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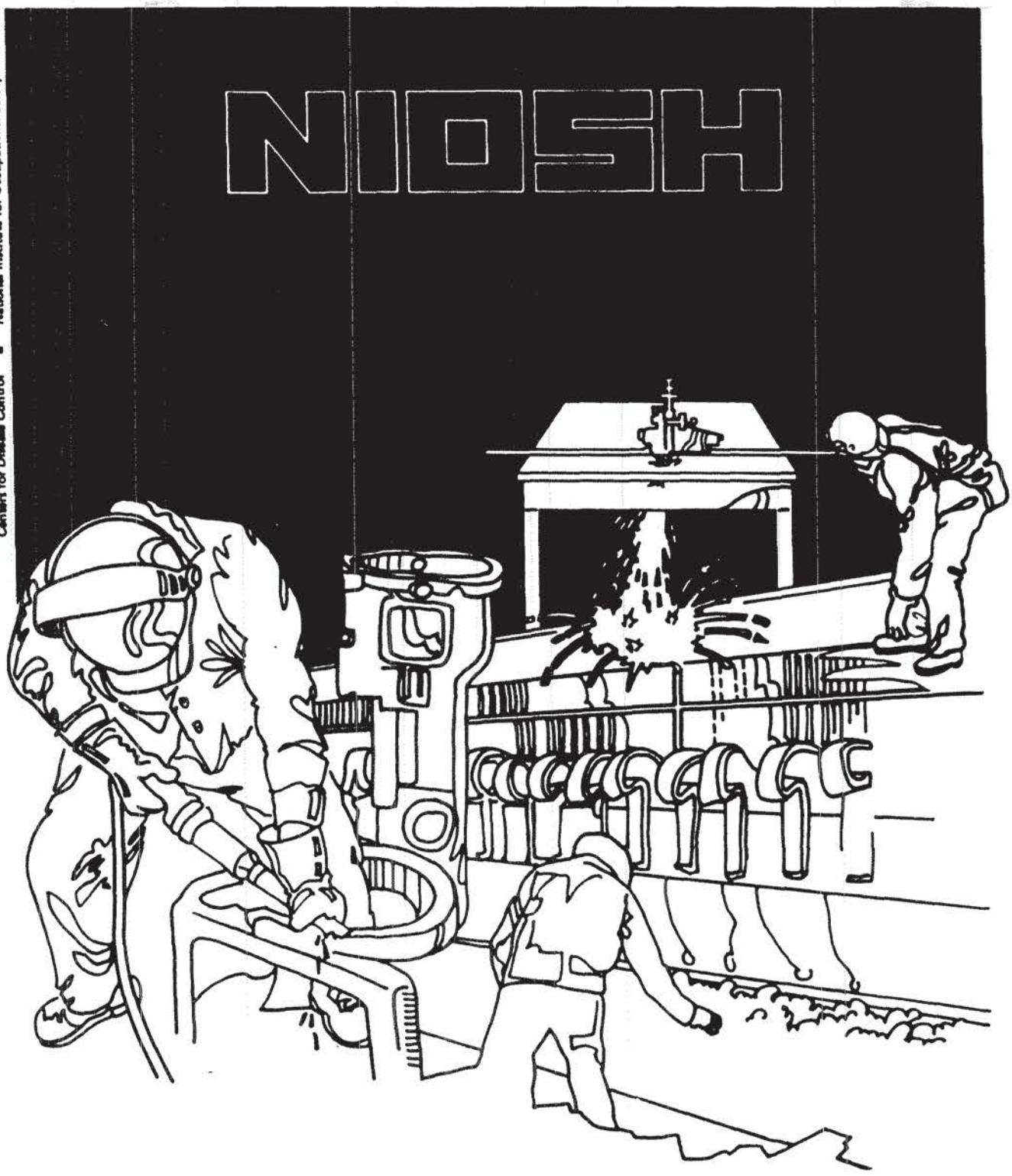

Health Hazard Evaluation Report

HETA 81-337-1125
BORDEN CHEMICAL DIVISION
FAYETTEVILLE, NORTH CAROLINA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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Borden Chemical Division
Fayetteville, NC

NIOSH INVESTIGATOR:
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I. SUMMARY

On June 1, 1981 The National Institute for Occupational Safety and Health (NIOSH) received a request from the International Chemical Workers Union, for a health hazard evaluation at the Borden Chemical Division, Fayetteville, N.C. Of concern were reported personal exposures of workers to formaldehyde (or other toxic substances) during production of formaldehyde and formaldehyde resins.

The health hazard evaluation was begun at the plant on June 15, 1981 by the University of North Carolina under a cooperative agreement with NIOSH. Three field sampling surveys were conducted in June-August to observe all operations producing and/or using formaldehyde and to evaluate the variation in day-to-day exposures. The plant normally employs 40 workers, including operating, maintenance, shipping, general labor and laboratory personnel. Workers are generally required to adjust equipment, take quality control samples and oversee operations throughout the plant. Except for the five quality control rooms, storage warehouse and hexa plant, the major production areas are out-of-doors or under roof in open-sided structures.

During the three first shift surveys, 21 personal and 135 area air samples were taken in the formaldehyde and resin reaction areas, quality control rooms and truck loading facilities. Impinger and molecular sieve samples were generally short-term, of approximately one hour duration; however badge samples, due to low diffusion rates, usually required four hours of sampling time to be above the lower limit of sensitivity of the analytic method. Analysis of personal samples of operators in the formaldehyde and resin quality control rooms showed air concentrations of formaldehyde vapor ranging from 0.04 to 0.81 ppm. Samples for formaldehyde vapor taken outside the quality control rooms ranged from 0.10 to 2.20 ppm. No phenol vapor was detected by means of detector tubes in the resin reaction areas where phenol-formaldehyde resins were being produced. Employee complaints were limited to sporadic peak exposures to formaldehyde during times of malfunctioning equipment, spills, quality control sampling and analysis. The current OSHA time weighted average permissible exposure limit of 2 ppm for formaldehyde was not exceeded.

Formaldehyde has been identified as a suspect carcinogen. Until safe levels of exposure to formaldehyde vapors have been demonstrated, NIOSH recommends that engineering controls and stringent work practices be employed to reduce occupational exposure to the lowest feasible limit. In this plant, the transport of fresh air to quality control rooms, the use of exhaust hoods during quality control testing, good work technique, preventive maintenance on operating equipment, and caution in handling formaldehyde and resins during transport and storage is recommended.

KEYWORDS: SIC 2868 and 2821, formaldehyde, formaldehyde resins, phenol, chemical workers.

