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CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION REPORT
HE 78-137-676

HI-G INCORPORATED
WINDSOR LOCKS, CONNECTICUT

MARCH 1980

I. SUMMARY

On September 29, 1978, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate recurring outbreaks of illness among employees of the Hi-G Company, Inc., Windsor Locks, Connecticut. To evaluate the causes of these episodes, NIOSH conducted an industrial hygiene and medical evaluation of the exposed workers. Personal and area samples for determination of airborne organotin, lead, trichlorotrifluoroethane (Freon TF), and 1,1,1-trichloroethane were obtained. Exposures to phosgene, hydrogen cyanide, hydrogen chloride, carbon monoxide, carbon dioxide, and formaldehyde were also evaluated. Bulk samples of solders, fluxes, and cleaning agents were analyzed for potential by-products which may be produced when these agents interact with heat. The medical evaluation included record reviews and personal interviews. A total of 38 organotin samples, 10 lead samples, and 22 samples for trichlorotrifluoroethane and 1,1,1-trichloroethane were taken. None of these indicated levels which exceed the NIOSH recommended standards of 0.1 mg/M^3, 0.05 mg/M^3, 7,600 mg/M^3, and 1,900 mg/M^3, respectively. Also, it was determined that phosgene was not produced under the work conditions evaluated at the plant.

In none of the outbreaks of illness discussed in this report was there any objective medical evidence of chemical toxicity. In many individual cases, as well as in the typical case in each outbreak of illness, the symptoms were non-specific. However, in some individual cases, they were suggestive of the hyperventilation syndrome. Except in the first outbreak (October 1976), the symptoms were generally not characteristic of the effects of the various toxic substances evaluated.

On the basis of the data obtained in this investigation, NIOSH determined that an environmental health hazard did not exist from any of the chemicals evaluated. However, it was concluded that after the initial outbreak of illness, employees had a heightened awareness of various environmental conditions, and that subsequent minor environmental changes may have precipitated outbreaks of illness.

Recommendations on ventilation controls, work practices, maintenance, and dealing with potential recurrences of illness outbreaks are discussed on pages 13-15 of this report.

II. INTRODUCTION

On September 29, 1978, the Hi-G Company of Windsor Locks, Connecticut submitted a request for a health hazard evaluation.* The request stated that since 1976 there had been numerous incidents of illness involving multiple employees. Among the reported symptoms were nausea, headaches, weakness, dryness, and tingling around the mouth. Federal OSHA and a private consultant had previously investigated the problem without satisfactorily determining the cause(s) of the illness episodes.

NIOSH investigators conducted field investigations on October 2-3, 1978 and March 26-27, 1979.

III. BACKGROUND

Hi-G, Inc. is an electronics company which is primarily engaged in the manufacturing of hermetically sealed relays for use in aircraft, missle, and similar applications where extreme environments are encountered. Among the different activities performed in the production of these parts are cleaning, degreasing, soldering, brazing, electroplating, and painting. Since all but one of the outbreaks involved 3 departments -- Electronics, "T05," and "411," -- the NIOSH investigation focused primarily on the employees working in these areas and the potential health hazards associated with their job. The T05 and 411 departments do primarily mechanical assembly work, with no substantial use or generation of chemicals. In the Electronics department, the employees performed various soldering operations on small parts. In the soldering operation the employees work with various solders which contain approximately 60-70% lead and 30-40% tin. These workers are also required occasionally to clean and/or degrease materials with Freon TF (1,1,1-trichlorotrifluoroethane). Although the other jobs described above (electroplating, brazing, and painting) were considered secondary concerns in this investigation, these were also evaluated for engineering and safety problems.

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*Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by any employee 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.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

A variety of sampling techniques were used to evaluate the suspected contaminants in the various departments surveyed. Personal and area samples were taken on a portion of the population from each of the departments of concern. The following is a description of the techniques used:

1. 1,1,1-Trichloroethane, Trichlorotrifluoroethane (Freon TF), and Other Organics

These suspected contaminants were measured by drawing air at 50 and 200 cc/minute through glass tubes containing activated charcoal collection media. Analysis was performed by gas chromatography using carbon disulfide desorption.

2. Volatile and Non-Volatile Lead and Tin Compounds

Sampling was performed in the field for volatile and non-volatile tin compounds. Extensive work has been performed by NIOSH's Measurements Research Branch on the sampling and analysis of non-volatile organotin compounds. This work included investigating various sampling techniques with both spiked and laboratory-generated samples of several organotin compounds. Field testing of several sampling techniques was also performed. The recommended sampling technique was glass fiber filter collection of non-volatile organotin compounds and impinger collection of volatile tin compounds in concentrated nitric acid. Because of the corrosive nature of concentrated nitric acid (70%) and the shipping restrictions for this acid, collection of organotin compounds in dilute nitric acid (7%) was investigated. The dilute acid solution was as efficient as the concentrated acid solution in laboratory tests. A more dilute solution (3.5%) was also investigated, but it was not as efficient as the 7% and the concentrated solutions. Therefore, we collected the non-volatile tin compounds on a glass fiber filter, followed by an impinger containing 7% nitric acid for the volatile tin compounds. These samples were also analyzed for lead since this is the other major component of the solder. Since the glass fiber filters contained no detectable amounts of lead, they were used to collect non-volatile lead compounds. Volatile lead compounds were collected in the impingers containing the dilute acid. The samples were analyzed for total tin and total lead by graphite furnace atomic absorption spectroscopy. Samples which were expected to contain the highest levels of contaminants were analyzed first. The sensitivity of this analytical procedure is such that tin levels well below the recommended exposure levels can be detected and quantitated.

3. Odors

Numerous odors were described to NIOSH investigators which the majority of affected employees felt were, or could have been, associated with the episodes. Among the odors mentioned were shoe polish, sweat smells, odors from outside the facility, a sweet pungent odor, and a sewage smell. These odors were traced by evaluating the odors emanating from chemicals used at Hi-G, odors which could be coming from the sewage system within the Hi-G facility, and potential chemical odors originating from outside sources. Once potential chemicals and/or sources were found, they were evaluated for their odor properties and compared against the list of odors given to us by the employees.

