The Vinyl Institute
A Division of The Society of The Plastics Industry, Inc.

Roy T. Gottesman
Executive Director

March 13, 1989

TO: Health, Safety & Environment Committee

RE: Fugitive Emissions Bagging

As follow-up to discussions at the last committee meeting, Joe Ledvina asked that I forward the attached to each of you.

Meredith

Meredith N. Scheck

MNS/pmb
enclosure

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March 9, 1989

VISTA

Ms. Meredith N. Scheck
The Vinyl Institute
Wayne Interchange Plaza II
155 Route 46 West
Wayne, NJ 07470

Re: FUGITIVE EMISSION BAGGING

Dear Meredith:

Our Aberdeen, MS plant recently received the results of a fugitive emission bagging study done by a contractor, TEAM Inc. The results of the study were so favorable that I thought it would be worthwhile passing them along to other VI members so they could get a better idea of the benefits of such a study.

TEAM did site bagging work the week of November 28, 1988. Thirty seven components were subjected to bag sampling; 16 valves, 19 flanges, 2 compressors. In general, the study showed that the SOCMI stratified leak factors correctly characterized the fugitive emissions from a leaking component. However, the number of leaking components in our plant (and probably most PVC plants) is very low. The study showed that the EPA factor for non-leaking components overestimates fugitive emissions by a considerable amount. By using the factors derived from the bagging study, Aberdeen fugitive emissions were lowered to 15% of the level reported under SARA 313 last year.

The cost of our bagging study was approximately $20,000. We were able to keep the cost down by doing a screening of all the components in the plant ourselves. This screening is needed to determine the percent of components leaking. The cost of the project would have been higher if TEAM did the screening.

Since there has been interest among some members of the VI Health, Safety, and Environment Committee in bagging, I suggest you distribute this memo to the Committee members. I have attached selected pages from the report describing the process.

Sincerely,

Joseph C. Ledvina
Director, Environmental Activities

dlj
Attachment

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ABSTRACT

The purpose of this study was to present accurate mass emission estimates for components in vinyl chloride (VCM) service at Vista Chemical Company, Aberdeen, Mississippi.

Screening data, supplied by Vista Company, along with response factor testing and bagging data generated by Team, Inc. was used to compile the emission estimates for VCM.

The testing was concentrated in the new module and old module sections which were considered identical (sister) units by Vista Chemical Company. The unit boundary also incorporated the compressor shed and tank farm as part of the testing region. Data gathered from testing of the VCM areas was compiled and used to compute the VCM emissions from the process.

Emissions estimates were calculated using five different computation methods. The factors used, along with the data requirements were as follows:

METHOD	DATA REQUIREMENTS
(1) Average SOCMI factors factors	Accurate component counts
(2) Leak/no leak factors	Accurate component counts, screening data, response factor data
(3) Stratified factors	Accurate component counts, screening data, response factor data
(4) EPA correlations with EPA "default zero" emission rates	Accurate component counts, screening data, response factor data, bagging data
(5) EPA correlations with "default zero" emission rates from bagging	Accurate component counts, screening data, response factor data, bagging data

Calculations using the bagging data from emitting sources yielded the EPA correlations for valves (LL) and valves (gas) reasonably fit the process under study. The EPA correlation for flanges was observed to overestimate emissions from the process under study, but was still used to generate conservative emissi n estimates.

Bagging data from "zero" sources yielded statistically different emission rates for valves (light liquid) and flanges from that of the EPA "default zero" emission rates. The "default zero" emission rates from bagging were used to calculate emissions from components screening at "zero" for these sources. Pumps, compressors, and valves (gas) "zero" components emissions were calculated using the EPA "default zero" emission rates.

A summary of total emissions from each method in pounds per hour may be found in Appendix K, page K-1.