II. INTRODUCTION

On June 1, 1981, the International Chemical Workers Union requested a health hazard evaluation of the Borden Chemical Division (Borden, Inc.) plant in Fayetteville, North Carolina. The request stated that workers producing formaldehyde and various formaldehyde resins were being exposed to formaldehyde during work procedures such as analysis of quality control samples without the use of local exhaust ventilation. The workers were also concerned about the long term effects of exposure to formaldehyde.

A health hazard evaluation was conducted at the plant by a team of industrial hygienists and technicians. Field sampling surveys were conducted on June 15, July 7, and August 2, 1981, in order to observe all operations producing and/or using formaldehyde and to evaluate the variations in day-to-day exposures.

III. BACKGROUND

The Borden plant began production of formaldehyde products about 25 years ago and has expanded its production areas several times. The company normally employs 40 workers, including operating, maintenance, shipping, general labor and laboratory personnel.

There are presently three reaction areas, designated I, II and III, for formaldehyde production and storage, and two quality control rooms. Two additional quality control rooms, designated I and II, exist in the resin production area. Portable charcoal absorbers with recirculating fans are provided in the quality control rooms for the purpose of removing organic contaminants. Various other operations such as the kettle area (resin mixing operation), hexa plant (quality control room, mixing and bagging hexamethylenetetramine), and the formaldehyde truck loading area were also evaluated.

Except for the five quality control rooms, storage warehouse and the hexa plant, the major production areas are outside or in open sheds.

IV. METHODS AND MATERIALS

A. Environmental

Three environmental sampling surveys were conducted by NIOSH representatives from the University of North Carolina. Information was obtained from the Company regarding product and operational procedures. Area and personal air samples were collected by various methods in the formaldehyde reaction areas for determination of organic vapor concentrations.

Due to lack of information comparing sampling methods and effects of other chemical or physical agents on these methods, i.e., humidity, temperature, chemical dust, other organic vapors, three different sampling methods were used. Variation in results is expected from these methods due to varied sampling rate, laboratory technique and analytical procedures.

Formaldehyde Determination:

Impingers (P & CAM 125)

The reference method for the collection and analysis of formaldehyde vapor was NIOSH Physical and Chemical Analytical Method 125 (1). Two midget impingers were connected in series and sample air bubbled through the absorbing solution at a flow rate of 1 liter/minute. Distilled water and 1% sodium bisulfite dissolved in distilled water were used as the absorbing media. The concentration of formaldehyde was determined colorimetrically from the absorbing medium by the chromotropic acid procedure. The reaction of formaldehyde with chromotropic acid, in the presence of sulfuric acid, causes a color change that is proportional to the formaldehyde concentration. The absorbance of the solution was determined at a wavelength of 580 nm on a Bausch and Lomb Spectronic 20 spectrophotometer. The concentration of formaldehyde was calculated from the absorbance using a previously prepared calibration curve.

Reported interferences with chromotropic acid include phenols, ethanol, higher molecular weight alcohols, nitrites, and aromatic hydrocarbons. Generally the interfering agents have to be present in high concentrations to cause significant deviation. Phenol present in an 8:1 excess causes a 10-20% negative interference. The chromotropic acid procedure is not affected by the presence of other aldehydes.

Molecular Sieves

The term "molecular sieve" was coined because of the ability of zeolites to act as sieves on a molecular scale by excluding molecules depending on size. Zeolites are defined as "alumino-silicates with a framework structure enclosing cavities occupied by large ions and water molecules, both of which have a considerable freedom of movement, permitting ion exchange and reversible dehydration" (2).

Zeolites differ from other adsorbents in that they have uniform pore size. Activated carbons may have a distribution of pore diameters ranging from 20-2000 angstroms, but molecular sieves have a unique size (3-10 Å) depending on the particular sieve. The pore diameter of the 13X molecular sieve is 10 angstroms. The internal structure of the zeolites consists of large cavities and interlocking channels that uniformly penetrate the solid. The size and nature of the channels determine which molecules are excluded. In addition

to separating compounds based on the sizes and configurations of their molecules, zeolites adsorb polar molecules more strongly than they do nonpolar molecules.

A procedure for collection of formaldehyde vapor using molecular sieves was developed by Hoffner (3). He placed 1 gram of activated 5 mesh 13X molecular sieve in a 10 cm x 9.5 mm glass tube. Glass wool plugs were used to hold the sieves in place while air was pulled through the cartridge at a flowrate of 0.5 liters per minute. After sampling, the formaldehyde was desorbed from the sieves by slowly pouring the sieves into 20 ml of chilled distilled water and allowing the mixture to stand for 23 minutes. The solution was then filtered to remove the sieve particles and analyzed by the chromotropic acid procedure.

In this study the procedure developed by Hoffner was used with minor modifications. The sampling cartridges were prepared with 1.5 grams of 5 mesh 13X molecular sieves and the sampling rate was lowered to 175 cc per minute. Both changes were made to allow a longer sampling period, approximately 50 minutes, and to prevent formaldehyde breakthrough at high relative humidities. After completion of sampling the sieves were transferred from the cartridge to a 1 dram vial. The vial was capped and stored in a freezer until analyzed.

The molecular sieve samples were analyzed within a week of completion of sampling in all cases. The formaldehyde was desorbed from the sieves in 20 ml of chilled distilled water for a minimum of 23 minutes. The solution was then filtered through a 15 ml medium pore fritted glass funnel to remove the sieve particles. Pressure was applied to the solution through a stopper using a 50 cc disposable syringe to reduce the time of filtration. A 4.0 ml aliquot was removed and the absorbance determined using the chromotropic acid procedure. A 2.5 ml aliquot was also removed after filtration to determine the absorbance by the modified pararosaniline procedure (4). Sipin (model SP 1) and SKC (model 222) personnel sampling pumps were used to obtain the lower sampling rate of 175 cc/min for the molecular sieve cartridges. For area samples the cartridges were attached to the pump inlet with a 1 cm section of tubing. The stroke volume was calculated for each pump, with a cartridge in line, prior to and upon completion of sampling. A 50 cc bubble flowmeter was used as the primary standard. All test tubes were cleaned with detergent and rinsed with tap water. Sulfuric acid was poured into tubes and allowed to stand for 1 hour, followed by repeated rinsing with tap water and a final rinse with distilled water.

