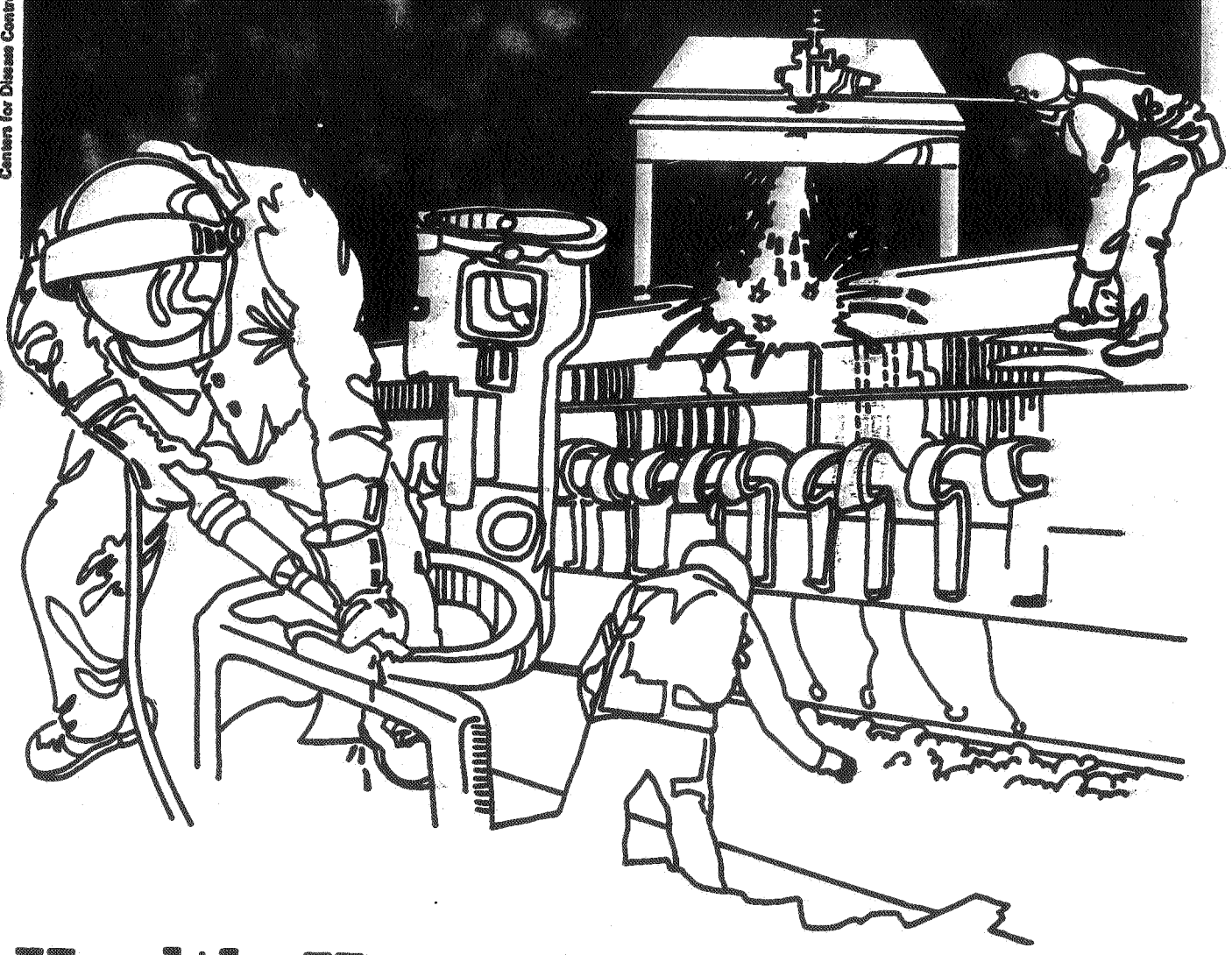
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES • Public Health Service
Centers for Disease Control • National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

HETA 82-273-1239
SPECTRUM CONTROL, INC.
FAIRVIEW, PENNSYLVANIA

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 nygiene 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 82-273-1239
DECEMBER 1982
SPECTRUM CONTROL, INC.
FAIRVIEW, PENNSYLVANIA

NIOSH INVESTIGATORS
Peter A. Boxer, M.D.
Richard Hartle, I.H.

I. SUMMARY

In May 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request to investigate an ongoing outbreak of illness at Spectrum Control, Inc., an electronic component manufacturing plant in Fairview, Pennsylvania, employing approximately 230 workers. Since the end of April 1982, a large number of production workers had been experiencing a variety of symptoms, including dizziness, headache, nausea, and disorientation.

On May 27-28, 1982, NIOSH investigators conducted a walk-through survey of the plant, spoke to representatives from the Occupational Safety and Health Administration (OSHA), the Hamot Medical Center, and a private environmental consulting firm who had conducted investigations prior to the NIOSH site visit, and interviewed a number of employees at the plant. Extensive environmental sampling performed by OSHA and private consultants failed to detect any chemicals in the plant at toxic levels. Levels of carbon monoxide, toluene, trichloroethylene, and ethyl acetate were well within currently recommended occupational criteria. Sampling for lead, formaldehyde, sewer gas, and "Freon" was negative.

On June 21, 1982, a NIOSH investigator administered a questionnaire to over 98% of all employees. Only production workers were "ill" by our definition. Of 41 ill employees, only one was male, compared to eleven males among the 59 well production employees ($\chi^2=5.96$, d.f.=1, $P<.05$). Compared to well employees, ill employees complained more of bothersome odors ($\chi^2=21.7$, d.f.=4, $P<.001$), discounted the role of psychological factors in the outbreak ($\chi^2=23.3$, d.f.=2, $P<<.001$), and felt that a greater chance of the illness recurring existed ($\chi^2=6.37$, d.f.=2, $P<.05$). Blood gas analyses of 7 of 11 ill workers showed respiratory alkalosis, consistent with the hyperventilation syndrome, a condition most commonly associated with anxiety.

Based on these results, NIOSH concluded that the episode of illness at the plant was most likely induced by psychosocial stressors, a phenomenon often referred to as industrial mass psychogenic illness. Release of diesel fumes into the plant from an automobile engine test may have contributed to a heightened awareness of a variety of odors in the plant. 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. This reaction can represent normal psychophysiological responses to a stressful environment. Recommendations to help prevent recurrences are presented in Section IX of this report.

KEYWORDS: SIC 3675 (Electronic Capacitors) and 3677 (Electronic Coils, Transformers and Other Indicators), stress-induced illness, mass psychogenic illness.

II. INTRODUCTION

In response to a confidential employee request and a separate request from management, the National Institute for Occupational Safety and Health (NIOSH) initiated Health Hazard Evaluation 82-273 at Spectrum Control, Inc., Fairview, Pennsylvania, with a site visit on May 27-28, 1982. According to the requests, a large number of production employees had been experiencing a variety of symptoms since the end of April 1982, including dizziness, headache, nausea, and disorientation. The Erie, Pennsylvania office of the Occupational Safety and Health Administration (OSHA), as well as a number of outside consulting firms, had already inspected the plant to investigate whether these symptoms might be related to a chemical exposure at the workplace. The NIOSH industrial hygienist and the medical officer reviewed all available environmental sampling and medical data relating to the episodes of illness. A letter outlining preliminary findings and recommendations was sent to management and the requester on June 8, 1982. The NIOSH medical officer made a return visit to the plant on June 21, 1982 to administer a questionnaire to all employees.

III. BACKGROUND

Spectrum Control, Inc. began operation in 1968 at a facility in downtown Erie, Pennsylvania. In 1979 the company moved to its present facility in Fairview, Pennsylvania. The plant is located on a formerly heavily wooded site outside Erie in a predominantly agricultural area. The nearest industry is approximately four miles away. Approximately 230 individuals are employed at the Fairview plant.

The 38,000 sq. ft. plant is used for designing, manufacturing, assembling, and testing a variety of electromagnetic components known as electromagnetic interference (EMI) and electromagnetic compatibility (EMC) products, used to control "electronic pollution". These products are used as shields to bar or reduce the escape of unwanted radio waves from electronic equipment, which can interfere with the operation of communication receivers and other electronic equipment.