4. Ventilation Systems

The make-up air and exhaust systems (both general and local) were evaluated with smoke tubes and an air velocity meter. Also, the exhaust stacks on the roof were evaluated to determine if these stacks were of the proper height to adequately dispose of the contaminants once they had left the stack.

5. Other

Hydrogen cyanide, hydrogen chloride, carbon monoxide, carbon dioxide, phosgene, formaldehyde, and toluene diisocyanate were evaluated using colorimetric gas detection devices. Each has an accuracy of $\pm$ 35 percent at one-half the exposure limit and an accuracy of $\pm$ 25 percent at one to five times the exposure limit.

B. Medical

The NIOSH medical evaluation included:

1. General discussions with OSHA and company representatives,
2. Review of OSHA inspection records,
3. Observation of production processes and work practices,
4. Discussions with the company's occupational health nurse,
5. Review of company medical records, and
6. Private interviews with employees identified by OSHA, the company, and/or medical records as having been frequently involved in outbreaks of illness.

The environmental and medical evaluation criteria used for this investigation are presented in Table 1.

The exposure limits to toxic chemicals are derived from existing human and animal data and industrial experience and represent levels to which it is believed that nearly all workers may be exposed for an 8-hour or 10-hour day, 40-hour workweek, over a working lifetime with no adverse effects. However, due to variations in individual susceptibility, a small percentage of workers may experience effects at levels at or below the recommended exposure limit, and a smaller percentage may be more seriously affected by aggravation of a pre-existing condition or by development of an occupational illness.

V. RESULTS AND DISCUSSION

A. Environmental

Employee exposure to suspected airborne concentrations of organotin, lead, trichlorotrifluoroethane (Freon TF), 1,1,1-trichloroethane, phosgene, hydrogen cyanide, hydrogen chloride, carbon monoxide, carbon dioxide, and formaldehyde were evaluated by review of the consultant's data, OSHA survey data, and NIOSH environmental survey data. Also, the general and local ventilation systems and the sewer system in the plant were assessed. The following are the results and conclusions of that portion of the evaluation:

1. Organotin and Lead

A total of ten swipe samples for tin and lead were evaluated from a variety of locations within the company (Table 2). Levels for organotin and lead were found at the majority of the areas sampled, and two of the samples showed high levels of both compounds. However, it was impossible to determine the length of time that the dust and materials found on these sites had been there, and therefore it was determined from these results that personal breathing zone sampling would be required. Table 3 illustrates the personal breathing zone levels that were found during our investigation. The highest level found for organotins was 0.01 mg/M^3 which was only a tenth of the NIOSH recommended standard of 0.1 mg/M^3. None of the 20 lead samples exceeded the OSHA standard of 0.05 mg/M^3 (the highest was 0.03 mg/M^3); no lead was detected in 11 of them. These results would indicate that a health hazard did not exist from the soldering operations we evaluated and that the high levels found on the swipes most likely were developed over many years.

2. Trichlorotrifluoroethane (Freon TF) and 1,1,1-Trichloroethane

Trichlorotrifluoroethane and 1,1,1-trichloroethane were evaluated at 22 different locations during our survey (Table 4). 1,1,1-trichloroethane levels were minimal compared to the recommended standard of 3,500 mg/M^3. This was also true for trichlorotrifluoroethane when compared against the recommended standard of 1,900 mg/M^3. Therefore, it can be concluded that no health hazard exists to the employees from these agents.

3. Hydrogen Cyanide, Hydrogen Chloride, Carbon Monoxide, Carbon Dioxide, Formaldehyde, and Toluene Diisocyanate

Toluene diisocyanate (which had not been used at the plant since 1976) was not detected. Each of the other chemicals was sampled in numerous locations throughout the plant during both survey periods using colorimetric tubes. In every case the results showed either non-detectable levels or partial detection, which in each case was less than 1/10 of a percent of the recommended standard.

4. Phosgene

Phosgene exposure had been suspected during the later part of our investigation. The reason for this concern developed from what was thought to be a reaction between the hot tip of the soldering gun and 1,1,1-trichloroethane, the cleaning solvent used at the soldering operations. Phosgene has been suspected as a by-product when temperatures greater than 500°F interact with halogenated hydrocarbons, such as 1,1,1-trichloroethane, and this was thought to be the case when the soldering iron interacted with the solvent. However, upon further investigation with colorimetric tubes and an infrared gas analyzer it was determined that this portion of the evaluation was no longer considered necessary due to the non-detectable levels found when using these sampling techniques. Also, observation of the work performed by the operator revealed that there was no interaction between the solvent and the soldering iron tip.

5. General and Local Exhaust Ventilation

The exhaust flow rate requirements for removal of soldering fumes are 100 fpm (feet per minute). Our investigation indicated that numerous areas in the soldering departments either had exhaust flow levels at 40-60 fpm at the point source, i.e., where the operation was being performed, or no exhaust flow at all at the point source. In one location in the Electronics area the worktable exhaust hood had a flow rate greater than 100 fpm; however, the duct leading out of this hood was disconnected and exhausting into the work area.

Two brazing exhaust systems were evaluated; the flow rates measured at the face of the hoods exceeded 100 fpm. However, the work that was being performed at these stations was approximately 12-16 inches from the face of the exhaust hood. Once the flow rates were measured at the point source, the levels ranged from 40-50 fpm, which was not adequate.

The majority of the plant had more than sufficient make-up air; however, in the 411 department, where a number of the employees complained of odors, it was determined that inadequate air distribution existed in the area. This was determined by comparing this area and other areas throughout the plant with smoke tubes and an airflow meter. Upon further investigation, it was determined that the Department 411 area lacked a make-up ventilation source, which probably accounted for the lack of air movement in the area.

