

At Union Carbide, several key personnel met on April 5 to determine how compliance with the new OSHA Standard could be attained. Five multiple sample point continuous monitors were established as an urgent requirement. The R&D Environmental Health Group had already begun monitoring vinyl chloride with a laboratory spectrometer at one of the South Charleston Plant vinyl resins units before the new OSHA standard was published. The data obtained was valuable in guiding the selection of automatic process monitoring systems.

The first monitor, complete with a 20 point sampling system, was installed and operating at the South Charleston Plant on May 1, 1974, two weeks from the decision to begin fabrication. The other four monitors were either in operation or ready for delivery to the plants by May 31, 1974.

Late in 1974, the decision was made to procure five additional monitors with data reduction and printing capability, and, to provide data systems for the original five analyzers. The project has now been completed except for the start-up of the last monitoring system, which is scheduled for the last quarter of 1975.

DISCUSSION:

The first step in obtaining automatic monitoring systems was to investigate the available methods for measuring vinyl chloride at low ppm concentrations. The initial measuring range desired was 0-100 ppm, but it was anticipated that eventually a 0-10 ppm range would be required (the ranges are now 0-25 ppm except for one analyzer which has a 0-50 ppm range). This was an important consideration in the selection of instruments.

Manufacturers of potentially suitable instruments and sampling systems were contacted by telephone. Other companies known to be using or acquiring multi-sampling point area monitoring systems were also contacted and/or reports of their systems were reviewed. The most important factors considered were reliability, sensitivity, specificity, ease of maintenance, delivery times and cost. The search quickly narrowed to two analytical techniques: infrared spectrometry and gas chromatography. As a result of firsthand experience by various Union Carbide instrument users with these types of analyzers, the choice was narrowed to three specific instruments: the Wilks Miran II infrared monitor, the Union Carbide Model 1200 process chromatograph, and a Honeywell process chromatograph. Table 1 is a compilation of important parameters for comparison of these analyzers.

After considering all the pertinent factors, chromatographs were concluded to be the best analyzers for the vinyl chloride measurement in plant atmospheres, primarily because of their superior sensitivity and specificity over conventional infrared analyzers. Immediate availability and better plant capability for maintenance were additional advantages which applied to the Carbide Model 1200 chromatograph. It has proven very reliable in numerous applications throughout Union Carbide. It was also known to have very high sensitivity and excellent specificity for vinyl chloride. Since several of these analyzers were already in use at both South Charleston and Texas City, the instrument servicemen at both locations were trained to maintain them and spare parts were readily available, facilitating any repair work. Therefore, the Union Carbide Model 1200 chromatograph was selected for the vinyl chloride measurement.

The auxiliary equipment included with the chromatograph for the first five monitoring systems were a 20 point electromechanical stream selector, and a strip chart recorder with an adjustable high level alarm, all mounted on a 24 by 52 inch panel. A stream switching station, including a sample pump and stream switching valves, was also provided with each system.

After the first system was installed and performing satisfactorily, an investigation of data acquisition and reduction systems was begun by Fisher(1). Such systems were found to be essential because manual tabulation and manipulation of the data from 720 analyses from each analyzer per day consumed too much time of operating personnel. The Union Carbide Model 2800 microcomputer, based on the Intel MCS-8 system, and the General Electric Terminet 300 printer were selected.

Soon after the data system was selected, five additional vinyl chloride monitoring systems, complete with data systems were ordered for the original monitoring systems. Figure 1 shows one of the original monitoring systems, including data acquisition, installed at the South Charleston Plant.

The new monitoring systems (Figure 2) are functionally the same as the original systems except that the stream selection logic is provided by the M2800 microcomputer rather than by the electromechanical stream selector. A description of the major components of the new systems follows.

Description of Major Components:

Model 1200 Chromatograph:

The Model 1200 chromatograph is a compact process analyzer equipped with solid state circuitry, including an electronic automatic zero. It is equipped with a flame ionization detector which is very sensitive to most organic compounds including vinyl chloride. It is purged with air and provided with a purge-power safety interlock system permitting safe operation in operating areas which can sometimes be hazardous (Class 1, Group D, Division 2).

A sample valve in the analyzer injects a 0.5 cc sample into a three-column system every two minutes. The first column separates the vinyl chloride from the high-boiling compounds, such as vinyl acetate, which might be present in the sample. A column valve diverts the unwanted compounds to vent, and at the proper time, diverts the vinyl chloride to the second column where it is separated from most remaining interferants. A second column valve diverts these interferants to vent, and at the proper time diverts the vinyl chloride to the third column, where the final separation is made. (Some of the analyzers, where few interfering compounds are present, contain only two columns).

The first two columns contain 20 percent Igepal CO-880 on a Chromasorb P support. The third column contains 20 percent Octoil S on a Chromasorb P support.

Sampling System:

The sampling system for the latest analyzers (Figure 3) includes a dual pump and switching valves which delivery fresh sample sequentially from 19 sample points plus a calibration sample. One pump pulls sample continuously from the longer sample points (e.g., over 200 feet) to the stream switching station, where the other pump takes over and delivers the samples to the analyzer, one point at a time. The second pump also delivers sample from the shorter sample points. If all the sample lines are short, only one pump is needed.

Most of the sample does not enter the analyzer, but is vented outdoors. The excess sample is required to rapidly flush the sample lines to insure that fresh sample reaches the analyzer within the two minutes allotted for purging each stream. The stream selector is programmed to purge one stream in advance of the one actually being analyzed to minimize analysis time.

Most of the sample lines are 1/4 inch O.D., 0.020 inch wall Type 304 stainless steel tubing. Some sample lines are 1/4 inch polyethylene tubing. A Mine Safety Appliances Company end-of-line filter and a rain guard are used at the end of each sample line to prevent dirt and water from being pulled into the system.

