Air Products and Chemicals INC.
CHEMICALS GROUP
CALVERT CITY PLANT
P. O. Box 97, Calvert City, Kentucky 42029 • Telephone 502 395-4181

In conformance with the Occupational Safety and Health Administration Standard relating to exposure to vinyl chloride, Section 1910.93 (q) (n) (3), this will advise you that on the monitoring required by such Standard disclosed that the vinyl chloride monomer concentration in the atmosphere around your working station was parts per million averaged over the 8-hour shift.

As you realize, this atmosphere measurement does not necessarily mean that you have been exposed to this level.

You are also aware that Air Products and Chemicals, Inc. is in the process of an extensive program to reduce the exposure to vinyl chloride in the work environment. As a part of this ongoing program, we have prepared and are in the process of implementing an engineering program designed to reduce your exposure and the exposure of your fellow employees to the greatest extent feasible in our plants. A copy of this engineering program is enclosed for your information.

Air Products very much appreciates the cooperation and patience which you have exhibited in helping to resolve this problem and we know that with the dedication and cooperation of all concerned, the protection of your health and the continuation of our operations will be achieved.

Very truly yours,

AIR PRODUCTS & CHEMICALS, INC.
Chemicals Group

A. F. Cantor

A. F. Cantor, Superintendent
PVC Resin Plant

AFC/jsd

ENGINEERING PROGRAM FOR

ABATEMENT OF WORKER EXPOSURE TO

VINYL CHLORIDE

The Engineering Program for abatement of worker exposure to Vinyl Chloride Monomer consists of a combined effort from Research, Plant Staffs and Divisional Management. Those programs which are active at this time are indicated below:

I. RESEARCH

The following studies are underway:

1. Methods to reduce exposure by decreasing the frequency of opening and closing or cleaning of reactors by developing effective antifoulents and more stable recipes which reduce the amount of wall fouling and scrap resin. Part of this work has been a joint project with a National Science Foundation fellow.

2. Methods to improve stripping by reformulation to produce more porous resins, and improved anti-foam agents.

3. Fundamental studies on diffusion constants and equilibrium data for the system PVC-Water-Vinyl Chloride in order to extend our knowledge of the stripping and drying processes, and thus reduce exposure in the production and fabrication stages.

4. Continuing studies are underway to reduce the monomer content of resin and compound after the production phase, also for protection of the worker and consumer.

II. PLANT STUDIES

Plant engineering and process studies now completed or underway include the following items:

1. Use of the fixed and portable monitors to locate sources of exposure, evaluate modifications to equipment and ventilation systems, and test the effectiveness of new work procedures.

2. Relocation of equipment so as to remove potential sources from the work area or relocate work positions away from possible exposures.

3. A continuing program of revision of procedures and retraining of personnel for the purpose of reducing the chance for error and improving work production. Revised copies of this written program are available at each plant and have been distributed to each affected employee.

4. A multimillion dollar program to improve slurry stripping and to reduce manual cleaning of reactors has been completed. The first continuous stripping unit has been in operation since November 1975 at Calvert City, and a similar unit is in operation at Escambia. The solvent recovery equipment has been expanded and improved.

5. The use of a computer to charge and drop batches to reduce the personnel exposure to VCM.

III. OUTSIDE ASSISTANCE

Assistance is being obtained from outside the company in the following ways:

1. Participation in information exchange with industry within the U.S. through the technical programs of the Vinyl Chloride Safety Association and the Society for the Plastics Industries, as well as through personal contacts.

2. Information exchange programs with PVC producers in Europe and Asia.

IV. PLANT MODIFICATIONS

A. Escambia Plant

1) A major capital investment has been made which resulted in a plant capable of reducing exposure to as low a level as any other plant. Two 24,000 gallon reactors have been installed complete with all required supporting equipment. Five of the existing reactors have been retrofitted so that the entire plant is now computer controlled from a remote area.

2) Controlled atmosphere areas exist on two floors of the old reactor building to provide a work area free from vinyl chloride.

3) Reactor relief lines have been extended above the roof peak.

4) A closed reactor rinse water system will be completed in mid-1978.

5) The personnel entrance gates and data logging equipment are currently being installed. Completion is expected in mid-1978.

6) A solvent cleaning system is in operation. Further capacity expansion is included under item #1.