6. Sewer Drainage

Hi-G presently has two main sewer systems within the plant. One system is designed to treat waste products from the Electroplating department, and the other, which has two main sewer lines, receives the treated waste from Electroplating, as well as the remaining domestic waste within the plant (Figure 1). It was determined that a portion of the drainage traps in the plant were dry, which can contribute to odors, and that one of the drainage lines in the Electroplating department might be draining directly into the domestic line without pre-treatment. The Hi-G plant has gone through a number of expansions over the years, and management was unable to determine whether a possible cross-connection could exist. However, during our investigation of the sewer system we found a problem in one of the sewer lines approximately 200 feet from the effluent stage of the electroplating treatment system (refer to footnote on Figure 1). The odors that were found in this section of the sewer line were extremely acidic, indicating untreated waste from the Electroplating department. This creates a condition in the sewage system known as die-off, i.e., killing off all living organisms, which can produce foul odors.

7. Odors

A number of odors were described to the NIOSH investigators as being present during the illness episodes. These included sweat smells, almond smell, shoe polish smell, antiseptic smell, pungent smell, sewer smell, etc. Chemicals mentioned in Table 1 could well have been responsible for the smells described by the employees.

Present research (Leonardos, 1969 and Rechtlinien, 1966) indicates that people react either positively or negatively to odor types, i.e., they like or dislike them. People will usually react more strongly to things that are different, and therefore what is normal or expected is frequently accepted whether it's good or bad. Another problem is associated with those odors that people dislike or are not familiar with and, in NIOSH's opinion, this is the effect that occurred with the odors described to us by the employees. That is, the unknown sources and health concerns regarding these transient odors contributed to the stress in the employees at Hi-G.

8. Poor Work Practices Noted During Investigations

   a. Use of fans at the soldering worksite.
   b. Failure to cover flux and solvents after use.
   c. Lack of protective gloves when cleaning parts.
   d. Freon TF (55 gallon drum) not capped.
   e. Mixing of chemicals or cleaning of parts not being performed under an exhaust hood.

B. Medical

1. Major Outbreak of Illness

Although there were verbal reports of illness outbreaks at the plant prior to 1976, the first episode for which specific information is available occurred Friday, October 1, 1976. At about 11:30 a.m. a five-gallon drum of toluene diisocyanate ruptured on the floor near the Electronics area. Attempts to absorb it with newspapers and an absorbent compound began immediately. After ten minutes the vapors became intolerable to the employees in the area, and within another ten minutes the area was evacuated. Further clean-up was done by personnel with air-supplied respirators.

Three employees (one of whom had a history of asthma) who reported chest tightness and cough were treated empirically with oxygen and intramuscular theophylline, although physical examination of the chest, heart, and mucous membranes was negative in each case. Examination was also negative in 11 other employees who reported chest soreness. All 14 had negative chest X-rays. Another employee who reported coughing had a negative physical examination but no X-ray. On October 26, 14 of these 15, three other symptomatic (headache, nausea, dry mouth) employees not from the immediate area of the spill, and two employees involved in the clean-up had a complete blood count. With two exceptions all were normal. A clean-up employee had abnormal red blood cell morphology, and another employee had an elevated white blood cell count. Both had repeat tests which were normal. The symptomatic employees all returned to work Monday (the next workday); some reported residual dry mouth or throat irritation.

On May 23, 1978, six employees in the Electronics area became ill about 9:00 a.m. Five of them had also been involved in the October 1976 incident. Symptoms included sensory abnormalities (numbness, tingling, feeling of swelling) affecting the lips (5 persons), shakiness (4), nervousness (4), "light-headedness" or "dizziness" (4), headache (4), dry mouth or throat (3), nausea (3), "passing out" (2), blurred vision (2), and "hot" or "flushed" face (2). Five of the six reported "lines" on their fingernails, although it is not clear whether this was supposed to have been an acute phenomenon (in only one case was it clearly not of recent origin). Initially, five other employees in the Electronics area and six in the T05 area also became symptomatic, but information about specific symptoms was not readily available. There was no report of any suspected chemical exposure at the time of this incident.

On the morning of July 14, 1978 numerous relay-floor employees complained of an irritating odor from a burning transformer. As some employees began experiencing symptoms, all persons in the area moved outside. During this time a boiler was malfunctioning, and there was apparently some sign of abnormal stack emissions. Thirty-one employees sought medical attention for symptoms associated with this episode. The most common symptoms, based on data from 23 persons, were nausea (21), headache (20), "light-headedness" (6), "burning" throat (6), and weakness (5). A variety of other symptoms, including diarrhea, vomiting, abdominal cramps, loss of appetite, drowsiness, numbness or tingling of the mouth or tongue, throat "tightness," shakiness, "cold," "tetany," "hysteria," nosebleed, "burning" eyes, drowsiness, and "acute bronchospasm," were also reported, but none was reported by more than two persons. Of the 25 seen at one of two emergency rooms, all were discharged without a specific common diagnosis. Except for an unknown test on a pregnant woman, no laboratory tests or X-rays were done. Among the six employees who sought medical attention elsewhere, one had a chest X-ray, and a pregnant woman had one or two laboratory "tests," all were reportedly negative. Recovery time ranged from a few hours to a few days. Electronics employees were not involved in this episode. Three T05 employees had itching, but apparently none of the other symptoms, and were not among the 31 who sought medical attention.

On August 22, 1978 an outbreak involving 13 employees occurred in the T05 area. Symptoms included headache, bitter taste, "burning" nose, "light-headedness," shakiness, and nausea, but more specific details were not readily available.

On September 1, 1978, at about 10:00 a.m., five employees in the Electronics area became ill. Four of them were also involved in the May 1978 episode, and three of these four were involved in the October 1976 episode. Symptoms included numbness of the face (4), nausea (2), bitter taste (2), headache (2), shakiness (1), "dizziness" (1), and "hot" face (1). Two hours later 21 employees from the T05 area became ill. Complete data are not available for all 21, but symptoms included nausea or upset stomach (9), headache (9), "light-headedness" or "dizziness" (8), shakiness (4), throat irritation (4), and "burning" or tearing of the eyes (4). Less frequent symptoms included unusual taste, difficulty breathing, weakness, and "burning" of the nose.