A broad range of electromagnetic compatibility devices are produced, including feed-through capacitors, hermetic seal capacitors and filters, multi-circuit filters, connector pin filters and capacitors, variable capacitors, miniature caseless capacitors, resin seal filters, filtered connectors, and various radio wave shielding devices, including viewing windows and knitted wire gaskets and panels. The manufacturing areas are segregated according to production processes, with production areas occupying approximately one half the floor area, and administrative areas the other half. The production and administrative areas are separated by a large, open walk-way running the length of the building.

Capacitors are assembled by hand, and most are subsequently soldered by automated processes (natural-gas fired and vented to the outside), although some types of capacitors require hand soldering (conducted under local exhaust ventilation). Small quantities of ethyl alcohol and ethyl acetate are used to remove excess solder flux. Cotton swabs are immersed in the solvent and used to swipe the capacitor, under local exhaust ventilation.

Resin sealed filters are produced in an adjacent area in essentially the same manner as capacitors. Again, ethyl acetate and ethyl alcohol are used to clean the parts.

Laminated viewing windows are produced in an enclosed area . A toluene-based adhesive is used to join the clear vinyl shields.

Glass-sealed filters are hand assembled and primarily hand soldered under local exhaust ventilation. The process and work practices are similar to those in capacitor and resin-sealed filter production.

The various other production departments include hand painting operations, where colored lines are brushed on capacitors; wire mesh knitting, where automated wire knitters produce various sized wire meshes for radio wave screening; and a gasket department, where wire impregnated rubber gaskets are cut and drilled to customer specifications.

Trichloroethylene (TCE) was used in the facility in several small degreasers. However, with the onset of health problems, these were removed and the use of TCE inside the building was discontinued.

Air is supplied to the work and administrative areas through thirteen 5 to 15-"ton" roof-mounted air conditioning units. A total of 45,400 (design) cubic feet per minute (CFM) is supplied via a system of air diffusion units located mid-way between the ceiling and floor level. Under normal operating conditions, approximately 80% of the air is reportedly recirculated. The air conditioning system is equipped with "economizers", which are activated when outside vs. inside air temperatures are such that the building can be cooled more economically by supplying total outside air, thus eliminating the need for refrigerated air.

A total of 12,000 CFM of air is exhausted through nine local exhaust systems. The majority of these systems are comprised of a branched network of ducts serving individual work stations where solvents are used or hand soldering is conducted. The remainder are for local exhaust ventilation serving solder dip tanks, various work benches, or degreasing units (no longer inside the building).

Following the initial major outbreak of illness, at the recommendation of the Hamot medical team, the return ducts for the general ventilation system were lowered to floor level in an attempt to remove the postulated higher concentrations of solvent vapors near the floor. In addition, the stacks for the local exhaust systems were raised to a height of six feet above roof top level to reduce the likelihood of re-entry of locally exhausted air.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

The NIOSH environmental evaluation included a walk-through survey of the facility to observe manufacturing processes and the conditions of use of chemical substances, and to conduct a visual evaluation of the

ventilation system. Discussions were conducted with OSHA investigators, company representatives, the Hamot Medical Center team, and numerous employees. In light of previous extensive environmental sampling conducted at the facility by OSHA and private consultants, the removal of TCE from the facility prior to the NIOSH visit, and the lack of any other potential environmental hazards which could possibly have caused the epidemic, no environmental samples were collected during the site visit.

B. Medical

The NIOSH medical evaluation included:

1. Review of OSHA inspection records

2. General discussions with OSHA and company representatives

3. Discussions with representatives of the Hamot Medical Center team which investigated the outbreak

4. Discussions with employee members of the "Safety and Health at Work" team

5. Observation of production processes and work practices

6. Review of emergency room records from the two local medical centers at which ill employees were seen

7. Informal interviews with several employees involved in the outbreaks of illness

8. Review of questionnaire data collected by the Hamot Medical Center team

9. A questionnaire survey of all employees. Anonymity was guaranteed to all respondents. The questionnaire was an abridged and modified version of a survey which had been designed for investigations of apparent mass psychogenic illness by the Behavioral and Motivational Factors Branch of NIOSH. It contained sections pertaining to demographic data, the episode of illness, general medical questions, the physical work environment, non-physical work conditions (e.g. overtime and job security), and socioeconomic variables (education and income). The major difference from the original questionnaire was the removal of psychological profile scales.

V. EVALUATION CRITERIA

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 work week, 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 limits, and a smaller percentage may be more seriously affected by aggravation of a pre-existing condition or by development of an occupational illness.

The following comments discuss several substances which might be generated as a result of normal operations at the plant.

1. Carbon Monoxide (1)

Carbon monoxide is a colorless, odorless gas, slightly lighter than air. It is produced whenever incomplete combustion of carbon-containing compounds occurs. The combination of incomplete combustion and inadequate venting often results in overexposure.

The danger of this gas derives from its affinity for the hemoglobin of red blood cells, which is 300 times that of oxygen. The hazard of exposure to carbon monoxide is compounded by the insidiousness with which high concentrations of carboxyhemoglobin can be attained without marked symptoms. Symptoms exhibited are related to the level of carboxyhemoglobin in the blood, as shown in the following table (13):

Atmospheric carbon monoxide concentration (ppm)	Carboxyhemoglobin concentration (%)	Principal symptoms
50	7	slight headache
100	12	moderate headache and dizziness
250	25	severe headache and dizziness
500	45	nausea, vomiting, collapse possible
1000	60	coma
10000	95	death

Intermittent exposures are not cumulative in effect and, in general, symptoms occur more acutely with higher air concentrations of carbon monoxide. The OSHA standard for carbon monoxide is 50 ppm averged over an 8-hour work shift. NIOSH recommends a ceiling level of 200 ppm and a 35-ppm TWA concentraion for up to an 8-hour work shift, 40-hour work week.

2. Trichloroethylene (TCE) (2,3)

Trichloroethylene is a central nervous system depressant. Effects include drowsiness, dizziness, disturbances of vision, impairment of the senses of smell and touch, tremor, impaired coordination, anxiety, confusion, and loss of consciousness. Other effects of TCE include vomiting, abdominal cramps, cardiac arrhythmias, and respiratory tract irritation. Skin contact can cause irritation and vesicles. Liver and kidney damage have resulted from drinking TCE. It is possible that such damage may also result from the repeated breathing of air contaminated with excessive levels of TCE.

The OSHA standard for TCE is 100 ppm as an 8-hour TWA with an acceptable ceiling concentration of 200 ppm; acceptable maximum peaks above the ceiling of 300 ppm are allowed for 5 minutes duration in a 2-hour period. NIOSH recommends limits of 100 ppm as a TWA and a peak of 150 ppm determined by a sampling time of 10 minutes.

TCE reduces tolerance to alcoholic beverages. Some individuals who have been exposed to TCE experience "degreaser's flush" after consuming alcohol. This apparently harmless condition lasts only a few hours, and consists of red areas of skin on the face, neck, shoulders, and back.

TCE has been shown to cause liver cancer in rodents. In light of the potential risks of human exposure in the work environment, NIOSH recommends that TCE be handled as a potential carcinogen.

Biological monitoring of TCE exposure may involve determination of air concentrations of TCE in exhaled air or determination of concentrations of TCE or its metabolites in urine. Several investigators have found that urine concentrations of total trichlorocompounds offers an approximate guide to exposure. Urine trichloroethanol concentrations in a specimen collected just before the start of the next work period should not exeeced 300 mg/L in persons exposed to 100 ppm of TCE daily(4).

3. Toluene

Toluene is a clear, colorless, non-corrosive liquid with a sweet, pungent, benzene-like odor. It is absorbed both by inhalation and through the skin. Local effects of toluene include irritation of the eyes, nose and throat, and dermatitis. Systemic effects are those of central nervous system depression, including headache, dizziness, fatigue, muscular weakness, drowsiness, incoordination with staggering gait, skin paresthesias (tingling), collapse, and coma (5).

Biological monitoring of toluene exposure is usually performed by measuring levels of hippuric acid in urine. This method is most useful in evaluating moderate to heavy exposure, since endogenous urinary hippuric acid levels may be as high as 1.4g/L. NIOSH has recommended that a level of 5g/L of hippuric acid in an end-of-shift urine specimen be considered an indication of unacceptably high absorption of toluene (4).

