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SEPTEMBER 1992
DANA PERFUME CORP
MOUNTAINTOP, PENNSYLVANIA

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I. SUMMARY

A Health Hazard Evaluation was conducted by the National Institute for Occupational Safety and Health (NIOSH) at the Dana Perfume Corporation in Mountaintop, Pennsylvania. This investigation was performed in response to a joint request from management and Local 8-782 of the Oil, Chemical and Atomic Workers International Union. The health concerns included nausea, tongue numbness, throat irritation, and headaches among employees working in the Spray Room.

On June 25, 1991, NIOSH investigators performed a walk-through inspection of the facility. Personal breathing zone (PBZ) and general area air samples were collected to evaluate workers' exposures to ethanol, aldehydes, and other volatile organic chemicals (VOCs). Private medical interviews were conducted with 18 (40%) of the 45 full or part-time Spray Room employees.

The most common health concerns reported were throat irritation, burning eyes, headaches, and a decreased sense of taste. Interviewed employees also reported being most bothered by perfume odor at the actuator-placing machine area, the filling area, the spray-off area, and the water bath.

The PBZ and area air sampling results indicated that detectable, but relatively low, concentrations of VOCs, including ethanol, were present. The ethanol concentrations in full-shift PBZ air samples obtained on an assembler and two line mechanics ranged from none detected (< 4 parts per million [ppm]) to 53 ppm. These concentrations are well below the NIOSH recommended exposure limit (REL) for ethanol of 1000 ppm. The concentrations of other VOCs (b-pinene, p-cymene, limonene, and benzyl acetate) were also low, with full-shift PBZ concentrations less than 0.3 ppm. NIOSH RELs have not been established for these substances.

VOC concentrations in area air samples obtained near the actuator, filling machine, and line wrapping areas were also low, with concentrations ranging from 0.2 to 0.3 ppm for the VOCs listed above. No detectable levels of aldehydes were found in an area air sample obtained in the spray room; the limit of detection was approximately 0.3 milligram per cubic meter (mg/m^3).

Based on the data collected in this investigation, the NIOSH investigators conclude that, although overexposures to perfume constituents were not documented, exposure to low concentrations of perfume constituents could cause some of the symptoms experienced by the Spray Room employees. The actuator-placement area and the filling machine area were the most likely sources of noticeable exposures. Recommendations are provided in section VIII of this report for reducing perfume exposures in the Spray Room.

Keywords: SIC 2844 (Perfumes, Cosmetics, and other Toilet Preparations), perfume, volatile organic chemicals, aldehydes, ethanol.

II. INTRODUCTION

A Health Hazard Evaluation (HHE) was conducted by the National Institute for Occupational Safety and Health (NIOSH) at the Dana Perfume Corporation on June 25-26, 1991. The HHE was requested jointly by management and local 8-782 of the Oil, Chemical and Atomic Workers International Union. The HHE request was prompted by health complaints of nausea, tongue numbness, throat irritation, and headaches among employees working in the Spray Room.

III. BACKGROUND

A. Facility

The Dana Perfume Corporation, located in Mountaintop, Pennsylvania, is a manufacturer of brand-name perfumes. The plant consists of several production/assembly areas, as well as storage, mixing, and gassing rooms.

The source of the employee health complaints was the Spray Room. The dimensions of the Spray Room are approximately 40 feet by 60 feet, with a 20 foot ceiling. On the day of our visit, the production line was packaging an aerosol perfume product.