On the latest systems, the stream selection is controlled by the M2800 microcomputer. Three modes of operation are possible: 1) continuous stream analyses on any desired stream, 2) automatic progression from stream 1 through 20, and 3) automatic progression through all streams while alternately selecting a single stream. For example, the stream progression could be 1, 4, 2, 4, 3, 4, etc.

With the earlier systems, an electromechanical stream selector was used. It permits operation on single stream, or automatic progression through all streams. Any number of streams can be bypassed if desired.

Data System:

A specially programmed M2800 microcomputer is included with each of the vinyl chloride monitoring systems for data acquisition. Each M2800 accepts raw analysis data from an analyzer, performs various checks to determine if the data is valid, and then stores the data for printout (refer to Tables 2-4) as raw data, shift summaries, daily summaries, and monthly summaries. The time of day is printed out with each line of raw data (which covers the analysis of 20 streams).

The shift summary consists of the average of the past eight hours analyses for each point, a count of how many times the unit exceeded a preset value, and a calculated average exposure by job-type for the past eight hours. The job-type averages are time-weighted averages for up to 16 different job types, which are based on the estimat average percent of time a man doing a particular type of job spends in the vicinity of each sample point being analyzed. It is calculated from the eight-hour averages.

The daily summary consists of two sections: 1) a summary of the past 24 hours in the form of averages for each point and the entire unit, and the number of times each point and the entire unit exceeded the preset limit; and 2) a month-to-date summary which consists of the average of all data accumulated to date for the current month, the standard deviation on that average, the total number of times each point exceeded the preset limit, and the average number of times per day each point exceeded the limit.

The monthly summary consists of six sections with the same format, one for each of the four shifts, one for day shift personnel, and one for the unit as a whole. Each section consists of a summary for the entire month and contains the average analysis value for each sample point and the entire unit, the standard deviation on that average, the total number of times each sample point exceeded the preset limit, the average number of times per day each point exceeded the limit, an average exposure by job-type as described in the eight-hour summary, the standard deviation on the average exposure by job-type, and finally, a calculated probability that a man working each job type was exposed to a concentration greater than a preset level.

Two system checks are performed by the M2800 which serve to improve the reliability of the data obtained. One parameter--sample flow--is checked during each analysis. If the sample flow is low, a flow switch is actuated, signaling the M2800 to ignore the data for that stream and to print out the word FLOW instead of the analysis value.

The other check is performed following each analysis of stream 20, which is the calibration sample. The analysis for stream 20 is checked to determine whether it falls between two preselected values. If not, an indicator lamp is turned on, and on the next printout, the message "CHECK GAS" is printed. Subsequent analyses values are not entered into the summaries, averages, etc. This override is cleared automatically after the stream 20 analysis returns to normal.

In addition to the checks, the M2800 can actuate up to four alarms, although only two are connected in the existing systems, one for a low VC concentration and the other for a high concentration. Each alarm is actuated if the VC analysis exceeds its adjustable set point. Alarms for low flow, and for out-of-range calibration gas can be connected if desired.

A strip chart, potentiometric recorder is supplied in addition to the printer. For some of the systems it can continue to provide data in case of failure of the M2800 or printer. The other systems can be modified to provide this capability. The recorder produces a bar, for each analysis, whose height is proportional to the vinyl chloride concentration. It also prints a wider bar to identify the stream being analyzed.

Monitoring System Performance:

The monitoring systems have performed very well. They are providing all the data desired, and are useful in reducing VC emissions.

However, the systems have not been completely trouble free. There have been problems with all major system components, particularly during start-up. Most of the component failures have been with sampling hardware. There have also been several problems with the printers and the M2800s. Its too early to assess the reliability of the entire systems, because most of them have been in operation for only a few months.

Model 1200 Chromatograph:

Very few problems have been experienced with the Model 1200 chromatographs. Occasionally, an electromechanical relay or a microswitch fails to operate properly. Various other problems have occurred on rare occasions.

Extensive tests were run with one of the analyzers to determine the reproducibility of the analyzer, and the interference effect of many different compounds on the VC analyses.

Under controlled ambient conditions, with the measuring range set to 0-10 ppm, the readings from a 5 ppm VC calibration sample reproduced within $\pm$0.05 ppm for 24 hours (refer to Figure 4). A sample containing no VC and another containing 1.0 ppm reproduced slightly better.

In other tests, with the measuring range set to 0-25 ppm, the 1 ppm sample reproduced within $\pm$0.1 ppm for 24 hours.

The average VC readings changed slightly as the ambient temperature changed. The results are shown in Figure 5.

Ambient temperature changes produced another effect which might in some circumstances have a small effect on the results. A rapid change in the temperature of the sample tubing near the analyzer by only 3 or 4°C within less than a minute can change the analyzer reading by as much as 20 percent of the VC concentration. A sudden increase of temperature increases the normal response from the sample, while a sudden decrease of temperature decreases the response. This apparently results from a small amount of adsorption of sample on the tubing walls. This is not believed to be a serious problem for the existing applications, but if the effect occurs, it can be reduced by insulating the sample tubing near the analyzer to prevent rapid temperature changes.

Operating personnel at the vinyl resins units were questioned concerning what compounds might be present in the atmosphere at the units. Synthetic samples of these compounds and others which were known to elute near the VC elution time were prepared and introduced into the analyzer to determine whether any of them would interfere with the VC analyses. Methyl chloride produced the greatest interference of any of the compounds. 20 ppm methyl chloride produced a response equivalent to 1 ppm VC. High concentrations of toluene were also found to cause some interference. 1000 ppm toluene produced a response equivalent to 6 ppm VC. The response to toluene was not immediate; it showed up approximately 40 minutes after it was sampled.

The complete results of the tests are shown in Table 5.