2.0 DEVELOPMENT OF EMISSION ESTIMATES

2.1 INTRODUCTION

In this section, the five methods used to compute the VCM emissions from equipment leaks in the VCM processing area are outlined and explained. Data collection technique and data analysis methods used are explained in detail in this section and with the use of the appendixes for each method. The most recent EPA protocol (reference 1) and the latest CMA protocol (reference 2) were adhered to very closely in compiling data and computing emission estimates. They will be referenced often and supplementary references should be sought through the reference list included in those protocols.

2.2 AVERAGE EMISSION FACTOR METHOD

All methods of calculating emissions required an accurate component count by type of equipment and by service. Application of the EPA average emission factors to equipment counts for the unit are used to calculate emissions. The EPA average emission factors are shown in Table 2-1 (reference 1, page 2-2) on the following page. The product of the emission factor and the number of equipment components are summed to generate the unit specific emission estimates (reference 1, page 2-1). The results of the emission estimates for VCM using the average emission factors may be found in Appendix B, page B-1.

2.3 LEAK/NO LEAK METHOD

The leak/no leak method requires screening of all equipment included in the inventory using a portable analyzer. Screening data of the VCM processing area using an HNU analyzer was supplied by Vista Chemical from a monitoring program performed in December, 1988. A list of the HNU screening values may be found in Appendix C, pages C-1, C-2. The HNU screening values were adjusted by response factors to yield actual VCM concentrati n (ppmv). The laboratory generated response factor data and computation methods were performed by Team, Inc. A detailed explanation of the response factor generation for the HNU to actual concentration of VCM may be found in Appendix D, page D-1. The adjusted HNU screening values are listed in Appendix D, pages D-5, D-6.

The leak/no leak approach is based on two emission rates: an emission rate for sources that "leak" (screening concentration above or equal to 10,000 ppmv) and an emission rate for sources that do not "leak" (screening concentrations less than 10,000 ppmv). Table 2-2 (reference 1, page 2-6) presents the leaking and non-leaking emissions factors for the different source/services.

TABLE 2-1. AVERAGE EMISSION FACTORS FOR FUGITIVE EMISSIONS

Equipment	Service	Emission Factor (kg/hr/source)
Valves	Gas	0.0056
	Light Liquid	0.0071
	Heavy Liquid	0.00023
Pump Seals	Light Liquid	0.0494
	Heavy Liquid	0.0214
Compressor Seals	Gas/Vapor	0.228
Pressure Relief Seals	Gas/Vapor	0.104
Flanges	All	0.00083
Open-Ended Lines	All	0.0017
Sampling Connections	All	0.0150

TABLE 2-2. LEAKING AND NON-LEAKING EMISSION FACTORS FOR FUGITIVE EMISSIONS (kg/hr source)

Equipment	Service	Leaking (≥10,000 ppm) Emission Factor	Non-leaking (<10,000 ppm) Emission Factor
Valves	Gas[a]	0.0451	0.00048
	LL[b]	0.0852	0.00171
	HL[c]	0.00023[d]	0.00023
Pump Seals	LL	0.437	0.0120
	HL	0.3885	0.0135
Compressor Seals[e]	Gas	1.608	0.0894
Pressure Relief Valves	Gas	1.691	0.0447
Flanges	All	0.0375	0.00006
Open-Ended Lines	All	0.01195	0.00150

[a]The leaking and non-leaking emission factors for valves in gas/vapor service are based upon the emission factors determined for gas valves in ethylene, cumene, and vinyl acetate units during the SOCMI Maintenance Study. References 8 and 15.

[b]LL - light liquid service.

[c]HL - heavy liquid service.

[d]Leaking emission factor assumed equal to non-leaking emission factor since the computed leaking emission factor (0.00005 kg/hr/source) was less than non-leaking emission factor.

[e]Emission factor reflects existing control level of 60 percent found in the industry; control is through the use of barrier fluid/degassing reservoir/vent-to-flare or other seal leakage capture system.

The adjusted screening inventory for VCM yielded all non-leaking components. The product of the total number screened in each source/service and the non-leaking emission factor for the source/service was calculated and an average emission rate for each source/service screened was computed. The total component count for each s/s (including those not screened because of difficult to monitor situations) multiplied by the average emission rate for those screened in each s/s was used to generate the emission estimate for each category. The results of emissions using the leak/no leak approach may be found in Appendix E, page E-1.

