IN-DEPTH SURVEY REPORT:

CONTROL TECHNOLOGY ASSESSMENT OF SOLID MATERIAL HANDLING PHASE I - BAG OPENING, EMPTYING, AND DISPOSAL

AT

Rohm and Haas Delaware Valley, Inc. - Bristol Plant
P.O. Box 219
Bristol, Pennsylvania 19007

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NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
Division of Physical Sciences and Engineering
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SIC CODE:	2821 (Plastic Materials, Synthetic Resins, and Non-Vulcanizable Elastomers)
SURVEY DATE:	June 4-7, 1984
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I. INTRODUCTION

BACKGROUND FOR CONTROL TECHNOLOGY STUDIES

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal agency engaged in occupational safety and health research. Located in the Department of Health and Human Services (formerly DHEW), it was established by the Occupational Safety and Health Act of 1970. This legislation mandated NIOSH to conduct a number of research and education programs separate from the standard setting and enforcement functions carried out by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards. The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering has been given the lead within NIOSH to study the engineering aspects of health hazard prevention and control.

Since 1976, ECTB has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques. Examples of these completed studies include the foundry industry; various chemical manufacturing or processing operations; spray painting; and the recirculation of exhaust air. The objective of each of these studies has been to document and evaluate effective control techniques for potential health hazards in the industry or process of interest, and to create a more general awareness of the need for or availability of an effective system of hazard control measures.

In these studies, an attempt is made to evaluate both the "effectiveness" and the "efficiency" of the control systems. Effectiveness may be defined as "the capability of the system to maintain work exposures at or below a stated hygienic standard or design exposure level." Thus, it is a function both of the control system and the hazard potential of the material being controlled. For example, a specific control system may be "effective" in controlling one type of nuisance dust (e.g., PVC or acrylic resin dusts); whereas, it may be "ineffective" in controlling a more hazardous type of dust (e.g., cadmium or cobalt salts).

"Control efficiency," however, may be defined as "the proportion of the dust removed from the environment by the control system relative to the total dust potentially emitted by the system." Our evaluations of "control efficiency" normally are indirect, approximate, and relative, since it is usually not feasible to measure the total amount of a potential emission source without major disruption of the control system and/or production operations. A control system may be highly "efficient" in controlling a dust source (e.g., 95% efficient); yet, it may be, at the same time, "ineffective," if that 5% emission results in exposures in excess of the hygienic standard. Conversely, a system may be of a low control efficiency (e.g., 50-80%); yet, it may be "effective," if the dust is relatively non-hazardous or the potential emission rate is low.

In this study, we define a term of "relative control efficiency index" as:

$$E_r = \frac{C_b}{C_s}$$

where C_b is the area or background dust concentration and C_s is the dust concentration at the potential source. As the source concentration, C_s, approaches the background concentration, (C_b),

$$\frac{C_b}{C_s} \rightarrow 1 \text{ and } E_r \rightarrow 1 \text{ or } 100\%.$$

Conversely, as C_s greatly exceeds C_b,

$$\frac{C_b}{C_s} \rightarrow 0$$

or the relative control efficiency index approaches zero.

These studies involve a number of steps or phases. Initially, several walk-through surveys are conducted to select plants or processes with effective and potentially transferable control concepts or techniques. Next, in-depth surveys are conducted to determine both the control parameters and the effectiveness of these controls. The reports from these in-depth surveys are then used as a basis for preparing technical reports and journal articles on effective hazard control measures. Ultimately, the information from these research activities builds the data base of publicly available information on hazard control techniques for use by health professionals who are responsible for preventing occupational illness and injury.

BACKGROUND FOR THE SURVEY

The purpose of this in-depth survey was to evaluate the control of exposures to airborne dusts, generated during the opening, emptying, and disposal of bags and drums during the production of KYDEX®, an acrylic polyvinyl chloride alloy. A preliminary survey of this plant in 1983 indicated that dust control procedures, during manual bag and drum handling operations, were effective in maintaining low dust exposures. Those procedures included: good housekeeping techniques, good work practices, effective engineering controls, the enforcement of a good respiratory protection program, and a verification of the controls by environmental and medical monitoring programs.

Industrial hygiene studies, conducted by Rohm and Haas over the past several years, have determined that personal exposures to total dusts, mainly polyvinyl chloride (PVC) and acrylic resins, have been reduced from approximately 160 mg/m^3, in 1974, to approximately 2 mg/m^3 in 1979. During the same period, average exposures to cadmium dust have been reduced from approximately 1 mg/m^3 to the 0.01 mg/m^3 level.(1) Based on these Company data, and a review of the instituted dust control procedures, a decision was made to conduct this in-depth survey of dust control procedures.

II. PLANT AND PROCESS DESCRIPTION

PLANT DESCRIPTION

Rohm and Haas Delaware Valley, Inc., a Division of the Rohm and Haas Company, is a major producer of chemicals, including Agriculture Chemicals, Industrial Chemicals, Plastics, Polymers, Resins, and Monomers. The main plant facility was constructed in 1919. The plant population of approximately 1,300 employees includes approximately 900 production and maintenance, 200 research, and 200 engineering employees.

In the KYDEX® Department, Building 46 of this plant (Figure A), the product KYDEX®, an acrylic-polyvinyl chloride alloy, is produced. This material, in the form of an acrylic-PVC sheet, is used to make thermoformed plastic parts, such as computer housings, and wall coverings. This Department operates five days per week, three shifts (24 hours) per day, with a six-person crew on each shift. Operations and processes are carried out in two main areas, the Mix Area and the Extruder Area. The Mix Area consists of three subareas: (a) the KYDEX® (Natural) Mix Room, Figure B; (b) the Pigment Mix Room, Figure C; and (c) the Pigments Weighing Area (a Binks Weigh Booth). This survey is concerned mainly with the bag/drum dumping, mixing, and disposal operations in the two Mix Rooms.

<u>KYDEX® (Natural) Mix Room</u> - Figure B

The KYDEX® Mix Room, located in the southwest corner of the building, is approximately 20 feet in length, by 20 feet in width, and 16 feet in height (room volume approximately 6,400 cubic feet). In this room, batches of (Natural) mix are formulated prior to polymerization. Raw materials for a natural mix batch consist of PVC powder (major ingredient), acrylic resins (butyl and ethyl acrylates), stabilizers, such as barium-calcium stearate, and lubricants, such as polyethylene-type waxes. PVC is fed from a 90,000-pound silo, through a weigh hopper, to the mixer. Some of the raw materials, such as acrylic resins in 50-pound bags, are manually fed into the mixer,

