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* OHIO BAR ONLY

May 11, 1981

Mr. John R. Lawrence
The Society of the Plastics
Industry, Inc.
355 Lexington Avenue
New York, New York 10017

Re: Employee Training Under OSHA Vinyl Chloride Standard

Dear John:

The purpose of this letter is to inform you of the recent completion of a case involving the employee training provisions of the Occupational Safety and Health Administration (OSHA) vinyl chloride standard. As you may recall, in September, 1978, an OSHA inspector issued a citation to Hooker Chemical Corporation. The citation noted Hooker's alleged failure to provide training on vinyl chloride for employees who worked in the calendering, compounding and warehouse areas.

Hooker contested the citation for its Burlington, New Jersey facility on the basis that employees working in these areas were not required to be trained on the hazards of vinyl chloride. Both Hooker and OSHA's monitoring of vinyl chloride in the calender and compound facilities indicated concentrations significantly below the 0.5 parts per million (ppm) action level.

20,003D

Activity: **ANALYSIS OF OSHA's DEVELOPMENT OF STANDARDS FROM 1974 TO THE PRESENT**

Scope: To gather, review and analyze regulations promulgated by OSHA since the VCM regulation. Primary emphasis will be to determine the evolutionary changes in philosophy concerning the exclusion of materials from the provision of the standards in instances when they contain low levels of regulated substances.

Responsibility: Safety, Product Responsibility

Status: Promulgated regulations have been gathered. Initial analysis demonstrates that for most regulated carcinogenic substances, an exemption level exists which excludes the application of the standard to residual levels below that level.

EXHIBIT VIII

BFG TECHNICAL DOCUMENT

A PHYSICAL MODEL FOR THE DIFFUSION OF VINYL CHLORIDE MONOMER FROM PVC UNDER VARIOUS CONDITIONS OF STORAGE

by
M. M. O'Mara
L. B. Crider
R. L. Bowles
C. J. Tomanek

B.F.Goodrich Chemical Company
Avon Lake Technical Center
P.O. Box 122
Avon Lake, Ohio 44012

August 25, 1975

Activity: **OPINIONS OF INDUSTRY TRADE ASSOCIATION COUNSEL AND BFG LAW DIVISION**

Scope: To ascertain whether legal counsel can recommend or approve of removal of the OSHA carcinogen label from PVC products and, if so, under what circumstances.

Status: We have received a written opinion from Keller and Heckman (Counsel for SPI) that under certain specified conditions, labeling would not be required. It also appears that the BFG Law Division concurs in that opinion.

Abstract

An empirical model, based on large scale laboratory experimental data, has been developed to show the relationship between the amount of residual vinyl chloride monomer (RVCM) in PVC resin and the concentration of atmospheric vinyl chloride monomer (AVCM) under various conditions of storage. The variables studies in the experimental work leading to the development of this model include temperature, time, ventilation rate, RVCM content of the resin, mass/volume ratio and resin type (varying in porosity).

The results obtained from a statistically designed series of 24 experiments show the interactions of all the variables and permit (1) the effects of the variables to be established and (2) the derivation of a model which permits the AVCM levels to be predicted for any combination of the variables.

The developed model has been used to predict the AVCM level in BFG warehouses at Avon Lake, Louisville and Pedricktown. We have found excellent agreement between predicted and measured AVCM levels at these three locations and under a variety of storage conditions.

Additionally, the model has been used to show that under less than the most severe storage conditions, the OSHA action level will not be exceeded (500 ppb AVCM) when the RVCM content of the stored resin does not exceed 18 ppm. Even under the most extreme storage conditions the OSHA action level is not exceeded when the RVCM content of the resin is 8.5 ppm or less.

Activity: **MODEL OF AVCM CONCENTRATION, PREDICTED FROM RVCM LEVELS IN PVC RESIN, IN TRANSPORTATION**

Scope: To model the transport of PVC resin under conditions which would result in the greatest possible AVCM concentrations.

To establish the RVCM concentration which will not result in the exposure of workers to VCM above the action level of 0.5 ppm averaged over an 8-hour workday.

Status: A significant amount of monitoring data are available from our Transportation Department. The data need to be gathered, reviewed, analyzed and supplemented, if necessary.
A report needs to be generated, based on the data, to reflect maximum RVCM concentration in resin which would support removal of the OSHA carcinogen label. Primary responsibility for this activity should rest with R&D.

Table of Contents

Activity: MODEL OF AVCM CONCENTRATION, PREDICTED FROM RVCM LEVELS IN PVC RESIN, IN THERMAL PROCESSING

Scope: To model the thermal processing of PVC resin under conditions which would result in the greatest possible AVCM concentrations.

To establish the RVCM concentration which will not result in the exposure of workers to VCM above the action level of 0.5 ppm averaged over an 8-hour workday.

Status. Although they will likely be of only marginal value, a significant amount of data are available concerning the monitoring of customer facilities during the period from 1974 to 1976. Furthermore, current BFG monitoring of process operations includes, not only the AVCM contribution from the thermal process being monitored, but also background AVCM contributed by our polymerization operations. A report needs to be generated to reflect maximum RVCM concentration in resin which would support removal of the OSHA carcinogen label.

List of Figures and Tables

I. Technical Objectives

Our major objective in this work was to develop a physical model for the diffusion of vinyl chloride monomer (VCM) from PVC resins and compounds under various conditions of exposure during storage and shipment. The critical variables included in the modeling study are:

(1) residence time

(2) temperature

(3) ventilation rate

(4) resin mass/storage volume ratio

(5) RVCM content of the resin or compound

(6) resin or compound type (varying in porosity)

The developed model should be based on a statistically significant number of large scale diffusion experiments so as to show the interaction of all the above variables and to allow the prediction of AVCM levels for any combination of the variables.

II. Introduction

At temperatures above the glass transition (Tg) point of PVC the solubility of vinyl chloride monomer (VCM) accurately follows Henry's law behavior for VCM contents up to 4000 ppm. This observation[1] has lead to a rapid, simple gas chromatographic method for the determination of VCM in PVC from an analysis of the vapor phase (head space) over PVC powders in a closed container. The time required for equilibration between the vapor and PVC phases can be estimated based on recently reported diffusion data[2].