2.4 STRATIFIED EMISSION METHOD

Another approach that requires accurate screening data is the stratified emission method.

The stratified emission method is based on three different ranges, each having an emission rate for different s/s. The three ranges used are:

(1) 0 - 1,000 ppmv
(2) 1,001 - 10,000 ppmv
(3) > 10,000 ppmv

Table 2-4 (reference 1, page 2-10) presents the emission rates for each strata by equipment type and service.

As with leak/no leak, the HNU screening values were adjusted by the proper response factor to yield actual concentration (ppmv). The screening concentrations for each s/s were multiplied by the proper strata emission rate and an average emission rate for each s/s screened was computed. The total components in each s/s was then used with the average emission rate for that s/s to generate the emission estimate. The results of the stratified emissions calculations may be found in Appendix E, page E-2.

2.5 EPA LEAK RATE/SCREENING VALUE CORRELATIONS

Mathematical correlations relating OVA measurements taken using Method 21 to mass emission rates have been published by EPA. The EPA correlations for valves (light liquid), valves (gas), pumps and flanges are shown in Appendix F (reference 1, page D-1), Pages F-1, F-2.

Bagging data for VCM emitting sources was gathered using the BLOW-THROUGH METHOD of bagging. The results were used to check the fit of the EPA correlations to the VCM processing area. A graphical comparison and a statistical analysis yielded that the EPA correlations for valves (light liquid), and valves (gas) were an adequate representation for valves (light liquid) and valves (gas) in the VCM processing area. The EPA correlation for flanges was observed to over estimate flange emissions for the

TABLE 2-4. STRATIFIED EMISSION FACTORS FOR EQUIPMENT LEAKS
(kg/hr/source)

Source	Service	Emission Factors (kg/hr/source) for Screening Value Ranges, ppmv		
		0-1,000	1,001-10,000	Over 10,000
Compressor seals	Gas/vapor	0.01132	0.264	1.608
Pump seals	Light liquid	0.00198	0.0335	0.437
	Heavy liquid	0.00380	0.0926	0.3885
Valves	Gas/vapor	0.00014	0.00165	0.0451
	Light liquid	0.00028	0.00963	0.0852
	Heavy liquid	0.00023	0.00023	0.00023
Flanges, connections	All	0.00002	0.00875	0.0375
Pressure relief devices	Gas/vapor	0.0114	0.279	1.691
Open-ended lines	All	0.00013	0.00876	0.01195

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VCM processing area. However, the EPA correlation for flanges could still be used as a conservative method for estimating flange emissions. The bagging method used and the calculation procedures may be found in Appendix G, pages G-1 thru G-6 (reference 2, pages 99-103). The bagging field data, graphical comparison and statistical analysis for the VCM area under study may be found in Appendix H, pages H-1 thru H-8.

Emissions were calculated for VCM emitters from the HNU monitoring survey completed by Vista in December 1988. The HNU screening values were first adjusted by appropriate response factors to yield equivalent OVA/methane screening values (reference 1, page 2-9). The equivalent OVA/methane screening values were then adjusted by appropriate OVA response factors to yield actual concentrations for OVA/methane ppmv over the entire range of screening values (reference 1, page 2-12). The adjusted equivalent OVA/methane concentrations were used with the EPA correlations to generate emissions from emitting sources. Response factor data and generation for the HNU to OVA/Methane adjustment and OVA to actual ppmv adjustment may be found in Appendix D, pages D-1 thru D-11.

2.6.1 EPA CORRELATIONS WITH EPA "DEFAULT ZERO" VALUES

In order to use the EPA correlations to generate emissions a separate treatment of "zero" components (sources that screen below the instruments lower limit of detection) has to be considered.

EPA has derived a "default zero" OVA/Methane screening value of 8 ppmv and an associated mass emissions rate for the screening values between zero and the "default zero" reading. These "default zero" emission rates are shown below (reference 1, page 2-12).