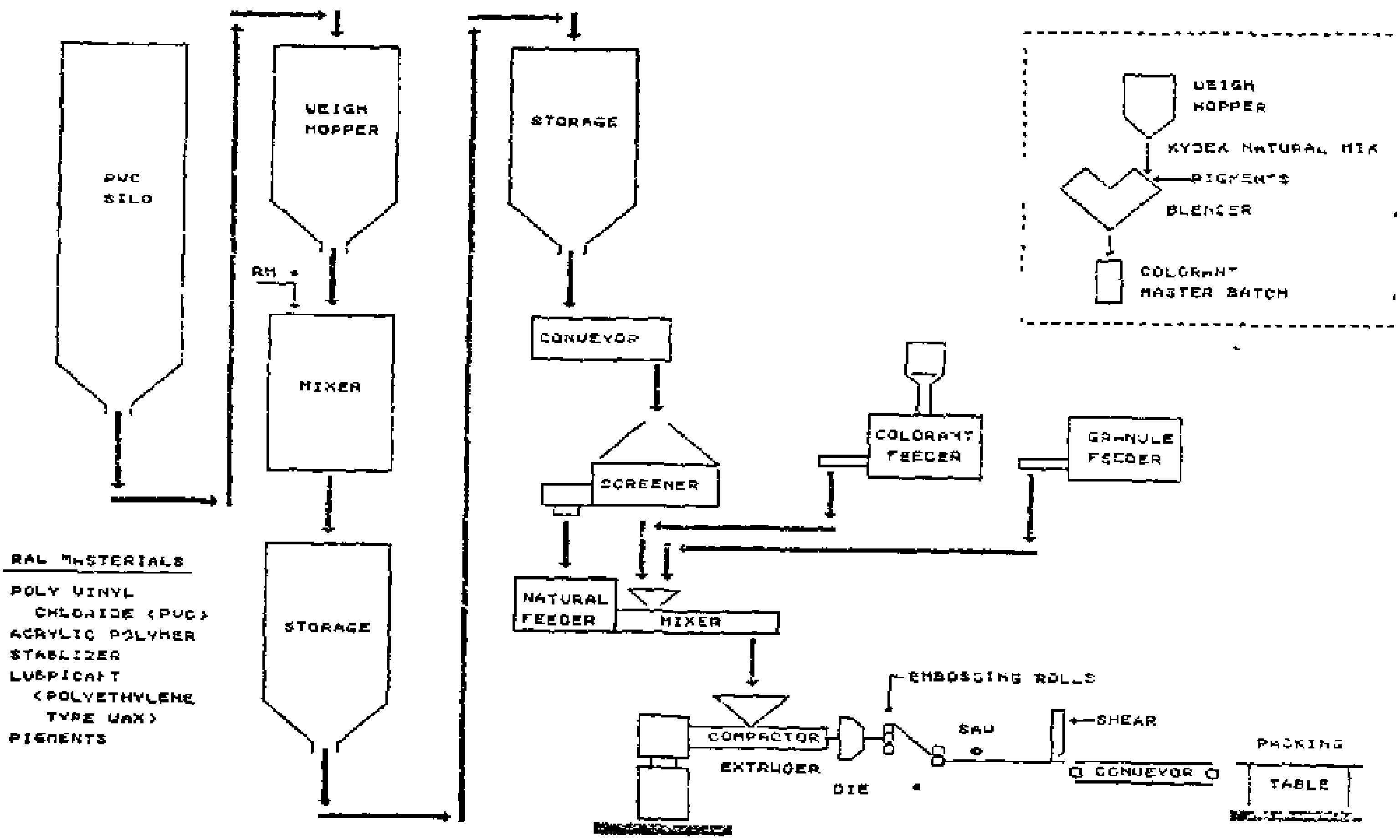


Figure A: KYDEX(R) DEPARTMENT (PROCESS) BUILDING 46.

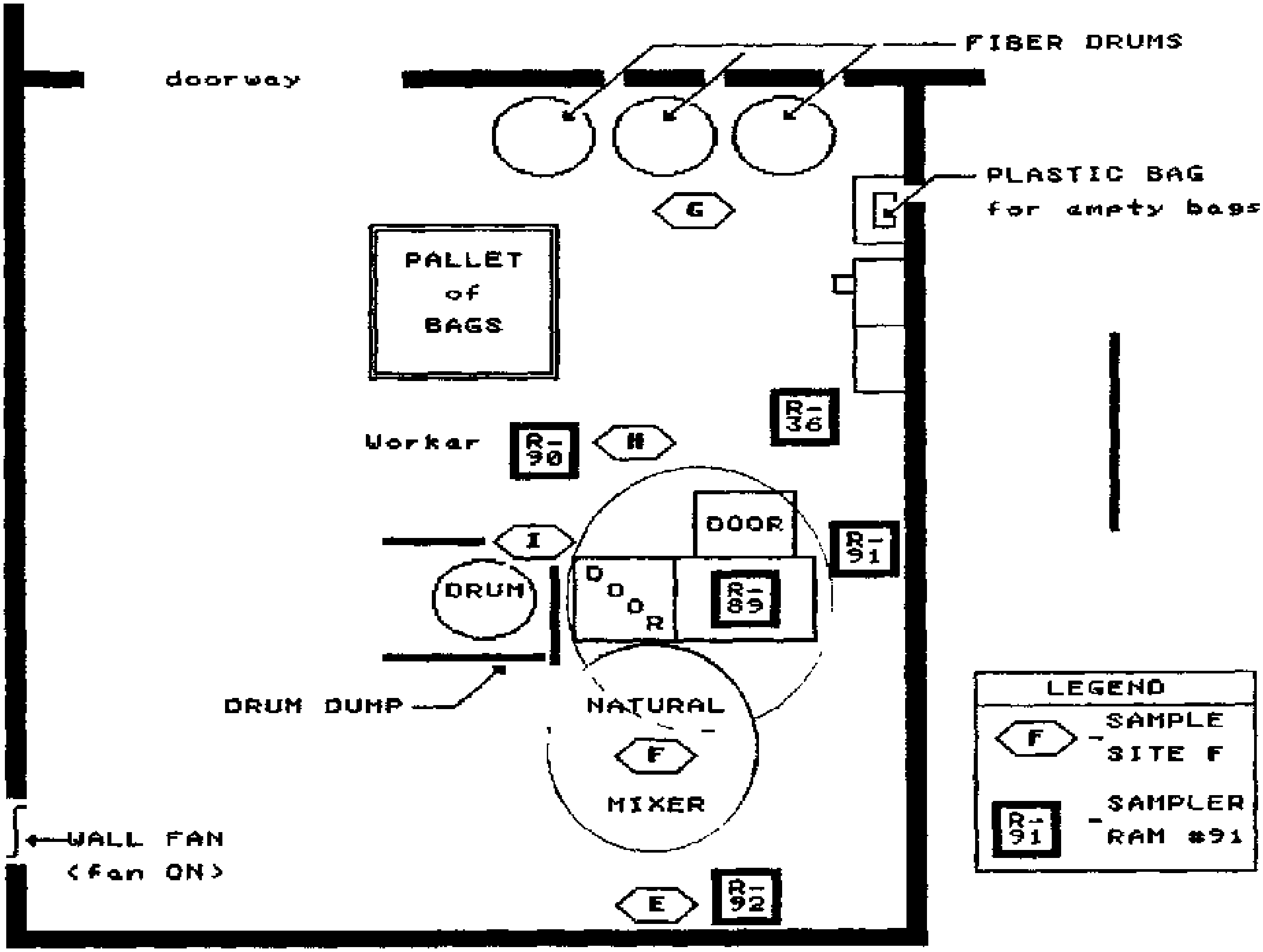


Figure 8: KYDEX(R) (NATURAL) MIX ROOM.

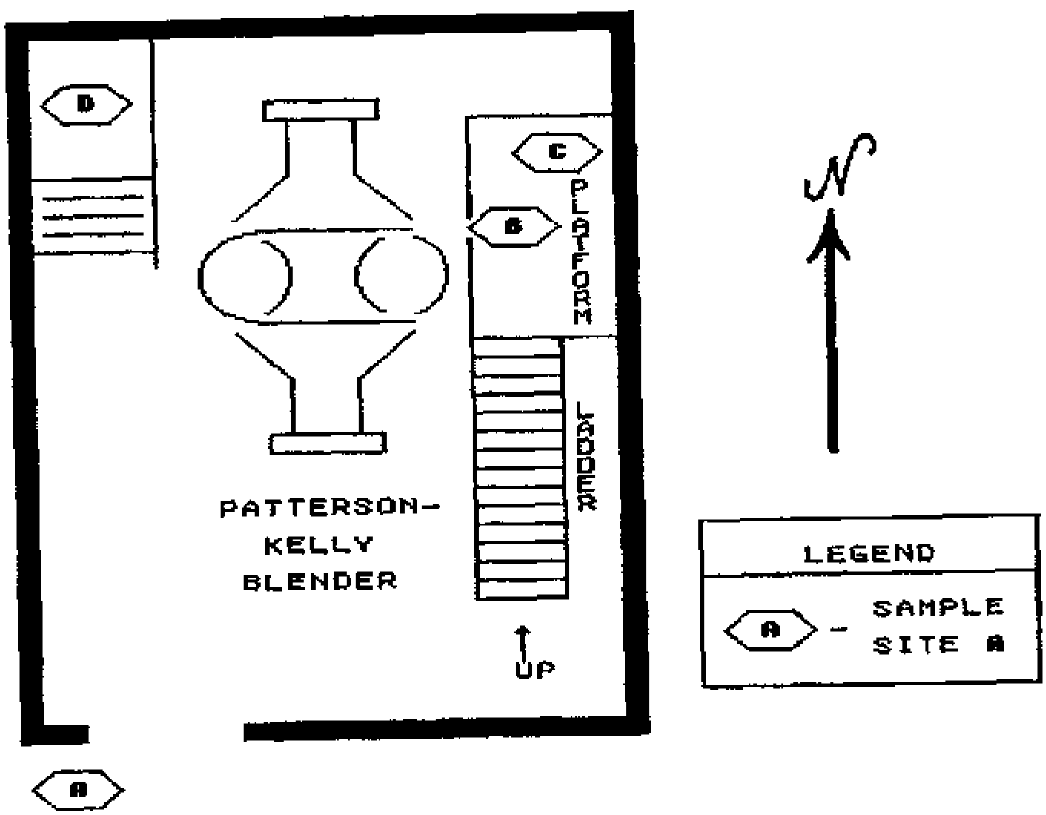


Figure C: PIGMENT MIX ROOM.