On October 5, 1978, 13 employees from T05 became ill; most reported only headache and nausea, but other reported symptoms included dry lips, bitter taste, and light-headedness. The air conditioner had been off since 8:00 a.m. and an odor was noted at 12:45 p.m.

On November 2, 1978, over 50 people reported illness between 9:00 and 9:30 a.m. Various odors were reported from various areas, including the relay floor, T05, electronics, and I.C. room. Symptoms were reported by employees from the relay floor, electronics, and other areas (only one from T05), and included burning eyes, nose, and throat; nausea, some with vomiting, "shakiness;" headache; abnormal taste; tingling or numbness of lips; light-headedness, dizziness, or a "high" feeling; crying; and general weakness. The plant nurse thought that employees who continued to work tended to have more severe symptoms than those who left work earlier.

On February 6, 1979, a few relay floor employees left work because of vertigo, nausea, and/or headache. On February 7, 1979, several employees from the relay floor and other areas reported illness. On February 8, at least 60 employees, mainly from the relay floor, reported illness. Common symptoms included dizziness, drowsiness, a burning sensation (anatomical location not known), nausea, anxiety and general weakness with a feeling of impending fainting. On February 9, reports of illness began at 8:30 a.m. Eight employees who were ill, or were considered - on the basis of previous experience - likely to become ill, were sent home. Only a few employees subsequently reported illness during the remainder of the day. During this week, the plant nurse recorded "a noticeable amount of hyperventilating with near tetany in several cases." Symptoms were reportedly relieved by breathing with a paper bag over the mouth and nose.

On February 21, 21 employees were sent home. Odors and mucous membrane irritation were reported from various locations. Individual reports of illness, mostly involving one or more of a small number of employees, occurred frequently during February and the first half of March.

2. Individuals Involved in Multiple Episodes

There were three episodes involving the Electronics area (October 1, 1976, May 23, 1978, and September 1, 1978). Five employees (including one who was no longer employed on September 1, 1978) were involved in at least two of these, and three were involved in all of them. Thus, of 14 chances for these five employees to have been involved in an episode of mass illness, they were involved in 13.

Of the four employees still employed at the plant at the time of the first NIOSH visit, all wore glasses and had had an eye examination within the preceeding two years. All thought that the lighting was adequate in the Electronics area, and none thought that eye strain was a problem at work. The only symptom common to all four was nausea. However, three of the four had had numbness of the face, headache, and "dizziness." Other symptoms among these three included shakiness (2), nervousness (2), increased heart rate (1), blurred vision (1), and breathing difficulty (1). The fourth also reported nervousness, feeling hot, and various upper respiratory tract symptoms. Three of them were transferred to another area, the relay floor, after the September 1978 incident; this had a beneficial effect on the symptoms in one case, a detrimental effect in another, and no effect in the third. Gross examination of the fingernails revealed no abnormalities. (There were some normal-appearing longitudinal ridges, or "lines.")

Between the November 1978 and February 1979 episodes, 3 of the 4 were transferred back to electronics. Only one continued to be affected frequently. However, 4 other employees, all from the relay floor, became the most frequently affected. None of these latter 4 perform any work that uses chemicals or generates fumes or vapors, nor do any of them work in close proximity to a source of these. Two of them originally worked in Department 411; they were transferred to T05, where they both continued to have symptoms, then to Electronics. One is still there and has had a considerable reduction of symptoms; the other remained symptomatic and was transferred back to Department 411.

Three of the 4 were interviewed in detail. All wore glasses and had had an eye examination within the preceding two years. None had eye strain. All reported that their symptoms typically start early in the day and can occur without a preceding odor. Two were affected in the July 1978 incident; the other was not yet employed at the plant. One said that she was usually the first affected; the other two said that when they became ill they did not necessarily know whether others were already affected. All three reported headache and light-headedness. Burning eyes, nausea, and shakiness were symptoms reported by only two of them (not the same two for all symptoms). Other symptoms included dry mouth, odd taste, numbness and dryness of lips, nausea, pounding heart, breathing discomfort, breathing hard, and burning nose.

On March 27, 1979, the NIOSH medical officer observed three employees who came to the nurse's office at about the same time. One had classical signs and symptoms of the hyperventilation syndrome (Dalessio, 1978; Missri and Alexander, 1978). The other two, both of whom were among the four employees most frequently affected, had signs and symptoms quite suggestive of the hyperventilation syndrome.

3. Anecdotal Reports and Other Observations

Several reported occurrences seemed relevant to the episodes of illness. During an OSHA inspection the occurrence of symptoms in one of the frequently affected Electronics employees was attributed by her to a personal air sampler she was wearing. On another occasion, symptoms in another frequently affected employee were precipitated by the shaking of a can of spray paint, even though nothing was released from the can.

Symptoms continued to occur among T05 employees after the department was moved to the opposite end of the plant. (This department does not use or generate any toxic substances; the work involves mechanical assembly of small parts.)

There were several reports attributing various acute and chronic illnesses to perceived chemical exposures at the plant. These included neurological, renal, hepatic, and laryngenal disorders. In none of the cases, individually or collectively, was there any available medical, environmental, or epidemiologic data to suggest that the illnesses were work-related.

On the basis of his employee interviews, it was the NIOSH medical officer's impression that some T05 and Electronics employees believed that virtually any physical discomfort they experienced (including such common occurrences as minor upper respiratory tract symptoms) was caused by environmental contaminants in and around the plant.

VI. CONCLUSIONS

In none of the outbreaks of illness discussed in this report was there any objective medical evidence of chemical toxicity. However, routine medical examinations often do not detect signs of chemical toxicity. In many individual cases, as well as in the typical case in each outbreak of illness, the symptoms were non-specific. However, in some individual cases, they were suggestive of the hyperventilation syndrome. In no case were the symptoms characteristic of the effects of lead; organotin compounds; diazinon (an organophosphate insecticide used at the plant); or low levels of methyl chloroform, fluorocarbon compounds, benzene, or petroleum hydrocarbons.