Equipment Type/Service	"Default Zero" Screening Value, ppm	Zero Screening Value Emission Rate (kg/hr/source)
Valves, gas	8	0.000033
Valves, light liquid	8	0.000451
Flanges	8	0.000093
Pumps and all other components	8	0.000039

"These emission factors should be applied to equipment components screening between 0 and 8 ppm. The published correlations would be applied to all screening concentrations above 8 ppm. The total emissions estimate for equipment leaks is generated by totaling emissions estimates for all "default zeros" and adding that total to the total estimates generated using the correlations." (Reference 1, page 2-12)

The adjusted equivalent OVA screening values from the VCM area monitoring were used with the EPA correlations along with the proper "default zero" emission rate to generate an average emission rate for each s/s under study. The total component count for each s/s in the VCM area was then used with the calculated average emission rate to generate the emission estimate for each s/s. Results of these calculation may be found in Appendix I, pages I-1 thru I-5.

2.6.2 EPA CORRELATIONS WITH "DEFAULT ZERO" EMISSION RATES FROM BAGGING DATA

Bagging data for "zero" components in the VCM area for various s/s was also collected and analyzed. A statistical test comparing the existing EPA "default zero" emission rates and the "default zero" emission rate from bagging was computed and used to determine if the "default zero" rate from bagging was statistically different from that of the EPA "default zero" emission rate. The statistical test used is outlined in Appendix J, pages J-1 thru J-5 (reference 1, pages G-1 to G-3).

The results of the statistical test revealed that for valves (light liquid) and flanges the "default zero" emission rate from bagging data was statistically different from the EPA "default zero" emission rates. The "default zero" emission rate from bagging data for valves (gas) however, was not found to be statistically different from the EPA "default zero" emission rate. The "zero" bagging data summary and statistical analysis for each s/s may be found in Appendix J, pages J-6 thru J-8.

Therefore, the EPA correlations along with the "default zero" emission rates from bagging were used to calculate emissions from valves (light liquid) and flanges as in section 2.6.1 above. The results of these calculations are shown in Appendix I, pages I-6 thru I-8.

One should also note that even though background bags were taken at the time of bagging "zero" components, the leak rate due to background was not accounted for in the "default zero" emission rate determinations. Thus, the "default zero" emission rates from bagging may be biased high. A supplementary to this report will be generated and take into account background in the "default zero" emission rate determination. The "default zero" emission rates will then be adjusted where warranted.

2.7 SUMMARY

A summary table of emission estimates calculated using all the above methods may be found in Appendix K, page K-1.

All the emissions calculated are believed to be statistically valid and acceptable estimates for the VCM process under study.

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APPENDIX G:

BLOW-THROUGH METHOD

AND

BAGGING FIELD DATA

BAGGING TECHNIQUE AND DATA

THE BAGGING DATA WAS COLLECTED USING THE BLOW-THROUGH METHOD OF BAGGING. THE BLOW-THROUGH METHOD IS DESCRIBED ON THE FOLLOWING PAGES ADAPTED FROM REFERENCE 2, PAGES 99 - 103. THE CALCULATION PROCEDURES ASSOCIATED WITH THE BLOW THROUGH BAGGING DATA IS SHOWN ON TABLE 4-1 ADAPTED FROM REFERENCE 3, PAGE 75.

THE BAGGING DATA COLLECTION AND CALCULATIONS FROM THE VISTA CHEMICAL VCM PROCESS STUDY WERE PERFORMED BY TEAM, INC.