(Photograph 1), via a door, to a ventilated, hooded, feed hopper. Other ingredients in drums, (preweighed in the Pigment Weighing Area), such as barium cadmium stearate, are mechanically emptied into the feed hopper via an automatic drum inverter feed (Photograph 2). Dust emissions of this hopper feed opening are also controlled by local exhaust ventilation during drum emptying.

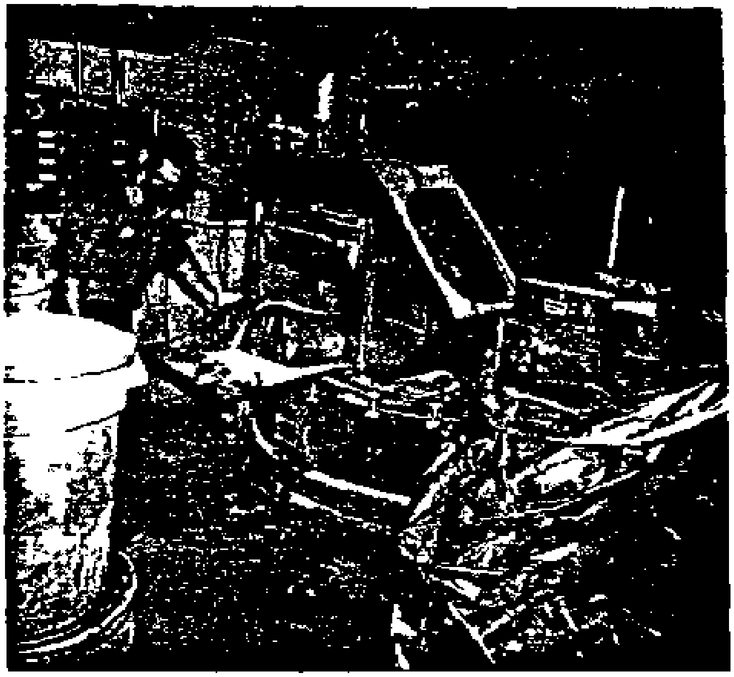
Empty bags are compressed (usually within the confines of the loading hood) and then placed in a plastic bag or drum, which is positioned either adjacent to the mixer (Photograph 3) or at the southeast corner of the room. The filled plastic bags are then transported by fork truck to a controlled landfill.

Potential dust emissions from the mixer are controlled with local exhaust ventilation, which is directed to a Mikro-D-Pulse air collector. Normally, one man conducts the mixer operations. Four or five batches are formulated per shift and each batching operation requires from 15 to 30 minutes for completion. Since each shift crew consists of six operators, these operations are rotated daily to a different operator.

Pigment Mix Room - Figure C

In the adjacent Pigment Mix Room, color pigment master batches are formulated and mixed in a blender, for subsequent addition to the Natural Mix materials (without pigment). This room measures approximately 19 feet in length, 13 feet in width, and 16 feet in height (room volume approximately 4,000 cubic feet). Batches of pigment, consisting of varying proportions of titanium dioxide, carbon black, and cadmium and cobalt-based salts, are blended and stored in drums to be added to Natural Batches as needed.

Basic ingredients, in bags on pallets, are brought, by fork truck, to the Pigment Mix Room and raised to an elevated platform. They are then manually carried to the blender, opened, and emptied into the loading hatch of the blender. A semicircular slot exhaust hood is placed around the loading hatch, during bag dumping, to control dust emissions. After the pigment batch is mixed, it is stored in drums or portable bins.

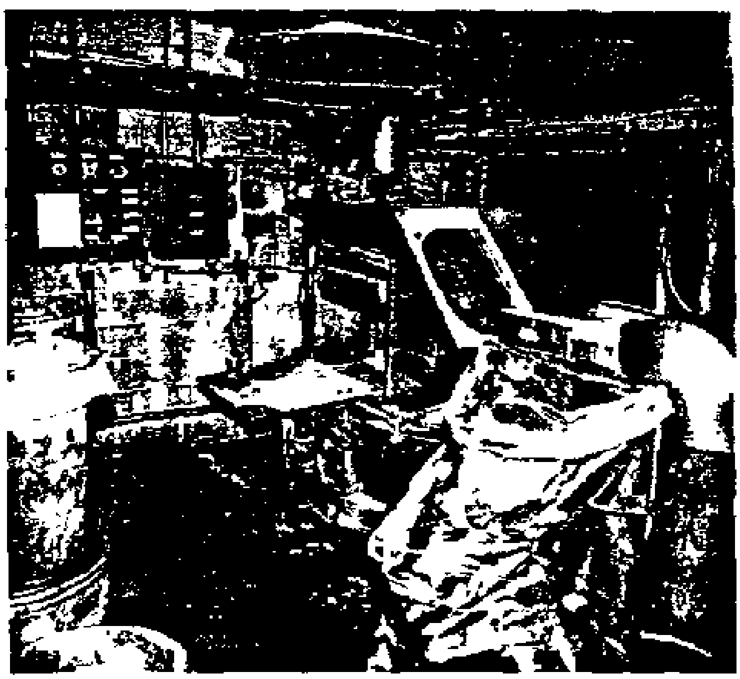


Photograph 1

Manual Feed into Mixer

Photograph 2

Automatic Drum Inverter



Photograph 3a

Disposal of Empty Bags

Photograph 3b

Disposal of Empty Bags

Normally, four batches of Natural Mix (without pigment) are prepared for every two batches of pigmented mix. This operation is also conducted by one crew member, whose assignment is rotated daily.

III. POTENTIAL HAZARDS

KYDEX® Mix Room

In the KYDEX® Mix Room, exposures to three types of particulates are possible:

1. Polyvinyl chloride (PVC) - Neither OSHA, NIOSH, nor ACGIH has proposed a hygienic standard for PVC dust. Although PVC is generally considered to be a "nuisance" type dust, recent epidemiological data, case histories, and animal studies(2-9) indicate that, at the "nuisance" dust level (TLV for Total Dust = 10 mg/m^3), PVC exhibits a weak biological reactivity. It may be the etiologic agent in a peculiar type of fibrosis,(2) or pneumoconiosis,(3) with slight restrictive respiratory function impairment.

2. Acrylic resins (polymers of butyl and ethyl acrylates) - These are also considered to be "Nuisance Type" dusts, with a TLV of 10 mg/m^3 for Total Dust.(10)

3. Barium-Cadmium Stearate - This is a heavy metal salt, which has a TLV(10), and Rohm and Haas "working limit", of 0.05 mg/m^3, as cadmium. The OSHA Permissible Exposure Limit (PEL) for cadmium dust is 0.2 mg/m^3 (11), and the NIOSH Recommended Limit (RL) is 0.04 mg/m^3 (11).

Pigment Mix Room

In the Pigment Mix Room, exposures to the following are considered possible in addition to the above particulates:

1. Carbon black - TLV of 3.5 mg/m^3

2. Cobalt pigment - TLV of 0.05 mg/m^3 (Intended Change for 1983-4)

3. Titumium dioxide (Nuisance Dust) - TLV of 10 mg/m^3

4. Other cadmium salts - TLV of 0.05 mg/m^3.

In recent years, NIOSH, OSHA, and others, including the Rohm and Haas industrial hygiene staff, have investigated the possibility of exposure to vinyl chloride monomer (a recognized carcinogen) as a residual vapor in PVC granules. This gas continues to be monitored yearly by the Rohm and Haas industrial hygiene staff.

Since noise is also a possible health hazard in this department, a Hearing Conservation Program has been instituted. This program includes monitoring of personnel and areas for noise exposures and audiometric testing for possible effects of noise on workers' hearing. Heat stress exposures have also been evaluated by the Rohm and Haas staff.

IV. CONTROL OF HAZARDS

At Rohm and Haas, control of hazards, including exposures to toxic dusts during bag handling operations, is accomplished by the application of several well established procedures. These procedures include engineering controls; good work practices, such as housekeeping; use of personal protection equipment; environmental and medical monitoring; and administrative controls.

A. Engineering Controls

General Plant Layout

The plant layout was designed to permit effective wash down of contaminated surfaces and floors (Photographs 4a and b). Additionally, specific areas in the plant were constructed as lunchrooms, washrooms, and showering facilities, where two lockers are provided for each employee.