B. Process Description

Perfume is piped into a filling machine in the Spray Room from 1000-gallon maceration tanks located 100 feet outside the room. Empty bottles are carried in pucks by conveyor to the filling machine. The bottles are automatically filled with perfume, gassed with carbon dioxide to remove any air, and sent on to the next station where valves are placed on the bottles and then crimped. If the perfume product manufactured on a given day is an aerosol, the bottles are sent out of the Spray Room through a tunnel to an adjacent building called the Block House. There, a rotary gas filling machine puts 14% gas (propellant consisting of butane, isobutane, and propane) into the bottle and sends it back to the Spray Room to the actuator-placing machine. Spray valves (actuators) are placed on the bottles and the bottles are conveyed to a 130°F water bath to detect leaks. An employee is stationed at the water bath to remove leaky bottles. The intact filled bottles are capped by hand, labeled, and placed in boxes. On average, 26,000 bottles are filled and packaged in one day. However, due to technical difficulties on the line, only 16,722 bottles were packaged on the day of our visit.

C. Ventilation

Air is drawn into the room from the warehouse by a 4000 cubic feet per minute (cfm) fan at the top of the far wall, and exhausted by a 3500 cfm fan at the bottom of the wall facing the Block House. The ventilation system is on from 6:00 AM until at least 4:30 PM (one hour after the end of the shift). There is no direct supply of outside air to the room. The

outside air intake is located on the roof approximately 50 feet from the exhaust vent.

D. Workforce

Ten employees were working in the Spray Room on the day of our visit: seven line assemblers, two line mechanics, and a supply aide. The plant operates only on the first shift (7 AM - 3:30 PM). Employees on the assembly line rotate positions throughout the day, so that over an 8-hour shift, each assembler has spent time on each part of the line. The assembly line runs a total of 182 days during the year, but production is heaviest during June (when production is increased for the Christmas season). Two to four employees work in the Spray Room 182 days per year; the other employees rotate throughout the plant. There are approximately 45 production employees who work in the Spray Room during the year.

Personal protective equipment is not generally required in the Spray Room, although employees are supplied with soft ear plugs upon request. The employee at the water bath wore rubber gloves.

IV. METHODS

A. MEDICAL

Private medical interviews were conducted with 18 (40%) of the 45 full- or part-time Spray Room employees. Prior to our arrival, employees had been informed of the NIOSH visit by union and management representatives and were free to volunteer to participate in the interview process. All of the Spray Room employees who reportedly expressed an interest in discussing their work-related health concerns with NIOSH representatives were interviewed.

B. ENVIRONMENTAL

Personal breathing zone (PBZ) and area air sampling were performed to assess airborne exposure to the vapors of ethanol, aldehydes, and other volatile organic chemicals (VOCs) in the Spray Room.

All air sampling pumps were calibrated prior to sampling and visually inspected during the sampling period. PBZ air samples were collected from three assemblers, two line mechanics, and one supply aide. Assemblers were selected at random, since they rotated positions throughout the shift. Area samples were taken at locations that were perceived to have the highest exposures -- i.e., at the filling machine and the actuator placing machine.

1. Ethanol

PBZ air samples were collected on charcoal sorbent tubes over a full shift using Gilian constant-flow pumps operating at 20 milliliters per minute (ml/min). Sequential sampling periods (four for each

individual) ranged from 1.5 to 2 hours in duration. Charcoal tube samples were packed in blue ice immediately after collection. Samples were analyzed according to NIOSH Method 1400, using gas chromatography with flame ionization detection (GC-FID).[1] Area air concentrations were also measured using Draeger colorimetric indicator tubes specific for ethanol.

2. Volatile Organic Chemicals (VOCs)

PBZ and area air samples were collected on charcoal sorbent tubes using Gilian constant-flow pumps operating at 50 ml/min. Serial PBZ samples of approximately 1.5 hours duration were taken over the course of the shift. Serial area samples (four at each site) were collected by the actuator and filling machines. Qualitative analysis was performed on two of the area samples; the rest were analyzed quantitatively based on the results of the qualitative analyses. A comparison air sample was collected near the line wrapping area, where perfume exposure was subjectively lower.

Qualitative charcoal samples were desorbed with 1 ml carbon disulfide and screened by GC-FID. Quantitative charcoal samples were desorbed with 1 ml of a 5% ethanol in carbon disulfide solution (to increase sensitivity) and quantified by GC-MSD-SIM (mass selective detection and single ion monitoring) using a 30 meter DB-1 column (splitless mode).

