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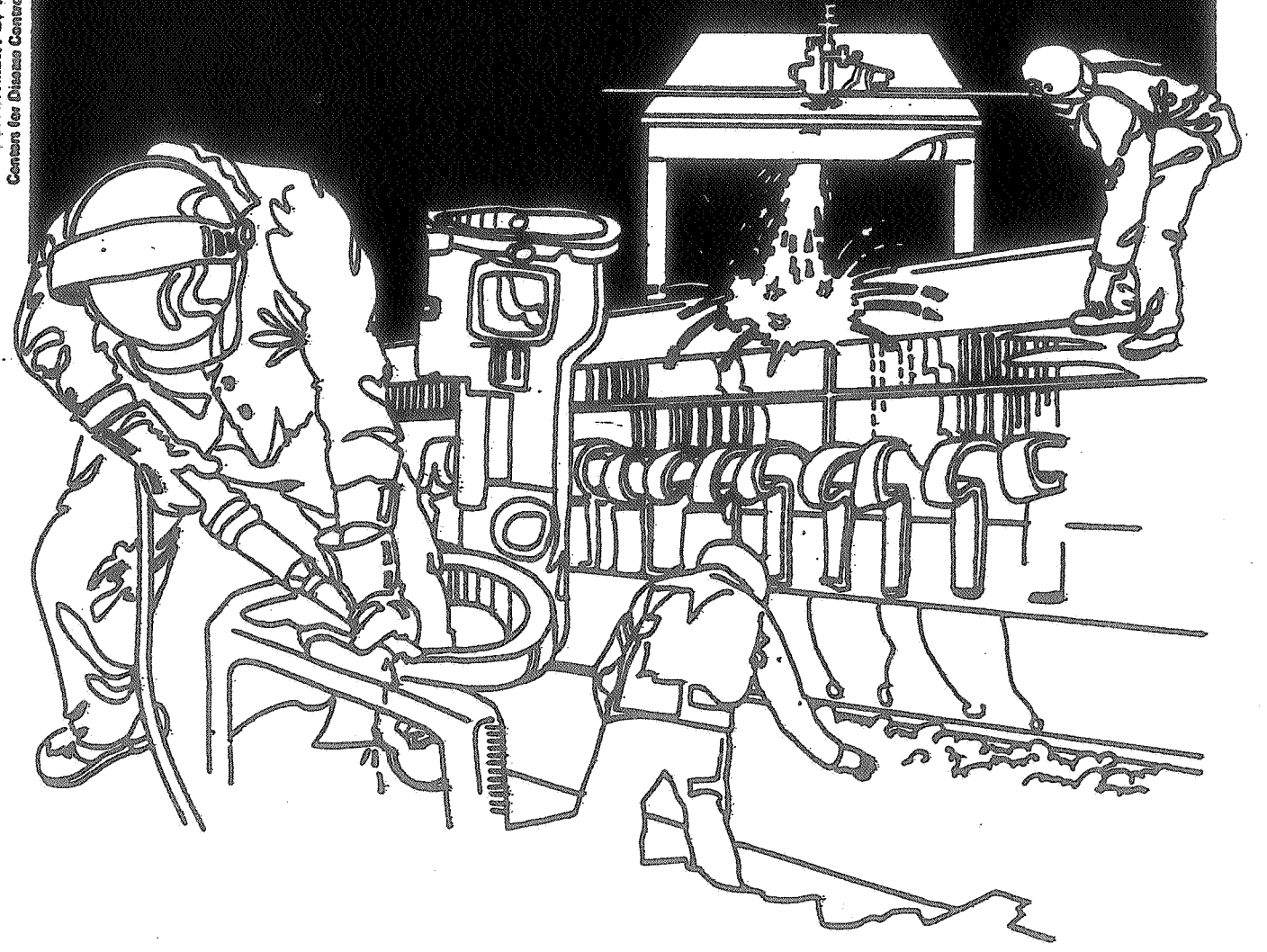

Health Hazard Evaluation Report

HETA 85-372-1728
BENDIX CHESHIRE CORPORATION
CHESHIRE, CONNECTICUT

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.