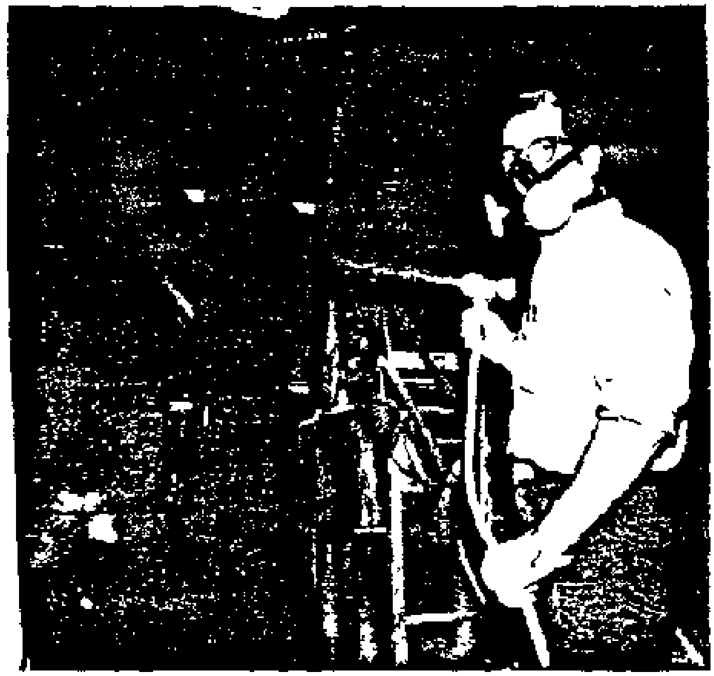
KYDEX® Mix Room

In the Mix Room, dust dispersion has been reduced over the past 10 years by several equipment modifications and installations. These changes include: (1) the mixer was installed in 1974; (2) improved pneumatic conveyance of mix was accomplished in 1974 and 1975; (3) feed of PVC was changed from manual bag loading to bulk loading from a storage hopper; (4) a local exhaust hood was placed over the mixer (designed for a hood face velocity of 100 fpm) (Photograph 5); (5) a central vacuum system was installed throughout the Department to improve the clean-up of spilled dust; and (6) general room ventilation is also provided by a 24-inch wall fan.

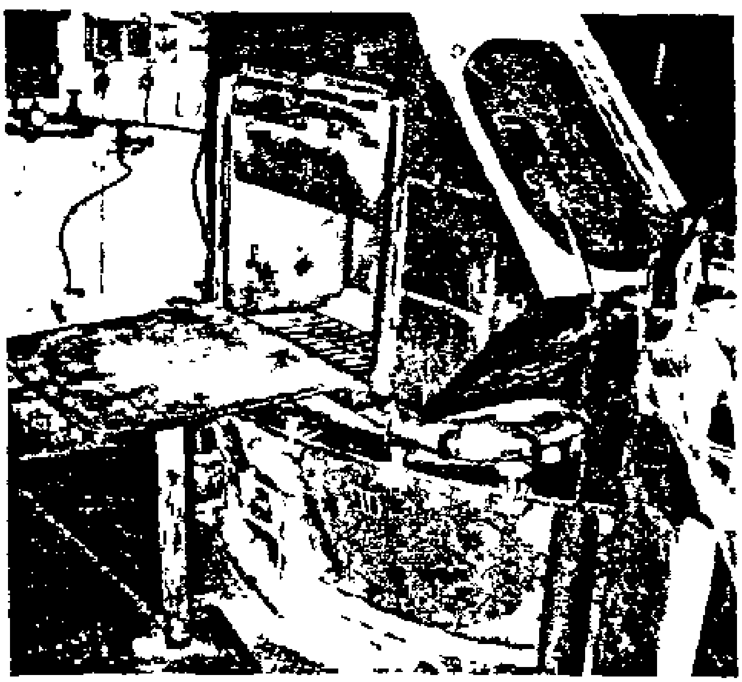
Pigment Mix Room

In the Pigment room, a dust control hood was installed over the pigment mixer in 1977 and the central air vacuum system was extended to this area.

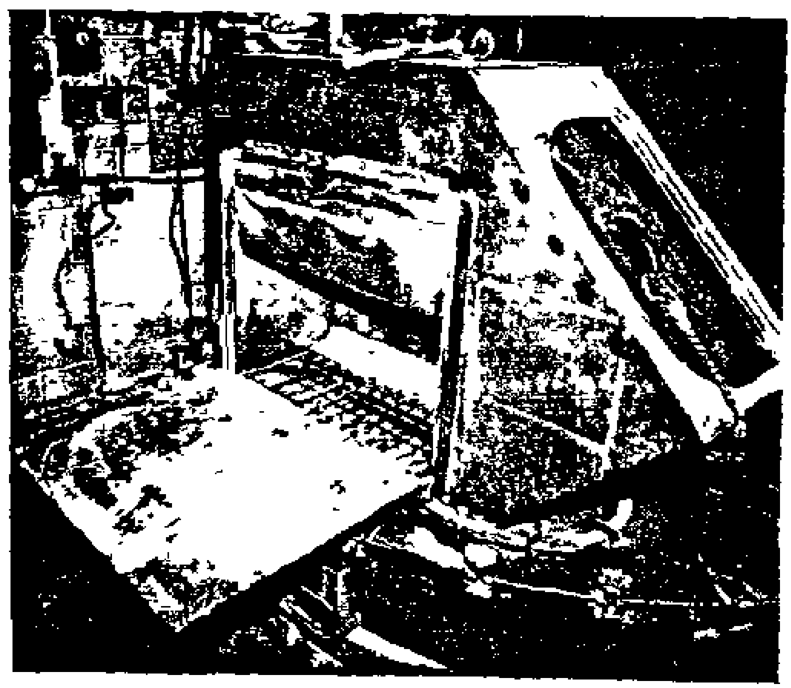
Photograph 4a
Water Washdown of Rooms



Photograph 4b
Water Washdown of Equipment



Photograph 5a
Exhaust Hood over Mixer



Photograph 5b
Exhaust Hood over Mixer

B. Work Practices

1. Hygiene practices include: daily showers are required (15 minutes of paid overtime are allowed for showering); no smoking is allowed in work area; eating is permitted only in designated and maintained lunch rooms; and washing prior to lunch is encouraged.

2. No incentive pay program is offered to encourage accelerated production rates. Although this procedure has mixed effects in different work situations, generally, incentive pay programs tend to encourage short-cut work habits that may lead to unsafe work practices.

3. Two 10-minute work break periods per day (in addition to a lunch break) provide a reduction of stress and safer work practices.

4. A daily clean-up (housekeeping) period is provided for operators to clean up spills in their work areas. Since operator rotation occurs, all operators are responsible for housekeeping. Spills and other contaminations are either washed down (by water hose) or vacuum cleaned (Photographs 4a and b). In the Pigment Room, clean up is done at least two times per day.

5. "Scheduled Maintenance" is provided for the oiling of production equipment. A "breakdown maintenance" schedule is followed for other types of maintenance. General ventilation systems are monitored annually, while laboratory hoods and other local exhaust ventilation systems are monitored quarterly.

C. Personal Protective Equipment

A strict Personal Protection Program requires all workers (and visitors) to wear respiratory protection at all times in the KYDEX® Mix Room and the Pigment Mix Room (Photographs 6a and b). This is required, even though recent environmental and medical monitoring data indicate that exposures to PVC, acrylic resins and cadmium-containing dusts are well below

Photograph 6a

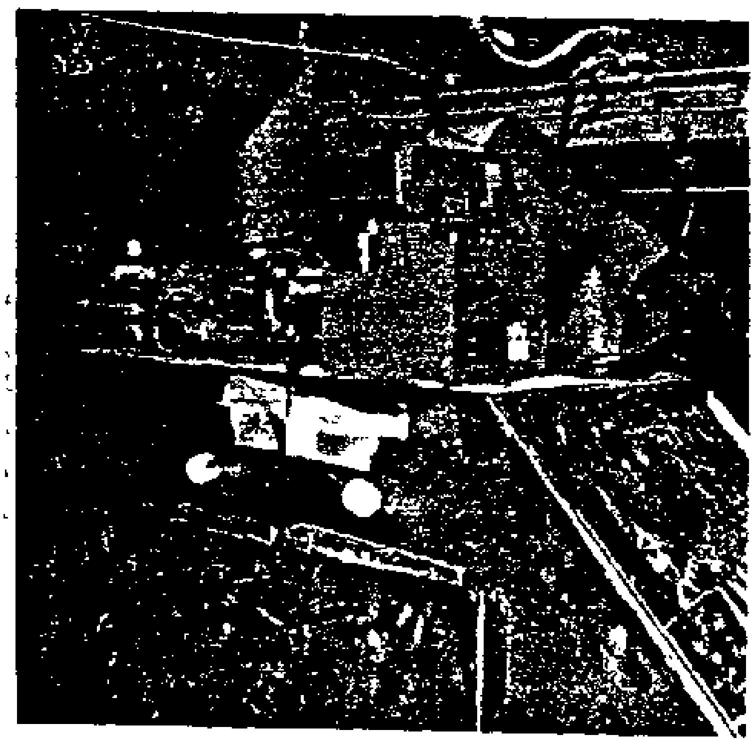
Use of Respiratory Protection

Photograph 6b

Use of Respiratory Protection

Photograph 7a

Use of RAM-1 Dust Monitor



Photograph 7b

Use of RAM-1 Dust Monitor

recommended hygienic standards. Willson R2 respirators, with HEPA (High Efficiency Particulate Air) filter cartridges, are used.