THE BLOW-THROUGH METHOD WAS ADHERED TO VERY CLOSELY. NITROGEN WAS USED AS THE PURGE GAS. THE ROTAMETER % WAS ADJUSTED AND LISTED IN UNITS OF LITERS/MINUTE. THE OVA READING GIVEN INSIDE THE TENT FOR EACH FLOW RATE WAS CONFIRMED BY TAKING SEVERAL READINGS INSIDE THE TENT UNTIL THE READINGS WERE CONSISTANT. THIS WAS REPEATED AT EACH FLOW RATE AT LEAST TWO TIMES UNTIL REPEATABLE READINGS WERE EVIDENT. WHERE NO DETECTABLE OVA READINGS WERE OBSERVED, SAMPLE WERE COLLECTED FROM THE TENT USING A PORTABLE SAMPLE PUMP AND TRANSFERED TO THE LAB FOR ANALYSIS. VISTA LAB PERSONEL PERFORMED THE G.C. ANALYSIS OF THE SAMPLE BAGS. THE TENT GAS TEMPERTATURE LISTED ALSO REFLECTED THE AMBIENT TEMPERATURE UNLESS OTHERWISE NOTED ON THE DATA SHEETS. NO MEASUREMENTS WERE TAKEN FROM THE TENTS UNTIL THE OXYGEN CONTENT WAS LESS THAN 5%.

THE BAGGING DATA AND CALCULATIONS ARE SHOWN IN THE FOLLOWING SECTION. THE DATA IS GROUPED BY SOURCE/SERVICE IN ASCENDING ORDER BY DATA SHEET NUMBER. EACH SOURCE/SERVICE IS BROKEN INTO AN EMITTER SECTION AND A "ZERO" COMPONENT SECTION. COMMENTS CONCERNING THE DATA COLLECTION PROCESS ARE PRINTED ON THE BOTTOM OF EACH BAGGING DATA SHEET.

4.2 BLOW-THROUGH METHOD

Blow-through refers to blowing nitrogen through a flexible tent to create a constant VOC concentration inside the tent. Nitrogen is metered into the tent through 1 or 2 polyvinyl chloride tubes. The temperature and oxygen concentrations are measured inside the tent with a platinum-RTD thermocouple and an oxygen/combustible gas monitor. The flow of nitrogen is monitored in a gas rotameter calibrated to nitrogen. The nitrogen passes through activated charcoal and drierite to remove any organics and moisture. The pressure in the tent never exceeds 1 psig. Figure 4-3 illustrates the equipment required for the blow-through method.

THE BLOW THROUGH DAGGING DATA IS SHOWN ON TABLE [illegible] ADAPTED FROM REFERENCE [illegible]. At least two OVA (Foxboro 108 Organic Vapor Analyzer) measurements are made inside the tent, each measurement at two or more differing nitrogen flow rates to increase accuracy. [The OVA must be attached to a dilution probe and calibrated to nitrogen-diluted gases to allow its use in the nitrogen atmosphere in the tent.] The OVA readings are converted to emission rates of VOC via response factors for the OVA; the calculation is shown in Table 4-1. Alternatively, gas samples from the tent can be collected with a portable sampling pump and transported to a lab for chemical speciation and concentration measurement., The calculation in Table 4-1 is also applicable for concentrations measured in this manner (except that the response factor is set equal to 1).

The oxygen concentration is also measured to determine the total gas flow rate through the tent. However, oxygen concentration is also used to rate the quality of the tent, and except for a few extremely difficult situations, VOC