III. Statistically Designed Experiments

Using COED (a time-share Computer Optimized Experimental Design program), 24 experiments were selected (see Table I) to study the variables listed below in an efficient manner and at the same time to describe their effects and interactions on AVCM as accurately as possible. The variables and the ranges over which they were studied were:

(1) Temperature - 74 - 115°F

(2) Ventilation Rate - 0.5 - 3.0 Turnovers/Hour

(3) Loading (PVC Volume/Storage Volume) - 11 - 34%

(4) Resin RVCM - .01 - 123 ppm

(5) Resin Type - 102EP F-5; 103EP F-76; 103EP; 110X334

(6) Dispersant Type - old technology; new technology

(7) Time - 1 - 170 Hours

IV. Experimental

(A) Description of Model

In order to meet the demands of the statistically designed (COED) diffusion study, the experimental phase of this program had to be capable of controlling the following experimental parameters:

(1) temperature

(2) ventilation rate

(3) mass/volume ratio

The basic physical model that was chosen to meet these requirements was one based on sealed metal storage bins (55-gallon drums) housed in an environmental

chamber where the temperature could be varied and controlled. A schematic of the entire experiment is shown in Figure 1. The schematic is divided into four key areas (A - D) which reflect the methods of ventilation, the sampling system and the analytical methodology. These four areas are described in Table II. Basically, the system was constructed in the following manner. Clean, dry nitrogen (A) enters the environmental chamber (B) through a split manifold. The ten drums were piped into the two manifolds through ten flow regulators. In this way, ventilation rates could be independently set in each drum. The exhausted atmosphere from the drums was directed to a sampling system (C) that provided a split stream; one for vent and one for sampling. The sampling stream was interfaced to a gas sampling value/gas chromatograph/ data handling system (D). Sequential sampling of each of the drums was possible with this system. The environmental chamber is a Conrad Model WD-624 Temperature Humidity Chamber with an internal volume of 938 cubic feet.* Temperature control inside the chamber was ± 2°C; a maximum exposure temperature of 100°C is possible within the chamber. Photographs of the entire experimental system are shown in Figures 2 - 5.

(B) Analytical Methodology

In order to analyze atmospheric vinyl chloride monomer (AVCM), a flame ionization gas chromatograph was interfaced to the sampling system through a gas sampling valve. To avoid human error in data calculations, a dedicated data handling system was interfaced to the gas chromatograph. Experimental specifics relative to these two systems are contained in Table III.

*Conrad Inc.; 141 Jefferson Street; Holland, Michigan.

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Table II

Basic Description of Physical Model
(Refer to Figure 1)

Section	Description
A	inlet nitrogen purge gas; maximum flow ~ 20 liters/minute
B	environmental chamber containing ten air-tight 55-gallon metal drums
C	55-gallon drum sampling system
D	flame-ionization gas chromatograph/data handling system

GENERAL LABELING REQUIREMENTS & EXCEPTIONS

Export shipments of PVC resins or compounds will not normally be made if the product contains more than 10 ppm Residual Vinyl Chloride Monomer (RVCM). Packaged Geon resins and compounds meeting the above requirements and prepared for export shipment shall not be labeled. Materials containing higher RVCM levels than stated above can be shipped export only on the approval of the Administrative Director, International Department, each container of these materials, although approved as stated above, must then be labeled with the required OSHA statement. Pallet loads, not requiring the OSHA labels, will be stenciled "For Export" on all four (4) sides of the top and bottom corrugated trays. If an export overwrap (Package Code 7 and 14) is required, stencil the words "For Export" on all four sides of the overwrap in the upper righthand corner. When individual bags are shipped, stencil the words "For Export" on each bag. Do not label or tag "Export" shipments of Geon latex packaged in drums. Stencil the words "For Export" on the side-wall of the drum near the top.

All products marked "For Export" shall be stored in segregated areas of warehouses. Appropriate signs must be placed in these areas indicating that the material has been prepared for export; the signs must also display the OSHA warning label.

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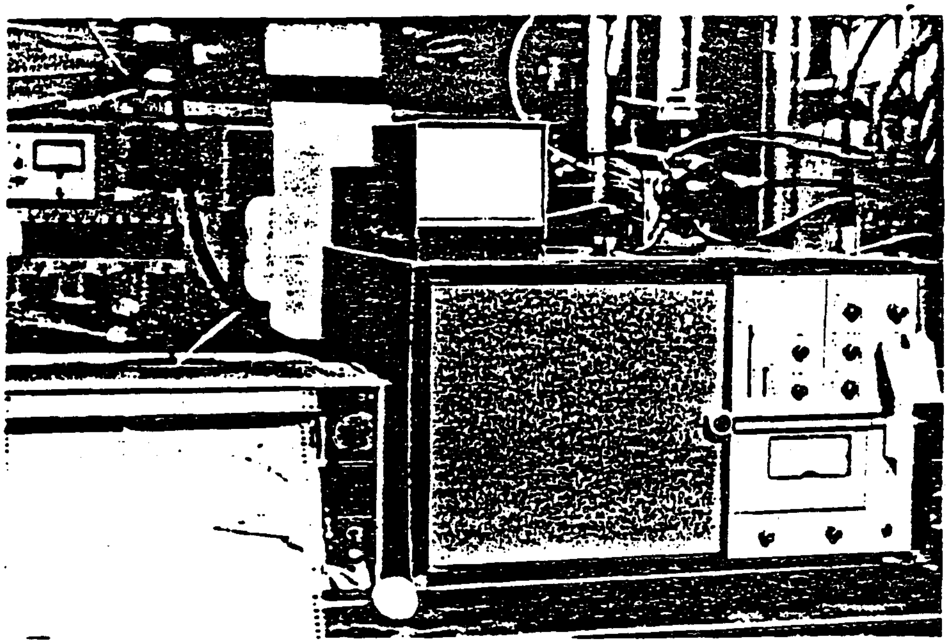