Workers are also provided with safety shoes and clean clothes daily, including under-shorts, shirts, trousers, and work gloves. Each worker is provided with a one-week supply of clean clothing, which he stores in his "clean" locker.

D. Monitoring Control

Environmental Monitoring

Environmental monitoring has been conducted at this facility for at least 11 years. Both Short term (S) and Full Shift (T) Personal (P) and Area (A) samples have been collected and analyzed for Total Dust (essentially acrylates and PVC), Cadmium salts, carbon black, and several other chemical and physical agents.

Company industrial hygiene data have shown that significant reductions of Total Dust and Cadmium Dust have been achieved in the Mix Area as shown in Table 1.[1] For example, in the Mix Room, air concentrations of Total Dust in 1974 averaged (geometrically) 160 mg/m^3 (range: less than 6 to 1480 mg/m^3); in 1979, full shift personal samples, in both mix rooms, averaged 1.3 mg/m^3 (range: 0.6 to 4.8 mg/m^3). Additionally, a single measurement of cadmium dust level, in 1974, yielded a result of 1.2 mg/m^3. In 1979, it was reduced to an average of 0.013 mg/m^3 (range: less than .01 to 0.02 mg/m^3). These reductions were achieved by the above mentioned engineering control modifications. Monitoring data for carbon black, vinyl chloride monomer, hydrogen chloride, butyl and ethyl acrylates, and other chemicals also show good dust and vapor control.

Noise levels in some areas have been above the OSHA Standard of 90dBA. Therefore, an active Hearing Concentration Program, including periodic audiometric testing and environmental monitoring, is in effect.

Table 1

Total Dust and Cadmium Dust Concentrations(1)
in KYDEX® Department - (Average Concentrations)
(prior to 1984)

		Dust Concentrations(2) - mg/m3			
		Total Dust		Cadmium Dust	
Location/Operation	Year	Short-Term Personal and Area Samples	Full-Shift Personal Samples	Short-Term Personal and Area Samples	Full-Shift Personal Samples
1. Pigment weighing area weighing pigments	1972	2.2			
	1973	5.3			
	1974			1.2	
2. KYDEX® (Natural) mix room, dumping bags of PVC and acrylates in mixer	1974	384			
	1976	59		0.48	0.05
	1977		3.3		0.03
	1978		0.8		0.03
	1979		1.3		0.01
3. Pigment mix room, filling P-K mixer	1974	160			
	1977		2.1	0.03	0.02
Hygiene Standard or Threshold Limit Value			10(3)		0.05(4)

(1) Source: Industrial Hygiene Data of Rohm and Haas Delaware Valley, Inc.
(2) Geometric mean concentrations
(3) Assumed to be "Nuisance Dust" classification of ACGIH - 1984
(4) TLV of ACGIH - 1984-1985.

V. METHODOLOGY OF THE IN-DEPTH SURVEY

A. Dust Sampling Procedures

Atmospheric dust levels were measured in the plant to evaluate the following questions:

1. Are the existing controls effective in maintaining safe working environments by reducing dust exposures to (or below) the applicable hygienic standards?

2. To what degree, do the operations of bag opening, emptying, storage, and disposal contribute to the general air contamination level of the KYDEX® Department, or, conversely, what is the efficiency of control of the potential dust emission sources?

Control Effectiveness

The effectiveness of the controls was evaluated by monitoring the workers' dust exposures during normal work operations, over two complete work shifts, and comparing these exposures with the hygienic standard listed in Section IV. Personal, area, and source atmospheric samples were collected in the two mix rooms and analyzed for Total Dust and metallic salts. Sampling and analytical procedures are described in Appendix A. Personal (Breathing Zone) samplers were clipped to the workers' shirt collar, and samples were collected for the period of their activity in these mix areas. Area samples were collected in the general work areas of the rooms, away from potential emission sources, to estimate general levels of dust exposure. Potential source samples were collected during periods of active bag opening, dumping, and disposal, as close to the potential dust emission points as possible, to estimate levels of dust emission. In the Pigment Mix Room, one personal sample, one area (background) sample, and two source samples were collected, during one work shift. In the KYDEX® mix room, a total of two personal samples, two background samples, and six potential source samples were collected over the course of two work shifts.

Control Efficiency

The efficiency of the control systems (or the contribution of dust by the work operations to total atmospheric dust levels) was estimated by evaluation of combinations of personal, area, and source sample results. The hypothesis (null) was presented that, if the dust controls (for the bag opening, emptying, and disposal operations) were both effective and completely efficient (100%), there would be no dust emission at these operations, and no increase of dust concentration (above background) near these locations: or $C_w = C_s = C_b$ where:

C_w = dust concentration at Worker's Breathing Zone

C_s = dust concentration at the potential dust source

C_b = dust concentration of general area or background.

The absolute control efficiency, E_a, requires a measurement of the total dust potentially emitted, C_t; a measurement of the total dust captured by the control system, C_c; and/or a measurement of the total dust escaping to the work environment, C_e. In this situation:

$$C_t = C_c + C_e$$

and the absolute control efficiency,

$$E_a = 1 - \frac{C_e}{C_t}$$

As $C_e \rightarrow 0$, $E_a \rightarrow 1$; and as $C_e \rightarrow C_t$, $E_a \rightarrow 0$.

Since it is not feasible to measure the total dust potentially emitted by a source or the dust collected by the control systems, without turning off the controls or using a tracer dust, a "relative control efficiency index," E_r, was estimated as:

$$E_r = \frac{C_b}{C_s}$$

so that, as the concentration of dust at a source approached the background dust concentration, the relative control efficiency index approached 1 (or 100%).

In addition to measuring dust concentrations by collection on filters, real-time respirable dust concentrations were estimated and recorded with a GCA Real Time Aerosol Monitor (RAM) Model 1 (Photographs 7a and b), at locations shown in Figures B and C. The RAM probes were used to monitor "instantaneous" dust levels before, during, and after specific bag handling operations. At each location, the RAM measurements were used to test the "null hypothesis" that dust concentrations did not increase when bag opening and disposal operations were performed.

B. Ventilation Control Measurements

Ventilation measurements and airflow patterns were made to evaluate the operation, effectiveness, and efficiency of the local exhaust and general ventilation systems. A TSI Air Velocity Meter, Model 1650, and Gastec Smoke Tester Tubes were used for quantitative and qualitative evaluations. Measurements were made of: two local exhaust hoods in the KYDEX® Mix Room; two exhaust hoods (a flexible hose and a circular slot hood) in the Pigment Mix Room; and a wall fan in the KYDEX® Mix Room.

C. Additional Control Procedures

The effectiveness of other dust control procedures were evaluated qualitatively. These included: the central vacuum system; enclosures on product handling equipment; work practices; monitoring programs; and personal protective equipment programs.

VI. STUDY RESULTS AND DISCUSSION

Evaluations of atmospheric dust concentrations and ventilation systems in the KYDEX® Mix Room and the Pigment Mix Room are shown in Tables 2 and 3.

A. KYDEX® Mix Room

1. Atmospheric dust exposures

As shown in Figure B, and Table 2, all dust exposures, including Total Polymer Dusts, and Cadmium Salts Dusts were effectively controlled to well below their respective Hygienic Standards. Background levels of Total Dust (location E) averaged approximately 0.6 mg/m^3, while the mixing operations were in progress. The operator's breathing zone exposure level (locaton H) averaged approximately 1.4 mg/m^3; and no detectable exposures (less than 0.01 mg/m^3) to cadmium salts were found during three normal runs. Total Dust Exposures averaged approximately 1.6 mg/m^3, above and below the two ventilated hood openings, during manual dumping of bags and automatic dumping of drums (locations F and I). Slightly higher exposure levels of Total Dust were produced at the disposal station for empty bags (location G). Exposures ranged from 1.6 to 4.8 mg/m^3 and averaged 2.8 mg/m^3. Figure D indicates the fluctuations of respirable dust concentrations at location G (near the bag disposal station) as measured by the GCA Real Time Aerosol Monitor. Although the magnitude of these readings has not been accurately calibrated, they indicate that short, peak exposures, lasting approximately one minute, may exceed background levels by an order of magnitude (from approximately 0.15 to 1.3 mg/m^3 of respirable dust.) Since most of the dusts being handled in this room are considered to be "non-toxic" (see discussion of PVC dust toxicity as a potential cause of weak pulmonary effects, Section IV), and since the use of respiratory protection is mandatory at all times in this room, the engineering and work practices controls are "effective" in maintaining exposures to a safe level.