The OSHA standard for toluene is 200 ppm as an 8-hour TWA with an acceptable ceiling concentration of 300 ppm; acceptable maximum peaks above the ceiling of 500 ppm are allowed for 10 minutes duration. NIOSH recommends a limit of 100 ppm (TWA) with a ceiling of 200 ppm for a ten minute sampling period.

4. Ethyl acetate

Ethyl acetate has a fruity odor detectable at 10 ppm. It causes irritation of the respiratory tract and, rarely, sensitization resulting in inflammation of the mucous membranes and dermatitis. Very high concentrations of ethyl acetate produce central nervous system depression. The OSHA standard for ethyl acetate is 400 ppm averaged over an 8-hour work shift.

VI. RESULTS

A. Chronology of events

OSHA records indicated that an employee complaint was received in September 1980 specifying that workers were exposed to excess concentrations of unspecified solvent vapors. According to the complaint, workers were experiencing symptoms of "dizziness, nausea, mental confusion, a 'high' feeling, stomach problems, headaches, and chest congestion". In May 1981 an OSHA inspection of Department 5 (capacitor manufacturing) was conducted. Although a formal survey report from OSHA was unavailable, the compliance officer indicated that results of detector tube sampling in Department 5 indicated levels of TCE of approximately 10 parts per million (ppm) in work areas. Process sampling (samples collected near the process, but not necessarily in the breathing zone of employees) indicated levels of TCE from 0 to 17 ppm.

On April 21, 1982, three production employees, all on first shift, complained of nausea and headache, and reportedly were disoriented. They complained of "fumes", and were sent to the emergency room of a local hospital. Two of the three were advised to go home, and one returned to work. On April 22 the two individuals who had been sent home remained away from work. One worker in the shipping department suggested that the air conditioning system might be the source of the problem, since the system had started up several days prior to the workers' illnesses. The air conditioning system was checked, but no refrigerant leaks were found. On the following day one employee remained out of work and one more employee was sent home because of illness. All doors to the plant were opened, since it was thought that insufficient makeup air might have caused the problem. On April 26 and 27 a diesel engine was tested in the anechoic chamber (EMI test room) and the smell of diesel fuel was evident in the plant. This apparently aroused concern among a large number of employees who were unaware of the source of the odor and suspected that they might be exposed to dangerous levels of unknown toxic chemicals.

On April 27, a representative from the Pennsylvania Manufacturers Association conducted environmental sampling for a variety of substances, including carbon monoxide, toluene, trichloroethylene, and ethyl acetate. No levels exceeded currently recommended standards, and the representative reportedly announced to the employees that the illness was "all in their heads". A repeat check of the air conditioning system on April 28 again failed to detect any refrigerant leaks.

On May 4 a number of employees complained of becoming ill from a variety of odors. Two were sent to a local emergency room. The remainder rapidly recovered after being taken out into fresh air. The following day, May 5, three people in department 2 complained of gas leaks and a "dead fish" smell. The gas company's check for sewer gas was negative. By noon, approximately 30% of the production work force reportedly exhibited an erythematous rash on the face, neck, and hands. At 3 P.M. all employees were sent home, and assistance was requested from the Hamot Medical Center to determine the cause of the illness. The company, suspecting that the cause might be related the the use of agricultural chemicals in the surrounding farmland, contacted the Erie County

Extension Service for information on who had recently received permits to fertilize, but this did not provide any clues as to the source of the problem. Another theory proposed by management at this time was that the outbreak was one of vertigo caused by reflection of the sun's rays off the blinds separating the assembly/production area from the office/engineering area.

The Hamot Medical Center team, consisting of five members (Director of Ambulatory Services, Director of Pharmacy and Drug Information Services, Director of Wellness Center, Director of Cardiopulmonary Center Services, and Epidemiologist/Safety Officer) arrived at the plant on the morning of May 6. On the same day, OSHA industrial hygienists began their investigation. Detector tube sampling was negative for TCE, ethyl acetate, and formaldehyde. Long-term sampling for lead and TCE in dept. 5 was also negative.

Shortly after the arrival of the investigators, five more workers became ill. The Hamot team obtained a list of all chemicals used in the plant and categorized who had been ill by department and time of onset. They found that only employees on the assembly/production side of the plant had become ill, and that only females were affected. (Approximately 8% of the assembly-production area employees are male). Also, only first-shift employees were affected. The team conducted a walk-through survey and concluded that the local exhaust systems at some work stations was inadequate. Recommendations to improve the exhaust were made and implemented.

Identification of all chemicals used in the plant revealed that all were used in small quantities, with TCE being used in the largest amounts. The bulk of the chemicals are stored in the chemical house, 40-50 yards from the plant. Interviews with several ill employees indicated that they had a wide variety of symptoms, most frequently those of central nervous depression, although some were described as being euphoric. A number of ill employees were reportedly disoriented, tearful, and did not know their names. One individual seen in a hospital emergency room was reportedly mute and unable to voluntarily move any part of her body. All ill employees were transferred to the Hamot Medical Center for evaluation, where a diagnosis of acute carbon monoxide poisoning was suggested. (It was subsequently realized that this diagnosis was in error-see Discussion).

On May 7, approximately ten more employees became ill in the morning, and the plant was closed at noon as a precautionary measure. Microbac Laboratories, Inc., a division of the Erie Testing Laboratory of Erie, Pa., conducted initial environmental sampling at the facility on that afternoon. A portable gas chromatograph was utilized to identify the major constituents of the plant air in the lobby, the stock room, and departments 2, 4, 5, and 6. Results showed levels of oxygen at 20.9%, nitrogen at 79%, carbon dioxide at 0.1%, methane at less than 25 ppm, hydrogen sulfide at less than 0.5 ppm, and carbon monoxide at less than 15 ppm. Also, one charcoal tube sample was collected for a period of approximately one hour and analyzed with the following results: trichloroethylene at less than 1 ppm, toluene at less than 1 ppm, ethyl acetate at less than 1 ppm, and "Freon" at less than 5 ppm.

National Fuel Gas and OSHA also surveyed for carbon monoxide, both with negative results. OSHA sampled for trichloroethylene, but the highest level found was 1.2 ppm, well within current occupational exposure criteria. High volume charcoal tubes were run for several hours and analyzed by GC-mass spectroscopy. Three small peaks- toluene, TCE, and ethyl acetate- were identified, none at potentially hazardous concentrations.

The Microbac investigators returned to the facility Monday morning, May 10, 1982, during a period of normal production. Charcoal tube samples were collected in Departments 5 and 6. Air samples collected in Dept. 5 showed levels of TCE at 6.0 ppm, toluene at less than 1 ppm, and ethyl acetate at less than 1 ppm. Department 6 had levels of TCE at 5 ppm and toluene at 3 ppm. A portable gas chromatograph was used at various locations and times with results similar to those found on the previous Friday. Samples collected at the base of a degreasing unit indicated levels of TCE at 14 ppm, toluene at 6 ppm and ethyl acetate at less than 1 ppm. Additional floor level samples collected from various departments showed levels of TCE well within the recommended occupational exposure guidelines. Sampling was again conducted on Tuesday, May 11, 1982. Airborne concentrations of toluene and TCE were below 1 ppm, with one sample showing concentrations of ethyl acetate at 15.96 ppm (Dept. 6). Additional air sampling conducted with charcoal tubes was found to be negative for "Freon", chloroethane, methylene chloride, trichlorofluoromethane, 1,1-dichloroethylene, bromochloromethane, 1,1-dichloroethane, chloroform, 1,1,1-trichloroethane, carbon tetrachloride, dichloropropane, tetrachloroethylene, benzene, tetrachloroethane, and chlorobenzene. Additional charcoal tube sampling was conducted on Saturday, May 15, and Monday, May 17, 1982, with no significant air contamination found.

Church Water Purification Laboratory of Fairview, Pa., tested the in-plant drinking water, and found no contamination. Also, according to the management of Spectrum Control, a study of "vibrations and subaudible sounds" performed by a private consultant was negative.