Figure 4

D - Gas Chromatograph with Sampling Loop

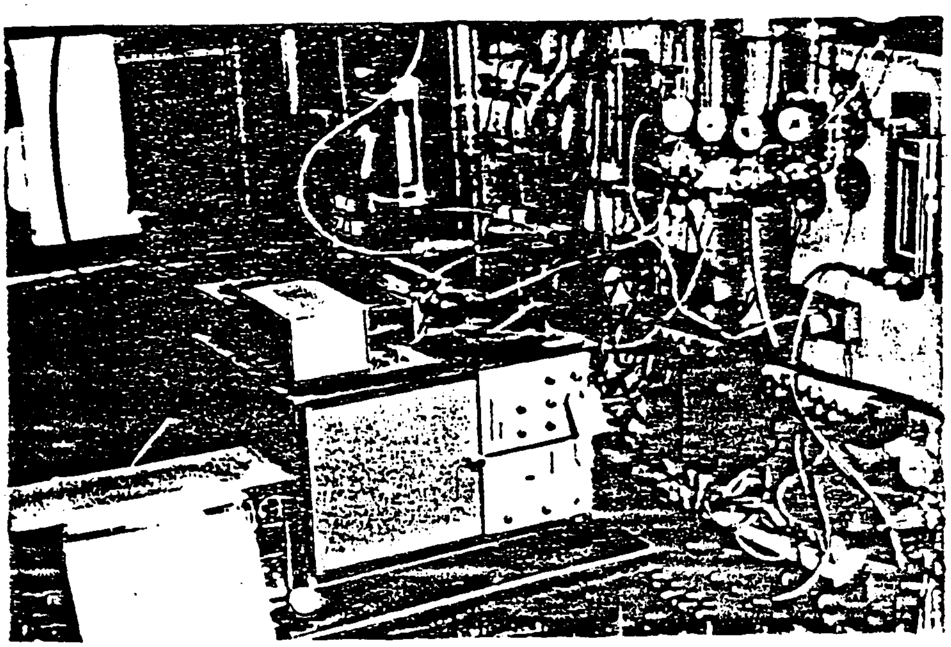

Figure 5

C

D Gas Chromatograph with Sampling System

The following "exception" products <u>should</u> be labeled:

1. All dispersion resins above (1) ppm will be considered as in grade 6. Any of th se mat ials over one (1) ppm shipped domestically from our pla ts must have the normal Marketing and Distribution approvals for this grade prior to shipment.
2. Hycar Acrylic Latex 2600X189 & 2600X228 should be labeled according to procedure covering Geon latexes. These are the only Hycar latexes that will require the OSHA label.
3. The following products have been classified as Flexible Geon Compounds and should be labeled: 8880-021, 8880-288 and 8878-288.

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Calibration of the system was accomplished through the use of commercially available standards (Precision Gas Sampling Corporation) and dynamic dilution of those standards. A typical calibration (checked periodically) and a regression analysis of that data is summarized in Table IV. This analysis indicates good linearity over the range from 128 - 2000 ppb of VCM in the atmosphere. The slope from the linear regression analysis was used as input to the integrator/calculator in order to calculate all data. It is important to note that as the sampling proceeded to a range outside of the calibration range shown in Table IV, new calibrations were carried out to reflect these different ranges. At no time was a calibration extrapolated beyond the experimentally determined range and used as a basis for analysis.

(C) Theoretical Diffusion of VCM in the Physical Model

It was necessary to check out the performance of the system in terms of theoretical diffusion. The main reason for doing this was to provide a final and independent check of the model, the sampling system and the analytical system interacting together. It was further felt that this approach would lead to a definition of any VCM system absorption (or leakage) problems. The *ab initio* derivation of the mathematical model which describes the build-up of a gas in a dynamic system is described below.

if:

C_o = concentration of incoming air stream
C_t = concentration in drum at any time (t)
V = volume of drum
M = flow into and out of drum
t = minutes

GEON LATEX TANK TRUCK

All tank trucks containing Geon latexes shall be tagged with a single trip service tag (approximately 3" X 5") (BFG 16590A). These tags shall state:

POLYVINYL CHLORIDE
CONTAINS
VINYL CHLORIDE
VINYL CHLORIDE IS
A CANCER-SUSPECT AGENT

The required statement is in 3/8" high letters. The tags are off-white with black lettering. The OSHA statement shall be printed on both sides of the tag. Tags are supplied with eyelets and wire ties attached.

One tag shall be tied to each loading hatch and to the end of each discharge outlet.

Requirements for these tags (BFG 16590A) can be reordered by using a Forms Requisition. This requisition should be sent to the attention of the Cleveland Forms Group.

GEON RESINS AND COMPOUNDS IN BAGS

It is necessary to label (or stamp) each bag, prior to filling or shipment (in the case of filled bags), containing designated products. The following label (or stamp) will be used on each bag:

POLYVINYL CHLORIDE
CONTAINS
VINYL CHLORIDE
VINYL CHLORIDE IS
A CANCER-SUSPECT AGENT

The OSHA statement is in 1/4" high letters. All label printing is in BFG red on kraft colored pressure sensitive label stock. Any packages shipped individually, as non-unitized loads, must have one of the above specified labels affixed to each individual container. Hand stamps, containing the required OSHA statement in 1/4" high letters, have been supplied to the PVC producing plants by the Warehousing & Packaging group. Hand stamping ink will be black. These hand stamps may be used as an alternate to labels. Stamping should be done, in a clear area, on the bottom end of each bag where the product and lot identification is located.

Requirements of labels (BFG 16591A) can be reordered by using a Forms Requisition. This requisition should be sent to the attention of the Cleveland Forms Group.

Summary of All VCM Diffusion Experiments

Experiment No.	Resin Type	RVC (pp	Total Exposure Time (hrs.)	Ventilation Rate (t.o./hr.)	Resin Mass/Storage Volume (lbs./ft.^{3})	Maximum AVCM (ppm) and Time (hrs.)
Temperature: 23°C						
1	B	0.	8	0.5	30	.075, 2.5
2	A*	0.	5	0.5	30	.076, 3.0
3	B*	0.	4	3.0	90	.015, 2.5
4	C	0.	6.5	1.5	90	.167, 0.5
5	D	<1.	6.0	3.0	90	.051, 4.0
Temperature: 44°C						
6	A	0.	27	0.5	30	.579, 16.5
7	B	0.	12	1.5	30	<.04, -
8	C	0.	23	3.0	30	.763, 0.5
9	B*	0.	13	1.5	90	<.04, -
10	A*	0.	13	1.5	90	<.04, -
11	A	0.	26	0.5	30	.565, 16,0
Temperature: 32°C						
12	B	0.	44	.5	90	.375, 8.5
13	C	0.	44.5	.5	90	.934, 1.5
14	D	0.	44.5	.5	90	.258, 0.3
Temperature: 98°F						
15	A*	25.	173	0.5	50	209, .75
16	A*	28.	173	1.5	50	98, .75
17	A*	46.	173	0.5	67.5	384, 1.0
Temperature: 115°F						
18	A*	110	170	0.5	50	526, 3.0
19	A*	101	170	1.5	50	272, 1.0
20	A*	123	170	0.5	90	523, 3.0

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GEON RESINS AND COMPOUNDS IN (CT-200) BULK BOXES

One label (BFG 16591A) should be placed on each large side panel (2 labels/box) to the left of the Geon Vinyls logo on specified Geon products. The following label is to be applied to these boxes:

POLYVINYL CHLORIDE
CONTAINS
VINYL CHLORIDE
VINYL CHLORIDE IS
A CANCER-SUSPECT AGENT

The OSHA statement is in 1/4" high letters. All printing is in BFG red on kraft colored, pressure sensitive label stock.