Table 2
Dust Exposures in KYDEX® Mix Room

Sample No.	Location Operation	Run(a) No.	Operating Time (min.)	Dust Levels mg/m^3 Total Dust	Cobalt Salts	Cadmium Salts	Remarks
					(b)	(b)	
1	Near south wall, background sample (location E)	1	21	0.90	[0.01	[0.01	area samples, normal operations.
		2	25	0.40	[0.01	[0.01	
		3	20	0.42	[0.01	[0.01	
		Av.	21	0.57	[0.01	[0.01	
2	Above mixer feeder hood (location F)	1	21	0.48	[0.01	[0.01	source samples; 1&2 normal operations; #3 badly leaking bag.
		2	25	0.88	[0.01	[0.01	
		3	20	2.33	[0.01	[0.01	
		Av.	21	1.23	[0.01	[0.01	
3	Below mixer feeder hood (location I)	1	21	0.88	[0.01	[0.01	source samples; 1&2 normal operations; #3 badly leaking bag.
		2	25	0.14	[0.01	[0.01	
		3	20	4.89	[0.01	[0.01	
		Av.	21	1.97	[0.01	[0.01	
4	N.E. Corner of room storage of empty bags in plastic bag (location G)	1	21	1.59	[0.01	[0.01	source samples; area not well controlled. #3 badly leaking bag.
		2	25	2.00	[0.01	[0.01	
		3	20	4.83	[0.01	[0.01	
		Av.	21	2.81	[0.01	[0.01	
5	Following worker, between loaded pallent, feed hopper and empty bag dump (location H)	1	21	0.86	[0.01	[0.01	OBZ(c) samples; operator wearing toxic dust respirator; #3 badly leaking bag.
		2	25	0.98	[0.01	[0.01	
		3	20	2.44	[0.01	[0.01	
		Av.	21	1.43	[0.01	[0.01	
	Hygienic Standard (TLV)			10	0.05	0.05	

(a) Run #1 6/6/84 - 099 to 0927 and 1022 to 1035 = 21 minutes
Run #2 6/6/84 - 1217 to 1230 and 1328 to 1340 = 25 minutes
Run #3 6/7/84 - 0844 to 0854 and 1030 to 1040 = 20 minutes
(b) [- less than
(c) OBZ - Operator's Breathing Zone

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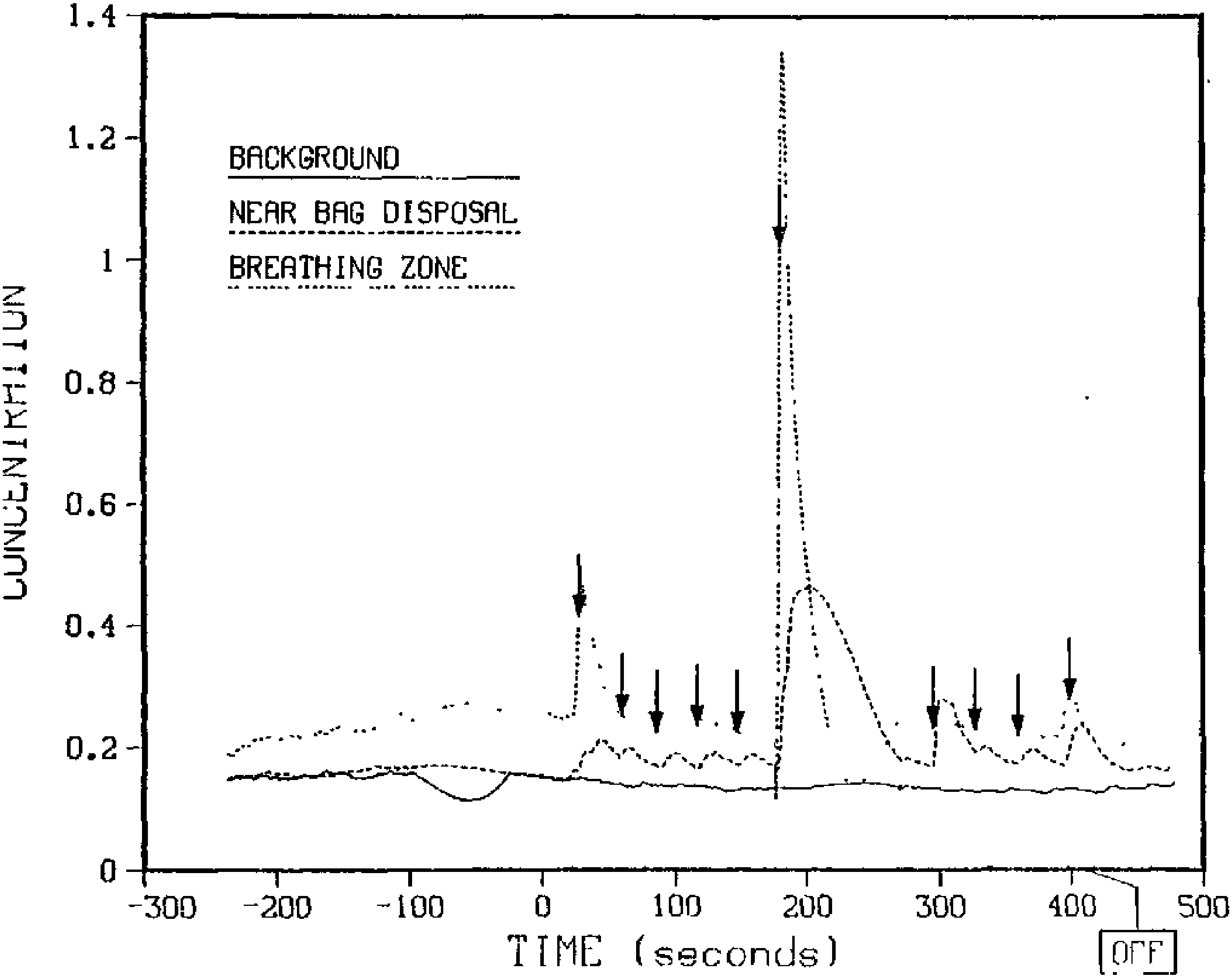

Figure D: DUST CONCENTRATIONS AT BAG DISPOSAL STATION, KYDEX(R) MIX ROOM. (RAM DATA)

2. Dust control systems

An evaluation of the efficiency of the dust control systems, is shown in Table 3 and Figure E. During the manual dumping of 50-pound bags of acrylic resins and cans of lubricants, fugitive dust emissions are controlled by the use of a local exhaust ventilation hood attached to the front of the mixer (Figure E and Photograph 5a). According to the ACGIH, the recommended control velocity for bin and hopper ventilation (for manual bag loading) is 150 fpm (150 cfm/sq.ft. of opening).(13) Air velocities at this hood averaged 140 fpm (ranging from 60 to 190 fpm). Thus, under normal operating conditions of emptying of intact bags, dust control should be both effective and efficient. This hypothesis is verified by the air sampling results in Table 3, which showed "relative control efficiency indices" of 45 to 100% during Runs No. 1 and 2. When a broken bag was handled, however, dust emission control was less efficient, as shown in Run No. 3, with a relative control efficiency index of about 20%.

During the automatic dumping of drums of stabilizers into the side door of the mixer, dust control was also both effective and efficient. Although the observed average control velocity of 125 fpm (range 100 to 160 fpm), Figure E, was less than the recommended(13) control velocity of 150 fpm, "relative control efficiency indices" were excellent, as shown in Table 3, location I. During both "normal" Runs, No. 1 and 2, dust levels at this potential source were less than background levels, indicating complete dust control (or Relative Control Efficiency Index of approximately 100%). Again, during the handling of a broken bag, Run No. 3, high dust exposures were observed at this location.