Because of the array of symptoms reported by the ill workers and the essentially negative physical findings of the employees seen at the medical center, the Hamot team decided to distribute a questionnaire on May 10. They defined the study group as including anyone who had been sent home ill or who had been seen at an emergency room or by a private physician. All other employees were designated as controls. By these criteria, there were 63 incidents of illness affecting 46 different people. The questionnaire elicited potential chemical exposures, odors detected, and symptoms experienced. While a number of statistically significant differences between responses of the study and control groups were identified, overall the questionnaire results were not helpful in pointing to the source of the outbreak. It should be pointed out that the validity of the analysis is open to some debate since: (1) A large fraction of the "control" group experienced similar symptoms as the "study" group. Thus, the control group may not have been truly representative of those employees without illness, and differences between the study and control groups would be minimized. (2) The presumably ill and well employees received slightly different

questionnaires. Symptoms for the ill employees referred specifically to the recent outbreak, while for the control group they referred to the preceding two months. A shorter time interval should probably have been chosen for the control group, since the use of a two month period for only the control group will again tend to obscure differences between the two groups.

Based on its survey, including the on-site observation of plant layout, handling and storage of materials, and environmental control systems, and analysis of questionnaires and emergency room and company medical records, the Hamot team concluded in its final report of May 14 that the two major contributing factors to the outbreak of illness were "(1) practices in the handling and use of chemicals, particularly volatile hydrocarbons such as trichloroethylene, and (2) airflow and ventilation of workbench areas." Their theory was that TCE, being heavier than air, was forming clouds or patches lying near the floor, resulting in the outbreak of illness. Based on this theory the following recommendations were made to the management of Spectrum Control:

(1) remove all pregnant workers during the crisis
(2) improve ventilation
(3) take ill employees into the open air
(4) retain the services of Erie Testing Labs
(5) seal all exhaust vent connections at work stations
(6) ventilate the loading dock area where chemnicals are stored
(7) remove trichloroethylene
(8) remove the hanging blind partition in the center of the plant

Most of the above recommendations were promptly implemented. Also implemented were the following changes: a separate room was set up for vapor degreasing and chemical cleaning; degreasers were removed from the production area; 1,1,1-trichloroethane was substituted for TCE; roof stacks were extended another six feet; new air filters were installed to scrub hydrocarbons; cold air returns were extended to the floor to force fresh air to floor level and draw out any "cloud patches" of TCE; the air conditioning system on the north side of the plant was shut down, doors were opened, "cloudbuster" fans were placed at each door, and slow moving floor-level fans were placed indoors.

No illness was reported for a period of over one week, and on May 18 the company called a news conference to announce that implementation of the above steps had ended the outbreak of illness. However on Friday, May 21, nineteen employees became ill and were seen by the plant's paramedic. The outbreak of illness started less than 45 minutes after the air conditioning system was restarted. Common complaints were dizziness, dry cleaning fluid smell, metallic taste in mouth, burning eyes, and numbness around the lips. Another check of the air conditioning system for Freon leaks was negative. However the air conditioning system was again shut down as a precautionary measure. On Monday, May 24, ten employees became ill. On each of the next three days, several employees were ill.

On May 27, the first day of the NIOSH site visit, two employees from the quality assurance area reported being ill. One reported headache and a numb face, and returned to her work station. The other was weak, shaky, nauseated, felt numb around the lips, and reportedly collapsed. She was taken home.

On May 28, no illness was officially reported, although in discussions with the NIOSH medical officer one employee, who had witnessed the collapse of the employee on the previous day, reported feeling weak and experiencing numbness of the face and lips. Several workers expressed the feeling that they were being mocked both by supervisors and well employees who felt that their illness was "not real". Some employees from the assembly/production area who had become ill during the major outbreak and who had subsequently been temporarily moved to a work area on the other side of the plant as a precautionary measure viewed the move as a form of punishment. Suspicion among employees reportedly existed that the company had been testing a new chemical which had been removed from the plant only after numerous employees became ill.

On the afternoon of May 28, at the suggestion of the NIOSH investigators, the NIOSH medical officer explained our preliminary findings to all employees in a group session. It was emphasized that all environmental measurements had failed to detect any toxic levels of chemicals, but that NIOSH would review in detail all the available data and do further testing if necessary. It was also explained that the number and severity of cases had markedly diminished since the implementation of various environmental controls by the company. It was stressed that employees should continue to inform their supervisor if they feel ill. It was also emphasized that there was nothing particularly unusual about the outbreak of illness, and there was no basis for the press labeling the outbreak a "mystery illness". Finally, the employees were notified that NIOSH would be in touch with management to outline preliminary recommendations, and that the company had agreed to keep employees informed via newsletter of all information recieved from NIOSH.

No unusual employee illness at Spectrum Control has been subsequently reported, and the air conditioning system was uneventfully restarted on June 14, 1982.

B. Medical records

Emergency room records from the Hamot Medical Center and St. Vincent's Hospital indicated that thirty emergency room visits were made by Spectrum Control employees between April 21-May 24, with the distribution by date as follows: April 21 (1), May 4 (2), May 5 (2), May 6 (10), May 7 (12), May 10 (1), May 21 (1), May 24 (1). Diagnosis was as follows: mild carbon monoxide exposure (6), anxiety reaction (2), syncope by history (1), contact dermatitis (1), normal exam (2). The remainder of the diagnoses indicated some type of environmental exposure to an unknown agent.

The most frequently reported symptoms were headache, lightheadedness, passing out at work, nausea, palpitations, weakness, tearfulness, and numbness/tingling of the lips. Treatment consisted of monitoring of vital signs, oxygen, several precautionary intravenous lines, and occasionally a tranquilizer.

Two blood and four urine samples from four workers were sent to National Medical Laboratories, Willow Grove, Pennsylvania on May 4-5. Ethyl acetate was not found in either blood specimen. Three urine samples were analyzed for toluene and volatiles (ethanol, acetone, methanol, and isopropanol), and two were analyzed for TCE and trichloroorganic metabolites; all results were negative. Three urine samples had fluoride concentrations between 0.1-0.3 mg/L (toxic range usually greater than 10 mg/L).

All urine samples were also analyzed for silicon. Values ranged between 3.3-22 mg/L (reference range of laboratory: 4.2-14 mg/day). The reason for measuring silicon, how it could conceivably appear in the urine, and the basis for the reference range cited by the laboratory are all unclear. We would consider the results of the silicon analyses uninterpretable.

One blood and four urine specimens were obtained from five ill workers on May 21. The blood sample was analyzed for TCE, perchloroethylene, trichloroethane, and toluene; all were absent. No halogenated hydrocarbons were found in the urine specimens. However, toluene was present in three urine samples at concentrations between 0.06-0.19 ppm. Since less than 0.1% of absorbed toluene is excreted unchanged in the urine, these levels in the urine would imply massive overexposure of workers to toluene. Measurement of urinary hippuric acid, a metabolite of toluene, is a more widely accepted index of toluene exposure. Accordingly, the laboratory analyzed the urine sample containing 0.16 ppm toluene, and found 0.2 g/L of hippuric acid, well within what is generally considered an acceptable concentration. According to the laboratory performing the analyses, exposure to 200 ppm of toluene in air for 8 hours should give a urinary hippuric acid level of about 3.5 g/L. The chemist responsible for the analyses concluded that the results of the urinary toluene analyses were probably "spurious".

Because analyses of all blood and urine samples had yielded negative results for all suspect chemicals, it was decided not to analyze ten blood and nine urine specimens which had been obtained on May 24.

Fourteen workers seen in the emergency room, most of whom were cigarette workers, had levels of carboxyhemoglobin measured. Values ranged from 0.8-7.4% (median 3.5%, mean 2.8%). Eleven workers had arterial blood gas determinations, all of which were considered normal. However NIOSH's evaluation of these results, using the nomogram designed by Arbus (6), indicates that seven of these results are consistent with acute respiratory alkalosis, a condition which commonly occurs from hyperventilation, while four results were normal. Results of arterial blood gas and carboxyhemoglobin analyses are listed in Table 1.

C. Questionnaire survey

Two hundred twenty individuals, representing over 98% of all Spectrum Control employees located at the Fairview facility, responded to a NIOSH questionnaire on June 21, 1982. For purposes of analysis, each individual was assigned to one of three groups, based on the response to the question "What happened to you during this event?" Those who responded "I did not experience symptoms" were classified as "well". Those who responded "I was seen in a hospital emergency room, I was seen by a private physician, or I experienced symptoms and I was sent home early from work, but did not go the the emergency room or to a private physician" were classified as "ill". Those who responded "I experienced symptoms but did nothing about them" were placed in an "intermediate" category. Unless specified otherwise, analysis was limited to a comparison of responses of the "ill" employees with those of the "well" employees in the assembly/production area. (No non-assembly/production employees fell into the "ill" category).