HETA 85-372-1728
September 1986
BENDIX CHESHIRE CORPORATION
CHESHIRE, CONNECTICUT

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I. SUMMARY

On May 27, 1985 the National Institute for Occupational Safety and Health (NIOSH) received a request from the Service Employees International Union to conduct a Health Hazard Evaluation at Bendix Cheshire Corporation, Cheshire, Connecticut. The request reported that employees were experiencing adverse health effects consistent with solvent exposures: lightheadedness, red eyes, itching of exposed parts of the body, upset stomach, dry mouth and sore throats. Chemicals identified in the request include Freon and 1,1,1-trichloroethane.

An initial site visit and walkthrough was conducted on August 14, 1985 by an industrial hygienist, followed by an industrial hygiene survey on September 16 and 17, 1985. Air samples were collected in six areas of solvent generation, where exposures would be expected to be highest: directly above solvent spray booths. Also at this time, ventilation design specifications were reviewed and the system operation evaluated.

A medical site visit was made on December 17-18, 1985, which consisted of a walkthrough, medical interviews and a review of company and union generated data.

Results of the NIOSH sampling indicated freon 113 concentrations were 0.75 ppm - 10.0 ppm (n=6), while 1,1,1-trichloroethane concentrations were 8.9 ppm - 32.3 ppm (n=6). The exposure criteria established for these solvents, which indicate the levels to which most employees may be exposed without adverse health effect, are: 1000 ppm for Freon 113 and 350 ppm (as a 15 minute ceiling concentration) for 1,1,1-trichloroethane. A review of the design specifications of the ventilation system indicated that, at a minimum, 13,200 cfm of fresh outside air is admitted into the building. The exhaust fans are designed to discharge 25,400 cfm. The minimum amount of fresh air needed to satisfy the ASHRAE guidelines is 18,795 (537 employees times 35 cfm per person in an area where smoking is allowed). Ventilation measurements indicated the units on the roof had been changed substantially from the original design specifications. In addition, carbon dioxide levels were measured at 1,500 ppm.

A review of completed medical questionnaires (n=187, or 33% of the workforce) provided by the union indicated that the most frequently reported symptoms experienced on a daily basis were: skin irritation/dryness (57%), fatigue (53%), eye irritation (53%), throat irritation (41%) and sinus congestion (40%).

The large preponderance of reported symptoms are all consistent with adverse health effects frequently noted with general indoor air quality problems that result from inadequate ventilation. In view of the ventilation problems noted, most of the reported symptoms can be attributed to inadequate ventilation, particularly in view of the low environmental sampling results for solvents. Recommendations are found in the body of this report concerning work practices when dealing with solvents and to have a ventilation contractor conduct a comprehensive re-balancing of the various HVAC systems to meet ASHRAE guidelines.

KEYWORDS: SIC 3811, Indoor Air Quality, Freon, Solvents, 1,1,1-trichloroethane, Clean rooms, Electronics.

II. INTRODUCTION

On May 27, 1985 the National Institute for Occupational Safety and Health (NIOSH) received a request from the Service Employees International Union to conduct a Health Hazard Evaluation at Bendix Cheshire Corporation, Cheshire, Connecticut. The request stated that employees were experiencing adverse health effects consistent with solvent exposures: lightheadedness, red eyes, itching of exposed parts of the body, upset stomach, dry mouth and sore throats. Chemicals identified in the request include Freon and 1,1,1-trichloroethane.

Two similar requests were addressed by the Connecticut Department of Labor, (report dated August 5, 1985, and report of February 1984 visit), as a result of employer initiated consultative investigations. The reports from the Conn-OSHA Division were obtained and reviewed. This information and documented exposure information provided by the company, indicated minimal exposure levels to all solvents. However, the Conn-OSHA report indicated carbon dioxide levels in the 800-1200 ppm range. Thus, NIOSH broadened the scope to include an indoor air quality assessment.

An initial site visit and walkthrough was conducted on August 14, 1985 by an industrial hygienist. On September 16 and 17, 1985 an industrial hygiene survey was conducted. A medical site visit was made on December 17-18, 1985, which consisted of a walkthrough, medical interviews and a review of company and union generated data.

An interim report was issued in March, 1986 transmitting the results of the environmental evaluation.

III. BACKGROUND

The Bendix Cheshire Corporation (division of Allied Bendix) is located in a 14 year old, one story building of brick and concrete construction. Total floor area is approximately 160,000 square feet. The facility operates three shifts, employing 537 workers in the manufacture of gas and electric gyros. The majority of the workforce reports on the first shift. Process operations in this plant can be likened to high-tech electronics assembly. The manufacture of gyros goes through several stages and requires repeated cleaning and degreasing along the way. Some of the operations are performed in "clean rooms" (positive pressure rooms where the air is highly filtered, and employees are required to wear body covering).