It is possible that some employees may be able to detect and perhaps even have mucous membrane effects from relatively low levels of substances used or generated in or around the plant. It is also possible that exposure levels may occasionally be transiently high enough to be apparent to more than a few employees. Thus, it is conceivable that some individual cases of illness in the past could have been due to a toxic substance. However, most of the symptoms reported by the employees most frequently affected are not considered to be the results of toxicologic effects of chemical substances in the plant's environment, either those used or generated in the plant or those originating outside the plant. Most of the outbreaks of illness discussed in this report were most likely mass psychogenic phenomena, although irritating or offensive vapors or fumes may have been the precipitating event.

The conclusion that an illness is psychogenic does not mean that it is not "real." The term refers to illness in which the primary cause is psychological stress, arising from the occupational and/or general social environment, rather than from environmental, chemical, physical, or infectious agents or metabolic abnormalities. The occurrence of psychogenic illness does not mean that there is any psychiatric disorder; it can represent normal psychophysiologic responses to a stressful environment.

VII. RECOMMENDATIONS

In view of the findings of NIOSH's environmental and medical study, as well as personal communications with individuals at Hi-G, the following recommendations are made to provide a better work environment for the employees covered by this determination. These recommendations are also based on NIOSH's review of OSHA's results, the environmental consultant's studies, and those ventilation proposals submitted by the ventilation consultants hired by Hi-G.

A. Medical

1. The medical investigation was greatly facilitated by the high quality of the medical records at the plant. The system, which included (a) an individual file on each employee, including a pre-employment medical history, (b) a daily log of individual clinic visits, (c) summary reports of unusual occurrences, and (d) pertinent outside medical data, should be continued.

2. There is no apparent need for additional medical screening or biological monitoring of Electronics, Department 411, or T05 employees. In the absence of a medical history suggestive of major physical impairment a physical examination is not necessary. Additionally, there is no apparent need to screen or monitor employees for effects of organotin, fluorocarbons, or petroleum solvents, since there is no evidence at this time of any biologically significant "exposure" to these substances. If the environmental survey (see page 14, B-1) establishes the presence of lead exposure, a medical monitoring program (as specified by the current OSHA standard, 29 CFR 1910.1025) should be instituted.

3. Outbreaks of acute stress-related illness can be intensified by the appearance of confusion and the arrival of ambulances, the fire department, etc. Thus, personnel responsible for first aid should not contribute to this crisis atmosphere by over-reacting to workers "fainting" or "passing out." Such personnel, to the extent that they are medically qualified, should reassure other employees that a victim of what appears to be hyperventilation or simple "fainting" is not seriously ill. While such persons should avoid "diagnosing" hyperventilation, they should also avoid diagnosing "poisoning" by "fumes" or "chemicals." If possible, affected persons should be taken to a quiet area out of the sight of other production area employees. Unless trained medical personnel or lifesaving equipment are required, transportation for medical evaluation does not require an ambulance. If an ambulance must be called, the use of sirens and flashers should be avoided in the vicinity of the plant.

In general, the plant's occupational health nurse seemed to understand these concepts, as demonstrated by her apparently competent handling of both outbreaks and individual illnesses in the past.

B. Environmental

Even though the environmental deficiencies we found could not have directly caused the outbreaks of illness, except as precipitating events, they could have been responsible for offensive odors, physical discomfort, and potential adverse health and safety problems. Whenever possible, engineering controls are the preferred method for decreasing potential environmental exposures to toxic substances for the protection of the employees' health. Therefore, based on the evaluation of the present data and the environmental problems discussed in Part VI, the following recommendations are offered to help ensure the workers' safety and health:

1. Lead

Because there were three lead samples that showed "action level" exposures (0.03 mg/M^3) in soldering operations, the company should conduct an environmental survey for lead to determine if, under current conditions, there is action level exposure to lead. If such exposure exists, the company should institute environmental and medical monitoring and control measures that meet the current OSHA standard (29 CFR 1910.1025).

2. Ventilation

a) Local Exhaust Ventilation

Based on the local exhaust ventilation problems described earlier the following recommendations should be attended to as soon as possible if they have not been already: (a) Any existing exhaust ventilation systems which are damaged e.g., hoods, ducts, and/or filters, should be restored to their original condition or replaced as necessary; (b) Any of these systems that have hoods which are improperly located, i.e., in order to increase the capture velocity the distance from the face of the exhaust hood to the point of particle generation, should be positioned as close to the point of particle generation as is possible; and (c) Hoods which are insufficiently designed should be redesigned in order to increase the capture velocity of these systems, i.e., in such a manner that will encompass the source point without interfering with the operator's work, and thus, effectively collect the contaminant at the source (refer to figures 2-4 for examples of proper exhaust ventilation designs).

b) General Room Ventilation

The lack of adequate air circulation in the Department 411 can best be resolved by extending a ventilation duct into this area. Several make-up air systems were within 100 feet of this department, and therefore, one of these could be used to supply fresh air. Prior to extending this ducting an evaluation of the overall system's capabilities should be made in order to determine if the existing system can efficiently supply this department with ten air changes per hour or as deemed appropriate after reviewing the system.

3. Sewer Systems

The suspected cross-contamination in the sewer line, located in the electroplating department, should be eliminated in order that this waste can be pre-treated prior to discharging into the main affluent line. Also, the floor drains should be checked periodically to make sure the traps are water sealed. Any floor drains not in use should be capped with removable caps.