Sampling System:

The performance of the sampling systems has been very good, although some problems have occurred with solenoid valves and pumps. Inspection of faulty valves and pumps at the South Charleston Plant has shown that most of these malfunctions were caused by dirt. Since filters are used for each sample line, apparently the dirt entered during installation of the system. A report by this author[2] was recently issued describing this problem and recommending a solution. It also shows a simple way to determine whether the sampling system is performing as it should. In general, the solution to the dirt problem is to purge the tubing after installation. Long lines should be purged one section at a time, e.g., every 50 feet. The performance of the system can be checked easily by observing the sample vacuum and sample flow data for each stream, and comparing with data obtained during initial operation.

A more comprehensive check of the system performance can be made by connecting a gas bag filled with a known concentration of VC to the end of each sample line. If there is any problem with any line being checked, the analyzer readings will be low.

Tests were performed on two different sample lines at the South Charleston Plant to determine whether any VC is lost in the sampling system, and to determine the system's response times. A report by this author(3) described the test results. No reduction in the response to a 1 ppm VC sample was detected when pulled through a 400 foot by 1/4 inch type 304 stainless steel sample line. Also, full response to the sample was obtained within the 2 minute analysis cycle time. However, a loss of about 25 percent of the response to the same sample occurred when it was pulled through a 125 foot by 1/4 inch polyethylene sample line, regardless of the sampling time.

Earlier tests with 50 ppm VC samples also showed no VC loss in stainless steel tubing, but about 10% of the VC was lost in 500 feet of polyethylene tubing. The loss of VC in the polyethylene tubing is directly proportional to concentration and the length of the tubing, and inversely proportional to the sample flow rate. Apparently it is lost by absorption and permeation through the wall of the tubing.

Polyethylene tubing is also much less rugged than stainless steel, and therefore is more likely to develop leaks. For the above reasons, the best results will normally be obtained with stainless steel tubing.

Data System:

The data systems for most of the VC monitoring systems have been performing very well after the start-up problems were eliminated. Some of the systems occasionally pick up erroneous data, and the causes haven't been found yet. Nevertheless, the systems are saving a lot of operator time which would otherwise be used for manually logging and manipulating data.

During start-up of the systems, a number of problems were experienced. This was not surprising since this was the first project involving a major program for the M2800. The problems were caused primarily by faulty memory "chips", and some other M2800 components. There have also been far more problems with the printers than expected, but these problems seem to be diminishing.

The alarms, checks, and redundancy which are built into the system greatly increase the chances that a malfunction to the analyzer, sampling system, or data system will be quickly noticed and corrected. However, an accurate assessment of the reliability of the data system probably will not be possible for four to six more months.

Calibration:

VC calibration samples are prepared by the partial pressure technique, in a nitrogen matrix, and kept in steel cylinders. The cylinders normally contain enough gas to calibrate the analyzer for several months. A 10 ppm sample is automatically introduced into each analyzer on stream 20 (except for one analyzer, which uses a 25 ppm sample) so the analyzers rarely run over 40 minutes between calibration checks. In addition, the analyzer "zero" is automatically corrected before each analysis, so calibration errors are kept at a minimum.

Duplicate calibration samples of 10 ppm VC are reproducible within ±0.1 ppm. No deterioration of the samples has been observed. Samples which are 6 months old are identical with fresh samples within ±0.1 ppm.

CONCLUSIONS:

The VC monitoring systems which have been started up and debugged have performed very well. The data have been obtained and logged on permanent records without consuming valuable operator time. The systems have been valuable in rapidly detecting VC emissions into the working environment so that immediate corrective action can be taken and employee exposure minimized. These or equivalent monitoring systems are essential to the vinyl resins units to meet the existing regulations affecting personnel exposure to VC.

The systems are very sensitive and accurate. VC concentrations can be read to the nearest 0.1 ppm, and very few compounds affect the VC readings. Several built-in system checks, such as sample flow and the automatic introduction of calibration gas help to ensure that the data obtained is accurate and reliable.

It is still too early to assess the reliability of the overall systems, because the data acquisition systems have been in operation for only a few months. However, the analyzers have been very reliable, and have required little maintenance. The sampling systems have performed well, although they have required some maintenance to the pumps and solenoid valves, primarily because of dirt in the systems. The data systems have required more maintenance than anticipated, but the problems seem to be diminishing.

With routine maintenance, the VC monitoring systems will provice necessary historical data and aid in the protection of unit personnel.