Diffusion Badges

The Pro Tek™ Formaldehyde Badge is a diffusion monitor marketed by DuPont. Each badge contains 2.0 ml of an absorption solution and has a sampling temperature of 40°F to 120°F. The badges are sealed in foil pouches until initiation of sampling and must be resealed upon completion of sampling. The samples must be analyzed by a modified chromotropic acid procedure. Each lot of badges has a calibration factor provided in units of absorbance per ppm hrs of exposure. The range of capacity of the badges is stated as 2-50 ppm hrs; a 40 mm rectangular semi-micro cuvette is necessary to obtain the absorbance at the lower range. This cuvette has a long pathlength and a relative small volume. Because of this small volume, a critical factor in the badge analysis is proper alignment of the cuvette in the spectrophotometer. The badges are subject to the same interferences as the impingers analyzed by the chromotropic acid method.

The modified chromotropic acid analysis procedure specified by DuPont was followed: A 2.0 ml volume of the absorbing solution from each badge was pipetted into a test tube and 0.3 ml of 1% chromotropic acid solution added. To this solution a 3.0 ml aliquot of sulfuric acid was added followed by capping of the tube and further mixing. All test tubes so prepared were placed in a 90-95°C water bath for 15 minutes for development of color. Samples were subsequently cooled and analyzed on a Beckman DB spectrophotometer at a wavelength of 580 nm.

Phenol Determination:

Draeger detector tubes were used to sample for phenol in the general work area of the Resin II quality control room. The lower limit of detection for this method is approximately 2.5 ppm. Discoloration of the detector tubes from the normal color change expected would indicate interference from organic or water vapor.

B. General

A closing conference was held between company management, union representatives and University personnel to discuss the nature and scope of the evaluation, and to offer suggestions for improving conditions as observed during the three days of evaluation.

V. EVALUATION CRITERIA

The criteria for evaluating organic vapors assayed are the current American Conference of Governmental Industrial Hygienists Threshold Limit Values (ACGIH-TLV), the U.S. Department of Labor Occupational

Health Standards (OSHA), NIOSH Criteria Documents, and the NIOSH Registry of Toxic Effects of Chemical Substances. Limits appearing below reflect the lowest found among these sources.

Substance	Ceiling Limit or STEL (ppm)	8-hour time Weighted Average (ppm)	Source	OSHA 8-hour Limit (ppm) (6)
Formaldehyde	LFL*	LFL	NIOSH (5)	2
Phenol	10	5	ACGIH-TLV (8)/ OSHA (8)	5

* Lowest Feasible Limit (LFL)

Formaldehyde is both toxic and a primary irritant. It may produce a toxic response when inhaled, ingested, or absorbed through the skin. In addition to systemic toxic response, formaldehyde solutions also induce dermatitis.

Exposure to formaldehyde vapors produces burning and watering of the throat and nose. The odor threshold is reported as 0.05 ppm with irritation of the throat occurring at 0.5 ppm (10). There seems to be some uncertainty in the concentration of formaldehyde vapor necessary to produce eye irritation. Morrill determined the threshold for irritation of the eyes to be from 0.9-1.6 ppm (11). Bourne and Seframan reported eye irritation at concentrations of 0.13 to 0.45 ppm (12). Using blink rate as an index, Schuck concluded that the human eye can detect and react to as little as 0.01 ppm of formaldehyde vapor (13). Due to some adaptation upon exposure and variations in individual response, the threshold of eye irritation may be impossible to determine quantitatively. However, most studies seem to support the lower range of values (0.13-0.45 ppm) reported by Bourne and Seframan. Exposure to high concentrations (10-20 ppm) of formaldehyde vapor can produce coughing, heart palpitations, and intoxication (14).

In 1960 Amdur reported on the effects of the inhalation of formaldehyde by guinea pigs (15). One hour exposures to formaldehyde vapor produced an increase in pulmonary flow resistance and a decrease in lung compliance at concentrations as low as 0.3 ppm. These effects were completely reversed one hour after exposure except at concentrations above 50 ppm. A gas aerosol mixture using sub-micron sodium chloride crystals in combination with formaldehyde vapor produced a statistically significant increase in pulmonary flow resistance accompanied by decreased lung compliance at concentrations of 0.07 ppm. This enhancement of response indicates that with the aerosol present more of the formaldehyde reached the alveolar regions of the lung. Amdur suggested that the adherence of formaldehyde to the submicron particles reduced the scrubbing efficiency of the upper respiratory system. This means that in dusty areas individuals may respond to lower concentrations of formaldehyde than in dust free areas.

The most recent and controversial health effect attributed to formaldehyde is carcinogenesis. The Chemical Industry Institute of Toxicology recently presented data in a final report showing an increased incidence of nasal carcinomas in groups of 240 rats exposed to 15 ppm formaldehyde for 6 hrs/day, 5 days/week over 18 months (16). No increased incidence was detected in rats exposed to 2 or 6 ppm and in mice exposed to 2, 6, or 15 ppm of formaldehyde. After 24 months a total of 93 rats developed nasal carcinomas from exposure to 15 ppm formaldehyde and 2 rats developed nasal carcinomas from 6 ppm exposures (16).

In a study at New York University, 25 out of 100 rats developed squamous cell carcinomas of the nasal cavity when exposed to a mixture of formaldehyde and hydrogen chloride for 6 hrs/day over 814 days (17). Cancer of the nasal turbinates is an unusual form of cancer and rarely occurs spontaneously. Only 2 cases were observed in 5,844 unexposed rats at the National Cancer Institute (17). Further investigation is needed to confirm or refute the carcinogenicity of formaldehyde in humans. NIOSH currently recommends engineering controls and improved work practices be used to reduce the occupational exposure to formaldehyde to the "lowest feasible limit" (LFL) until the extent of the cancer risk at 3 ppm can be quantified (5).

Phenol is reported to be a general protoplasmic poison which is corrosive to cells. Poisoning can occur by skin absorption, vapor inhalation, or ingestion. Phenol vapors readily penetrate the skin surfaces with an absorption efficiency equal to that for inhalation (18).

VI. RESULTS AND DISCUSSION

During three separate first shift surveys, 21 personal and 135 area samples were collected. Results of their analyses are summarized in Table 1 and individually listed in the Appendix. Impinger and molecular sieve samples were generally short-term, of approximately one hour duration, however, badge samples, due to low diffusion rates, usually required four hours of sampling time. Samples were taken in formaldehyde and resin reaction areas, quality control rooms and truck loading facilities. Figure 1, a schematic diagram of the plant, shows general location of quality control rooms, reaction areas and storage areas for resin and formaldehyde. Field samples by area are marked and correspond to item number in Table 1. In all cases workers were not limited to a single work area but were generally required to adjust equipment, take quality control samples, and oversee the operations throughout their work areas.