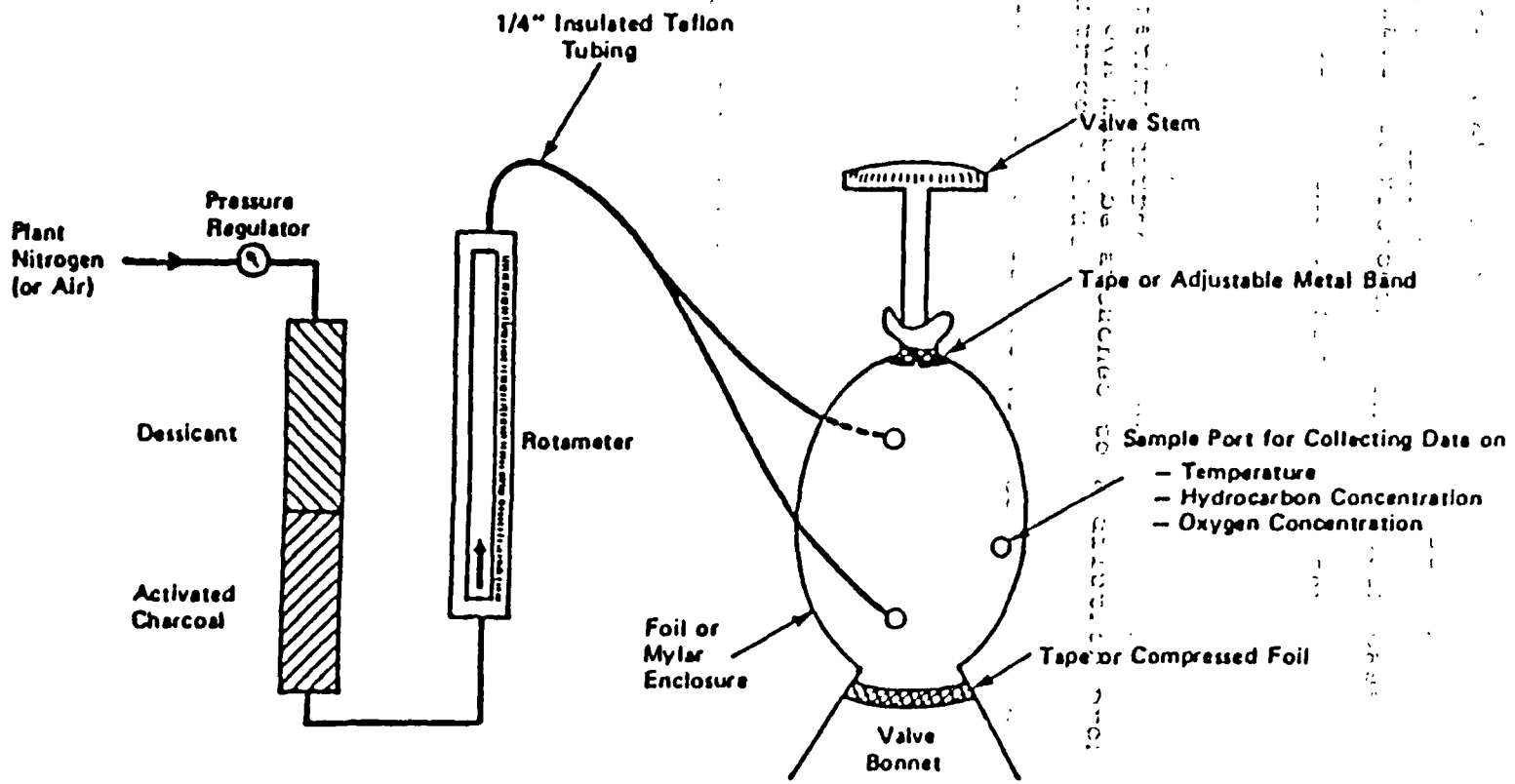

Figure 4-3. Equipment required for the blow-through sampling technique.

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concentrations are not measured until the oxygen concentration in the tent is reduced below 5%.

Air can replace nitrogen as a dilution gas if the hydrocarbon concentration is not expected to be high enough to cause an explosive atmosphere inside the tent. However, calculations based on air tent data must assume a nominal tent leakage rate, i.e., extra flow through the tent due to air entering the tent that is not metered through the tubing.

Safety has been a key factor in the development of this procedure. Over 400 valves have been tented with this technique without incident. Nitrogen is used as a dilution gas instead of air to prevent an explosive atmosphere within the tent. All of the instruments used are battery-operated and approved for Class I, Division I use. In summary, the blow-through method consists of the following steps:

- Interview the unit operator to determine the composition of the material in the designated equipment component (in weight or volume %), and the operating conditions of the pump.

- Screen the component by placing a Tygon nozzle on the end of the Foxboro/Century OVA (Organic Vapor Analyzer), holding the end of the nozzle within 1 centimeter of the leak interface, and recording the highest concentration seen on the OVA readout.