7) A separate air system, with carbon-bed protection against VC contamination, has been installed, to provide VCL free breathing air to be used with continued flow respirators where overexposure potential exists.

8) The reactor seal pressure system has been redesigned to minimize possible agitator seal leakage.

9) All reactor manways and sightglass assembly are routinely serviced to reduce the possibility of leakage.

10) A revision is underway on the recovered monomer water drain line to eliminate monomer spillage.

B. Calvert City PVC Plant

1) The monomer recovery system has been rebuilt, modernized and located outside a process building.

2) Electronic processing of the area monitoring data will be installed.

3) Ventilation has been improved in the compound, warehouse and bagging area, so that these are not regulated areas.

4) The expanded plant is computer controlled.

5) Relief valves have been placed on the charge pots to control emissions from overpressure.

6) Continuous strippers have been installed to reduce residual vinyl chloride in the product.

C. Calvert City Emulsions Plant

Monitoring results show that workers are not generally exposed to concentrations above 0.5 ppm vinyl chloride during normal production of VC-containing polymer, but may be affected by upsets in the PVC Plant, or during some venting and repair operations. The engineering program is designed to reduce further these possible excursions.

1. Items listed under IV B, above, will reduce the effects of upsets in the PVC Plant.

2. A major project is underway to recover and recycle the unreacted monomers, thus reducing emissions and potential exposure.

3. In the interim, operators are furnished respirator protection.

4. To reduce the potential for operators exposure to VCM, a direct vinyl chloride monomer feed is being installed. This will eliminate the present charge tank and certain sequences in the operation for VCM addition.

VINYL CHLORIDE IN AIR

Physical and Chemical Analysis Branch

Analytical Method

Analyte: Vinyl Chloride	Method No.: P&CAM 178
Matrix: Air	Range: 0.008 to 5.2 mg/m³ in a 5 - liter air sample
Procedure: Adsorption on activated carbon, desorption with carbon disulfide, gas chromatography	Precision (CV_T): 0.08 at levels of 7 and 71 mg/m³
Date Issued: 9/3/74	Classification: B (accepted)
Date Revised: 1/29/76	

1. **Principle of the Method**

A known volume of air is drawn through two small sorbent tubes in series containing activated carbon (made from coconut shells), which adsorbs the vinyl chloride present in the air sample. The collected vinyl chloride is then desorbed with carbon disulfide, and the resulting solutions are analyzed by gas chromatography with a flame ionization detector. The areas under the resulting peaks are compared with areas obtained from the injection of standards.

2. **Range and Sensitivity**

2.1 The minimum detectable amount of vinyl chloride was found to be 0.2 ng per injection at a 1 x 1 attenuation on a gas chromatograph. This corresponds to an estimated concentration of 0.008 mg/m³ in a 5-liter air sample analyzed by this method. However, the desorption efficiency from activated carbon of amounts of vinyl chloride as small as 40 ng (0.008 μg/ℓ x 5 liters) has not been determined. Therefore, the detection limit of the overall method may be somewhat higher than 0.008 mg/m³.

2.2 At the recommended sampling flow rate of 50 mℓ/min, the total volume to be sampled should not exceed 5 liters. This value is based upon data which indicated that more than 10 liters of air containing 2.6 μg/ℓ (1 ppm) of vinyl chloride could be sampled on activated carbon before 5% breakthrough was observed. This indicates that 5 liters of air containing no more than 5.2 mg/m³ may be sampled without significant breakthrough. (The sorbent tube consists of two sections of activated carbon separated by a section of urethane foam. [See Section 6.2.]) If a particular atmosphere is suspected of containing a high concentration of contaminants or a high humidity is suspected, the sampling volume should be reduced by 50%. A safety factor has been included in the recommended 5-liter volume and the capacity of the first tube should be within these limits except under the most extreme conditions.

3. Interferences

3.1 When the amount of water in the air is so great that condensation actually occurs in the tube, organic vapors will not be trapped effectively. Experiments indicate that high humidity severely decreases the capacity of activated carbon for organic vapors.

3.2 When two or more substances are known or suspected to be present in the air, such information, including their suspected identities, should be transmitted with the sample since these compounds may interfere with the analysis for vinyl chloride.