Detailed results of the analysis of questionnaire data are presented in Appendix 1. The following results were statistically significant:

1. A higher percentage of females than males were classified in the ill (28% vs. 8%) and intermediate (39% vs 8%) categories. (χ^2=13.3, d.f.=2, P<.01) Of 41 ill employees, only one (2%) was male, compared to eleven males (27%) among the 59 well production employees (χ^2=5.96, d.f.=1, P<.05).

2. The percentage of workers who felt that the direct cause of the outbreak of illness was due to problems with chemical fumes, the ventilation system, or the air conditioning system was highest in the ill group (70%), lowest in the non-assembly/production well group (19%). and intermediate in the assembly/production well group (44%). Conversely, the percentage of workers who felt that psychological factors accounted for the outbreak, either all or in part, was highest in the non-assembly/production well group (41%), lowest in the ill group (0%), and intermediate in the assembly/production well group (19%) (χ^2=23.3, d.f.=2, P<.001).

3. A significantly higher percentage of ill workers compared to well workers felt that danger of the illness recurring existed (32% vs. 22%, χ^2=6.37, d.f.=2, P<.05).

4. In response to the question "How often are you bothered during an average month by tension", the distribution of responses varied between the ill and well groups (χ^2=11.64, d.f.=4, P<.05). However, examination of the responses indicates that this difference, while of statistical significance, is bidirectional and thus not readily interpretable..

5. A significantly higher percentage of ill employees compared to well employees complained of bothersome odors during the two months preceding administration of the questionnaire (χ^2=21.7, d.f.=4, P<.001).

The questionnaires were reanalyzed, changing the definition of "ill" to include only those 18 individuals who were seen in an emergency room (presumably the sickest individuals). The comparisons which attained statistical significance were unchanged, and no new statistically significant differences emerged.

Fifty-nine per cent of ill employees reported that they had heard about other workers being ill before they themselves experienced symptoms. Fifty-one per cent reported witnessing other workers becoming ill before they themselves experienced symptoms. The ten most frequent symptoms were the same for the "ill" and "intermediate" groups, although the order of frequency was different. A complete list of symptoms is included in Appendix 1. Overall attack rates were highest in department 5 (48%), 6 (35%), and 10 (50%).

Detailed results of a series of questions relating to overtime and employment at other jobs are not reported, since almost all employees work 40 hours per week with no overtime, and few hold additional jobs.

VII. DISCUSSION

The initial diagnosis of acute carbon monoxide poisoning in six employees resulted from a misinterpretation of laboratory data. While carboxyhemoglobin levels in non-smokers are normally less than 1.5%, levels may range up to 10% in smokers (2). When smoking history is taken into consideration, the carboxyhemoglobin levels measured in employees seen at hospital emergency rooms were not abnormally high. This was later realized by the Hamot Medical Center team, and environmental sampling for carbon monoxide confirmed that this was not the cause of the problem. However, the initial mention of carbon monoxide poisoning continued to cause concern among employees, as evidenced by the fact that the employee request of May 22 listed carbon monoxide as one of the chemicals to which employees are exposed.

It had been suggested that reflection of sunlight off vertical blinds might have caused an outbreak of vertigo among employees. Vertigo, a feeling of whirling or rotation, is usually acccompanied by perspiration, pallor, nausea, and vomiting (7). The wide variety of symptoms reported by ill employees is not suggestive of vertigo nor, to our knowledge, has vertigo been reported to be caused by stationary reflected sunlight.

While the theory that the outbreak was caused by employees being exposed to excessive levels of TCE because of formation of TCE "clouds" lying close to the ground cannot be as easily discarded, it is an unlikely explanation for the following reasons:

1. TCE had been used at the plant since it opened in 1979. No change in the production process or in the ventilation system occurred which could explain why TCE vapors would suddenly cause an epidemic of illness.

2. While TCE vapors are heavier than air (vapor density=4.53; air=1.00), it is unlikely that "clouds" of TCE vapor would persist for a significant period of time. Once liberated into the plant atmosphere, the vapor would tend to diffuse, forming a homogeneous mixture. In a "dead" air space, the relatively heavier vapor may tend to stratify at areas near the floor, but even slight air currents would cause a mixing effect.

3. The distribution of ill employees in the plant by work area does not correlate well with the areas where TCE levels would presumably be highest. Additionally, it is difficult to envision any mechanism of air flow which would explain the fact that nearly all ill employees worked on first-shift, on one side of the main aisle, and that when some formerly ill employees were moved across the aisle, they continued to become ill, while employees near them in other departments remained unaffected.

4. Most important, more than a week after use of TCE had been discontinued, and large fans had been in place to break up the hypothetical low-lying clouds of TCE, a major outbreak of illness again occured. Overexposure to TCE could not conceivably have caused this second outbreak.

The above points can be generalized to argue against any chemical etiology of the illness. Indeed during the NIOSH site visit we could identify no potential chemical exposures which could have accounted for the illness among employees.

The emergency room medical records provided no objective evidence of chemical toxicity. However routine medical exams often do not detect signs of chemical toxicity. Symptoms were in some cases suggestive of the hyperventilation syndrome, defined as ventilation (breathing) in excess of that required to maintain normal levels of oxygen and carbon dioxide in the bloodstream, produced by an increase in frequency and/or depth of respiration(8). While symptoms are diverse, possibly encompassing the cardiovascular, respiratory, neurologic, gastrointestinal, and musculoskeletal systems, the major complaints are commonly lightheadedness, dizziness, and a vague "out-of-touch" feeling. In more serious cases, or cases with acute onset, paresthesias, abnormal skin sensations such as tingling, are classically seen.

Seven of eleven arterial blood gas measurements of employees seen at emergency rooms showed acute respiratory alkalosis, a condition most commonly resulting from hyperventilation, often associated with anxiety. These blood gas results had all been interpreted as normal by hospital physicians. This discrepancy in interpretation may result from the fact that each blood gas result viewed individually is not strikingly abnormal, and the relatively minor deviations may have legitimately been considered to be of no clinical significance. Taken as a group, however, a trend toward respiratory alkalosis clearly emerges. Thus the difference in interpretation of results probably reflects, to some degree, the difference between an epidemiological and a purely clinical aproach to investigation of multiple cases of illness.

Fifty-nine per cent of ill employees reported hearing of other workers being ill and 51% reported witnessing other workers becoming ill before they themselves experienced symptoms. However 54% of ill workers said they first found out that something was happening in the plant when they experienced symptoms. Clearly, these results are incompatible. While any explanation of this discrepancy is necessarily speculative, it is likely that the responses to the questions regarding hearing and/or seeing ill employees are more accurate, since these questions required simple "yes" or "no" answers. In contrast, some ill employees may have quickly circled "I experienced symptoms" even though this was not how they first found out of the outbreak of illness in the plant. Thus the 54% figure is likely inflated by at least 10%.

The Hamot Medical Center report stated, "It must be recognized that the incidence of reported symptoms may have been exacerbated by tension and stress connected with the overall condition existing at the plant..." The NIOSH investigation supports this assessment . While it is possible that exposure levels of substances used in the plant may occasionally be transiently high enough to be apparent to some employees and possibly even cause symptoms, and while it is conceivable that some of the initial cases of illness in the plant could have been the result of toxicologic effects of chemical substances in the plant's environment, it is our opinion that most of the illness at the plant was likely a mass psychogenic phenomenon. Irritating or offensive vapors or fumes, for example fumes from the diesel engine test and from various solvents, may have been the precipitating factor. Indeed, a statistically significant higher percentage of ill employees compared to well employees complained of bothersome odors. On the Hamot questionnaire, ill employees complained of the following odors: dead fish, sweet smell, burnt gasoline, rubber, musky odor, glue, ammonia, "dirty coins", TCE, Freon, vinegar, ashes, and sauerkraut. While there is no evidence that recommended exposure limits were exceeded, the odor thresholds for the chemicals used in the plant are far below such levels.