Table 1. Formaldehyde vapor concentrations (ppm) measured in various work areas at the Borden Chemical Plant during three first shift surveys, June-August, 1981 (See Tables 3-4 in appendix for individual sample results)

1. Formaldehyde I and II Quality Control Room

	Area Samples			Personal Samples	
	Impinger	Badge	M.S.	Impinger	M.S.
Mean	0.38(9)	1.30(2)	0.42(8)	0.46(2)	0.50(4)
+ S.D.	0.20		0.15		0.30
Range	0.05-0.68	0.95-1.65	0.23-0.64	0.31-0.60	0.09-0.81

2. Formaldehyde III Quality Control Room

	Area Samples			Personal Samples
	Impinger	Badge	M.S.	M.S.
Mean	0.06(9)	0.21(2)	0.07(9)	0.23(6)
+ S.D.	0.05		0.05	0.13
Range	0.00-0.14	0.18-0.24	0.03-0.18	0.04-0.41

3. Formaldehyde I and II Reaction Area

	Area Samples		
	Impinger	Badge	M.S.
Mean	0.74(12)	0.20(2)	0.61(11)
+ S.D.	0.65		0.41
Range	0.23-2.20	0.16-0.24	0.10-1.40

4. Formaldehyde III Reaction and Storage Areas

	Area Samples		
	Impinger	Badge	M.S.
Mean	0.24(6)	0.22(2)	0.17(6)
+ S.D.	0.14		0.02
Range	0.12-0.45	0.20-0.24	0.15-0.21

5. Resin I Quality Control Room

	Area Samples		Personal Samples
	Impinger	M.S.	M.S.
Mean	0.29(5)	0.27(3)	0.10(3)
+ S.D.	0.16	0.30	.06
Range	0.18-0.57	0.02-0.60	0.04-0.16

6. Resin II Quality Control Room

	Area Samples			Personal Samples	
	Impinger	Badge	M.S.	Impinger	M.S.
Mean	0.43(9)	0.57(2)	0.20(9)	0.16(1)	0.36(1)
+ S.D.	0.33		0.37		
Range	0.13-0.70	0.47-0.66	0.05-1.06		

7. Formaldehyde Truck Loading Area

	Area Samples		Personal Samples
	Impinger	M.S.	Impinger
Mean	0.86(4)	1.33(3)	0.55(2)
+ S.D.	0.66	2.11	
Range	0.07-2.83	0.07-3.80	0.07-1.03

8. Below Kettle Area (resin mixing operation)

	Area Samples	
	Impinger	M.S.
Mean	0.04(4)	0.06(4)*
+ S.D.	0.02	0.01
Range	0.02-0.07	0.04-0.07

* One additional sample (badge) taken on the mezzanine floor at kettle opening was 1.49 ppm Formaldehyde vapor concentration.

9. Hexa Plant Quality Control Room and Area

	Area Samples			Personal Samples
	Impinger	Badge	M.S.	Badge
Mean	0.53(3)	2.66(3)	0.41(3)	5.30(2)
+ S.D.	0.07	1.49	0.05	
Range	0.47-0.60	1.80-4.31	0.37-0.46	5.00-5.50

10. Quality Control Laboratory

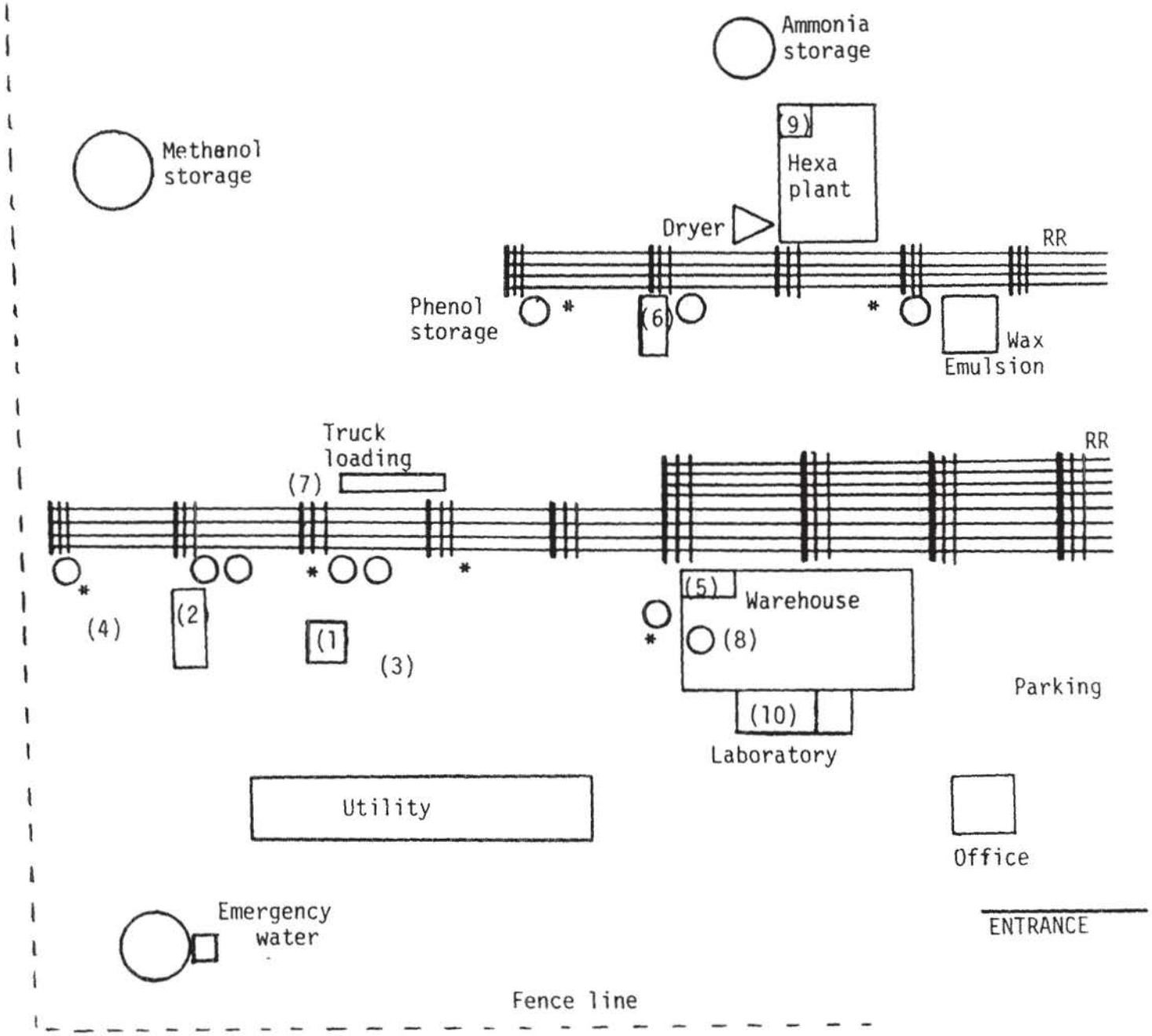
	Area Samples
	Impinger
Mean	0.12(6)
+ S.D.	0.08
Range	0.04-0.27

Impinger - two impingers in series with 1% sodium bisulfate

Badge - duPont Pro-tek™ monitoring badge

M.S. - 13-X molecular sieve tubes (Mesh 5)

Figure 1. Schematic of Borden Chemical Plant in Fayetteville, N.C. showing general location of quality control rooms and reaction and storage areas for resins and formaldehyde.