3.3 Any compound that has the same retention time as vinyl chloride at the operating conditions described in this method is an interference. Hence, retention time data on a single column, or even on a number of columns, may not provide proof of chemical identity. Often, operating conditions can be modified to eliminate interferences. Samples should be analyzed by an independent method when overlapping gas chromatographic peaks cannot be resolved.

4. Precision and Accuracy

4.1 The coefficients of variation resulting from the analysis of two sets of sorbent tubes, one set of 27 tubes exposed to a vinyl chloride concentration of 7.2 mg/m^3 in air and another set of 29 tubes exposed to a concentration of 71.3 mg/m^3, were 0.076 and 0.075, respectively. These values reflect total sampling and analytical error as well as desorption efficiency correction errors.

4.2 Experiments were performed to obtain some indication of the accuracy, although accuracy was difficult to evaluate in the absence of a primary standard. These experiments generally involved six sorbent tube samples exposed to a synthetic atmosphere. The calculated value was the concentration expected based on the measured amounts of vinyl chloride and air mixed to prepare the synthetic atmosphere. Therefore the calculated value was not the "true" value, since it was subject to experimental error. The value found from analysis of each sorbent tube, after correction for desorption efficiency, was also compared to that found by the direct injection of gas samples from the same synthetic atmosphere used in loading the tubes. The results of these experiments are shown in the table below. It should be noted that average concentrations determined by analysis of sorbent tubes were within 6% of the average concentrations determined by analysis of gas samples.

Experiment No.		Concentration, calculated, mg/m³	Concentration, experimental, mg/m³	Estimated error, %[a]
I	Gas samples	64	71.2 ± 0.7[b]	
	Sorbent tubes	64	69.8 ± 1.5	-2
II	Gas samples	13	14.5 ± 0.5	
	Sorbent tubes	13	13.6 ± 0.4	-6
III	Gas samples	2.6	2.88 ± 0.07	
	Sorbent tubes	2.6	2.91 ± 0.13	+1
IV	Gas samples	1.3	-	-
	Sorbent tubes	1.3	1.27 ± 0.09	-

a. The estimated error is the average of concentrations determined from sorbent tubes minus the average of concentrations determined from gas samples, divided by the average of concentrations determined from gas samples, multiplied by 100.

b. The number given is the mean value plus or minus the 95% confidence level. The 95% confidence level is defined as the standard deviation multiplied by Student's *t* at the 0.05 significance level, divided by the square root of the number of samples.

5. Advantages and Disadvantages of the Method

5.1 The sampling device is small, portable, and involves no liquids. Interferences are minimal, and most of those that do occur can be eliminated by altering chromatographic conditions. The tubes are analyzed by means of a rapid instrumental method. The method can also be used for the simultaneous determination of two or more components suspected to be present in the same sample by changing gas chromatographic conditions from isothermal to a temperature-programmed mode of operation.

5.2 One disadvantage of the method is that the amount of sample that can be taken is limited by the amount of vinyl chloride that the tube will hold before it becomes overloaded. When the sample value obtained for the backup section of the sorbent tube exceeds 20% of that found on the front section, the possibility of sample loss exists. During storage, volatile compounds such as vinyl chloride will migrate throughout the tube until equilibrium is reached. At this time, 33% of these compounds will be found in the backup section. This may lead to some confusion as to whether sample loss has occurred. This migration effect can be considerably decreased by shipping and storing the tubes at -20°C. (See Section 8.2.10.)

5.3 The precision of the method is limited by the reproducibility of the pressure drop and, therefore, the flow rates across the tubes. Because the pump is usually calibrated for one particular tube, differences in flow rates can occur when sampling through other tubes and can cause sample volumes to vary.

6. Apparatus

6.1 Personal Sampling Pump. The pump should be a properly calibrated personal sampling pump for personal and area samples. It should be calibrated with a representative sorbent tube in the sampling line. A dry or wet test meter or a glass rotameter that will determine the flow rate (50 mℓ/min) to within ± 5% may be used for the calibration.