Ventilation is accomplished mechanically using 34 air handling units (HVAC type) and 12 exhaust fans. Most of the exhaust fans are connected to the solvent spray booths for environmental control, but three are in roof openings for general ventilation.

Two rounds of personal exposure monitoring by the Connecticut Department of Labor indicated low level solvent exposure in this plant. Freon 113 exposures ranged from less than 1 ppm to 4.0 ppm (n=6). 1,1,1-trichloroethane exposures ranged from 2.0 ppm to 16 ppm (n=11).

Other solvents identified by Conn-OSHA, but at levels too low to be quantitated include: ethyl alcohol, toluene, n-hexane and 1,2-epoxybutane.

Personal and area air sample results reported by the company (samples collected 9/18-19/85) were also well within the occupational exposure criteria established by NIOSH, OSHA and ACGIH. Freon 113 levels ranged from a low of 2.1 ppm to a high of 105 ppm (area) (n=18). 1,1,1-trichloroethane levels were 2.0 ppm - 22 ppm (n=18). Trace levels of ethyl alcohol, acetone, naphtha, and isopropyl alcohol were also identified.

MATERIALS AND METHODS

Environmental

A raw materials inventory was obtained and searched for materials which could produce the reported symptoms.

Air samples were collected in six areas of solvent generation, where exposures would be expected to be highest: directly above solvent spray booths. These areas were chosen to simulate a worst case situation, as all previous personal sampling indicated minimal exposures. Samples were collected on activated charcoal at a flow rate of 50 cc per minute, and analyzed according to NIOSH Method 1003.[1]

Ventilation design specifications were reviewed and the system operation evaluated, using a Kurz™ velometer and carbon dioxide (CO_2) detector tubes.

Medical

A walk-through tour of the facility was performed, with particular attention given to departments and areas identified by the union as being of special concern for potential adverse effects attributable to solvents, or other occupational exposures. Individual medical interviews were conducted with 12 employees (selected by the union representatives) who had had symptoms or adverse health effects that they had attributed to occupational exposures. Additional brief interviews were conducted during the walk-through survey.

Further medical information was obtained in a meeting held in New Haven with staff members of the Occupational Medicine Program at Yale Medical School, where a number of Bendix employees had been examined.

Finally, the results of a union-conducted survey of employees were obtained and re-analyzed. On review of this material, it was decided that the union survey provided useful information and that a NIOSH questionnaire survey would duplicate this material, and not provide sufficient additional data to justify its administration.

IV. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for 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 of workers may experience adverse health effects because of individual susceptibility, a pre-existing medical condition and/or by 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 at the level set by the evaluation criterion. These combined effects are often not considered in 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 become available.

The primary sources of environmental evaluation criteria considered for this study were: 1) NIOSH criteria documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV°s), and 3) the U.S. Department of Labor (OSHA) federal occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also 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 found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

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

The criteria judged most appropriate for this study are as

Substance	NIOSH Recommended Exposure Limit	ACGIH TLV	OSHA Standard
1,1,1-Trichloroethane	350 ppm (15 min. ceiling)	350 ppm	350 ppm
Freon 113	1000 ppm	1000 ppm	1000 ppm
Acetone	250 ppm	750 ppm	1000 ppm
Isopropyl alcohol	400 ppm	400 ppm	400 ppm

NOTE: ppm = parts per million parts of air

Indoor air quality was assessed relative to guidelines established by the American Society of Heating, Refrigeration and Air Conditioning Engineers, (ASHRAE 62-1981 Ventilation for Acceptable indoor Air Quality), and the NIOSH experience to date in dealing with indoor air pollution. ASHRAE calls for 35 cfm fresh outside air per person in an industrial environment.

B. Toxicity

The adverse health effects from excess exposure (exposures to airborne concentrations above the evaluation criteria) are summarized below:

1,1,1-Trichloroethane

1,1,1-Trichloroethane is irritating to the eyes on contact. Exposure to the vapors depresses the central nervous system. Symptoms include dizziness, incoordination, drowsiness, increased reaction time. Unconsciousness and death can occur from exposure to excessive concentrations.[2]

Isopropyl Alcohol

Vapors are mildly irritating to the conjunctiva and mucous membranes of the upper respiratory tract. Isopropyl alcohol is potentially narcotic at high concentrations.