GLB:sgm

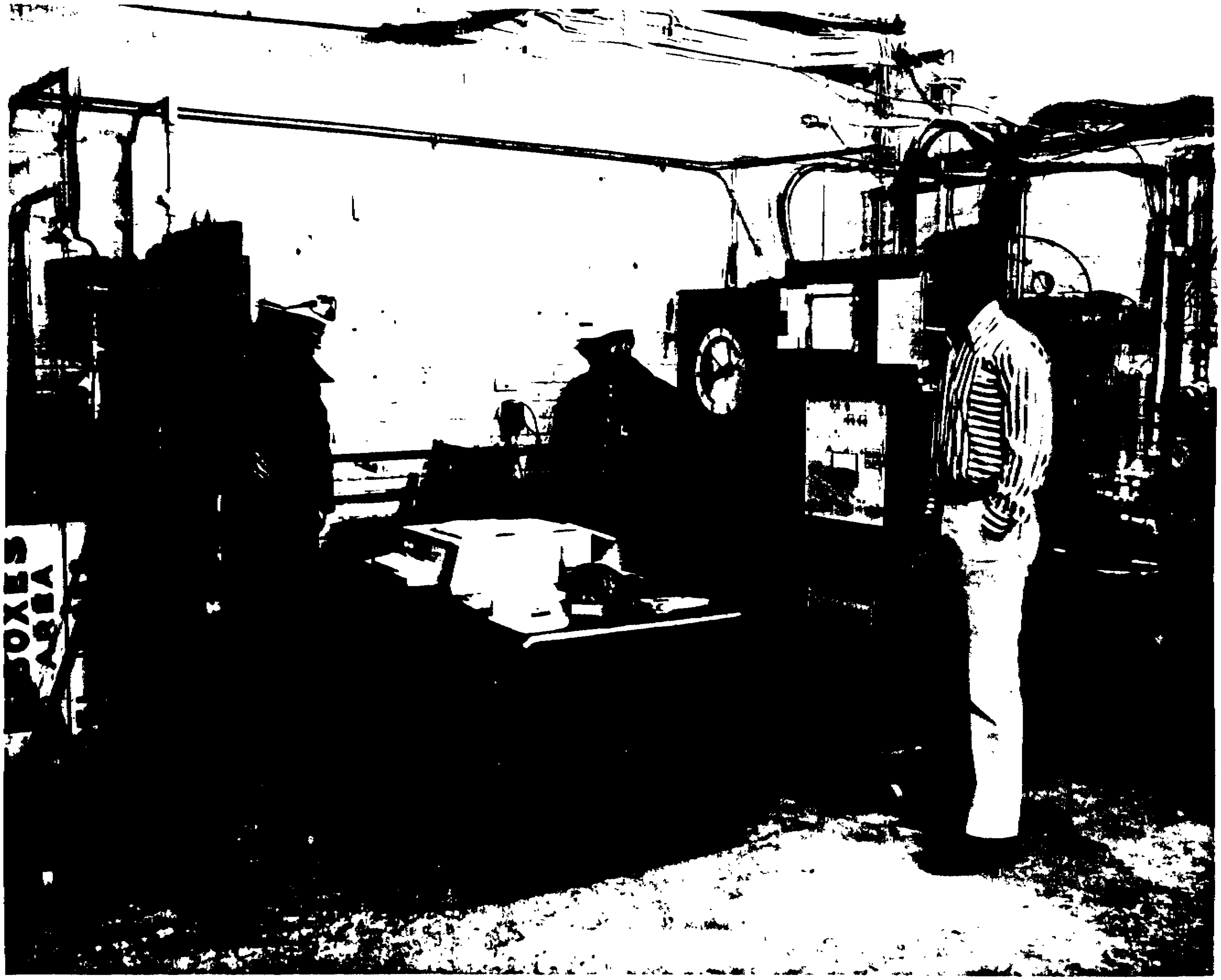

Figure 1

Original Vinyl Chloride Monitoring System

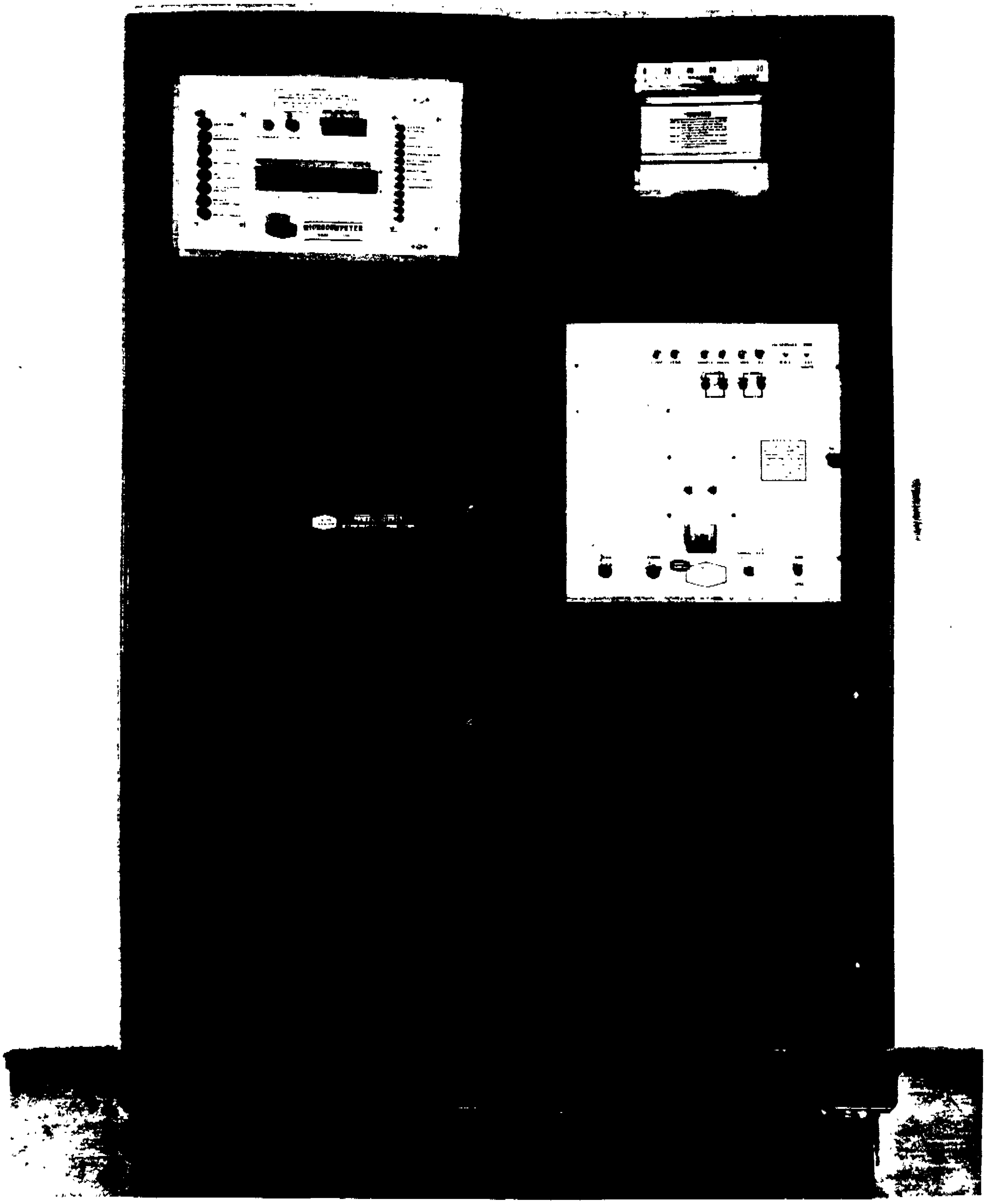

Figure 2

Latest Vinyl Chloride Monitoring System without Printer

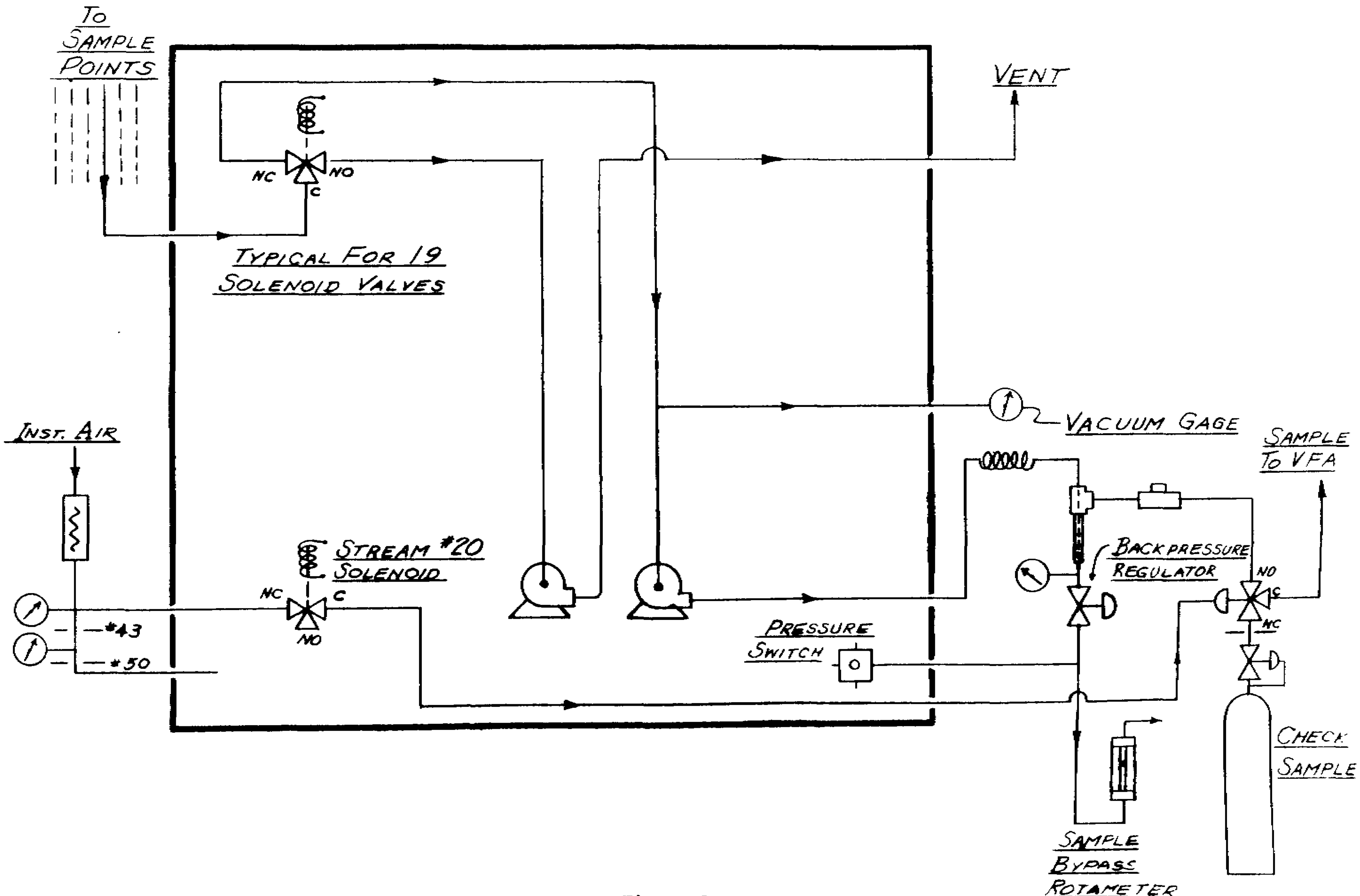

Figure 3

Sampling System

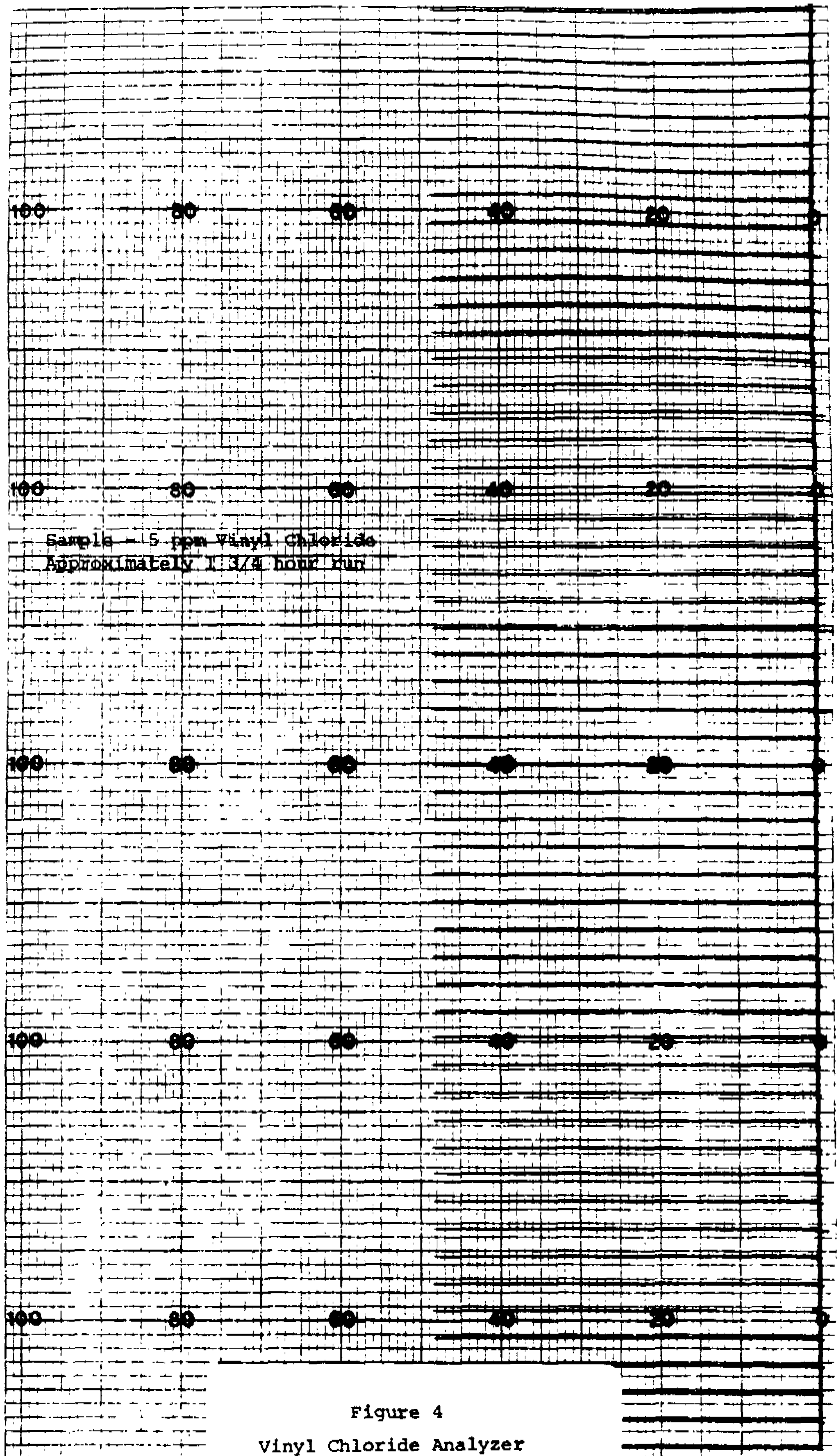

Figure 4

Vinyl Chloride Analyzer
Stability Record

UCC 095589

Table 2

Portion on Typical Shift Summary*

*Note: Job-Type exposure data is non-factual. Values were inserted for programming purposes only.

VINYL CHLORIDE BY CONTINUOUS MULTIPOINT GAS CHROMATOGRAPHIC ANALYSIS
SOLVENT VINYL RESINS UNIT - #2 - SOUTH CHARLESTON
06/29/75

SAMPLE POINT

TIME	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
A SHIFT																				
00:12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3
00:52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
01:32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
02:12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
02:52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
03:32	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
04:12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
04:52	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
05:32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.1
06:12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