6.2 Sorbent Tubes. The glass tubes have both ends flame sealed. Each is 7 cm long, 6-mm o.d., 4-mm i.d., and contains two sections of 20/40-mesh activated carbon separated by a 2-mm portion of urethane foam. The activated carbon is prepared from coconut shells and is fired at 600°C prior to packing to remove adsorbed materials. The primary adsorbing section contains 100 mg of sorbent, the backup section 50 mg. A 3-mm portion of urethane foam is placed between the outlet end of the tube and the backup section. A plug of silanized glass wool is placed in front of the adsorbing section. The pressure drop across the tube must be less than 2 in. of water at a flow rate of 0.2 ℓ/min.

6.3 Gas chromatograph equipped with a flame ionization detector.

6.4 Stainless steel column (20 ft x 0.125 in.) packed with 10% SE-30 on 80/100-mesh Chromosorb W (acid washed, silanized with dimethyldichlorosilane). Other columns capable of performing the required separations may be used.

6.5 A mechanical or electronic integrator or a recorder and some method for determining peak area.

6.6 Vials (2-mℓ) that can be sealed with caps containing Teflon-lined silicone rubber septa.

6.7 Microliter syringes (10-μℓ, and convenient sizes for making standards).

6.8 Gas-tight syringe (1-mℓ, with a gas-tight valve).

6.9 Pipettes (0.5-mℓ delivery pipettes or 1.0-mℓ type graduated in 0.1-mℓ increments).

6.10 Volumetric Flasks (10-mℓ, or convenient sizes for making solutions). It is preferable to have plastic stoppers for the volumetric flasks.

7. Reagents

7.1 Carbon disulfide, spectroquality or better grade.

7.2 Vinyl chloride, lecture bottle, 99.9% minimum purity.

7.3 Toluene, chromatographic quality.

7.4 Purified helium.

7.5 Prepurified hydrogen.

7.6 Filtered compressed air.

8. Procedure

8.1 Cleaning of Equipment. All glassware used for the laboratory analysis should be washed with detergent and thoroughly rinsed with distilled water.

8.2 Collection and Shipping of Samples

8.2.1 Immediately before sampling, the ends of two tubes are broken to provide an opening at least one-half the internal diameter of the tube (2 mm).

8.2.2 The second sorbent tube is used as a backup and is positioned next to the sampling pump in tandem with the first tube.

8.2.3 The sorbent tubes are placed in a vertical position with the larger section of sorbent pointing up during sampling to minimize channelling of the vinyl chloride through the sorbent.

8.2.4 Air being sampled is not to be passed through any hose or tubing before entering the sorbent tubes.

8.2.5 The flow rate and time, or volume, must be measured as accurately as possible. The sample is taken at a flow rate of 50 mℓ/min. The maximum volume to be sampled should not exceed 5 liters. (See Section 2.2.)

8.2.6 Relatively large volumes (10 to 20 liters) of air also should be sampled through other sorbent tubes at the same time personal samples are taken. These bulk air samples will be used by the analyst to identify possible interferences before the personal samples are analyzed.

8.2.7 If the temperature and pressure of the atmosphere being sampled are significantly different from 25°C or 760 mmHg, they should be measured and recorded.

8.2.8 The sorbent tubes are capped with the supplied plastic caps immediately after sampling. Under no circumstances are rubber caps to be used.

8.2.9 One tube is handled in the same manner as a sample tube (break, seal, and transport), except that no air is sampled through this tube. This tube is labeled as a blank.

8.2.10 Capped tubes are packed tightly before they are shipped to minimize tube breakage during transport to the laboratory. The use of two tubes in series has eliminated the need for cooling during shipping. However, if *two* tubes are *not* used, *i.e.*, only one tube is used, and if the samples will spend a day or more in transit, then cooling (*e.g.*, with Dry Ice) is necessary to minimize migration of vinyl chloride to the backup section.

8.2.11 Samples received at the laboratory are logged in and immediately stored in a freezer (around - 20°C) until time for analysis. Samples may be stored in this manner for long periods of time with no appreciable loss of vinyl chloride (2 months). Even around -20°C, vinyl chloride will equilibrate between the two sections of activated carbon, *i.e.*, it will migrate to the backup section. This phenomenon is observable after 2 weeks and may be confused with sample loss after 1 to 2 months.