VOCs were also sampled using Carbotrap 300 thermal desorption tubes containing a three-bed sorbent of Carbotrap C/Carbotrap/Carbosieve S-III materials. Prior to sampling, the thermal tubes were conditioned using a Tekmar Model 5100 Thermal Trap Conditioner and cleaned by baking at 400°C for 24 hours with helium flowing through the tubes at 10 ml/min. One-hour area air samples were collected by the filling machine and the actuator machine in the morning and afternoon using Gilian constant-flow pumps operating at 20 ml/min. A sample was also collected at the outside air intake. All thermal tubes were inserted directly into a desorber oven and desorbed for 10 minutes at 400°C. Samples were analyzed using a Tekmar Model 5010 automatic thermal desorber interfaced directly to a HP5890A gas chromatograph and HP5791 mass selective detector (TD-GC-MSD).

3. Aldehydes

Area air sampling for aldehydes was carried out using ORBO-23 solid sorbent tubes and Gillian constant-flow pumps operating at 20 ml/min for 3-4 hours. Samples were desorbed with 1 ml toluene in an ultrasonic bath for 60 minutes and analyzed according to NIOSH Method 2539 using GC-MSD (full scan) with a 15 meter DB-1301 column (splitless mode).[1]

V. EVALUATION CRITERIA

A. General Guidelines

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled to the level set by the evaluation criterion. These combined effects are not often considered by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs). The OSHA PELs may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits (STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

B. Perfumes

Perfume may contain hundreds of different substances, most of which do not have established exposure criteria. The toxicity of most of these "essential oils," or fragrances, has not been well-characterized. Many can irritate the skin, eyes, and mucous membranes, and cause allergic dermatitis and photosensitization.[2] Essential oils may also stimulate or

paralyze sensitive nerve terminals. Depression of the central nervous system has been reported at high doses.[2]

For example, three of the fragrance ingredients present in the perfume manufactured on the day of the survey include limonene, beta-pinene, and benzyl acetate. Limonene has been reported to cause allergic contact dermatitis.[3] Beta-pinene has been associated with irritation of the mucous membranes of the eyes, nose, throat, and upper respiratory tract[4] and contact allergies.[5] Occupational exposure limits have not been established for either of these terpenes (limonene and beta-pinene).

Benzyl acetate can cause irritation of the eyes and respiratory tract, as well as narcotic[6] or anesthetic[7] effects. Neither OSHA, NIOSH, nor ACGIH have established occupational exposure limits for benzyl acetate. The Council of Europe has set workplace exposure limits for benzyl acetate at 94 mg/m^3, and in Romania, permissible exposure levels have been established at 50 mg/m^3 as a TWA and 100 mg/m^3 as a ceiling limit.[8]

The major component of perfume is ethanol (75% by volume). Ethanol is irritating to the eyes and mucous membranes and causes central nervous system depression. Overexposure to ethanol vapor may result in mucous membrane irritation, headache, lack of concentration, dizziness, drowsiness, nausea, and vomiting. Exposures to high concentrations of ethanol during gestation have been associated with fetotoxicity in laboratory mice. Ethanol may also increase the toxicity of other chemical exposures.[9,10] The OSHA PEL and NIOSH REL for ethanol are 1000 ppm as a TWA exposure.

Butane, propane, and isobutane are constituents of perfume propellants. Propane is an asphyxiant and can cause shortness of breath, unconsciousness, and death. However, toxic effects are seen only at extremely high levels.[9] The OSHA PEL and NIOSH REL are 800 ppm for butane and 1000 ppm for propane.

VI. RESULTS

A. MEDICAL

Figure 1 shows the results of the medical interviews. The most common work-related health concerns were throat irritation, burning eyes, headaches, and a decreased sense of taste. There were no reports of tongue numbness (a concern in the original HHE request), although burning and soreness of the tongue were reported by two of the interviewed employees. Three of the employees reported nausea, another of the concerns listed in the original HHE request.