4. Other

a. Each of the improper work practices described earlier should be corrected. Emphasis should be placed on educating individuals about the problems which can occur if improper work practices are allowed to continue.

b. The maintenance performed on the paint spray booth, e.g., filters, flow rates, etc., should be increased. Also, the length of time between the completion of the painting operation and turning off the exhaust system here should be extended. This procedure should reduce the likelihood of odors emanating into the electronics assembly area.

c. The partition which separates the potting and paint spray department from the electronic assembly area should be extended to the ceiling. This should eliminate the possibility of drawing odors from the spray booth operation into the assembly area. Also, a door should be installed at the entranceway leading into the potting and paint spray area. This should reduce the potential of other odors escaping from this area into the assembly department. (This was in the finishing stage during our last survey.)

d. Increased communications between management and the employees at Hi-G should be maintained regarding the findings from this report. Also, any other physical changes should be communicated to the employees and timetables set for completion of such projects.

VIII. AUTHORSHIP AND ACKNOWLEDGEMENTS

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IX. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this report are currently available, upon request, from NIOSH, Division of Technical Services, Publications Dissemination, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

Copies of this report have been sent to:

1) International Union of Electrical Workers Local 380
2) Hi-G, Inc.
3) International Union of Electrical Workers
4) U.S. Department of Labor, OSHA, Region I
5) NIOSH, Region I

For the purpose of informing the "affected employees," the employer shall promptly "post" the determination report for a period of 30 days in a prominent place near where exposed employees work.

To Union and Management:

NIOSH is thankful to the employees and management for their cooperation and assistance with this Health Hazard Evaluation. The information gathered from this study will not only assist in maintaining the health and safety of those persons working in this company, but also other electronic companies that we investigate.

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TABLE 1
Environmental/Medical Evaluation Criteria
Hi-G Incorporated
Windsor Locks, Connecticut
February 1980

Substance	Recommended Environmental Limit[1]	Reference Source	Primary Health Effects[3]	Type Odor	OSHA Standard
Organotin	0.1 mg/M^3*	NIOSH	Eye, nose, respiratory tract, and skin irritation, headache, upper abdominal discomfort, nausea, vomiting	Varies on type of compound	0.1 mg/M^3
Lead	0.05 mg/M^3	OSHA (29 CFR 1910.1025)	Abdominal discomfort, anemia, weakness of wrist and ankle muscles, kidney damage	Varies on type of compound	0.05 mg/M^3
Trichlorotrifluoroethane (Freon TF)	7600 mg/M^3	ACGIH[2]	Throat irritation, drowsiness, loss of coordination, dermatitis	Ether-like odor	7600 mg/M^3
1,1,1, Trichloroethane	1,900 mg/M^3	ACGIH	Eye irritation, dermatitis, incoordination, disturbance of equilibrium, confusion	Sweet like chloroform	1,900 mg/M^3
Hydrogen chloride	7 mg/M^3(C)**	ACGIH	Eye, nose, throat, and skin irritation, cough, choking sensation, erosion of teeth, lung injury	Pungent odor	(C) 7 mg/M^3
Hydrogen cyanide	5 mg/M^3	NIOSH	Weakness, headaches, confusion, nausea, vomiting, breathing difficulty; a single large dose can be fatal	Bitter almond	11 mg/M^3

TABLE 1 (Continued)
Environmental/Medical Evaluation Criteria
Hi-G Incorporated
Windsor Locks, Connecticut

February 1980

Substance	Recommended Environmental Limit[1]	Reference Source	Primary Health Effects	Type Odor	OSHA Standard
Carbon monoxide	35 ppm*** (C) 200 ppm	NIOSH	Headanhe, nausea, weakness, dizziness, confusion, loss of consciousness	Odorless	50 ppm
Carbon dioxide	10,000 ppm (C) 30,000 ppm	NIOSH	Headache, shortness of breath, dizziness, sweating, restlessness, tingling sensations, increased heart rate and blood pressure, loss of consciousness	Odorless	5,000 ppm
Formaldehyde	0.8 ppm	NIOSH	Eye, nose, throat, and respiratory tract irritation; dermatitis	Pungent	3 ppm

(1) All air concentrations are expressed as time-weighted average (TWA) exposures for up to a 10 hour workday unless designated "ceiling".

(2) ACGIH = American Conference of Governmental Industrial Hygienists

(3) References 16 and 25

* mg/M^3 = Approximate milligrams of substance per cubic meter of air

** C = A ceiling limit which should not be exceeded

*** ppm = Parts of vapor per million parts of contaminated air by volume

TABLE 2
Summary of Organotin and Lead Swipe Samples
Hi-G Incorporated
Windsor Locks, Connecticut
February 1980

Sample Number	Location	Lead mg/sample*	Tin mg/sample
W_1	Bench (lamp) 4-E	.01	ND**
W_2	Bench (lamp) N-E	.03	.03
W_3	Bench (lamp/filter)	.64	.95
W_4	Lepel Brazer (lamp)	.02	.04
W_5	Solder exhaust fan	1.10	.71
W_6	Relay Floor - west bench	.02	.02
W_7	Relay Floor - east bench	.10	.09
W_8	TO-5	.02	ND
W_9	TO-5	.04	ND
W_{10}	TO-5	.02	ND

*mg/sample = milligrams per sample on the filter area sample analyzed.
**ND = non detectable value

TABLE 3

Summary of Personal Air Sampling for Organotin and Lead
Hi-G Incorporated
Windsor Locks, Connecticut
February 1980

Job Description	Sample Number	Sampling Time (Min.)	Organotin (mg/M^3)*	Lead (mg/M^3)
Soldering	T_1	270	.0002	ND**
"	T_2	270	.0005	ND
"	T_3	270	.0005	.02
"	T_4	270	.0003	.02
"	T_5	270	.001	.03
"	T_6	270	.0002	ND
"	T_7	270	.0002	ND
"	T_8	270	.0003	ND
"	T_9	270	.002	.02
"	T_{10}	270	.0002	.02
"	T_{11}	260	.0001	.02
"	T_{12}	260	.0008	ND
"	T_{13}	260	.01	ND
"	T_{14}	260	.0003	.03
"	T_{15}	270	.002	.03
"	T_{16}	270	.0005	ND
"	T_{17}	270	.0005	.02
"	T_{18}	270	.0009	ND
"	T_{19}	270	.0002	ND
"	T_{20}	270	.0002	ND
Environmental Criteria			0.1 mg/M^3	0.05 mg/M^3
Limits of Detection			.0001 mg/M^3	0.02 mg/M^3

*mg/M^3 = Approximate milligrams of substance per cubic meter of air.