However, no cases of poisoning from industrial exposure have been recorded for either normal or isopropyl alcohol.[2] The odor threshold is reported to be 40-200 ppm.[3] The NIOSH recommended exposure limit was established to prevent narcosis, although slight upper respiratory irritation may still be experienced. The current OSHA permissible exposure limit is 400 ppm.

FREON 113

Chemically known as 1,1,2-trichloro-1,2,2-trifluoroethane, freon 113 vapor in high concentrations (above 2,500 ppm) is a narcotic. Below 1,500 ppm, no adverse effects have been observed. Concentrations above 5,000 ppm have produced cardiac sensitization to epinephrine in experimental animals. A recommended exposure limit of 1,000 ppm should provide a margin of safety for systemic effects, and an adequate margin of safety against cardiac sensitization.[7]

Acetone

Acetone has been considered to be a low hazard to health, since few adverse effects have been reported, despite widespread use for many years. Awareness of mild eye irritation occurs at airborne concentrations of about 1000 ppm. Very high concentrations (12,000 ppm) depress the central nervous system, causing headache, drowsiness, weakness, and nausea. Repeated direct skin contact with the liquid may cause redness and dryness of the skin.[3] However, at least 6 studies have been reported in the literature which have documented possible adverse effects on humans at exposures below 1000 ppm. Furthermore, the available evidence indicates that occupational exposure to acetone may lead to its accumulation in the body. NIOSH has therefore recommended lowering the current exposure limit from 1000 ppm to 250 ppm.[5] The current OSHA permissible exposure limit is 1000 ppm.

V. RESULTS AND DISCUSSION

A. Environmental

The results of the NIOSH sampling can be found in Table 1. As with the Conn-OSHA data, the exposure levels were well within the established criteria. Freon 113 concentrations were 0.75 ppm - 10.0 ppm (n=6), while 1,1,1-trichloroethane concentrations were 8.9 ppm - 32.3 ppm (n=6). The exposure criteria established for these solvents, which indicate the levels to which employees may be exposed without adverse health effect, are: 1000 ppm for Freon 113 and 350 ppm (as a 15-minute ceiling concentration) for 1,1,1-trichloroethane.

However, the walkthrough revealed several areas in which it appeared that available local ventilation was inadequate. In particular, this was the case in the grinding room and the bellows room. In general, the spray booths appeared to be adequately exhausted.

In many assembly areas where solvents are dispensed from small, open jars for use in cleaning parts, however, there was no local exhaust. Where hoods were present, they were designed to maintain cleanliness of the assemblies by blowing filtered air down onto the work. Rather than protect the operator, they would have the effect of directing any fumes or vapors generated in the process toward the worker.

Finally, the process in the bellows room involved spraying parts held on trays with solvents and/or alcohols, with the parts then being rinsed in the collected liquid. This process was performed in a hood, but the fluids were then poured off through funnels into collecting flasks located on the floor. This part of the procedure was not hooded and often involved some splashing and escape of the solvent or alcohol.

All processes and materials used in the company's processes (e.g., solvents, alcohols, solders, etc.) are reported to be essentially the same as were employed in the previous building, where symptoms such as those prompting this investigation were not reported. The only factor that has changed significantly is the building layout. The company's previous building was a relatively open facility, whereas the new building has been subdivided into many smaller rooms with reportedly poorer air circulation. Also, workers report that the new building is better insulated and generally more airtight than their previous building. The workforce is a relatively stable one, and many current employees have experience in both buildings.

Indoor air quality was assessed relative to guidelines established by the American Society of Heating, Refrigeration and Air Conditioning Engineers, (ASHRAE 62-1981 Ventilation for Acceptable Indoor Air Quality), and the NIOSH experience to date in dealing with indoor air pollution. Using carbon dioxide levels as an indicator of dilution ventilation has been one effective means of identifying indoor air problems. Although carbon dioxide (CO_2) is not the cause of indoor air complaints, it is a good indicator of the relative air quality.

Out of doors, CO_2 levels exist at around 300 ppm. Generally speaking, it has been the NIOSH experience that employee complaints of headache, afternoon fatigue, and stuffiness begin to surface indoors when CO_2 levels reach 600-700 ppm. Complaints become more pronounced as the level of CO_2 rises, and are almost universal at levels above 1200-1500 ppm. Symptoms also include eye irritation, sinus congestion, and other non-specific upper respiratory ailments. It must be emphasized that carbon dioxide does not cause these symptoms, but as the level of CO_2 rises, so does every other contaminant within the building. It has been suggested that continuous low level exposure to the wide variety of contaminants within buildings is the cause of employee symptoms.