Requirements for form BFG 16591A can be reordered by using a Forms Requisition. This requisition should be sent to the attention of the Cleveland Forms Group.

(5) storage time increases

(6) higher porosity resin is used. This latter effect is significant only at early aging times (1 - 24 hours).

Using the relationships described in the model, maximum RVCM resin levels can be determined which will assure that AVCM levels will be less than 500 ppb for a variety of storage conditions. (See Figures 8 - 12 which show the effects of temperature, time, ventilation rate, loading and RVCM on AVCM.)

Assuming that 99% of the storage conditions are better than the adverse conditions [Temperature = 86°F, Ventilation = 0.6 turnovers/hour, % volume of VCl containing material in the warehouse = 30%], the RVCM of PVC resin must be no greater than 18 ppm to assure that the action level is not exceeded.

If compound is stored rather than resin; the RVCM of the resin going into the compound can safely be 50 ppm. This applies to the following compounds: flexible, rigid cubes, and rigid powder.

If the 500 ppb AVCM action level must be met even under the most adverse storage conditions [Temperature = 105°F, Ventilation = 0.6 turnovers/hour, 35% loading of a warehouse volume with VCl containing material], then the resin RVCM must be no higher than 8.5 ppm. Resin going into compound can still be 50 ppm.

Figure 13 shows how well the model predicts the warehouse samples obtained in April, 1975 at Avon Lake, Louisville and Pedricktown. As the

MISCELLANEOUS PACKAGES & SAMPLES

We occasionally package small volumes of Geon resins, or compounds in special bags, boxes, fibre drums, etc. These containers frequently contain no Company identification. Each of these packages must be labeled:

POLYVINYL CHLORIDE
CONTAINS
VINYL CHLORIDE
VINYL CHLORIDE IS
A CANCER-SUSPECT AGENT

The required OSHA statement is in 1/4" high letters. This pressure sensitive label will normally be in BFG red (BFG 16591A) on kraft colored label stock; a kraft colored label with BFG blue printing (BFG 16592A) may be used if the prime container Company identification is blue.

A label shall be nearly applied to each container.

These labels can be reordered by using a Forms Requisition. This requisition should be sent to the attention of the Cleveland Forms Group.

PVC resins, compounds and latexes are frequently distributed in sample (less than standard package) quantities. The inside containers must also be marked to comply with OSHA regulations. If containers are large enough, labels as specified above, should be used. For small sample containers attach a tag (BFG 16590A) as specified under the "Geon Latex Tank Trucks,"

Figure 9.