Control of dust was relatively inefficient, however, during the compression and disposal of empty bags in a plastic disposal bag at the northeast corner of the room, location G. The average "Relative Control Efficiency Index" of 20% (range from 9 to 50%), was very dependent upon the work practices involved in handling empty bags. As

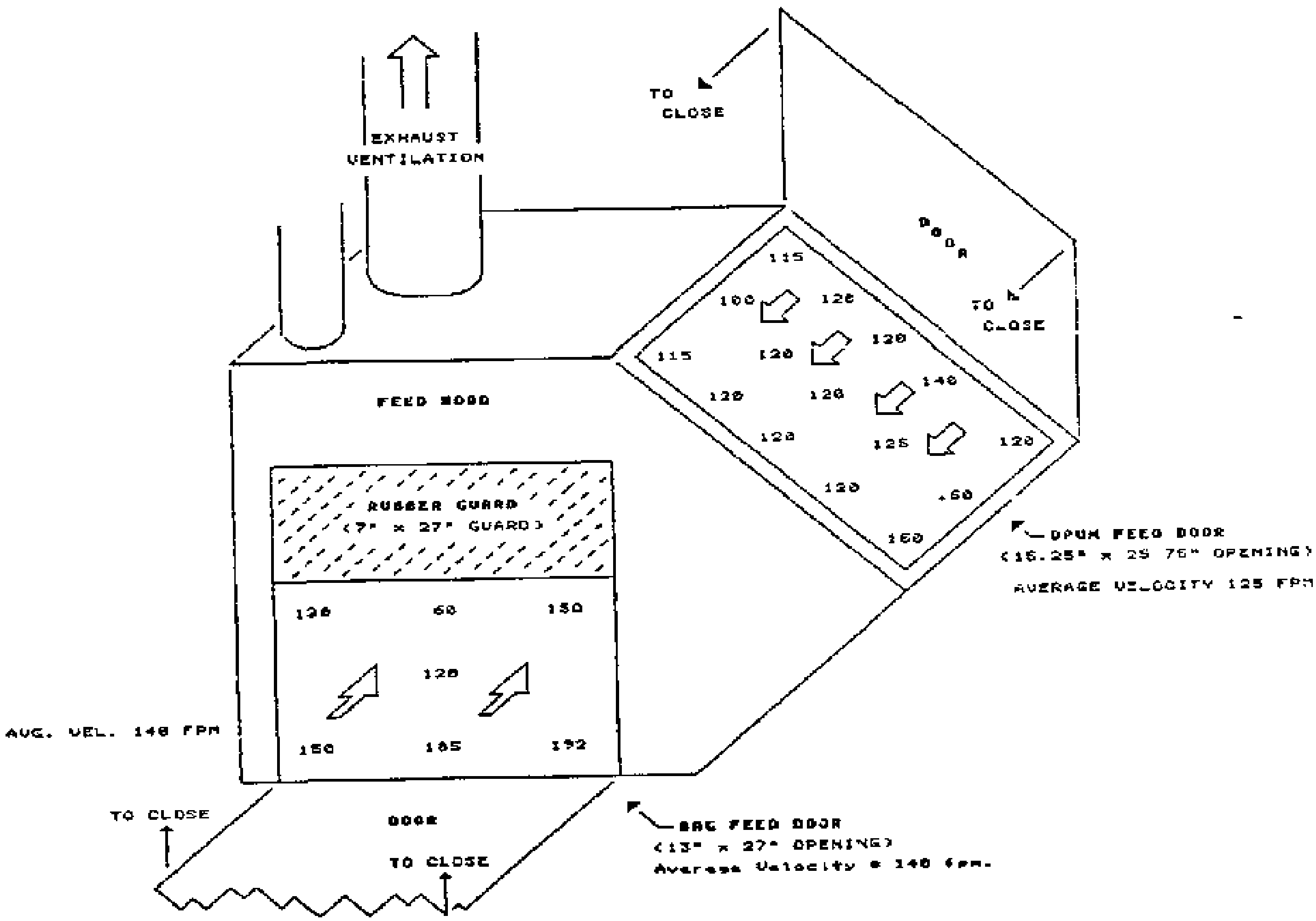

Figure E: KYDEX(R) MIX ROOM – FEED HOODS TO MIXER.

Table 3

Effectiveness and Relative Efficiency of Dust Control Systems in KYDEX® Mix Room

Location/Operation	Description of Hood or Fan	Hood Velocity FPM	Total Dust Levels - mg/m^3 at source location C_s	background C_b	Excess dust C_s-C_b	Relative Control Efficiency Index $E_{RE} = \frac{C_b}{C_s}$	Remarks
1. Front door of feed hood to hopper for manual dumping of bags (location F)	Rectangular hood 27" width x 13" height (to rubber plugs)	60–190	0.48 0.88 2.33	0.90 0.40 0.42	— 0.44 1.91	1 00 .45 .18(a)	side door for drum dumping closed; generally good control, except when broken bag (Run #3) created dust
		Av 140	1.23	0 57	0 63	46	
2. Side door of feed hood to hopper for mechaical dumping of drums (location I)	Rectangular hood 15-1/2" width 25-3/4" height to rubber plugs	100–160	0.88 0.14 4.89	0 90 0.40 0.42	— — 4.47	1.00(b) 1.00(b) .09(a)	front door for bag dumping closed, design velocity = 200 FPM, generally good control control, except when bag brake on run #3.
		Av. 125	1 97	0.57	1.40	.29	
3. Storage of empty bags, northeast corner of room (location G)	No localized dust control hood	—	1.59 2.00 4.83	0.90 0.40 0.42	0.69 1.60 4.41	1.00(b) 1.00(b) .09(a)	dust control poor, adequate for non-toxic dusts; depends on handling procedures.
		Av. —	2.81	0.57	2 24	.20	
4. Following operator, between loaded pallet, feed feed drums to hopper, and empty bag storage (location H)	No localized dust control hood	—	0.86 0.98 2.44	0 90 0.40 0.42	— 0.58 2.02	1.00(b) .41 .17(a)	a combination of controls at hoods; opening bags and drums, and storing empty containers generally effective.
		Av. —	1.43	0.57	0.86	.40	
5. Background sample near wall, (Location E)	—	—	—	0.90 0.40 0.42	—	—	used to estimate background concentration in room.
		Av. —	—	0.57	—	—	
Wall fan on West wall S-W corner of room (room vol 8140 ft	Circular fan 24" diameter total effective area = 2.5 M	1200 to 2400 Av. 1800					used for dilution ventilation developing approximately 44 air changes per hour.

Hygienic Standard or Threshold Limit Value 10 mg/m^3

(a) Leaky bags caused high exposures during Run #3.
(b) Relative Control Efficiency Index estimated to be 1.0, since source dust levels were less than background levels.

shown in Figure D, short time dust exposures of about one minute duration, are created during the compression of the bags away from the exhaust hood of the mixer. This uncontrolled dust source is probably the most significant contribution to the overall dust load in this room. The operations of bag slitting, dumping, compression and placing in a disposal container should be performed as close to the local exhaust system as possible to capture potential fugitive dust emissions.

B. Pigment Mix Room

1. Atmospheric dust exposures

As shown in Figure C and Table 4, Total Dust exposures are effectively controlled in all areas of the Pigment Mix Room. All Total Dust exposure levels were below the hygienic standard of 10 mg/m^3. However, the exposure level of cadmium dust, collected at the operator's breathing zone, was slightly excessive, 0.21 mg/m^3. This sample was taken during a 13-minute period, as he manually moved bags from a loaded pallet to the feed hatch of the mixer. Figure F, also indicates, semi-quantitatively, that instantaneous levels of dust fluctuate widely at the operator's breathing zone, as he opens and moves bags from the pallet to the blender. Peak exposures, of approximately 2 minute duration, also are approximately an order of magnitude higher than background levels. They contribute significantly to the worker's total exposure. Since the operator was required to wear respiratory protection at all times in this room, and since the total period of operation was short, the operators absorbed dose was probably low.

2. Dust control systems

Ventilation control of dust in this room consists of a 6-inch circular flexible hose at the lower level of the mixer, which is used during the emptying of mix batches; and a semi-circular slot exhaust, which

Table 4

Dust Exposures in the Pigment Mix Room

Sample No.	Location Operation	Run[b] No.	Operating Time (min.)	Dust Levels mg/m^3 Total Dust	Cobalt Salts	Cadmium Salts	Remarks
1	Outside door, background (location A)	1	13	0.26	[c] [0.02	[c] [0.01	general area sample
2	Upper level, on ramp following operator (location B)	1	13	6.77	[0.02	0.21	OBZ[b] sample; operator wearing respirator, normal operations
3	Upper level, 4 feet from blender at pallet (location C)	1	13	0.09	[0.02	[0.01	source sample; removing bags from pallet
4	East wall, main floor, on ladder, away from blender (location D)	1	13	0.33	[0.02	[0.01	general work area sample
	Hygienic Standard-TLV			10	0.05	0.05	

(a) Run #1 6/5/84 - 1325 to 1300 and 1628 to 1636 = 13 minutes
(b) OBZ = Operator's Breathing Zone
(c) [- less than

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is positioned around the loading hatch of the mixer during batch loading.