8.3 Analysis of Samples

8.3.1 **Preparation and Desorption of Samples.** The two tubes used in the collection of a single sample are analyzed separately. Each tube is scored with a file and broken open at each end. The glass wool is discarded. Both sections of each tube are transferred to a small vial containing 1 mℓ of carbon disulfide. It is important to add the sorbent to the carbon disulfide and not the carbon disulfide to the sorbent. The vial is topped with a septum cap. The separating section in each tube is discarded. Tests indicate that desorption is complete in 30 min if the sample is agitated occasionally during this period. The samples should be analyzed within 60 min after addition to carbon disulfide. If only one tube is used for sampling, then each section of activated carbon should be analyzed separately.

8.3.2 **Gas Chromatographic Conditions.** The typical operating conditions for the gas chromatograph are:

1. Helium carrier gas flow, 40 mℓ/min (80 psig).

2. Hydrogen gas flow to detector, 65 mℓ/min (20 psig).

3. Air flow to detector, 500 mℓ/min (50 psig).

4. Injector temperature, 230°C.

5. Detector temperature, 230°C.

6. Column temperature, 60°C.

8.3.3 **Injection.** The first step in the analysis is the injection of the sample into the gas chromatograph. To eliminate difficulties arising from blowback or distillation within the syringe needle, one should employ the solvent flush injection technique. The 10-$\mu\ell$ syringe is first flushed with solvent several times to wet the barrel and plunger. Two microliters of solvent is drawn into the syringe to increase the accuracy and reproducibility of the injected sample volume. The needle is removed from the solvent and the plunger is pulled back about 0.4 $\mu\ell$ to separate the solvent flush from the sample with a pocket of air to be used as a marker. The needle is then immersed in the sample, and a 5-$\mu\ell$ aliquot is withdrawn to the 7.4 $\mu\ell$ mark (2 $\mu\ell$ solvent + 0.4 $\mu\ell$ air + 5 $\mu\ell$ sample = 7.4 $\mu\ell$). After the needle is removed from the sample and prior to injection the plunger is pulled back a short distance to minimize evaporation of the sample from the tip of the needle. Duplicate injections of each sample and standard are made. No more than a 3% difference in area is to be expected. Automatic sampling devices may also be used.

8.3.4 **Measurement of Area.** The area under the sample peak is measured by an electronic integrator or some other suitable form of area measurement, and preliminary results are read from a standard curve prepared as discussed below.

8.4 **Determination of Desorption Efficiency**

8.4.1 **Importance of Determination.** The efficiency of desorption of a particular compound can vary from one laboratory to another and also from one batch of sorbent to another. Thus, it is necessary to determine at least once the percentage of vinyl chloride that is removed in the desorption process. Desorption efficiency should be determined on the same batch of sorbent tubes used in sampling. Results indicate that desorption efficiency varies with loading (total vinyl chloride on the tube), particularly at lower values, *e.g.*, 2.5 μg.

8.4.2 **Procedure for Determining Desorption Efficiency.** Sorbent tubes from the same batch as that used in obtaining samples are used in this determination. A measured volume of vinyl chloride gas is injected into a bag containing a measured volume of air. The bag is made of Tedlar (or a material that will retain the vinyl chloride and not absorb it) and should have a gas sampling valve and a septum injection port. The concentration in the bag may be calculated if room temperature and pressure are known. A measured volume is then sampled through a sorbent tube with a calibrated sampling pump. At least five tubes are prepared in this manner. These tubes are desorbed and analyzed in the same manner as the samples. (See Section 8.3.) Samples taken with a gas-tight syringe from the bag are also injected into the gas chromatograph. The concentration in the bag is compared to the concentration obtained from the tubes.

The desorption efficiency equals the amount of vinyl chloride desorbed from the sorbent divided by the quantity of vinyl chloride contained in the volume of synthetic atmosphere sampled, or

$$\frac{\text{(amount of vinyl chloride from sorbent)}}{\left(\begin{matrix}\text{concn of vinyl chloride}\\ \text{in bag}\end{matrix}\right) \times \left(\begin{matrix}\text{vol of atmosphere}\\ \text{sampled}\end{matrix}\right)}$$

9. Calibration and Standards

CAUTION: Laboratory Operations Involving Carcinogens

Vinyl chloride has been identified as a human carcinogen and appropriate precautions must be taken in handling this gas. The Occupational Safety and Health Administration has promulgated regulations for the use and handling of vinyl chloride. They may be found in 29 CFR 1910.93q (Section 1910.93q in Title 29 of the Code of Federal Regulations available in the Federal Register, Vol. 39, No. 194, Friday, October 4, 1974, pp. 35890-35898).