In addition to the health concerns, employees reported that the areas of the Spray Room that are most bothersome include the actuator-placing area, the area where excess perfume is sprayed off, the filling area, and the water bath late in the day. Most of the interviewed employees reported that their symptoms were worse when a TABU® perfume was

being manufactured than when the other fragrances were in the Spray Room. This perfume was not being manufactured during the NIOSH visit. Interviewed employees also reported worsening of symptoms whenever the Spray Room doors were kept closed during operation, i.e., during the winter and when a non-aerosol was being bottled.

B. ENVIRONMENTAL

Quantitative air sampling results are presented in Tables 1 through 3.

1. VOCs

Qualitative analysis of thermal tube samples identified limonene as a major component of all samples. Other terpenes and derivatives were also present, including pinenes and possibly citronellol. Additional compounds identified included p-cymene (isopropyl toluene), a dimethyl styrene, phenylethyl alcohol, benzyl acetate, p-anisaldehyde, and piperonal. These results were consistent with the analysis of a bulk sample of the perfume being packaged during our visit. The qualitative charcoal samples provided a similar profile, but also identified toluene and butanes. Piperonal was not present on the charcoal tube samples. Ethanol was present on all samples. A thermal tube sample from the outside air intake showed detectable, but very small, peaks for VOCs as compared to the Spray Room samples.

PBZ air samples obtained on two assemblers and one supply aide showed only traces of p-cymene (<0.04 ppm). Benzyl acetate and b-pinene were present in TWA concentrations of less than 0.03 ppm. Limonene TWA concentrations did not exceed 0.23 ppm. Traces of p-anisaldehyde were found on some samples, but all concentrations were at or below the limit of quantitation (0.01 ppm).

VOC area air samples obtained at the actuator and filling machines detected similar VOCs as the PBZ samples. As shown in Table 2, VOC levels were slightly higher at the actuator machine than at the filling machine.

It is important to note that the collection efficiencies and/or stability of the foregoing VOC compounds on charcoal is unknown. Therefore, all concentrations reported in the table should be considered as minimum amounts present.

2. Ethanol

The detector tube measurements revealed that ethanol was not present above the limit of detection of 100 ppm in area air samples

obtained at the filling machine and the actuator machine at 12:40 PM when the machines were not in operation. However, at 1:40 PM, when both machines were running, ethanol concentrations were 600 ppm at the actuator and 300 ppm at the filling machine.

All PBZ ethanol concentrations were well below the NIOSH REL of 1000 ppm (Table 3). The time-weighted average concentrations for the two line mechanics were 53 and 45 ppm, respectively. Ethanol was not present above a limit of detection of 4 ppm in the air samples obtained on the assembler.

3. Aldehydes

Since there were no aldehydes detected on the qualitative air sample obtained in the spray room, no further analysis of the remaining ORBO-23 tubes was performed. The limit of detection is estimated to be approximately 0.3 ppm.

VII. DISCUSSION AND CONCLUSIONS

The main source of exposure in the Spray Room appears to be the actuator machine. Each time a spray valve is placed on a bottle, perfume is sprayed into the air. By the end of the day, the odor in that portion of the Spray Room is quite strong.

The actuator is adjacent to the water bath, where perfume containers are tested for leaks. If the seals leak, bubbles will be formed under water. Occasionally, glass bottles will explode in the water bath. Leaky and broken containers are discarded into an uncovered trash can and emptied at the end of the day. In the interim, the perfume from the discarded containers can evaporate from the open can. The water in the water bath is changed infrequently.

Perfume bottles that elude the actuator machine (and therefore have no spray valves) are removed from the conveyer and poured through a filter into an open metal can. The perfume is later recycled, but in the meantime, the open can may be a significant source of exposure.