Several employees indicated on the questionnaire survey that unusually warm weather might have caused the outbreak of illness in the plant. Data obtained from the National Weather Service at Erie International Airport indicated that unseasonably high temperatures did indeed exist on May 4-6, which coincides with the major episode of illness. While the sudden change to summer-like temperatures may have contributed to the development of illness among some employees, it appears unlikely that this was a major factor, since the air conditioning system was functioning in the plant during this period, and temperatures were mild on May 21, the date of the second major outbreak.

Definition of a case in a syndrome with a variety of clinical manifestations and no pathognomonic findings is difficult. Our approach was to include in the ill group all symptomatic workers who sought medical attention (hospital emergency room and/or private physician) or who were sent home early from work after being seen by a paramedic. All other symptomatic workers were placed in an intermediate group and were omitted from the analysis. The well group contained only asymptomatic individuals. By these criteria, over 95% of ill individuals reported five or more symptoms, whereas nearly one half of individuals in the intermediate group had fewer than five symptoms (see Appendix 1).

While this approach undoubtedly excludes some truly ill individuals from the analysis, it avoids the disadvantages of a case definition based on number of symptoms. The latter makes the tenuous assumption that number of symptoms correlates with severity of illness, and implicitly assigns equal weight to each symptom.

If, nevertheless, one wished to construct a case definition based on number of symptoms, in our study it seems reasonable to define anyone with five or more symptoms as ill, and all other individuals as well. Using this case definition, we recalculated all differences which had been found to be statistically significant. All remained statistically significant; because of the increased number of individuals, the Chi-square values increased in all but one case.

The more sensitive case definition, based solely on a minimum number of symptoms, may be useful in generating hypotheses regarding the etiology of mass psychogenic illness in industrial settings. These hypotheses could then be tested in investigations of future similar incidents. In contrast, our conservative approach, using a case definition with greater specificity, may be more applicable in field investigations whose primary goal is to ascertain less equivocal factors in a particular plant which may be related to the outbreak of illness under investigation.

The phenomenon of mass psychogenic illness has typically been reported in plants with a largely female, high school-educated workforce doing routine, repetitive work (9,10). Such a condition clearly exists at the Spectrum Control plant. Similar outbreaks at electronic plants have been investigated (10,11). It should be emphasized that the association of sex and educational level with mass psychogenic phenomena does not necessarily imply that these are causative factors. Little is known about the epidemiology of mass psychogenic illness. Women without higher education are likely to find employment in stressful, low-paying, highly routine jobs, and this may explain, in part, why outbreaks of mass psychogenic illness are usually associated with unskilled or semi-skilled female work forces.

No ill employees felt that psychological factors played a role in the outbreak of illness. This is understandable since:

1. The employees were clearly physically ill, and may find it difficult to understand how psychological factors can play a role in producing physical illness.

2. Some employees may interpret the use of the term psychogenic to mean that some ill workers were either psychiatrically disturbed or malingering, or that the illness was their own fault. These are serious misconceptions which, unfortunately, are probably widely held.

As of June 21, the date of administration of the NIOSH questionnaire, only 12% of the ill employees were convinced that the problem at the plant had been solved. This is in spite of the fact that four weeks had elapsed since the last reported case of illness, and numerous changes had

been instituted by the company with regard to ventilation and use of chemicals. Thus there remains at the plant a large number of employees who are seemingly reluctant to accept a primarily psychological explanation of the outbreak of illness, and who believe that the problem may recur.

It is possible that incidents of mass psychogenic illness in industry occur only when high levels of job stress are present (12). This may explain why analysis of the relatively insensitive questions on the NIOSH survey failed to show statistically significant differences between responses of well and ill employees with regard to most stressors in the work environment.

However, during the two visits to the plant by the NIOSH investigators, a number of potential stressors were identified:

1. Much of the work involves routine, highly repetitive operations, requiring careful concentration and fine manipulations of very small parts.

2. Sources and health effects of a variety of odors were not known to the employees.

3. While few individuals responding to the questionnaire indicated that they were concerned about activities in the EMI test room (anechoic chamber), only about 20% of ill employees knew, in a general sense, what type of tests are conducted here. During administration of the questionnaire, it became apparent that many respondents were not clear as to which area of the plant the EMI test room referred. It is possible that some respondents indicated that the activities in the room did not concern them since they refer to the EMI test room by some other name, and thus did not understand the question. Therefore it is difficult to ascertain the level of concern regarding testing in the anechoic chamber from the questionnaire responses. From discussions with several employees and members of the "Safety and Health at Work" committee, it would appear that concern about activities in the EMI test room does exist among some employees and this longstanding concern, combined with the release of diesel fumes into the plant from an automobile engine test run in the EMI test room on April 26 and 27, may have contributed to a heightened awareness of a variety of odors in the plant.

4. The major outbreak of illness occurred within hours after the arrival of a large team of inspectors both from OSHA and the Hamot Medical Center. Although the company did distribute a newsletter in an attempt to keep employees up to date with the situation, it is likely that many employees were not well informed of the steps that the company was taking to solve the problem. The arrival of a large team of investigators, combined with media reports of a "mystery illness" at the plant, likely served to substantially increase the level of anxiety among employees.

5. The anxiety level among employees may also have been increased by the use of ambulances with flashing lights and sirens to transport employees to the medical centers, and by the frequent paging of the paramedic over the loudspeaker system whenever an employee became ill. Ill employees felt that they were not being taken seriously by their supervisors and some unaffected employees, and the announcement to employees by an outside consultant that the problem was "in their heads" certainly could not have contributed to allaying concerns among employees.

6. The view of employees transferred across the aisle that their being moved was a form of punishment for being ill, again suggests that effective communication between the company and its employees was not optimal.

VIII. CONCLUSIONS

Extensive environmental investigation did not provide any obvious explanation of the sudden outbreak of illness among production/assembly employees. No data suggested that air levels of any chemical substance in the work environment exceeded currently recommended standards.

Analysis of the NIOSH questionnaire survey and review of hospital emergency room records suggests that the episode of illness at the plant was likely a mass psychogenic phenomenon. Factors which may have contributed to the initiation and propagation of the outbreak include odors in the plant; the routine, repetitive nature of the work performed; concerns regarding activities in the EMI test room; media reports of a "mystery illness"; and the possibility that some workers were not adequately informed of the nature of the involvement of large teams of investigators.

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 psychophysiological responses to a stressful environment.

IX. RECOMMENDATIONS

1. Workers should be educated regarding the proper use of chemicals, their odors, and their health effects. Since only a limited number of chemicals are used by most employees at Spectrum Control, it should not be difficult to thoroughly review basic health and safety information. The recent formation of a "Safety and Health at Work" committee is a positive step in involving employees in occupational safety and health. We encourage this committee to become active in a worker education program.

2. Tours of the EMI test room should be arranged for all employees. A short tour and explanation of activities in this room should take only several minutes. It should dispel any fear among employees that they are exposed to either radiation or chemicals from tests conducted here.

3. While management made an earnest attempt to keep employees informed during the outbreak of illnesss via distribution of a newsletter, newsletters are frequently not read by employees. The best method of communication is oral, in an organized meeting.

As mentioned previously, many misconceptions surround the term "psychogenic illness". Open communication between employees and management represents the best way of disspelling these erroneous ideas. Points which repeatedly need to be emphasized are:

a. Symptoms occurring during an outbreak of psychogenic illness are "real". The use of the term psychogenic is not meant to imply either that the symptoms were imaginary or that some employees were malingering.

b. Psychogenic means "of psychologic origin". The term is not synonymous with "neurotic", "psychotic", or "psychopathologic", and in no way suggests that any employees were suffering from a psychiatric disorder.

c. In general, the etiology of mass psychogenic illness involves a complex interaction of a variety of environmental, physiological, psychological, and social variables. Yet it is all too easy to "blame" employees for psychogenic illness. The major purpose in investigation of an outbreak of illness is to identify factors which can be modified to prevent further occurrence of illness. The concept of blame, addressed to either employees or management, is an absurdity when dealing with such a complex situation, further polarizes employees and management, and is counter-productive in preventing further similar outbreaks of illness in the plant.

Management may wish to consider hiring outside consultants to evaluate management/labor relations and provide suggestions for improving communications between the company and its employees.

4. Should any Spectrum employee again become ill with symptoms similar to those which were experienced by a large number of workers in this outbreak, we recommend that the employee be removed to a quiet room out of the sight of other employees. Unless trained medical personnel and 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 addition to performing diagnostic tests indicated at the time, serum and urine specimens from employees seen in hospital emergency rooms should be properly stored until it can be determined whether any additional analyses are appropriate. NIOSH can provide assistance in deciding which analyses might be useful.