**ND = Non detectable value

TABLE 4

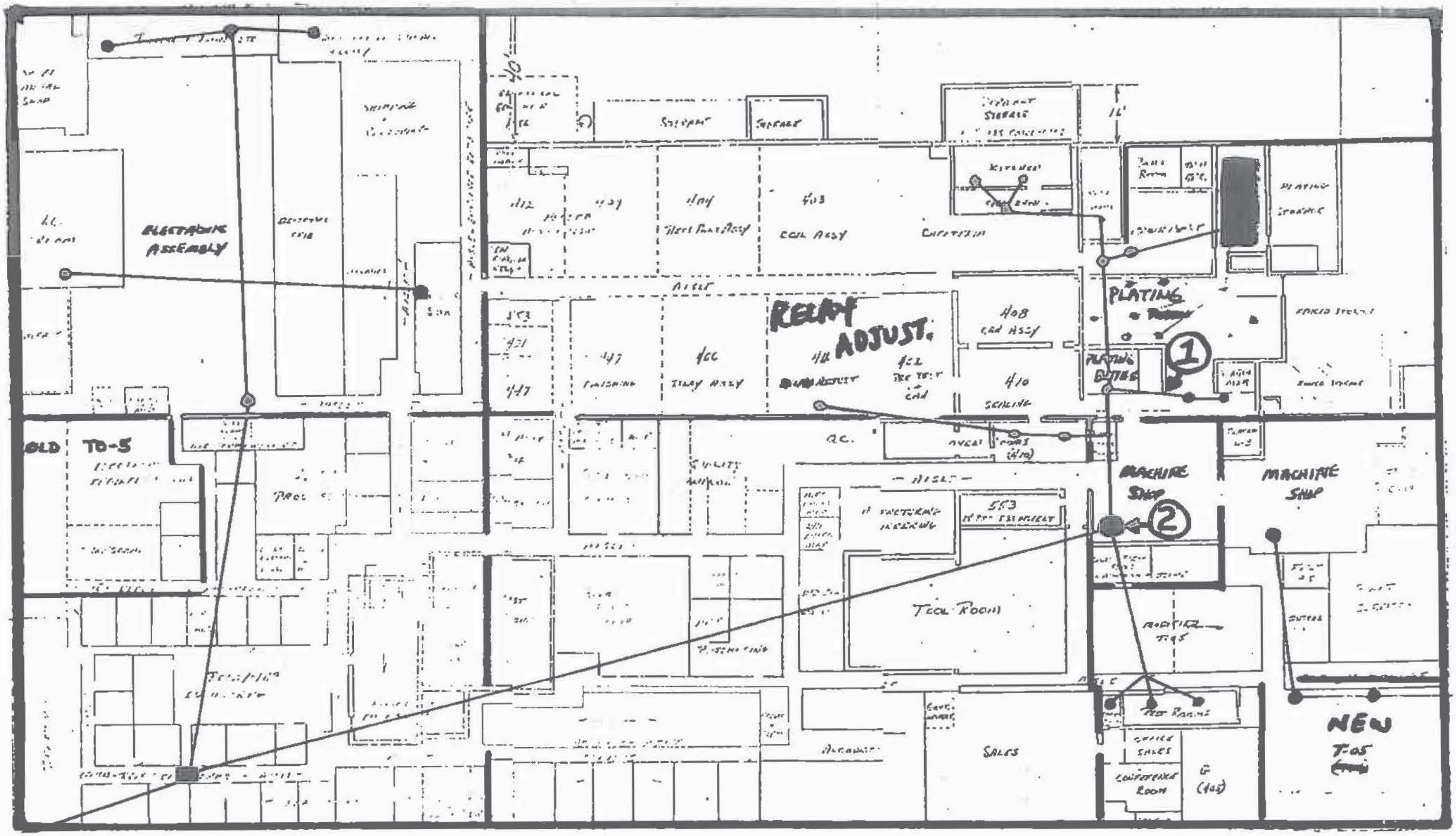
Summary of Air Sampling for Freon TF and 1,1,1, Trichloroethane
Hi-G Incorporated
Windsor Locks, Connecticut
February 1980

Job and/or Area	Sample Number	Sampling Time (Min.)	1,1,1, Trichloroethane (mg/M^3)*	Freon TF (mg/M^3)
Assembly solder	C/T_1	345	.07	ND**
" "	C/T_2	345	.47	ND
" "	C/T_3	345	.11	ND
" "	C/T_4	350	.22	.62
Table in solder room	C/T_5	270	.27	ND
Table in solder room	C/T_6	270	.20	ND
Table in solder room	C/T_7	270	.18	.38
Cleaning booth	C/T_8	270	.16	.08
TO-5 area	C/T_9	270	.07	ND
TO-5 area	C/T_{10}	270	1.09	.04
Canning	C/T_{11}	240	.12	.32
Canning	C/T_{12}	240	.09	.04
Assembly area	C/T_{21}	345	.07	.06
" "	C/T_{22}	345	.18	.12
" "	C/T_{23}	345	.03	ND
" "	C/T_{24}	345	.77	ND
TO-5	C/T_{25}	270	ND	.03
TO-5	C/T_{30}	270	2.05	.16
Canning	C/T_{31}	240	.75	.07
Cleaning booth	C/T_{32}	345	1.61	.06
Canning	C/T_{33}	270	.57	ND
Cleaning booth	C/T_{34}	240	2.61	ND
Evaluation criteria			3,500 mg/M^3	1,900 mg/M^3
NIOSH limit of detection			0.02 mg/M^3	0.02 mg/M^3