The filling machine may be another source of exposure. Several employees reported that when bottles are overfilled, perfume collects in the pucks. According to these employees, sometimes the pucks are cleaned out with air hoses. This practice was not observed on the day of our visit. Several employees reported that overfilled bottles are depleted by spraying off the excess perfume in the Spray Room. This reportedly had been done outside in the past.

Since only one perfume product was on the assembly line on the day of our sampling, our air sampling results are applicable to that product only. Many employees noted that health symptoms were most prevalent when another specific product was on the production line. However, the observations and recommendations made in this report should be generalizable to any of the perfume products packaged by Dana Perfume Corporation.

The PBZ and area air sampling results indicated detectable, but relatively low, exposures to ethanol and other VOCs. One set of ethanol measurements (from the assembler) found no detectable ethanol. These results are puzzling because the assembler spent part of the day at the water bath (near the actuator) where exposures should have been highest. The sampling results from the line mechanics and the Draeger tubes also suggest that the assembler's exposure readings may be erroneous.

Although no overexposures were found, the presence of work-related health complaints should not be ignored. There are several possible explanations for symptoms: (1) The numerous chemical substances in the perfume may interact synergistically; that is, their combined effect may be greater than the sum of the effects of each individual ingredient. (2) Some perfume ingredients may cause hypersensitivity. If this has occurred, certain individuals could experience allergic-type symptoms even at very low levels of exposure. (3) Since there are no established exposure guidelines for most perfume ingredients, it is difficult to predict at what level health complaints would be expected. Certain perfume ingredients may produce symptoms at very low levels of exposure.

It is also important to note that since the collection efficiency and/or stability of the sampled VOCs (other than ethanol) on charcoal is unknown, the concentrations reported should be viewed as minimum concentrations. In addition, the production level on the day of our visit was substantially lower than usual; therefore, it is possible that exposures on other days may be higher than those that were measured.

Excessive temperature levels may contribute to employee discomfort and health complaints. The temperature in the Spray Room was 81° F at 12:45 pm.

General dilution ventilation was the only type of ventilation used in the Spray Room to control exposures. Smoke tubes indicated that the room was under positive pressure (a safety precaution for combustible materials). Inside the room, air was supplied at the top of the far wall (where perfume exposure was relatively low) and exhausted at the base of the opposite wall facing the Block House (where exposures were highest). This direction of flow -- from the least contaminated to the most contaminated area -- is appropriate. However, dilution ventilation may not be adequate in situations where there is a significant point source, such as the actuator machine. In addition, there was no air supplied directly from outside; all intake air came from the warehouse.

VIII. RECOMMENDATIONS

In an industry which uses so many different substances for which there has been little toxicological research, air sampling may not yield definitive information on the specific cause of employee health complaints. If work-related health complaints occur however, steps should be taken to reduce exposures, regardless of the air sampling results.

1. A local ventilation hood enclosure with a flexible duct should be installed over the actuator machine to control exposures arising from

perfume spray. Because the actuator apparatus is already partially enclosed, this control measure should be feasible. Since this machine is a major source of VOC exposure, local ventilation should significantly lower employee exposures to perfume constituents.

2. Overfilled containers should not be discharged in the Spray Room. Excess perfume should be sprayed off outside.

3. The water in the water bath should be changed frequently. Perfume should not be allowed to accumulate in the water bath.

4. Perfume spills (in pucks or elsewhere) should be removed promptly. Air hoses or other methods that could result in aerosolization of the perfume should not be used.

5. Filtered perfume should be stored in a closed bin. If necessary, the bin should be ventilated to minimize perfume vapors.

6. Discarded perfume containers should be kept in a closed bin to prevent fugitive perfume vapors.

7. The ventilation system should operate for a period of time after the end of the shift to remove residual perfume vapors before the beginning of the next workday.