06:52	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	10.2
07:32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3
8 HOUR AVERAGES A06/30/75																				
	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2

NUMBER OF TIMES EXCEEDING 5.0 PPM: 0

AVERAGE EXPOSURE BY JOB TYPE

JOB00: 0.0	JOB01:21.3	JOB02: 0.0	JOB03:20.3	JOB04:13.7	JOB05:25.0	JOB06:12.9	JOB07:25.6
JOB10:19.3	JOB11: 0.0	JOB12:14.8	JOB13:12.8	JOB14:12.9	JOB15:15.2	JOB16:12.8	JOB17: 0.0

TIME	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
B SHIFT																				
08:12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3
08:52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2
09:32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3
10:12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3
10:52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4
11:32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4
12:12	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4
12:52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4
13:32	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4
14:12	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	10.5
14:52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.7	0.1	0.0	0.0	10.5
15:32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5
8 HOUR AVERAGES B06/30/75																				
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	10.4

NUMBER OF TIMES EXCEEDING 5.0 PPM: 0

AVERAGE EXPOSURE BY JOB TYPE

JOB00: 0.0	JOB01:21.6	JOB02: 0.0	JOB03:20.6	JOB04:13.8	JOB05:25.4	JOB06:13.1	JOB07:26.1
JOB10:19.3	JOB11: 0.0	JOB12:15.2	JOB13:13.0	JOB14:13.0	JOB15:15.2	JOB16:13.0	JOB17: 0.0

UCC 095590

Table 3

Typical Daily Summary

VINYL CHLORIDE BY CONTINUOUS MULTIPOINT GAS CHROMATOGRAPHIC ANALYSIS
SOLVENT VINYL RESINS UNIT - #2 - SOUTH CHARLESTON

SUMMARY FOR 06/30/75

	SAMPLE POINT																				ENTIRE UNIT
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
24 HOUR AVERAGES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3	0.0
NUMBER OF TIMES EXCEEDING 5.0 PPM (EACH POINT)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
MONTH-TO-DATE SUMMARY																					
AVERAGE FOR MONTH	0.4	0.3	0.1	0.1	0.5	2.6	0.4	0.4	0.3	1.0	0.1	0.3	0.2	0.3	0.2	2.2	0.3	1.3	0.2	10.1	0.6
STANDARD DEVIATION OF AVERAGE	1.7	1.6	0.5	0.5	1.6	6.4	0.9	1.1	0.6	2.9	0.4	0.8	0.7	0.9	1.1	6.3	0.9	3.7	0.9	0.6	2.5
NUMBER OF TIMES EXCEEDING 5.0 PPM (EACH POINT)	14	8	0	1	20	137	10	7	3	38	0	5	6	7	5	106	7	78	8		460
AVERAGE NUMBER OF TIMES PER DAY EXCEEDING 5.0 PPM (EACH POINT)	1	1	0	0	2	17	1	0	0	4	0	0	0	0	0	13	0	9	1		57

DAY SHIFT

Table 4
Portion of Typical Monthly Summary*

*Note: Job-Type exposure data is non-factual. Values were inserted for programming purposes only.