Numbers match Table 1. listings

(1) Formaldehyde I and II control room.
(2) Formaldehyde III control room.
(3) Reaction area formaldehyde I and II.
(4) Reaction area formaldehyde III.
(5) Resin I Quality control room.
(6) Resin II Quality control room.
(7) Truck loading for formaldehyde
(8) Kettle mixing area
(9) Hexa plant quality control
(10) Quality control laboratory room.

* Formaldehyde and resin storage areas.

Formaldehyde I, II and III and Resin I and II (Table 1, items 1-6)

Personal sample data in the formaldehyde I, II and III and resin I and II locations ranged from 0.04 to 0.81 ppm formaldehyde vapor concentrations for sampling times of 42 to 78 minutes. Area air samples in these same general locations inside and outside the quality control rooms ranged from 0.00-1.65 ppm formaldehyde vapor concentration for sampling times of 20-260 minutes. No phenol vapor was detected by means of detector tubes in the resin reaction areas where phenol-formaldehyde resins were being produced. Interference of this method from organic or water vapor was not indicated by discoloration of the detector tubes.

Truck Loading (Table 1, item 7)

Two personal air samples of 51 and 50 minutes collected during truck-loading of formaldehyde showed 0.07 and 1.03 ppm formaldehyde vapor concentration respectively. Area air samples in the same general location ranged from 0.07 to 3.80 ppm formaldehyde vapor concentration for sampling times of 40 to 57 minutes. On one occasion a liquid formaldehyde spill occurred during loading and could account for the increased range recorded. Table 3, item 7 in the appendix lists samples taken during formaldehyde spill at the loading area.

The Kettle area (Table 1, item 8)

The kettle (resin mixing operation) area is sporadically operated and in three surveys was observed operating only once for a few hours. Area sample results indicated relative low levels of formaldehyde, 0.02 to 0.07 ppm for sampling times of 57 to 255 minutes. However, one sample of 246 minutes taken on the mezzanine floor near the kettle opening was 1.49 ppm formaldehyde vapor concentration.

Hexa Plant (Table 1, item 9)

In the hexa plant, mixing and bagging of dry chemicals increase the potential for airborne chemicals, primarily hexamethyltetramine. The potential for formaldehyde vapors is slight except when the operation is starting up, closing down, or not operating properly. Area air samples for formaldehyde using impingers and molecular sieve tubes ranged from 0.37 to 0.60 ppm for sampling times of 68 to 83 minutes. Badges, both personal and area, taken at the same time and in approximately the same location had higher results; they ranged from 1.80 to 5.50 ppm for sampling times of 246 to 254 minutes. Badges A-1 and A-1' were duplicate samples and resulted in 1.88 and 1.80 ppm formaldehyde. Six other samples, impinger and molecular sieve, taken at the same location as A-1 and A-1' ranged from 0.37 to 0.60 ppm and averaged 0.47 ppm over the same sampling time. The badge analyses were over three times higher than other

samples. Results obtained with badges in the Hexa plant as shown above are felt to be invalid. The surveying industrial hygienist's evaluation of the higher levels of formaldehyde found with the badges appeared to be an overestimation of the concentration as determined by the impinger and molecular sieve. Interferences from the dust and other organics in the hexa plant is suspected in the higher formaldehyde results. Chemical odors were detected throughout the hexa plant but not the odor associated with formaldehyde at greater than 1 ppm.

Quality control laboratory (Table 1, item 10)

Occasionally formaldehyde solutions will be analyzed for quality in the major laboratory. Area air samples for formaldehyde vapors ranged from 0.04 to 0.27 ppm for sampling times of 60 to 68 minutes. Formaldehyde and resin plant operators generally spend over 50 percent of their time in the quality control rooms. In these rooms where hoods are available and used during formaldehyde quality control testing, a negative pressure is created allowing formaldehyde to enter the room from the reaction areas. Air recirculating units with charcoal filters are located in these rooms and are generally operating twenty-four hours per day. Tests of the formaldehyde collection efficiency of these units were not undertaken.

Interviews with several formaldehyde and resin plant operators indicated, as a general rule, that they were not irritated by the formaldehyde. Only on a few occasions when there was malfunctioning equipment, spills or during the testing and analysis of quality control samples did they have a slight irritation.

VII. CONCLUSIONS

Until safe levels of exposure to formaldehyde vapors have been demonstrated, NIOSH recommends that engineering controls and stringent work practices be employed to reduce occupational exposure to the lowest feasible limit.

Formaldehyde data collected during the three surveys indicated worker exposure was less than 1.0 ppm. Exceptions to this were the truck loading during a formaldehyde spill and the Hexa plant. The Hexa plant badge samples were considered invalid and the exposure level was felt to be more in line with the other types of sampling methods, less than 1.0 ppm.

Exposure to formaldehyde vapors of workers who generally spend over 50 percent of their time in the quality control rooms could be greatly reduced if fresh air devoid of contaminants could be brought in from an area beyond the reaction area. Also, this air could be supplied in such a way that the rooms would be under slight positive pressure and would facilitate use of laboratory hoods when operators handle formaldehyde solutions during quality control analyses. In work areas where hoods are available for

quality control analyses, they are generally not used because the hood exhaust brings make-up air into the room through doors leading to the reaction area where formaldehyde vapors are found. Make-up air is thus one source of formaldehyde vapor in the room. The charcoal filters on the air recirculating units require periodic maintenance and would not be as effective as fresh uncontaminated air being supplied from other areas.

Worker technique is very important in handling grab samples of formaldehyde and other chemicals for quality control analysis, and in loading various containers (trucks, metal containers, etc.) for shipment. Liquid formaldehyde spills which occur from containers overflowing, leaking fill hoses, and dripping quality control grab samples, should be carefully controlled through worker technique and maintenance on faulty hoses or pipes.