Indoor contaminants include all the chemicals people bring into the building on their bodies (perfumes, hair sprays, detergents, deodorants etc.) and all the chemicals from the building materials themselves (plastics, paper goods, furniture, and construction materials). Industrial settings add to this burden all of the manufacturing raw materials.

The Connecticut OSHA report indicated levels of CO_2 in the 800-1200 ppm range. NIOSH measurements showed levels approaching 1500 ppm in certain areas. Thus, the ventilation system was examined to determine if specific problems could be identified. A review of the design specifications of the ventilation system indicated that, at a minimum, 13,200 cfm of fresh outside air is admitted into the building. The exhaust fans are designed to discharge 25,400 cfm. The minimum amount of fresh air needed to satisfy the ASHRAE guidelines is 18,795 (537 employees times 35 cfm per person in an area where smoking is allowed).

Several hours were spent on the roof measuring the fresh air intake volumes on individual air handlers. The hydraulic fresh air dampers on many of the units had been disconnected, and the dampers on many were fully closed. Some of the dampers had set screws installed to keep the dampers open to a pre-determined minimum. Those units which were allowing fresh air in were not exhausting any recirculated air. Exhaust ventilation was accomplished by means of the exhaust fans only. It was obvious that the units on the roof had been changed substantially from the original design specifications. Measuring fresh air intake did not provide adequate information upon which to make any conclusions.

The volume of air exhausted to the roof by the exhaust fans was measured, and compared fairly well to the design specifications. However, not all of the exhaust fans run continually, so how much air is exhausted at any given time could not be determined. The measurements did indicate that if all of the air exhausted was replaced by fresh outside air, there would be more than enough dilution ventilation to comply with the ASHRAE guidelines. This was not the case in all areas of the plant because some areas were under negative pressure and others under positive pressure, i.e., clean rooms.

On the day of this survey, the favorable weather conditions afforded the opportunity to open two of the fresh air intakes 100%. No air was exhausted by the unit even though the fresh air damper was open full. Immediate improvement was noticed by employees in the areas serviced by these two units.

B. Medical

Prior to the NIOSH site visits, the union conducted a health effects survey of its membership. This survey was distributed to all members, and completed questionnaires were received from workers in 14 departments (to which 565 employees are assigned).

Copies of these questionnaires were obtained and re-analyzed. According to the information received from the union, questionnaires were completed by 187 employees which represents 33% of available workers. Response rates from individual departments ranged from 4% (1 of 24 workers) to 100% (4/4). Among departments with larger rosters, the greatest response rates were in departments 4721 (28 responses, 45%), 4754/56 (34 responses, 41%), 4757 (39 responses, 41%), and 4759 (38 responses, 79%).

The prevalences of reported symptoms (experienced daily) are shown in Table 2. The most frequently reported symptoms experienced on a daily basis were: skin irritation/dryness (57% of respondents), fatigue (53%), eye irritation (53%), throat irritation (41%), and sinus congestion (40%). The least frequently reported symptoms were epistaxis [nosebleeds] (10% of respondents), confusion (10%), and loss of appetite (10%).

Since those who responded to the survey may not have been a representative sample of the workers, the positive responses were also applied to the entire eligible population of 565 workers (i.e., assuming that all non-respondents had no symptoms). Even under this conservative assumption, prevalences of daily symptoms among all workers in all of the concerned departments would be: skin irritation, 19%; fatigue, 18%; eye irritation, 18%; throat irritation, 14%; and sinus congestion, 13%.

As shown in Table 3, the departments with the highest mean number of daily symptoms per respondent were 4757 (7.1 daily symptoms per person), 4760/65 (5.3), 4790 (5.3); the latter three results were based on small numbers of respondents. The departments with the lowest mean number of symptoms per respondent were 4758 (1.0 symptom) [one respondent] and 4744 (1.8) [six respondents]. Relatively low mean numbers of symptoms were also reported by departments 4721 (2.5) and 4759 (2.6).

No analysis could be done to investigate possible associations of symptom prevalences with job categories.

The information obtained from the union survey was consistent with the information obtained in the medical interviews, and in the discussions with medical personnel who had evaluated employees.