A series of standards, varying in concentration over the range of interest, is prepared and analyzed under the same gas chromatographic conditions and during the same time period as the unknown samples. Curves are established by plotting concentration in μg/mℓ *versus* peak area. There are two methods of preparing standards and, as long as highly purified vinyl chloride is used, both are comparable.

If no internal standard is used in the method, standard solutions must be analyzed at the same time that the sample analysis is done. This will minimize the effect of day-to-day variations of the flame ionization response.

9.1 Standard Preparation

9.1.1 **Gravimetric Method.** Vinyl chloride is slowly bubbled into a weighed 10-mℓ volumetric flask containing approximately 5 mℓ of toluene. After 3 min, the flask is again weighed. A weight change of 100 to 300 mg is usually observed. The solution is diluted to exactly 10 mℓ with carbon disulfide and is used to prepare other standards by removal of aliquots with different sized syringes. Subsequent dilution of these aliquots with carbon disulfide results in a series of values that are linear from the range of 0.2 ng per injection, the minimum detectable amount of vinyl chloride, to 1.5 μg per injection.

9.1.2 **Volumetric Method.** A 1-mℓ gas sample of pure vinyl chloride is drawn into a gas-tight syringe and the valve is closed. The tip of the needle is inserted into a 10-mℓ volumetric flask containing approximately 5 mℓ of CS_2. The valve is opened and the plunger is withdrawn slightly to allow the CS_2 to enter the syringe. The action of the vinyl chloride dissolving in the CS_2 creates a vacuum and the syringe becomes filled with the solvent. An air bubble (2%) is present and has been found to be due to the void volume in the needle of the syringe. The solution is returned to the flask and the syringe is rinsed with clean CS_2 and the washings added to the volumetric flask. The volumetric flask is then filled to the mark with CS_2. Other standards are then prepared from this stock solution.

Standards are stored in a freezer at -20°C and have been found to be stable at this temperature for 3 days. Tight-fitting plastic tops on the volumetric flasks seem to retain the vinyl chloride better than ground-glass stoppers.

10. Calculations

10.1 The weight, in μg, corresponding to the area under each peak is read from the standard curve for vinyl chloride. No liquid volume corrections are needed because the standard curve is based on the number of micrograms in 1.0 mℓ of CS_2 and the volume of sample injected is identical to the volume of the standards injected.

10.2 Corrections for the blank are made for each sample.

$$\mu g = \mu g_s - \mu g_b$$

where: μg_s = μg found on sample tube.

μg_b = μg found on blank tube.

A similar procedure is followed for the backup sections.

10.3 The amounts present in the front and backup sections of the same sample tube are added to determine the total amount of vinyl chloride in the sample.

10.4 The total amount is corrected for the desorption efficiency at the level of vinyl chloride measured.

$$\text{Corrected amount (in } \mu g) = \frac{\text{amount (in } \mu g)}{\text{desorption efficiency}}$$

10.5 The concentration of vinyl chloride in air may be expressed in mg/m^3:

$$mg/m^3 = \frac{\text{corrected weight (in } \mu g)}{\text{volume of air sampled (in } \ell)}$$

10.6 The concentration may also be expressed in terms of parts per million (ppm) by volume:

$$ppm = mg/m^3 \times \frac{24.45}{M.W.} \times \frac{760}{P} \times \frac{T+273}{298}$$

where: 24.45 = molar volume (ℓ/mole) at 25°C and 760 mmHg.

M.W. = molecular weight.

P = pressure (mmHg) of air sampled.

T = temperature (°C) of air sampled.

11. References

11.1 Hill, R.H., C.S. McCammon, A.T. Saalwaechter, A.W. Teass, and W.J.Woodfin, "Determination of Vinyl Chloride in Air," in preparation.

11.2 White, L.D., D.G. Taylor, P.A. Mauer, and R.E. Kupel, "A Convenient Optimized Method for the Analysis of Selected Solvent Vapors in the Industrial Atmosphere." Amer. Ind. Hyg. Ass. J.,31, 225 (1970).