AVERAGE FOR MONTH
0.3 0.3 0.2 0.1 0.4 2.4 0.3 0.3 0.2 0.6 0.1 0.2 0.2 0.3 0.2 2.2 0.3 1.3 0.3 10.2 0.5
STANDARD DEVIATION OF AVERAGE
0.7 1.2 0.3 0.3 0.9 5.1 0.6 0.6 0.4 1.1 0.2 0.6 0.4 0.5 1.6 6.3 0.7 2.8 1.2 0.5 2.1
NUMBER OF TIMES EXCEEDING 5.0 PPM (EACH POINT)
1 2 0 0 2 48 1 0 0 3 0 0 0 0 1 35 1 31 5 130
AVERAGE NUMBER OF TIMES PER DAY EXCEEDING 5.0 PPM (EACH POINT)
0 0 0 0 0 6 0 0 0 0 0 0 0 0 0 4 0 3 0 16

AVERAGE EXPOSURE BY JOB TYPE
JOB00: 6.4 JOB01:33.7 JOB02: 2.0 JOB03:25.9 JOB04:17.0 JOB05:45.3 JOB06:21.2 JOB07:47.2
JOB10:22.5 JOB11: 0.4 JOB12:24.3 JOB13:16.5 JOB14:20.2 JOB15:17.7 JOB16:16.6 JOB17: 3.6

STANDARD DEVIATION ON AVERAGE EXPOSURE
JOB00: 3.3 JOB01: 2.0 JOB02: 3.6 JOB03: 4.9 JOB04: 4.6 JOB05: 4.2 JOB06: 6.6 JOB07: 7.2
JOB10: 4.4 JOB11: 0.7 JOB12: 2.7 JOB13: 4.2 JOB14: 7.1 JOB15: 4.2 JOB16: 6.6 JOB17: 6.6

PER CENT PROBABILITY OF EXPOSURE GREATER THAN 1.8 PPM:
JOB00:91.9 JOB01:99.9 JOB02:51.7 JOB03:99.9 JOB04:99.9 JOB05:99.9 JOB06:99.7 JOB07:99.9
JOB10:99.9 JOB11: 2.5 JOB12:99.9 JOB13:99.9 JOB14:99.3 JOB15:99.9 JOB16:98.7 JOB17:60.3

UNIT

AVERAGE FOR MONTH
0.4 0.3 0.1 0.1 0.5 2.6 0.4 0.4 0.3 1.0 0.1 0.3 0.2 0.3 0.2 2.2 0.3 1.3 0.2 10.1 0.6
STANDARD DEVIATION OF AVERAGE
1.7 1.6 0.5 0.5 1.6 6.4 0.9 1.1 0.6 2.9 0.4 0.8 0.7 0.9 1.1 6.3 0.9 3.7 0.9 0.6 2.5
NUMBER OF TIMES EXCEEDING 5.0 PPM (EACH POINT)
14 8 0 1 20 137 10 7 3 38 0 5 6 7 5 106 7 78 8 460
AVERAGE NUMBER OF TIMES PER DAY EXCEEDING 5.0 PPM (EACH POINT)
1 1 0 0 2 17 1 0 0 4 0 0 0 0 0 13 0 9 1 57

AVERAGE EXPOSURE BY JOB TYPE
JOB00: 6.9 JOB01:35.1 JOB02: 2.1 JOB03:26.1 JOB04:17.2 JOB05:47.1 JOB06:22.0 JOB07:49.2
JOB10:22.7 JOB11: 0.4 JOB12:24.5 JOB13:17.2 JOB14:20.2 JOB15:17.7 JOB16:17.0 JOB17: 4.0

STANDARD DEVIATION ON AVERAGE EXPOSURE
JOB00: 7.4 JOB01: 7.8 JOB02: 4.8 JOB03: 5.4 JOB04: 6.1 JOB05: 5.9 JOB06: 3.9 JOB07: 7.0
JOB10: 5.9 JOB11: 1.1 JOB12: 5.2 JOB13: 6.5 JOB14: 6.9 JOB15: 5.5 JOB16: 2.5 JOB17: 2.1

PER CENT PROBABILITY OF EXPOSURE GREATER THAN 1.8 PPM:
JOB00:74.9 JOB01:99.9 JOB02:51.7 JOB03:99.9 JOB04:99.3 JOB05:99.9 JOB06:99.9 JOB07:99.9

Table 5

Response of VCl Monitor to
Compounds Other Than VCl
(Analazer Range - 25 ppm Full Scale)

Compound	Concentration, ppm	Response, as ppm VCl
acetaldehyde	25	None
acetone	10,000	None
butadiene	100	None
n-butyl acrylate	1,000	1*
1-butyne	100	None
chlorine	100	None
ethyl chloride	100	None
ethylene oxide	100	None
hydrogen oxide	100	None
isobutane	100	None
isobutene	1,000	0.2
isopropanol	1,000	None
methanol	1,000	None
methyl acetate	1,000	None
methyl chloride	20	0.6
methyl ethyl ketone	1,000	None
n-nonane	1,000	None
1-pentene	100	None
toluene	1,000	6*
trichloroethylene	1,000	None
vinyl acetate	1,000	None
methane ethane ethylene acetylene propane propylene allene propyne n-butane 1-butene cis-2-butene trans-2-butene	1,200 Total	0.6

* Does not appear in output of sample in which it occurs, but will appear approximately 20 samples later.