There are several recommendations listed below which would reduce worker exposure to formaldehyde vapor as NIOSH has recommended.

VIII. RECOMMENDATIONS

On the basis of observation, the environmental sampling data listed in this report, and good industrial hygiene practice, the following recommendations are made:

1) Fresh air devoid of contaminants should be supplied from an area beyond the reaction area into all quality control rooms.

2) Laboratory exhaust hoods that are available in quality control rooms should be used during testing of formaldehyde solutions. Where hoods are not available they should be installed and used.

3) Good worker technique, preventive maintenance of operating equipment, and caution in handling formaldehyde and resins during transport and storage is recommended.

4) It is recommended that a program for monitoring concentrations of formaldehyde vapor to which personnel are exposed and which occur in occupied work areas be initiated. NIOSH recently published a new analytical method for formaldehyde (PCAM 354, Vol 7, NIOSH Manual of Analytical Methods, August 1981) and now recommends its use in preference to other methods.

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X. AUTHORSHIP AND ACKNOWLEDGEMENTS

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XI. DISTRIBUTION AND AVAILABILITY

Copies of this Determination report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After ninety (90) days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati, Ohio address.

Copies of this report have been sent to:

(a) Borden Inc., Columbus, OH
(b) International Chemical Workers Union, Akron, OH
(c) Borden Chemical Plant, Fayetteville, NC
(d) U.S. Department of Labor, OSHA, Region IV
(e) NIOSH Region IV
(f) North Carolina Department of Human Resources
(g) North Carolina Department of Labor

Table 2. Formaldehyde Vapor Concentration from Environmental Survey, July 15, 1981

1. Formaldehyde I and II Quality Control Room

Number and Type Sample	Location	Duration (min)	Formaldehyde Concentration (ppm)
2-B, impinger, personal	Operator, 15 minutes involved with quality control.	10:05-11:05 (60)	0.60
14-B, impinger, personal	Same as above. 20 minutes involved with quality control.	1:54-3:09 (75)	0.31
4-B, impinger, area	Quality control room, table top, 15 minutes of quality control work in room.	10:06-11:07 (61)	0.19
11-B, impinger area	Same as above. No quality control work.	1:56-3:09 (73)	0.05
10-B, molecular, sieve, area	Same as above.	1:56-3:09 (73)	0.23

2. Formaldehyde III Quality Control Room

7-B, molecular, sieve, personal	Operator, 10 minutes involved with quality control.	10:14-11:18 (64)	0.31
16-B, molecular, sieve, personal	Same as above. 15 minutes involved with quality control.	2:14-3:32 (78)	0.15
3-B, impinger, area	Quality control room, table top, 10 minutes of quality control work in room.	10:15-11:17 (62)	0.14
4-B, molecular, sieve, area	Same as above.	10:15-11:17 (62)	0.18
15-B, molecular, sieve, area	Same as above. No quality control work in room.	2:02-3:32 (90)	0.07
12-B, impinger, area	Same as above.	2:02-3:32 (90)	0.11

Table 2 (continued)

3. Formaldehyde I & II Reaction Area

Number and Type Sample	Location	Duration (min)	Formaldehyde Concentration (ppm)
A-1, impinger, area	In reaction area base of tower.	10:28-11:08 (40)	1.87
A-1, molecular, area	Same as above.	10:28-11:08 (40)	1.40
A-2, molecular, sieve, area	Same as above.	11:22-12:04 (42)	1.20
A-2, impinger, area	Same as above.	2:16-2:58 (42)	2.20

4. Formaldehyde III Reaction and Storage Area

1-B, impinger, area	Storage area, base of tank #31 between #34-33 and #31 tank.	10:22-11:21 (59)	0.45
3-B, molecular, sieve, area	Same as above.	10:22-11:21 (59)	0.18
13-B, impinger, area	Same as above.	2:11-3:14 (62)	0.40
14-B, molecular, sieve, area	Same as above.	2:11-3:14 (62)	0.17

5. Resin I Quality Control Room

A-1, molecular, sieve, personal	Operator, resin I plant	10:14-10:59 (45)	0.04
A-2, molecular, sieve, personal	Operator, same as above	11:00-11:46 (46)	0.10
A-3, molecular, sieve, personal	Operator, same as above.	2:12-2:54 (42)	0.16
A-1, impinger, area	Quality control, table top, 2 feet right of sink.	10:12-10:59 (47)	0.19
A-1, molecular, area	Same as above.	10:12-10:59 (47)	0.02
A-3, impinger, area	Same as above.	2:13-2:52 (39)	0.57
A-3, molecular, sieve, area	Same as above.	2:13-2:52 (39)	0.60

Table 2 (continued)

6. Resin II Quality Control Room

Number and Type Sample	Location	Duration (min)	Formaldehyde Concentration (ppm)
A-1, molecular, sieve, personal	Operator, resin II plant.	10:57-11:42 (45)	0.16
A-1, impinger, area	Quality control room, 6 feet from sink on countertop.	10:51-11:41 (50)	0.62
A-1, molecular, sieve, area	Same as above.	10:51-11:41 (50)	0.05
A-2, impinger, area	Quality control room room on shelf above sink	2:32-3:13 (41)	0.26
A-2, molecular, sieve, area	Same as above.	2:32-3:13 (41)	0.05

7. Formaldehyde Truck Loading Area

A-1, impinger area	Scale house, 3 feet off floor, door open	10:45-11:30 (45)	0.32
A-2, impinger, area	Same as above.	3:04-3:44 (40)	0.23
A-2, molecular sieve, area	Same as above.	3:04-3:44 (40)	0.07
A-2, impinger, personal	Operator of loading operations.	2:02-2:53 (51)	0.07

8. Below Kettle Area (resin mixing operation)

Not operating - no samples taken.

9. Hexa Plant Quality Control Room Area

Not operating - no samples taken.