File vinyl chloride

NIOSH Recommended Precautionary Monitoring and Control Procedures for Polymerization Processes Involving Vinyl Chloride

I. General Housekeeping Procedures

A. The spillage of Vinyl Chloride and Polyvinyl Chloride in and around the production facilities should be controlled as follows:

1. Housekeeping procedures should be implemented to assure immediate removal of VC and PVC material around polymerization operations including drying, packaging and loading operations.

2. Recovered PVC material which is to be packaged should be stored in closed containers.

3. Waste PVC material should be stored in closed containers and consideration should be given to the adequacy of its disposal and/or destruction. Care should be taken in the storage of closed containers to insure that unsafe conditions do not result from an internal build-up of pressure in the container.

B. Inventories of beginning and recovered quantities of VC and quantities of PVC produced, packaged and recovered should be made to determine losses and probable areas affected.

C. PVC material should be removed from overhead structures and conduits where it tends to collect.

D. Consumption of food should be permitted only in separate facilities provided for this purpose, and no food products should be permitted elsewhere in the polymerization facility.

II. Protective Clothing

A. A daily change of protective clothing including full coveralls, or the equilvalent, should be provided each employee in areas where possible exposure to VC PVC could occur. Clothing contaminated by accidental spills should be changed as soon as feasible.

B. Protective gloves and footwear, or footcovers, should be worn as appropriate in those PVC operations where exposure to PVC material is possible.

C. Protective head covers should be worn during PVC operations as appropriate (e.g. hard hats in those areas where physical protection of the head is necessary and hair coverings, or the equilvalent, in

operations such as cleaning of polymerization reactor tanks and packaging operations).

D. Where employees are engaged in maintenance or cleaning operations of polymerization reactors tanks they should wear full impervious suits to guard against skin contact of PVC material and VC vapors. Procedures for safe entry to confined spaces should be observed.

III. Showers

Showers at the termination of an eight-hour work shift should be mandatory for all workers with possible contact with VC-PVC.

IV. Monitoring

A. Environmental Monitoring

1. In-plant environmental monitoring programs should be implemented; and where workers are required to enter polymerization tanks, a survey of the VC concentrations should be made in the reactors immediately after opening, immediately prior to entry of maintenance personnel and during the tank cleaning operation.

2. Data obtained from the environmental monitoring program should be used to indicate those areas where efforts should be directed to reduce airborne levels of VC.

3. Positive programs to initially control VC levels well below the present Federal Standard of 500 ppm should be developed (some companies are targeting at 50 ppm) and efforts to further reduce levels should be given consideration concomitantly with the necessary modifications in engineering and design controls.

4. The concentration of VC in exhaust ventilation should be determined to estimate the amount of VC lost during operations and the possible exposure of personnel immediately outside the facility.

5. Monitoring for PVC particulate material should be accomplished to estimate the degree of exposure to this substance throughout the facility.

B. Personal Monitoring

1. Integrated, eight-hour personal monitoring samples should be obtained from those employees considered to receive the greatest exposure to VC or PVC.

2. Breathing zone samples should be obtained to complement environmental monitoring program for VC, and similar samples should be obtained for PVC.

V. Respiratory Protection

Because VC is a gas under ambient conditions and PVC is a solid under these conditions, it is recommended that respiratory protection for employees take these circumstances into consideration.

A. Where employees are engaged in cleaning and maintenance operations inside polymerization reactors they should be equipped with an atmosphere-supplied respirator in order to protect against both VC vapor and PVC particulates.

B. During housekeeping procedures and packaging operations where the possibility of PVC dust inhalation is a factor, it is recommended that an air-purifying respirator equipped with a mechanical filter designed to remove particulate material be worn. Respiratory protective devices which meet this requirement, as well as protect against VC vapors in concentrations less than 0.1% have been approved by the NIOSH Testing and Certification Laboratory and bear the numbers: TC-23C-40, TC-23C-47, TC-23C-48.

C. Where employees are engaged in transfer operations of VC from railway tankcars to storage facilities or at any similar transfer point which requires manual operations, they should wear a self-contained breathing apparatus (SCBA) during such operations to guard against unexpected release of VC during such operations.

D. Other operations involving possible exposure to VC or PVC should be evaluated as the individual situation exists and respiratory protection provided as appropriate.