These two exhaust ducts are very efficient in capturing fugitive dust emissions during the loading and unloading of the mixer, as shown in Table 5, locations C and D and Figure F. Dust levels at these two potential source points were of the same magnitude (or lower) as background dust levels. However, a sample collected at the operators breathing zone, location B and Figure F, as he moved between the pallet and the hatch dumping station, showed very poor control efficiency (about 4%). Bags of pigment are opened away from the exhaust hood. Therefore, exposures to cadmium dust must be controlled by the mandatory use of respirators, as shown in Photograph 5. The total control system (short exposure time, use of respiratory protection and engineering controls) was effective.

Additional atmospheric dust dispersion is minimized by routine cleaning of all surfaces at least two times per shift, with a water hose or with the central exhaust ventilation system Photographs 4a and 4b.

C. Additional Dust Control Systems

1. A centralized, 10 H.P. Spencer house vacuum system was installed in 1967. This system included 25 inlet ports strategically located throughout the KYDEX® Department. This system is used for routine, scheduled clean-up of dust spills, and for general plant housekeeping.

2. The dust collection system, for the manual dump operations in the KYDEX® (natural) Mix Room, consists of a DCF-70 SEMCO Fan Assembly, which was designed to move 560 cfm. This is attached to a DCV-85 Automatic Dust Collector which contains 85 square feet of polyslick filter media.

Table 5

Effectiveness and Relative Efficiency of Dust Control Systems in the Pigment Mix Room

Location/Operation	Description of Hood or Fan	Hood Velocity FPM	Total Dust Levels - mg/m^3: at source location (C_s)	Total Dust Levels - mg/m^3: background (C_b)	Total Dust Levels - mg/m^3: Excess dust	Relative Control Efficiency Index $E_{RE} = C_b$	Remarks
1 Hose at base of mixer (lower level) (location D)	*						dust well controlled at this location
a) with upper slot closed	6" circular flexible hose	3100	0.33	0 26	0 07	0.79	
b) with upper slot opened	"	1800					
2 Upper level, at loading hatch, - at ventilated collar slot (location C)	circular slot hood 15" x 6"						excess dust at dump hatch well controlled
a) with bottom slot open		60					
b) with bottom slot closed		95	10 09	0 26	0	1 00	
3 Upper level following operator, moving between pallet and hatch dump station (location B)	no control at bag opening	--	6.77	0.26	6 51	0 04	OBZ sample on operator, dust from opening bags not well controlled
4 Background sample, outside south door of room (location A)	-- at bag opening	--		0 26	--	--	

Hygiene Standard or Threshold Limit Value 10 mg/m^3

(a) Background sample in KYDEX® Mix Room was location E, south wall of room
(b) Background dust sample in Pigment Mix Room was location A, outside south door of room.
(c) Leaky bags caused high exposures in KYDEX® Room, during Run #3
(d) Relative Control Efficiency Index estimated to be 1 0, since source dust levels were less than background levels

3. On the west wall of the KYDEX Mix Room, at the south corner of the room, a 24-inch wall fan continuously exhausts air from this room. The measured air movement by this fan was 4,700 cfm. Since the room volume is approximately 6,400 cubic feet, this fan provides approximately 44 air changes per hour.

VII. GENERAL OBSERVATIONS, CONCLUSIONS, AND RECOMMENDATIONS

A. Effective control during manual operations of bag emptying is achieved at this plant by a combination of procedures including:

1. Engineering controls, such as process enclosures and local exhaust ventilation.

2. Good work practices including housekeeping and personal hygiene.

3. An effective repiratory protection program; and

4. An effective medical and environmental monitoring program.

B. As dust emissions are reduced from point sources, it normally follows that levels of personal exposures are also proportionally reduced. In general, dust exposures are maintained at a safe level in this plant.

C. A firm commitment to implement and use good environmental control and occupational health programs is essential to their success. Both management and workers at this plant demonstrated their commitment.

D. Engineering controls to reduce exposures in the KYDEX® Mix and Pigment Mix Rooms included:

1. Plant layout and design
   a) Floors and walls were designed to permit effective wash down of contaminated surfaces.
   b) Personal hygiene is emphasized or specific areas were constructed in the plant or lunch rooms and showering facilities, where two lockers are provided for employees.

2. Equipment modifications
   a) In 1974 and 1975, the installation of the pneumatic conveyance system for mix materials greatly reduced emission sources.

b) The feed of PVC to the mixer was changed from manual bag loading to automatic bulk feed loading.

3. Exhaust ventilation systems

   a) In the KYDEX® Mix Room, a local exhaust hood was placed over the Nauta Mixer, with a designed face velocity of 100 FPM.

   b) In the Pigment Mix Room, a 6 inch circular flex hose (lower level for batch emptying) and a semi-circular slot (upper level, for mixer loading) provide local exhaust ventilation at these potential dust sources.

   c) A control vacuum system was installed, with 25 strategically located inlet ports, to provide for general plant housekeeping and routine clean-up of spills.

   d) General ventilation in the KYDEX® Mix Room was augmented by a 24 inch wall fan, moving 4700 CFM. This provides approximately 44 air charges per hour.

   e) Good work practices, which also are effective in reducing dust exposures, include:

      1) Personal hygiene habits are encouraged such as required daily showers (15 minutes of paid overtime are allowed for showering); no smoking is permitted in work areas, eating is permitted only in designated areas and the lunch room; and washing prior to lunch break is encouraged.

      2) No incentive pay program is in effect to encourage accelerated production rates. Although this procedure has mixed effects in different work situations, generally incentive pay programs tend to encourage short cut work habits that may lead to unsafe work practices.

      3) Two, 10-minute break periods per day (in addition to the lunch break) provide for a reduction of stress and safer work practices.

4) A daily housekeeping period is provided for the operators to clean up spills in the work area. Since operator rotation occurs, all operators are responsible for housekeeping. Spills and other contaminates are either washed down by hose or vacuum cleaners at least two times per day.

5) Scheduled maintenance is provided for the oiling of equipment. General ventilation systems are monitored annually, while laboratory hoods are monitored quarterly.

E. Personal Protective Equipment

A strict respiratory protection program requires all workers (and visitors) to wear respiratory protection at all times in the Mix Room and the Pigment Room. This is required, even though recent environmental and medical monitoring data indicate that exposures to PVC, acrylic resins and cadmium - containing dusts are well below recommended hygienic standards. Willson R2 respirators, with HEPA (High Efficiency Particulate Air) filter cartridges, are used.

Workers are also provided with safety shoes and clean clothes daily, including undershorts, shirts, trousers, and work gloves. Each worker is provided with a weekly supply of clothing, which he stores in his "clean" locker.

F. Several work practices were observed, however, that significantly contributed to the dust exposures. These should be modified to reduce dust dispersion.

1. Although the breaking of bags, during unloading from pallets, transfer and opening, has been minimized by careful bag handling, improper disposal of broken bags can be a major source of air contamination. During Run 3 in the KYDEX® Mix Room, a broken bag raised dust levels around the dump station to approximately 4 times the dust level during

normal operations. Provision of a separate area for disposal of dirty or broken bags would minimize this dust source.

2. The practice of compressing empty bags for disposal away from the influence of the exhausted feed hood (at the northeast corner of the KYDEX® Mix Room, location G), nullified the effectiveness of the exhaust hood. All of the operations of bag handling-slitting, dumping, compression and placing in a disposal container should be performed as close to the exhaust hood as possible to capture potential dual emissions.

G. The overall effectiveness of the dust control systems was verified by the Company's environmental and medical monitoring programs.

1. Environmental monitoring

Environmental monitoring has been conducted at this facility for at least 11 years. Short term (S), Full Shift (T), Personal (P) and Area (A) samples have been collected and analyzed for Total Dust (essentially acrylates and PVC), Cadmium salts, carbon black, and several other chemical and physical agents.

Exposures to PVC dust and cadmium containing dusts have been continuously reduced to safe levels, according to the company's hygiene monitoring records.

2. Medical Monitoring

An effective medical management program including scheduled physicals and biological monitoring, is carried out by the Medical Staff under the direction of David Spratt, D.O. The effectiveness of the environmental control program has been verified by the simultaneous reduction in urinary cadmium levels among exposed workers, according to a letter from Dr. I. Rosenthal, Corporate Director of Health and

Safety to Dr. Anthony Robbins, Director of NIOSH, dated September 20, 1979.[14]

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