IX. REFERENCES

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XI. AUTHORSHIP AND ACKNOWLEDGEMENTS

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XII. DISTRIBUTION AND AVAILABILITY OF REPORT

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Copies of this report have been sent to:

1. Dana Perfume
2. OCAW Union Local 8-782
3. Employee representatives
4. OSHA, Region III

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Figure 1: Medical Interview Data
Dana Perfume, Mountaintop, PA
HETA 91-026 June 26, 1991

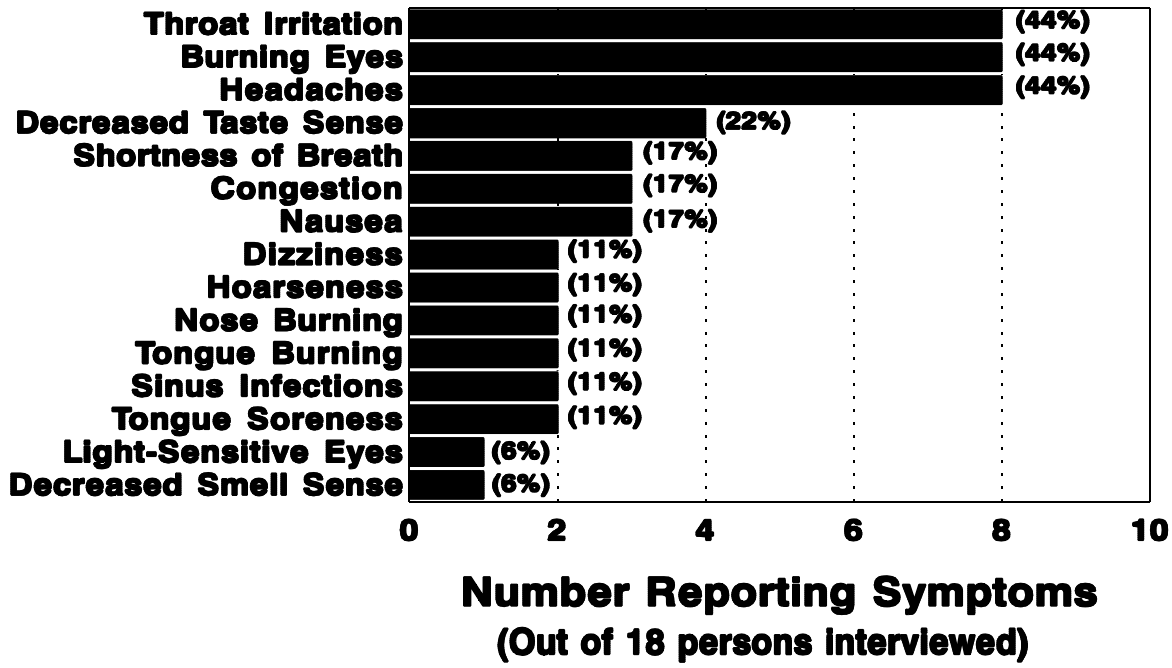

TABLE 1

VOC Concentrations in Personal Breathing Zone Air Samples

DANA PERFUME CORPORATION
Spray Room
Mountaintop, PA
HETA 91-026

June 26, 1991

Location	Time	Sample Volume	CONCENTRATION (ppm)[1] b-pinene	p-cymene	limonene	benzyl acetate
Assembler 1	0736-0942	5.8 L	0.02	trace[2]	0.22	trace
	0942-1124	5.1 L	trace	trace	0.27	trace
	1226-1412	5.3 L	trace	ND[3]	0.08	trace
	1412-1523	3.6 L	trace	ND	0.14	ND
					TWA[4] 0.16	
Assembler 2	0738-0945	6.4 L	0.03	trace	0.31	0.02
	0945-1120	4.8 L	0.03	trace	0.22	0.02
	1220-1406	5.3 L	trace	trace	0.15	0.02
	1406-1525	4.0 L	trace	trace	0.20	0.03
					TWA: 0.23	**0.02**
Supply Aide	0750-0944	5.7 L	0.03	trace	0.23	trace
	0944-1220	4.8 L	0.03	trace	0.22	trace
	1220-1413	5.7 L	trace	ND	0.12	trace
	1413-1522	3.5 L	trace	ND	0.15	trace
					TWA: 0.18	

[1] Collection efficiencies/stability of these compounds on charcoal is unknown; concentrations should be considered as minimum amounts present.