X. REFERENCES

1. National Institute for Occupational Safety and Health. Criteria for a recommended standard...occupational exposure to carbon monoxide. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1973. (DHEW publication no. 73-11000)

2. Proctor NH, Hughes JP. Chemical Hazards of the Workplace. Philadelphia. J.P. Lippincott Co., 1978

3. National Institute for Occupational Safety and Health: Special Occupational Hazard Review with Control Recommendations -- Trichloroethylene, 1978. (DHEW (NIOSH) publication no. 78-130)

4. Baselt RC. Biological Monitoring Methods for Industrial Chemicals. Davis, California: Biomedical Publications, 1980

5. National Institute for Occupational Safety and Health. Criteria for a recommended standard...occupational exposure to toluene. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1973. (DHEW publication no. 73-11023)

6. Arbus GS. An in vivo acid-base nomogram for clinical use. Can. Med. Assoc. J. 1973; 109: 291

7. Thorn GW, Adams RD, Braunwald E, Isselbacher KJ, Petersdorf RG eds. Harrison's Principles of Internal Medicine. Eighth edition. New York: McGraw-Hill Book Co, 1977

8. Missri JC, Alexander S. Hyperventilation syndrome. JAMA 1978; 240: 2093-2096

9. Colligan MJ, Urtes MA, Wisseman C, Rosensteel RE, Anania TL, Hornung RW. An investigation of apparent mass psychogenic illness in an electronics plant. J Behavioral Med 1979; 2: 297-309

10. Smith MJ, Colligan MJ, Hurrell JJ. Three incidents of industrial mass psychogenic illness. A preliminary report. J Occ Med 1978; 20:399-400

11. Pryor P, Singal M. Health hazard evaluation Windsor Locks, Connecticut. Report no. 78-137-676. Cincinnati, Ohio: NIOSH, 1978

12. Cohen BGF, Colligan MJ, Wester W, Smith MJ. An investigation of job satisfaction factors in an incident of mass psychogenic illness at the workplace. Occupational Health Nursing 1978; 26:10-16

13. Lindgren GO. "Carbon Monoxide" in Encyclopaedia of Occupational Health and Safety, International Labour Office, Geneva, 1971, p 254

XI. AUTHORSHIP/ACKNOWLEDGMENTS

Evaluation conducted and report prepared by:

Peter A. Boxer, M.D.
Medical Officer
Medical Section

Richard Hartle, I.H.
Industrial Hygienist
Industrial Hygiene Section

Originating Office:

Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard, Evaluations, and Field Studies
Cincinnati, Ohio

Report Typed By:

Terry R. O'Neal
Clerk-Typist
Medical Section

XII. 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 th Cincinnati address. Copies of this report have been sent to:

1. Spectrum Control, Inc., Fairview, Pennsylvania
2. NIOSH, Region III
3. OSHA, Region III
4. Confidential employee requester

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

Arterial blood gas and carboxyhemoglobin (CoHb) analyses -- 15 ill workers
May 1982

CoHb (%)	pH	pCO_2(torr)	pO_2(torr)	NIOSH interpretation of blood gas data
4.3	7.48	30	89	RA*
2.6	7.43	31	105	RA
3.0	7.46	37	76	NL**
4.9	7.44	32	81	RA
3.5	7.43	32	124	RA
2.2	7.44	37	79	NL
4.3	7.48	30	89	RA
---	7.41	36	91	NL
7.4	7.44	32	106	RA
2.5	7.42	41	95	NL
2.7	7.48	32	100	RA
3.5	----	--	---	--
0.8	----	--	---	--
7.1	----	--	---	--
1.3	----	--	---	--

*RA=Respiratory alkalosis
**NL=Normal

Note: All samples collected with patient breathing room air

Appendix 1

Comparison of questionnaire responses of 41 ill and 59 well assembly/production workers

Seven empoyees who completed questionnaires were not present at the plant at the time of the outbreak, and were thus excluded from the analysis. Of 56 non-production employees, 54 were classified as "well" and 2 as "intermediate". Unless specified otherwise, "ill" and "well" in the following tables refer to assembly/production employees only. Chi-square tests were performed on counts of the number of individuals in each category. However, for ease of comparison, data are often presented as percentages. Differences do not reach statistical significance at the 5% level by the Chi-square test unless indicated.

		No. Ill	No. Intermediate	No. Well
Sex	Male	1	1	11
	Female	40	56	48

X^2=13.3, d.f.=2, P<.01; Ill vs. well: X^2=5.96, d.f.=1, P<.05

Ethnic background: Ill: 100% white, not of Hispanic origin
Well: 98.3% white, not of Hispanic origin;
1.7% American Indian or Alaskan native

Age (years)	Range	Median	Mean
Ill	20-65	40	38y
Well	20-59	31	36y

Time at job task

Ill	1 mo-12y	2.2y	2.9y
Well	0.5 mo-12y	2.2y	2.7y

Time employed at Spectrum Control

Ill	1y 2mo-12y 5mo	4y 8mo	6.1y
Well	1mo-13y 6mo	4y	5.3y

How first found out that something happened

	% of Ill	% of Well
Saw someone become ill	22.0	33.9
Told by fellow worker	22.0	57.6
Told by supervisor	0.0	3.4
Experienced symptoms	53.7	---
Radio, TV, newspaper	0.0	5.1
No response	2.3	0.0

Are you fully recovered?

Yes	82.9%
No	9.8
No response	7.3

Attack rates by department

Dept.	No. ill	No. intermediate	No. well	% Ill
2	3	9	9	14
4	4	11	12	15
5	15	7	9	48
6	12	12	10	35
8	2	4	6	17
9	2	10	8	10
10	2	1	1	50
QA	1	2	1	25

Symptoms

	% of Ill	% of Intermediate
Lightheadedness	85.4	49.1
Headache	82.9	78.9
Sleepiness	68.3	75.4
Bad taste in mouth	65.9	42.1
Numbness or tingling	65.9	22.8
Dizziness	61.0	35.1
Weakness	61.0	31.6
Nausea	53.7	31.6
Dry mouth	51.2	31.6
Blurred vision	48.8	22.8
Difficulty swallowing or lump in throat	41.5	17.5
Racing heart	39.0	12.3
Abdominal pain	34.1	3.5
Tightness in chest	31.7	10.5
Diarrhea	31.7	7.0
Chest pain	24.4	3.5
Couldn't catch breath	22.0	10.5
Watery eyes	19.5	12.3
Ringing in ears	14.6	7.0
Passed out	14.6	0.0
Muscle soreness	14.6	17.5
Vomiting	12.2	3.5
Fever	7.3	0.0
Convulsions	0.0	0.0

Of the 27 ill workers reporting numbness or tingling, the areas affected were as follows:

mouth/face/lips	55.6%
hands	29.6
arms	22.2
legs	14.8
feet	7.4
"all over"	11.1

(Total is greater than 100%, since some individuals were affected in more than one part of the body)

Symptoms reported by ill employees that were not listed on the checklist of symptoms on the questionnaire:

	No. reports (N=41)
Shaking/twitching	5
"High blood pressure"	4
Insomnia	2
Bloated stomach	1
Belching	1
Cold fingers	1
Sweaty palms	1
Itchy arms	1
Feeling high	1
Crying	1
Loss of motor control in hands	1

Number of symptoms	Ill (N=41)	Intermediate (N=57)
1	0 (0.0%)	1 (1.8%)
2	0 (0.0%)	8 (14.0%)
3	0 (0.0%)	11 (19.3%)
4	2 (4.9%)	7 (12.3%)
5	4 (9.8%)	6 (10.5%)
6	5 (12.2%)	5 (8.8%)
7	5 (12.2%)	8 (14.0%)
8	3 (7.3%)	4 (7.0%)
9	3 (7.3%)	1 (1.8%)
10	5 (12.2%)	3 (5.3%)
11	3 (7.3%)	2 (3.5%)
12	1 (2.4%)	0 (0.0%)
13	5 (12.2%)	0 (0.0%)
14	1 (2.4%)	0 (0.0%)
15	2 (4.7%)	0 (0.0%)
16	1 (2.4%)	0 (0.0%)
17	1 (2.4%)	1 (1.8%)

Did you have a previous similar experience?