AVCM vs. RVCM and VENTILATION

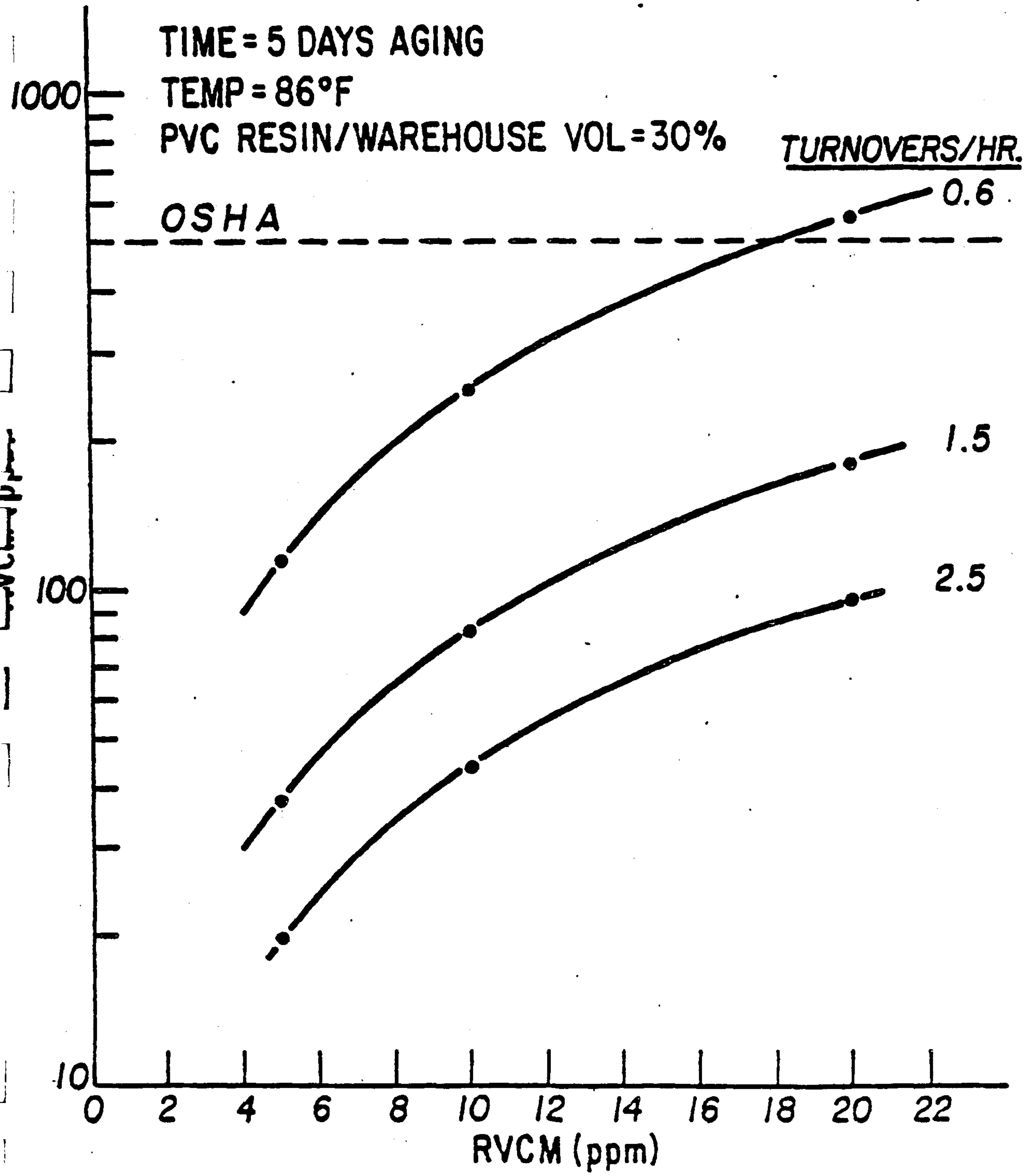
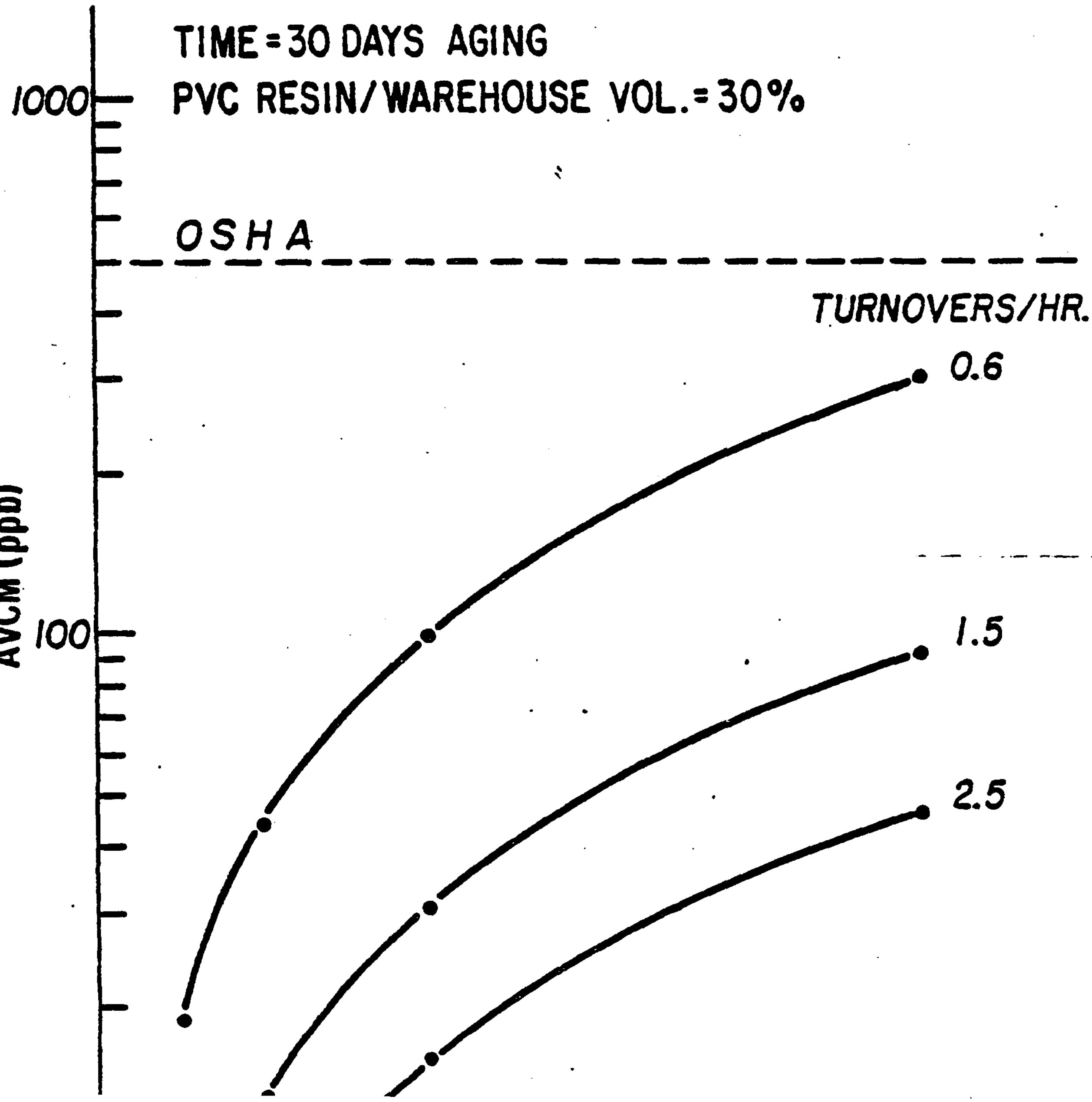


Figure 11.

AVCM vs. RVCM and VENTILATION



BFG TECHNICAL DOCUMENT

Statistics
and Computer

Author	Location	Date	Log Book Ref.
M.J.AHMED-H.S.HALLER	ALTC	4/12/83	
Requested by	Location	Project No	Group File No
[redacted]	CLEVELAND		

INTRODUCTION:

Since vinyl chloride monomer (or VCM) was determined a carcinogen BFGoodrich has successfully reduced the residual vinyl chloride monomer (or RVCM) content of its resins and compounds. Despite this dramatic decrease in RVCM, BFGoodrich has continued to put carcinogen labels on certain PVC products. However, better technical criteria need to be established for carcinogen labeling of PVC compounds and resins. To develop such criteria requires the determination of a relationship between RVCM in the PVC and the ambient VCM (or AVCM) during warehousing, storage and thermal processing of PVC. This report presents the data and relationship between resin RVCM and AVCM during transportation of PVC.

OBJECTIVES:

1. To collect relevant existing data on the transportation of PVC,

2. To simulate transportation of PVC under conditions which yield maximum AVCM concentrations,

and, hence,

3. Establish RVCM content of resins which yield AVCM concentration of ≤.5 ppm averaged over an 8-hour period.

CONCLUSION:

Using the herein derived minimum air turn-over rate of 3 per hour it can be seen from Fig. 1 that providing resin RVCM is ≤ 10 ppm the AVCM action level concentration of .5 ppm will not be exceeded.

Z-1, Z-2, or Z-3 for the material involved.

(ii) To illustrate the formula prescribed in subdivision (i) of this subparagraph, note that isoamyl acetate has an 8-hour time weighted average limit of 100 p.p.m. (table Z-1). Assume that an employee is subject to the following exposure:

Two hours exposure at 150 p.p.m.
Two hours exposure at 75 p.p.m.
Four hours exposure at 50 p.p.m.