[2] Trace refers to concentrations between the limit of detection (LOD) and limit of quantitation (LOQ).

[3] ND = none detected; the analytical LOD was 0.2 microgram (ug) per sample which corresponds with a minimum detectable concentration of 0.01 ppm based on a sampling volume of 3.5 liters. The analytical LOQ was 0.7 ug/sample; this corresponds with a minimum quantifiable concentration of 0.04 ppm based on a sampling volume of 3.5 liters.

[4] **The TWA concentrations are time-weighted averages for the entire sampling period.**

TABLE 2

VOC Concentrations in Area Air Samples

DANA PERFUME CORPORATION
Mountaintop, PA
HETA 91-026

June 26, 1991

Location	Time	Sample Volume	CONCENTRATION (ppm)[1] b-pinene	p-cymene	limonene	benzyl acetate
Filling Machine (Spray Room)	1009-1131	4.1 L	0.03	trace[2]	0.18	trace
	1233-1424	5.6 L	0.03	trace	0.23	0.03
	1424-1524	3.0 L	trace	ND[3]	0.22	trace
					TWA[4]: 0.21	
Actuator (Spray Room)	1011-1133	4.1 L	0.04	trace	0.34	0.07
	1232-1407	4.8 L	trace	trace	0.20	0.05
	1407-1525	3.9 L	0.04	trace	0.31	0.05
					TWA: 0.28	**0.06**
Line Wrapping	0834-1513	10.0 L	0.03	trace	0.20	0.01

[1] Collection efficiencies/stability of these compounds on charcoal is unknown; concentrations should be considered as minimum amounts present.

[2] Trace refers to concentrations between the limit of detection (LOD) and limit of quantitation (LOQ).

[3] ND = none detected; The analytical LOD was 0.2 microgram per sample; this corresponds with a minimum detectable concentration of 0.01 ppm based on a sampling volume of 3 liters. The analytical LOQ was 0.7 ug/sample; this corresponds with a minimum quantifiable concentration of 0.04 ppm based on a sampling volume of 3 liters.

[4] The TWA concentrations are time-weighted averages for the entire sampling period.

TABLE 3

Ethanol Concentrations in Personal Breathing Zone Air Samples

DANA PERFUME CORPORATION
Spray Room
Mountaintop, PA
HETA 91-026

June 26, 1991

Job Title	Type	Time	Sample Volume (liters)	Concentration (ppm)	TWA[1]
Assembler	PBZ	0738-0946	2.6	ND[2]	ND
Assembler	PBZ	0946-1120	1.9	ND	
Assembler	PBZ	1221-1406	2.1	ND	
Assembler	PBZ	1407-1525	1.6	ND	
Line Mechanic 1	PBZ	0743-0940	2.3	55	53
Line Mechanic 1	PBZ	0941-1127	2.1	63	
Line Mechanic 1	PBZ	1224-1411	2.1	30	
Line Mechanic 1	PBZ	1411-1526	1.5	71	
Line Mechanic 2	PBZ	0747-0942	2.3	55	45
Line Mechanic 2	PBZ	0942-1128	2.1	53	
Line Mechanic 2	PBZ	1229-1410	2.0	21	
Line Mechanic 2	PBZ	1410-1526	1.5	49	

[1] The TWA concentrations are time-weighted averages over the entire sampling period.

[2] ND = none detected; the analytical limit of detection (LOD) was 0.01 milligram (mg) per sample; this corresponds with a minimum detectable concentration of 3 ppm based on a sampling volume of 2 liters. The analytical limit of quantitation (LOQ) was 0.03 mg/sample; this corresponds with a minimum quantifiable concentration of 8 ppm.