VI. CONCLUSIONS

Even allowing for the possibly non-representative nature and potential biases of the union-conducted survey, its results indicate that many employees are experiencing symptoms on a daily basis. These reports of symptoms must be considered in the context of a history of use of the same materials, processes, and procedures in the building previously occupied by the company without any reports of excessive physical problems. These response rates should also be evaluated in light of the fact that multiple attempts at environmental sampling (by NIOSH and others) failed to demonstrate any elevated air levels of any of the solvents in use at the facility.

The large preponderance of reported symptoms (particularly the more prevalent ones such as skin irritations, fatigue, eye and throat irritation, sinus congestion, and headaches) are all consistent with adverse health effects frequently noted with general indoor air quality problems that result from inadequate fresh air ventilation. In view of the fresh air problems noted earlier, most of the reported symptoms can be reasonably attributed to inadequate ventilation, particularly in view of the low environmental sampling results.

There remains, however, an irreducible minimum of symptoms that are also suggestive of solvent toxicity compatible with intermittent, elevated, short-term peak exposures (e.g., feelings of mental confusion, drunken sensations, dizziness, etc.). Despite the fact that such exposures were not documented by any of the available environmental sampling, we cannot exclude this possibility in specific operations such as in the bellows room and certain spray booths.

VII. RECOMMENDATIONS

1. A recommendation was made to have the ventilation contractor perform a comprehensive balancing of the entire ventilation system, and to insure an adequate distribution of fresh air to all areas, consistent with ASHRAE guidelines. Arrangements were made with the ventilation contractor before the conclusion of the environmental site visit.

2. In the bellows room and the grinding room, local exhaust ventilation should be added to capture solvent vapors at the source. These areas where open containers of solvents are used outside of the hoods, provide a potential source for employee exposure. An alternative would be to conduct all solvent transfer in the exhaust hood.

3. In the clean rooms where filtered air is blown downward onto the work, employees could minimize their exposure with careful work practices.

VIII. REFERENCES

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Bendix Cheshire Corporation
2. Service Employees International Union
3. NIOSH, Region I
4. OSHA, Region I

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.

TABLE 1

Air samples collected 9/17/85
Bendix Cheshire

Location	RESULTS ppm	FREON (mg/M^3)	ppm	1,1,1 TCE (mg/M^3)
Motor Wind	0.75	(5.7)	8.9	(17.0)
Repair	5.6	(42.2)	19.0	(36.2)
Package Assembly	3.2	(24.0)	28.6	(54.3)
Gas Sub Assembly	10.0	(75.8)	32.3	(61.4)
Bellows Room	8.0	(60.0	19.0	(36.2)
Gas/Elec Final Assy	10.0	(75.0)	9.0	(17.2)
Criteria	1000	(7600)	350	(1900)

TABLE 2

Prevalences of Symptoms Experienced Daily
Service Employees International Survey

Bendix Cheshire Corporation, Cheshire, Connecticut

August 1985

	Symptom	# Positive	% of Respondents	% of All Employees
1.	Skin irritation/rash	107	57	19
2.	Fatigue	100	53	18
3.	Eye irritation	99	53	18
4.	Throat irritation	77	41	14
5.	Sinus congestion	74	40	13
6.	Headache	65	35	12
7.	Dizziness	50	27	9
8.	Muscle weakness	37	20	7
9.	Numbness/tingling	33	18	6
10.	Other miscellaneous	24	13	4
11.	Drunken sensation	18	15	5
12.	Loss of appetite	18	10	3
13.	Confusion	18	10	3
14.	Epistaxis (nosebleeds)	18	10	3

TABLE 3

Mean Daily Symptoms by Department
Service Employees International Survey

Bendix Cheshire Corporation, Cheshire, Connecticut

August 1985

Department	# Members	Respondents	Response Rate	# Symptoms/Respondent
4757	95	39	41%	7.1
4790	10	7	70%	5.3
4760/65	50	6	12%	5.3
4724	7	4	57%	5.3
4791	4	3	75%	4.0
4745	24	1	4%	4.0
4746	135	20	15%	3.6
4754/56	83	34	41%	3.4
4761	17	1	6%	3.0
4752	4	4	100%	3.0
4721	62	28	45%	2.5
4759	42	33	79%	2.6
4744	21	6	29%	1.8
4758	11	1	9%	1.0