Substituting this information in the formula, we have

$$\frac{2\times 150+2\times 75+4\times 50}{8}=81.25 \text{ p.p.m.}$$

Since 81.25 p.p.m. is less than 100 p.p.m., the 8-hour time weighted average limit, the exposure is acceptable.

(2) (i) In case of a mixture of air contaminants an employer shall compute the equivalent exposure as follows:

$$E_m=\frac{C_1}{L_1}+\frac{C_2}{L_2}+\ldots\frac{C_n}{L_n}$$

Where:

E_m is the equivalent exposure for the mixture.

C is the concentration of a particular contaminant.

L is the exposure limit for that contaminant, from table Z-1, Z-1, or Z-3.

The value of E_m shall not exceed unity (1).

(ii) To illustrate the formula prescribed in subdivision (i) of this subparagraph, consider the following exposures:

Material	Actual concentration of 8-hour exposure	8-hour time weighted average exposure limit
Acetone (Table Z-1)	500 p.p.m.	1,000 p.p.m.
2-Butanone (Table Z-1)	45 p.p.m.	200 p.p.m.
Toluene (Table Z-2)	40 p.p.m.	200 p.p.m.

Substituting in the formula, we have:

$$E_m=\frac{500}{1{,}000}+\frac{45}{200}+\frac{40}{200}$$

$$E_m=0.500+0.225+0.200$$

$$E_m=0.925$$

Since E_m is less than unity (1), the exposure combination is within acceptable limits.

(e) To achieve compliance with paragraph (a) through (d) of this section, administrative or engineering controls must first be determined and implemented whenever feasible. When such controls are not feasible to achieve full compliance, protective equipment or any other protective measures shall be used to keep the exposure of employees to air contaminants within the limits prescribed in this section. Any equipment and/or technical measures used for this purpose must be approved for each particular use by a competent industrial hygienist or other technically qualified person. Whenever respirators are used, their use shall comply with § 1910.134.

Table Z-1-

Substance	p.p.m.*	mg./M³ *
Acetaldehyde	200	360
Acetic acid	10	25
Acetic anhydride	5	20
Acetone	1,000	2,400
Acetonitrile	40	70
Acetylene dichloride, see 1,2-Dichloroethylene		
Acetylene tetrabromide	1	14
Acrolein	0.1	0.25
Acrylamide—Skin		0.3
Aldrin—Skin		0.25
Allyl alcohol—Skin	2	5
Allyl chloride	1	3
C Allylglycidyl ether (AGE)	10	45
Allylpropyl disulfide	2	12
2-Aminoethanol, see Ethanolamine		
2-Aminopyridine	0.5	2
Ammonia	50	35
Ammonium sulfamate (Ammate)		15
n-Amyl acetate	100	525
sec-Amyl acetate	125	650
Aniline—Skin	5	19
Anisidine (o, p-isomers)—Skin		0.5
Antimony and compounds (as Sb)		0.5
ANTU (alpha naphthyl thiourea)		0.3
(Organic) Arsenic compounds (as As)		0.5
Arsine	0.05	0.2
Azinphos-methyl—Skin		0.2
Barium (soluble compounds)		0.5
p-Benzoquinone, see Quinone		
Benzoyl peroxide		5
Benzyl chloride	1	5
Biphenyl, see Diphenyl		
Boron oxide		15
C Boron trifluoride	1	3
Bromine	0.1	0.7
Bromoform—Skin	0.5	5
Butadiene (1,3-butadiene)	1,000	2,200
Butanethiol, see Butyl mercaptan		
2-Butanone	200	590
2-Butoxy ethanol (Butyl Cellosolve)—Skin	50	240
Butyl acetate (n-butyl acetate)	150	710
sec-Butyl acetate	200	950
tert-Butyl acetate	200	950
Butyl alcohol	100	300
sec-Butyl alcohol	150	450
tert-Butyl alcohol	100	300
C Butylamine—Skin	5	15
C tert-Butyl chromate (as CrO_3)—Skin		0.1
n-Butyl glycidyl ether (BGE)	50	270
Butyl mercaptan	10	35
p-tert-Butyltoluene	10	60
Calcium arsenate		1
Calcium oxide		5
Camphor		2
Carbaryl (Sevin ®)		5
Carbon black		3.5
Carbon dioxide	5,000	9,000
Carbon monoxide	50	55
Chlordane—Skin		0.5
Chlorinated camphene—Skin		0.5
Chlorinated diphenyl oxide		0.5
C Chlorine	1	3
Chlorine dioxide	0.1	0.3
C Chlorine trifluoride	0.1	0.4
C Chloroacetaldehyde	1	3
α-Chloroacetophenone (phenacylchloride)	0.05	0.3
Chlorobenzene (monochlorobenzene)	75	350
o-Chlorobenzylidene malononitrile (OCBM)	0.05	0.4
Chlorobromomethane	200	1,050
2-Chloro-1,3-butadiene, see Chloroprene		
Chlorodiphenyl (42 percent Chlorine)—Skin		1
Chlorodiphenyl (54 percent Chlorine)—Skin		0.5
1-Chloro,2,3-epoxypropane, see Epichlorhydrin		
2-Chloroethanol, see Ethylene chlorohydrin		
Chloroethylene, see Vinyl chloride		
C Chloroform (trichloromethane)		240
1-Chloro-1-nitropropane	20	100
Chloropicrin	0.1	0.7
Chloroprene (2-chloro-1,3-butadiene)—Skin	25	90