  The procedures for valves is the same; however, the analyzer does not need to be 1 cm away from the valve.

- Cut a tent from appropriate material (see section 4.3 - Source Enclosure) that will easily fit over the equipment component

- Connect tubing from the nearest low pressure nitrogen station to a rotameter stand, which includes a regulator, dessicant, activated charcoal, and a rotameter in series.

- Run tubing from the rotameter outlet to a "Y" that splits the nitrogen flow into two pieces of tubing. Insert the tubes into openings located on either side of the tent.

- Turn on nitrogen at the utilities station and regulate it at the rotameter to approximately 40 liters/minute.

- After the nitrogen is flowing, wrap aluminum foil around those parts of the equipment component where air could enter the tent-enclosed volume.

- Use duct tape, wire, and/or rope to secure the tent to the component.

- Put a third hole in the tent roughly equidistant from the two nitrogen-fed holes.

- Measure the oxygen concentration in the tent by inserting the lead from an O_2 meter into the third hole. Adjust the tent (add additional tape, foil, rope, etc.) until the O_2 concentration is less than 5%.

- Measure the temperature in the tent with a platinum-RTD thermocouple.

A thermometer may also be used.

- Calibrate the OVA to methane or hexane at a known concentration in nitrogen using the OVA dilution probe. Remember to correct for the dilution before inserting the OVA concentration reading into the calculation in Table 4-1.

- Check the VOC concentration at several points in the tent with the OVA to insure that the tent contents are at steady state.

- Measure the hydrocarbon VOC concentration in the tent with the OVA at three different nitrogen flow rates. Typically the flow rates will be 40, 30 and 20 liters/minute if there is no OVA response at the higher rates (i.e., the mass leak rate from the valve is very low). After each adjustment of the nitrogen flow, check the O_2 concentration to ensure it stays below 5%. Alternatively, collect samples in Tedlar or aluminized sample bags by drawing sample out of the bag with a portable sampling pump.

- Remove the tent and any plugs from the component and collect any condensate on the inside of the tent in a plastic graduated cylinder. Record the amount collected and the elapsed time the tent was on the component.

- If there is liquid dripping from the component, collect the drips for a timed period which produces enough collected material for accurate volume measurement. Record the amount in the report, but do not add it to the vapor leak rate.

FIGURE J-2

FUGITIVE VOC EMISSION CONTROL

CALCULATION PROCEDURES

(a) Screening Concentration

screening (vppm) concentration = (drift)(dilution)(OVA)

$$\text{drift} = \left(\frac{CA}{BE} + \frac{CA}{AF}\right)/2$$

where: CA = calibration gas concentration in vppm
BE = OVA response to calibration gas before screening in vppm
AF = OVA response to calibration gas after screening in vppm

$$\text{dilution} = \left(\frac{CA}{OB} + \frac{CA}{OA}\right)/2$$

where: CA = calibration gas concentration in vppm
OB = OVA response to calibration gas using dilution probe before screening in vppm
OA = OVA response to calibration gas using dilution probe after screening in vppm

OVA = highest instrument reading at the valve surface minus background reading, in vppm

(b) Tented Leak Rate

$$\text{Tent Rate (pounds/hour)} = \frac{4.836 \times 10^{-5}(Q)(MW)(OVA)(RF)}{T + 460}$$

where: Q = flow rate into tent in cubic meters/hour

$$= \frac{N_2 \text{ flow rate in liters/minute}}{1 - \left(\frac{\text{tent oxygen concentration in \%}}{21}\right)} \left[0.06 \frac{m^3\text{-minute}}{\text{liter-hour}}\right]$$

MW = molecular weight of gas in pounds/pound-mole
T = temperature in tent in °F
OVA = instrument reading minus background reading, in vppm
RF = response factor for leaking gas relative to calibration gas
4.836×10^{-5} = a conversion factor taking into account the gas constant and assuming a pressure in the tent of 1 atmosphere

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