10. Quality Control Laboratory

5-B, impinger, area	Laboratory, countertop center of room.	9:53-10:53 (60)	0.14
10-B, impinger area	Same as above.	1:49-2:55 (66)	0.55

Table 3. Formaldehyde Vapor Concentration from Environmental Survey, August 7, 1981

1. Formaldehyde I and II Quality Control Room

Number and Type Sample	Location	Duration (min)	Formaldehyde Concentration (ppm)
B-204, molecular, sieve, personal	Operator formaldehyde I and II, quality control testing, 20 minutes during survey.	10:06-11:17 (71)	0.09
B-207, molecular, sieve, personal	Same as above. Checked outside operations.	11:18-12:20 (62)	0.58
B-212, molecular, sieve, personal	Same as above.	12:20-1:12 (52)	0.51
B-216, molecular, sieve, personal	Same as above.	1:13-2:12 (59)	0.81
B-2, impinger, area	Quality control room, countertop.	10:01-11:12 (71)	0.24
B-201, molecular, sieve, area	Same as above.	10:01-11:15 (74)	0.26
B-6, impinger, area	Same as above.	11:14-12:08 (54)	0.44
B-210, molecular, sieve, area	Same as above.	11:16-12:17 (61)	0.46
B-9, impinger, area	Same as above.	12:11-1:09 (58)	0.24
B-211, molecular, sieve, area	Same as above.	12:18-1:12 (54)	0.31
B-12, impinger, area	Same as above.	1:11-2:08 (57)	0.54
B-215, molecular, sieve, area	Same as above.	1:12-2:09 (57)	0.64

Table 3 (continued)

2. Formaldehyde III Quality Control Room

Number and Type Sample	Location	Duration (min)	Formaldehyde Concentration (ppm)
B-202, molecular, sieve, personal	Operator Formaldehyde III, quality control testing 10 minutes during survey.	10:16-11:26 (70)	0.04
B-209, molecular, sieve, personal	Same as above.	11:26-12:27 (61)	0.25
B-214, molecular, sieve, personal	Same as above.	12:27-1:19 (52)	0.41
B-218, molecular, sieve, personal	Same as above.	1:20-2:18 (58)	0.23
B-3, impinger, area	Quality control room, countertop between sink and door.	10:20-11:21 (61)	0.09
B-203, molecular, sieve, area	Same as above.	10:20-11:23 (63)	0.03
B-7, impinger, area	Same as above.	11:23-12:24 (61)	0.05
B-208, molecular, sieve, area	Same as above.	11:24-12:26 (62)	0.03
B-10, impinger, area	Same as above.	12:26-1:16 (50)	0.02
B-213, molecular, sieve, area	Same as above.	12:26-1:18 (52)	0.07
B-13, impinger, area	Same as above.	1:18-2:15 (67)	0.07
B-217, molecular, sieve, area	Same as above.	1:19-2:17 (58)	0.06

Table 3 (continued)

3. Formaldehyde I and II Reaction Area

Number and Type Sample	Location	Duration (min)	Formaldehyde Concentration (ppm)
A-1, impinger, area	Open area near reactor area, 2 feet off floor.	10:09-11:01 (52)	0.63
A-1, molecular, sieve, area	Same as above.	10:09-11:01 (52)	0.72
A-2, impinger, area	Same as above.	11:12-12:01 (49)	0.76
A-3, impinger, area	Same as above except 8 feet closer to reactor.	1:08-2:00 (52)	0.51
A-3, molecular, sieve, area	Same as above.	1:08-2:00 (52)	0.68
A-4, impinger, area	Same as above.	2:00-2:51 (51)	0.49
A-4, molecular, sieve, area	Same as above.	2:00-2:51 (51)	0.59
B-15, impinger, area	Reactor area near tank #15, three feet off ground.	2:40-3:02 (22)	0.46
B-219, molecular, sieve, area	Same as above.	2:41-3:02 (21)	0.59
B-14, impinger, area	Formaldehyde I and II reaction area beside methanol tank.	2:49-3:09 (20)	0.95
B-220, molecular, sieve, area	Same as above.	2:49-3:09 (20)	0.71

4. Formaldehyde III Reaction and Storage Area

No samples were taken in this area on this survey.

5. Resin I Quality Control Room

A-1, impinger, area	Resin I quality control room, on countertop near sink.	9:54-10:45 (51)	0.18
A-2, impinger, area	Same as above.	10:59-11:52 (53)	0.28
A-2, molecular, sieve, area	Same as above.	10:59-11:52 (53)	0.18
A-3, impinger, area	Same as above.	1:05-1:55 (50)	0.22

Table 3 (continued)

6. Resin II Quality Control Room

Number and Type Sample	Location	Duration (min)	Formaldehyde Concentration (ppm)
A-1, impinger, personal	Operator resin I plant, in and out of quality control room.	10:17-11:20 (63)	0.36
A-1, impinger, area	Quality control room on countertop near sink.	10:20-11:20 (60)	0.70
A-1, molecular, sieve, area	Same as above.	10:20-11:20 (60)	0.73
A-2, impinger, area	Same as above.	1:13-2:13 (60)	0.66
A-2, molecular, sieve, area	Same as above.	1:13-2:13 (60)	0.26
A-3, impinger, area	Quality control room, control panel wall away from sink.	2:13-3:01 (58)	0.67
A-3, molecular, sieve, area	Same as above.	2:26-3:01 (35)	1.06

7. Formaldehyde Truck Loading Area

A-1, impinger, personal	Operator, loading operation and scale house.	11:46-12:36 (50)	1.03
A-1, impinger, area	In scale house, during survey some formaldehyde leaked from fill line.	11:24-12:21 (57)	2.83
A-1, molecular, sieve, area	Same as above.	11:24-12:21 (57)	3.80
A-2, impinger, area	In scale house but not loading trucks.	2:25-3:11 (46)	0.07
A-2, molecular, sieve, area	Same as above.	2:25-3:11 (46)	0.12

8. Below Kettle Area (resin mixing operation)

Not operating - no samples taken.

9. Hexa Plant Quality Control Room and Area

Not operating - no samples taken.

Table 3 (continued)

10. Quality Control Laboratory

Number and Type Sample	Location	Duration (min)	Formaldehyde Concentration (ppm)
B-1, impinger, area	Quality control laboratory, countertop, center of room.	9:46-10:54 (68)	0.04
B-4, impinger, area	Same as above.	10:56-11:56 (60)	0.09
B-8, impinger, area	Same as above. (duplicate with sample number B-4)	10:56-11:56 (60)	0.10
B-11, impinger, area	Quality control laboratory, countertop, center of room.	12:59-2:00 (61)	0.27

Table 4. Formaldehyde Vapor Concentration from Environmental Survey, October 7, 1981

1. Formaldehyde I and II Quality Control Room

Number and Type Sample	Location	Duration (min)	Formaldehyde Concentration (ppm)
A-3, impinger, area	Quality control room, countertop.	10:05-11:21 (76)	0.68
A-3, molecular, sieve, area	Same as above.	10:05-11:19 (74)	0.58
A-4, impinger, area	Same as above.	11:24-12:59 (95)	0.53
A-4, molecular sieve, area	Same as above.	11:20-12:59 (99)	0.45
A-7, impinger, area	Same as above.	1:01-2:23 (82)	0.47
A-7, molecular, sieve, area	Same as above.	1:02-2:23 (81)	0.44
A-3, badge, area	Same as above.	10:07-2:25 (258)	0.95
A-3', badge, area	Same as above. (duplicate with sample A-3)	10:07-2:25 (258)	1.65