Table Z-1-Continued

Substance	p.p.m.*	mg./M³ *
Chromium, sol. chromic, chromous salts as Cr		0.5
Metal and insol. salts		1
Coal tar pitch volatiles (benzene soluble fraction) anthracene, BaP, phenanthrene, acridine, chrysene, pyrene		0.2
Cobalt, metal fume and dust		0.1
Copper fume		0.1
Dusts and Mists		1
Cotton dust (raw)		1*
Crag® herbicide		15
Cresol (all isomers)—Skin	5	22
Crotonaldehyde	2	6
Cumene—Skin	50	245
Cyanide (as CN)—Skin		5
Cyclohexane	300	1,050
Cyclohexanol	50	200
Cyclohexanone	50	200
Cyclohexene	300	1,015
Cyclopentadiene	75	200
2,4-D		10
DDT—Skin		1
DDVP—Skin		1
Decaborane—Skin	0.05	0.3
Demeton®—Skin		0.1
Diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)	50	240
1,2-diaminoethane, see Ethylenediamine		
Diazomethane	0.2	0.4
Diborane	0.1	0.1
Dibutyl phosphate	1	5
Dibutylphthalate		5
C o-Dichlorobenzene	50	300
p-Dichlorobenzene	75	450
Dichlorodifluoromethane	1,000	4,950
1,3-Dichloro-5,5-dimethyl hydantoin		0.2
1,1-Dichloroethane	100	400
1,2-Dichloroethylene	200	790
C Dichloroethyl ether—Skin	15	90
Dichloromethane, see Methylenechloride		
Dichloromonofluoromethane	1,000	4,200
C 1,1-Dichloro-1-nitroethane	10	60
1,2-Dichloropropane, see Propylenedichloride		
Dichlorotetrafluoroethane	1,000	7,000
Dieldrin—Skin		0.25
Diethylamine	25	75
Diethylamino ethanol—Skin	10	50
Diethylether, see Ethyl ether		
Difluorodibromomethane	100	860
C Diglycidyl ether (DGE)	0.5	2.8
Dihydroxybenzene, see Hydroquinone		
Diisobutyl ketone	50	290
Diisopropylamine—Skin	5	20
Dimethoxymethane, see Methylal		
Dimethyl acetamide—Skin	10	35
Dimethylamine	10	18
Dimethylaminobenzene, see Xylidene		
Dimethylaniline (N-dimethylaniline)—Skin	5	25
Dimethylbenzene, see Xylene		
Dimethyl 1,2-dibromo-2,2-dichloroethyl phosphate (Dibrom)		3
Dimethylformamide—Skin	10	30
2,6-Dimethylheptanone, see Diisobutyl ketone		
1,1-Dimethylhydrazine—Skin	0.5	1
Dimethylphthalate		5
Dimethylsulfate—Skin	1	5
Dinitrobenzene (all isomers)—Skin		1
Dinitro-o-cresol—Skin		0.2
Dinitrotoluene—Skin		1.5
Dioxane (Diethylene dioxide)—Skin	100	360
Diphenyl	0.2	1
Diphenylmethane diisocyanate (see Methylene bisphenyl isocyanate (MDI))		
Dipropylene glycol methyl ether—Skin	100	600
Di-sec, octyl phthalate (Di-2-ethylhexylphthalate)		5
Endrin—Skin		0.1
Epichlorhydrin—Skin	5	19
EPN—Skin		0.5
1,2-Epoxypropane, see Propyleneoxide		
2,3-Epoxy-1-propanol, see Glycidol		

See footnotes at end of table.

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2. Analysis of Model Variables (Cont'd)

2.3 Truck loading (L)

Equation 1 shows that, as might be expected, increased truck loading produces higher concentrations of AVCM. In discussions with transportation experts the assumption was made that 80% loading is the maximum that could be expected. In this study, therefore, the truck loading was set at 80%.

2.4 Ventilation rate (V)

Ventilation rate as measured by air turn-over/hour cannot be readily ascertained for a truck since it is dependent on numerous factors e.g. truck's material of construction, design of truck, speed at which truck is traveling, and climatic conditions. However, an effective air turn-over rate can be calculated from Equation 1 if actual AVCM data measured inside the truck were available. Kruszynski[2,3] and Smith[4] have reported the AVCM concentrations inside the nose of a trailer immediately upon opening the doors, as well as immediately after a trailer has been unloaded. As can be seen from Table 1 AVCM concentrations did not exceed the action level limit for those cases where the samples were taken upon opening the doors. However, data where bag was broken and resin exposed did exceed the limit. Since this is the highest AVCM concentration reported, it was used in calculating the effective air turn-over rate. As shown in Appendix 1 the minimum effective air turn-over rate is approximately 6/hour. However, to ensure greater safety margin simulations were carried out using 3 air turnovers/hour.

3. Discussion of Results

With the variables fixed at levels given in Section 2 , Equation 1 can be solved to predict the resin residual VCM (RVCM) which would produce AVCM concentration below the action level limit of .5 ppm. However, one of the variables, the transportation time, cannot be ascribed a definitive value, and a range of values (4-72 hours) were assumed. Fig. 1 shows the relationship between the resin RVCM and the AVCM concentration inside a truck at 4, 24 and 72 hours. As can be seen from Fig. 1 the AVCM concentrations do not exceed the action limit of .5 ppm provided the resin RVCM content is below 10 ppm. It should be emphasized that Fig. 1 has been predicted using conditions which deliberately maximize the AVCM concentrations inside a trailer transporting PVC resins.