Table 1

Comparison of Vinyl Chloride
Measurement Systems

Features	Infrared Spectrometry MIRAN II	GAS CHROMATOGRAPHY UCC MODEL 1200	Honeywell MODEL 100
Specificity	Good	Excellent	Excellent
Maximum Sensitivity (ppm full scale)	100	< 10	< 10
Minimum Detectability	1 ppm	0.05 ppm	0.05 ppm
Stability	?	$\pm$1%/week	$\pm$1%/week
Reliability (malfunctions per year)	?	1 - 5	?
Ease of Maintenance	Moderate (modular const.)	Moderate	?
Trained Servicemen Available in Plants	No	Yes	No
Spare Parts Available	Can Buy	Yes	Can Buy
Analyses Per Hour	60	30*	60
System Availability			
(1 Unit)	8-12 weeks	2-3 weeks	4 weeks
(3 Units)	8-12 weeks	4-6 weeks	12 weeks
(5 Units)	8-12 weeks	4-8 weeks	?
Can Use with Data Logger	Yes	Yes	Yes
Contact Closure for Alarm	Yes	Yes	Yes
Suitable for Hazardous Area Division 2	Yes**	Yes	Yes

* May be able to obtain 60 analyses per hour if desired.

** Applies to complete system in a purged housing.

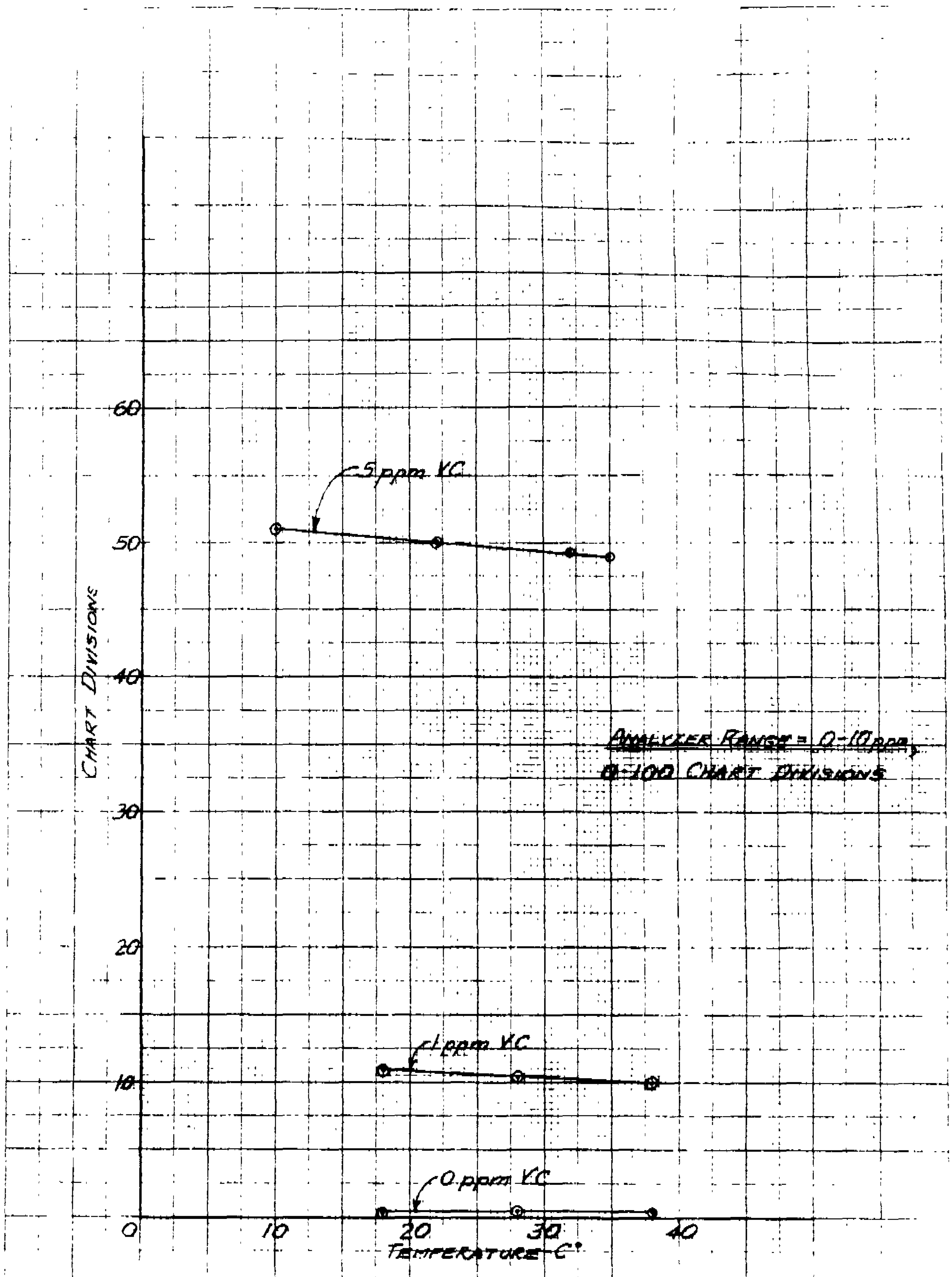

Figure 5

Effict of Ambient Temperature
on Re:ponse to Vinyl C'loride (VC)

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2) Baker, G. L., "Installation and Maintenance of Sampling Systems for Vinyl Chloride Analyzer," Technical Report TEC-75-6, April 24, 1975.

3) Baker, G. L., "Effect of Tubing Material on Samples Containing Trace Concentrations of Vinyl Chloride," Technical Report TEC-75-7, April 24, 1975.

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