2. Formaldehyde III Quality Control Room

A-2, molecular, sieve, area	Quality control room, countertop.	10:12-11:27 (75)	0.04
A-5, impinger, area	Same as above.	11:51-1:05 (74)	0.04
A-5, molecular, sieve, area	Same as above.	11:51-1:05 (74)	0.06
A-8, impinger, area	Same as above.	1:24-2:29 (65)	0.04
A-8, molecular, sieve, area	Same as above.	1:24-2:29 (65)	0.07
A-2, badge, area	Same as above.	10:12-2:32 (260)	0.24
A-2', badge, area	Same as above. (duplicate with sample A-2)	10:12-2:32 (260)	0.18

Table 4 (continued)

3. Formaldehyde I and II Reactor Area

Number and Type Sample	Location	Duration (min)	Formaldehyde Concentration (ppm)
B-5, impinger, area	Formaldehyde reaction areas I and II.	10:06-11:01 (55)	0.24
B-5, molecular, sieve, area	Same as above.	10:06-11:01 (55)	0.27
B-6, impinger, area	Same as above.	11:03-12:10 (67)	0.26
B-6, molecular, sieve, area	Same as above.	11:03-12:10 (67)	0.20
B-7, impinger, area	Same as above.	12:12-1:17 (65)	0.23
B-7, molecular, sieve, area	Same as above.	12:12-1:17 (65)	0.22
B-8, impinger, area	Same as above.	1:19-2:21 (62)	0.24
B-8, molecular sieve, area	Same as above.	1:19-2:21 (62)	0.10
B-200, badge, area	Same as above.	10:06-2:21 (255)	0.16
B-200', badge area	Same as above. (duplicate with sample B-200)	10:06-2:21 (255)	0.24

4. Formaldehyde III Reaction and Storage Areas

B-9, impinger, area	Reaction area, NW of quality control room.	10:19-11:20 (61)	0.15
B-9, molecular, sieve, area	Same as above.	10:19-11:20 (61)	0.16
B-10, impinger, area	Same as above.	11:24-12:21 (57)	0.12
B-10, molecular, sieve, area	Same as above.	11:24-12:21 (57)	0.15

Table 4 (continued)

4. Formaldehyde III Reaction and Storages Areas (continued)

Number and Type Sample	Location	Duration (min)	Formaldehyde Concentration (ppm)
B-11, impinger, area	Same as above.	12:21-1:32 (71)	0.14
B-11, molecular, sieve, area	Same as above.	12:21-1:32 (71)	0.17
B-12, impinger, area	Same as above.	1:35-2:35 (60)	0.19
B-12, molecular, sieve, area	Same as above.	1:35-2:35 (60)	0.21
B-300, badge, area	Same as above.	10:19-2:35 (256)	0.24
B-300', badge, area	Same as above. (duplicate with sample B-300).	10:19-2:35 (256)	0.20

5. Resin I Quality Control Room

No samples taken during survey.

6. Resin II Quality Control Room

B-13, impinger, area	Quality control room, control panel wall further from sink.	10:34-11:26 (52)	0.13
B-13, molecular, sieve, area	Same as above.	10:34-11:26 (52)	0.06
B-14, impinger, area	Same as above.	11:30-12:37 (67)	0.20
B-14, molecular, sieve, area	Same as above.	11:30-12:37 (67)	0.12
B-15, impinger, area	Same as above.	12:44-1:38 (54)	0.26
B-15, molecular, sieve, area	Same as above.	12:44-1:38 (54)	0.25
B-16, impinger, area	Same as above.	1:40-2:44 (64)	0.43
B-16, molecular, sieve, area	Same as above.	1:40-2:44 (64)	0.23

Table 4 (continued)

6. Resin II Quality Control Room (continued)

Number and Type Sample	Location	Duration (min)	Formaldehyde Concentration (ppm)
B-400, badge, area	Same as above.	10:34-2:44 (250)	0.66
B-400', badge, area	Same as above. (duplicate with sample B-400).	10:34-2:44 (250)	0.47

7. Formaldehyde Truck Loading Area

Not operating - No samples taken.

8. Below Kettle Area (resin mixing operation)

B-1, impinger, area	Ground level, below kettle opening.	9:59-10:56 (57)	0.07
B-1, molecular, sieve, area	Same as above.	9:59-10:56 (57)	0.07
B-2, impinger, area	Same as above.	10:58-12:00 (62)	0.05
B-2, molecular, sieve, area	Same as above.	10:58-12:00 (62)	0.06
B-3, impinger, area	Same as above.	12:02-1:06 (64)	0.03
B-3, molecular, sieve, area	Same as above.	12:02-1:06 (64)	0.04
B-4, impinger, area	Same as above.	1:09-2:14 (65)	0.02
B-4, molecular, sieve, area	Same as above.	1:09-2:14 (65)	0.05
B-100, badge, area	Same as above.	9:59-2:14 (255)	0.08
B-100', badge, area	Same as above. (duplicate with sample B-100)	9:59-2:14 (255)	0.16
A-5, badge, area	Four feet from kettle opening on mezzanine level.	11:09-3:15 (246)	1.49

Table 4 (continued)

9. Hexa Plant Quality Control Room and Area

Number and Type Sample	Location	Duration (min)	Formaldehyde Concentration (ppm)
B-107, badge, personal	Operator, in quality control room and other areas of plant.	10:53-3:07 (254)	5.0
B-110, badge, personal	Bagger, in separate bagging room.	10:56-3:05 (249)	5.5
A-1, impinger, area	Quality control room, countertop, near sink.	10:31-11:41 (70)	0.47
A-1, molecular, sieve, area	Same as above.	10:31-11:41 (70)	0.46
A-6, impinger, area	Same as above.	12:06-1:29 (83)	0.53
A-6, molecular, sieve, area	Same as above.	12:06-1:29 (83)	0.39
A-9, impinger, area	Same as above.	1:34-2:42 (68)	0.60
A-9, molecular, sieve, area	Same as above.	1:34-2:42 (68)	0.37
A-1, badge, area	Same as above.	10:32-2:45 (253)	1.88
A-1', badge, area	Same as above. (duplicate with sample A-1)	10:32-2:45 (253)	1.80
A-4, badge, area	Blending area, separate room from bagging, not operating during survey.	10:59-3:05 (246)	4.31

10. Quality Control Laboratory

No samples were taken in this area on this survey.