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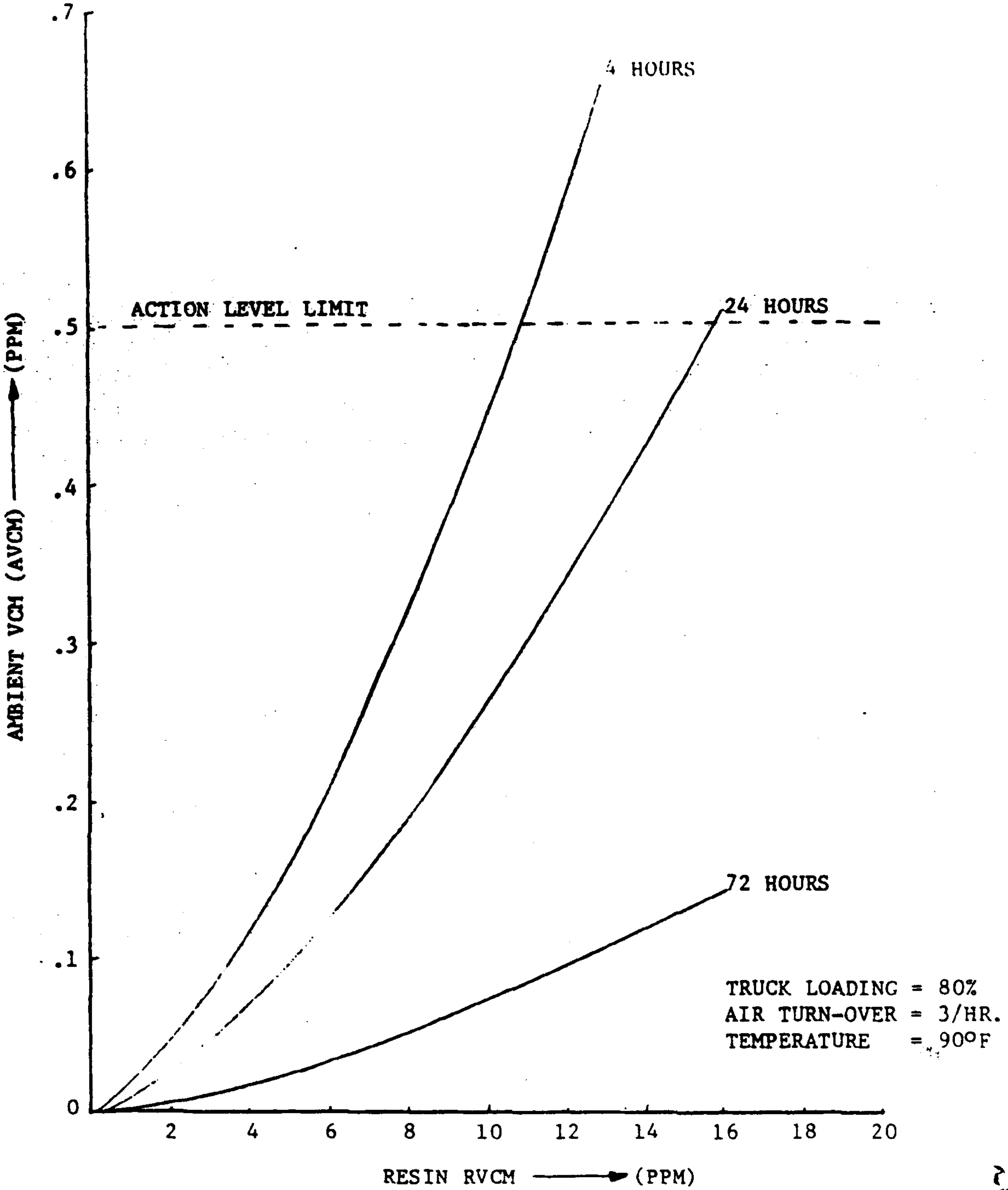

FIG. 1: RELATIONSHIP BETWEEN RESIN RVCM AND THE AVCM CONCENTRATIONS INSIDE A TRUCK AS PREDICTED BY O'MARA ET AL MODEL[1].

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(1) O'Mara, M. M. et al, Journal of Vinyl Tech. Vol. 1, 3, page 168 (1979).

(2) Kruszynski, R. J., BFG IOC, Dept. 5401, 7/8/75.

(3) Ibid, BFG Customer Service Report, Proj. No. 3689, 12/20/74.

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(5) Ahmed, M. J., Haller, H. S., BFG Technical Document, 3/31/83.

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SUBJECT - MODELING OF VCM CONCENTRATIONS DURING THERMAL PROCESSING OF PVC

INTRODUCTION:

Since vinyl chloride monomer (or VCM) was determined a carcinogen BFGoodrich has successfully reduced the residual vinyl chloride monomer (or RVCM) content of its resins and compounds. Despite this dramatic decrease in RVCM, BFGoodrich has continued to put carcinogen labels on certain PVC products. However, better technical criteria need to be established for carcinogen labeling of PVC compounds and resins. To develop such criteria requires the determination of a relationship between RVCM in the PVC and the ambient VCM (or AVCM) during warehousing, storage and thermal processing of PVC. This report presents the data and relationship between resin RVCM and AVCM during a thermal processing operation of PVC.

OBJECTIVES:

1. To collect relevant existing data on the thermal processing of PVC,

2. To model a thermal processing operation under conditions which yield maximum AVCM concentrations,

and, hence,

3. Establish RVCM content of resins which yield AVCM concentration of $\leqslant$ .5 ppm averaged over an 8-hour period.

CONCLUSION:

Using the herein derived minimum air turn-over rate of 5 per hour it can be seen from Fig. 2 that providing resin RVCM is $\leqslant$ 32 ppm the AVCM action level concentration of .5 ppm will not be exceeded.

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1. MODEL DEVELOPMENT (Cont'd)

However, the density of VCM changes with the inside temp. T. Using the ideal gas law the VCM density is given by

$$\rho_{VCM} = PM/RT, \qquad \text{----- (5)}$$

where P is the pressure (= 1 Atm),
R is the gas constant (= .7302),
T is ^{o}R,
M is the molecular weight of VCM (≈ 62.5).

Substituting equations 4,5 into (3) gives the volume of VCM inside a building, i.e.

$$V_T = 8(RVCM \times 10^{-6}) fW_{PVC} \times RT/M \qquad \text{----- (6)}$$

Let V_a be the volume of the air inside the building. (= volume of building V)

If the number of air turn-overs inside the building is N_T/hour then the total volume of air over an 8 hour period is given by

$$V_{aT} = 8VN_T \qquad \text{----- (7)}$$

Substituting (6), (7) into (1) $\Longrightarrow$ $AVCM = \dfrac{8(R_{VCM} \times 10^{-6})\ fW_{PVC} * RT}{8N_TV \quad 62.5}$

On ppm basis this becomes,

$$AVCM = (R_{VCM})(W_{PVC}) fRT/(N_TV \quad 62.5). \qquad \text{----- (8)}$$

To solve equation (8) requires quantification of each of the variables. This is discussed in the next section.

2. ANALYSIS OF MODEL VARIABLES

2.1 PVC Processing Rate (W_{PVC})

Since PVC processing rate is related to the volume of building (V_a) the two variables have to be quantified with respect to one another. In accordance with the philosophy of ensuring highest levels of VCM in the air and, hence, greater safety margin the approach taken in this study was to maximize PVC rate and minimize building volume. After consulting with thermal processing experts (J. Summers and G. Small) the building dimensions were assumed to be 25X40X100 ft. and PVC processing rate of 2000 #/Hr. This is equivalent to continuous running of almost 3 extruders over an 8 hour period in a small building.

2.2 Ambient Temperature

Inspection of Equation (8) shows that to maximize AVCM concentrations inside the building the ambient temperature needs to be maximized. Although the ambient temperature will depnd on the geographical location, type of building etc., it is safe to assume that temperature will have to be tolerable. Allowing for each of these factors 90^{o}F was selected as the ambient air temperature