*mg/M^3 = Milligrams substance per cubic meter of air

**ND = Non-detectable or below the NIOSH limit of detection

FIGURE 1

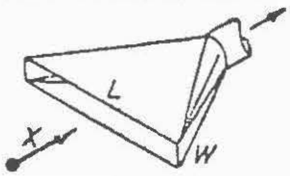
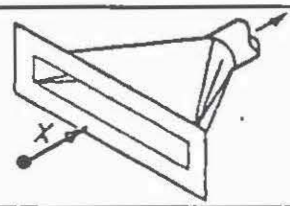
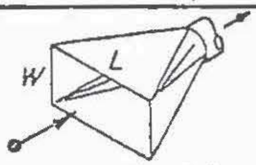
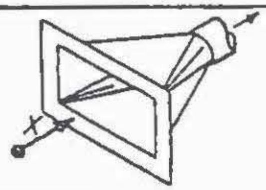
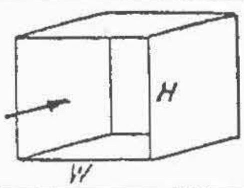
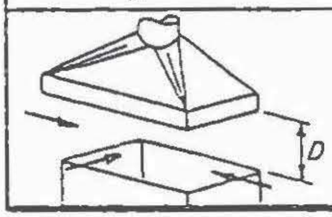


ELECTRONICS PLANT

NOTE:

1. Suspected cross contamination sewer line
2. Manhole where high acid concentration was found

FIGURE 2
INDUSTRIAL VENTILATION

HOOD TYPE	DESCRIPTION	ASPECT RATIO, $\frac{W}{L}$	AIR VOLUME
	SLOT	0.2 or less	Q = 3.7 LVX (Reference 38)
	FLANGED SLOT	0.2 or less	Q = 2.8 LVX (Reference 38)
 A=WL (sq. ft.)	PLAIN OPENING	0.2 or greater and round	$Q = V(10X^2+A)$ (Reference 9)
	FLANGED OPENING	0.2 or greater and round	$Q = 0.75V(10X^2+A)$ (Reference 9)
	BOOTH	To suit work	Q = VA = VWH
	CANOPY	To suit work	Q = 1.4 PDV See VS-903 P = perimeter of work D = height above work

Capture Velocities

Capture velocity is the velocity at any point in front of the hood necessary to overcome opposing air currents and to capture the contaminated air by causing it to flow into the exhaust hood.

Exceptionally high volume hoods (example, large side-draft shakeout) require less air volume than would be indicated by the capture velocity values recommended for small hoods. This phenomenon is ascribed to:

1. The presence of a large air mass moving into the hood.
2. The fact that the contaminant is under the influence of the hood for a much longer time than is the case with small hoods.
3. The fact that the large air volume affords considerable dilution as described above.

Table 4-1 offers capture velocity data. Additional information is found in Section 5, Table 5-9-2.

FIGURE 3

INDUSTRIAL VENTILATION

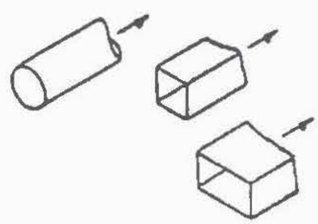
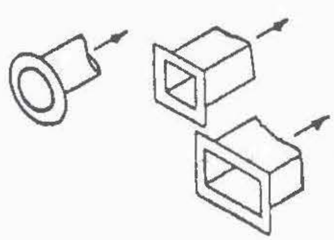
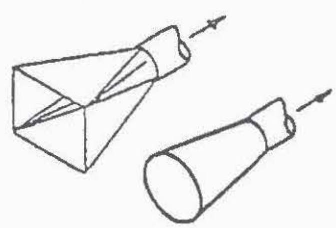
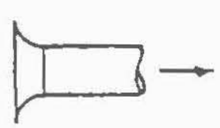
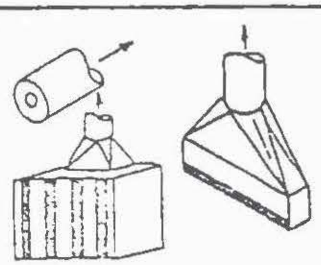
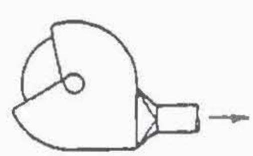
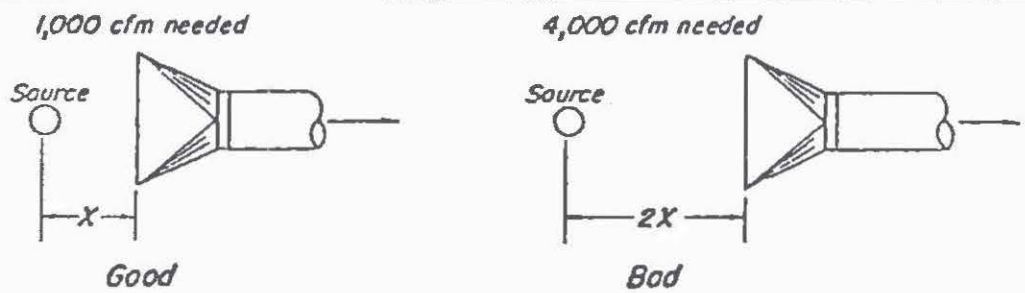
HOOD TYPE	DESCRIPTION	COEFFICIENT OF ENTRY, Ce	ENTRY LOSS
	PLAIN OPENING	0.72	0.93 VP
	FLANGED OPENING	0.82	0.49 VP
	TAPER or CONE HOOD	Varies with angle of taper or cone. See Fig. 6-10	
	BELL MOUTH INLET	0.98	0.04 VP
	ORIFICE	See Fig. 6-10	
	TYPICAL GRINDING HOOD	STRAIGHT TAKE-OFF	
		0.78	0.65 VP
		TAPERED TAKE-OFF	
		0.85	0.40 VP

FIGURE 4



LOCATION

Place hood as close to the source of contaminant as possible. The required volume varies with the square of the distance from the source.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS

PRINCIPLES OF EXHAUST HOODS

1-64	Fig. 4-9