Yes	26.8%
No	68.3
No response	4.9

Of those responding "Yes", 55% mentioned chemical exposures. Other responses included decreased blood sugar, bad air conditioner in an automobile, and "in high school".

Before you first experienced symptoms, did you hear about other workers becoming ill?

Yes	58.5%
No	36.6
No response	4.9

Before you first experienced symptoms, did you witness other workers becoming ill?

Yes	51.2%
No	41.5
No response	7.3

What do you think was the direct cause of the outbreak of illness? (open-ended question)

Direct cause	% of Ill	% of Well (Production)	% of Well (Non-production)
Chemicals, ventilation, air conditioning	70.7	44.1	18.5
Psychological factors	0.0	18.6	40.7
Other (e.g. swamp gas, high temperatures, people on medication	7.3	1.7	3.8
Don't know	22.0	35.6	37.0

$\chi^2=37.2$, d.f.=6, $P<<.001$

Psychological factors vs. all other causes: $\chi^2=23.3$, d.f.=2, $P<<.001$

Could the event have been prevented?

	% of Ill	% of Well (Production)	% of Well (Non-production)
No	7.3	8.6	24.1
Yes	36.6	22.4	14.8
Don't know	56.1	69.0	61.1

Is the problem now taken care of?

	% of Ill	% of Well (Production)	% of Well (Non-production)
Still danger	31.7	22.4	11.1
Taken care of	12.2	31.0	46.3
Don't know	56.1	46.6	42.6

Ill vs. well (production): $\chi^2=6.37$, d.f.=2, $P<.05$

Shortly before the outbreak of illness, was there a change in your work environment or routine?

	% of Ill	% of Well
No	85.4	87.8
Yes	14.6	12.2

Describe your general health

	% of Ill	% of Well
Excellent	34.1	30.5
Good	56.1	67.8
Fair	9.8	1.7
Poor	0.0	0.0

Days absent from work because of illness during average year

	Range	Median	Mean
Ill	0-30	2	3.7
Well	0-20	2	3.1

Use of medications during an average month (% of Ill/ % of Well)

	Times per week			
Medication	1	1-2	3-4	4
Aspirin or headache medicine	67.5/ 71.9	1.5/17.5	7.5/7.0	10.0/3.5
Aids for stomach or digestive problems	88.6/ 86.0	0.0/10.5	0.0/3.5	11.4/0.0
Laxatives	97.2/100.0	2.8/ 0.0	0.0/0.0	0.0/0.0
Cough, cold or sinus medicine	77.8/ 89.3	16.7/ 8.9	2.8/1.8	2.8/0.0
Medication to pep you up	100.0/100.0	0.0/ 0.0	0.0/0.0	0.0/0.0
Medication to calm you down	94.1/100.0	2.9/ 0.0	0.0/0.0	2.0/0.0

During an average month, how often are you bothered by..? (% of Ill/ % of Well)

	Never	Rarely	Sometimes	Fairly often	Very often
Colds	35.1/24.1	48.6/48.3	16.2/22.4	0.0/ 3.4	0.0/1.7
Sneezing spells	41.0/47.4	30.8/22.8	15.4/15.8	10.3/ 8.8	2.6/5.3
Asthma	97.0/73.2	2.9/ 7.1	0.0/12.5	0.0/ 3.6	0.0/3.6
Upset stomach	45.9/40.0	35.1/28.0	13.5/16.0	2.7/12.0	2.7/4.0
Muscle or joint stiffness	47.2/49.1	30.6/20.0	11.1/23.6	8.3/ 1.8	2.8/5.5
Tension*	20.0/36.8	40.0/17.5	20.0/35.1	12.5/10.5	7.5/0.0
Sensitive skin	72.2/68.1	13.9/10.6	11.1/19.1	2.8/ 2.1	0.0/0.0
Frequent or severe headaches	35.0/35.1	25.0/36.8	27.5/17.5	10.0/ 8.8	2.5/1.8
Faint feelings	82.0/85.7	12.8/ 8.9	2.6/ 5.4	2.6/ 0.0	0.0/0.0
Spells of fatigue or exhaustion	35.9/40.4	28.2/22.8	23.1/33.3	10.2/ 3.5	2.6/0.0

* $X^2=11.64$, d.f.=4, $P<.05$

ng the past two months, how often have you been bothered in your work by ?
f Ill/ % of Well)

	Never	Rarely	Sometimes	Fairly often	Very often
rbing noises	28.9/31.0	18.4/31.0	34.2/24.1	7.9/10.3	10.5/ 3.4
ersome odors*	5.0/25.9	7.5/27.6	42.5/31.0	20.0/12.1	25.1/ 3.4
	58.3/65.5	22.2/23.6	11.1/ 9.1	2.8/ 1.8	5.6/ 0.0
lighting	57.1/53.6	25.7/32.1	8.6/10.7	2.9/ 1.8	5.6/ 1.8
ations in mperature	9.8/21.4	4.9/ 7.1	51.2/39.3	9.8/21.4	24.4/10.7
ding	47.2/52.6	6.7/19.3	16.7/21.1	11.1/ 3.5	8.3/ 3.5
sure to increase k output	35.9/39.3	25.6/25.0	20.5/23.2	10.3/ 5.4	7.7/ 7.1

* $\chi^2=21.7$, d.f.=4, P<.001

satisfied are you with ? (% of Ill/ % of Well)

	Satisfied	Slightly Satisfied	Slightly Dissatisfied	Dissatisfied
rtunity to use ur knowledge	70.0/66.1	17.5/20.3	7.5/ 8.5	5.0/ 5.1
security	82.9/70.0	12.2/12.1	4.9/ 8.6	0.0/10.3
ption system	39.0/40.0	14.6/25.5	19.5/20.0	26.8/14.5
time pay	85.0/63.6	7.5/16.4	5.0/14.5	2.5/ 5.5
ry	43.9/40.0	24.4/23.6	24.4/25.5	7.3/10.9
unication with ervisors	43.9/53.4	29.3/22.4	14.6/12.1	12.2/12.1
uency of outbreaks	97.6/87.7	2.4/ 8.8	0.0/ 0.0	0.0/ 3.5
em of determining k schedules	87.5/73.2	5.0/14.3	5.0/ 8.9	2.5/ 3.6
od of determining offs	75.6/58.9	12.2/16.1	4.9/14.3	7.3/10.7
ormance evaluation tem	43.9/29.3	17.1/24.1	14.6/24.1	24.4/22.4
dom to make decisions	73.2/67.2	12.2/13.7	12.2/12.1	2.4/ 6.9

often are you concerned about ...? (% of Ill/ % of Well)

	Never	Rarely	Sometime	Fairly often	Very often
nted overtime	85.0/66.7	12.5/19.3	0.0/12.3	0.0/1.8	2.5/0.0
layoffs	56.4/36.2	23.1/31.0	12.8/22.4	0.0/5.2	7.7/5.2
ing up e workpace	51.3/39.7	7.7/19.0	30.8/25.9	2.6/6.9	7.7/8.6
ng your job	65.0/49.1	12.5/26.3	17.5/21.1	2.5/3.5	2.5/0.0
iving complaint from ervisor	45.0/43.1	32.5/32.8	17.5/24.1	2.5/0.0	2.5/0.0
vities in EMI st room	78.4/87.3	5.4/ 9.1	8.1/ 3.6	0.0/0.0	8.1/0.0

Do you know what type of work is done in the EMI test room?

	% Ill	% Well
No	70.7	62.7
Yes	19.5	30.5
No response	9.8	6.8

(Essentially all who responded "yes" gave a satisfactory general description of the activities).

Highest grade completed in school	% of Ill	% of Well
No schooling	0.0	0.0
1st-6th grade	0.0	0.0
7th-9th grade	2.6	5.2
10th-12th grade	89.5	70.0
Technical school	7.9	10.3
Associate degree	0.0	5.2
Bachelors degree	0.0	8.6
Graduate degree	0.0	1.7

Total household income	% of Ill	% of Well
< $7000	0.0	4.9
7000-9999	25.0	7.3
10,000-12,999	21.4	19.5
13,000-15,999	10.7	7.3
16,000-18,999	3.6	4.9
19,000-21,999	7.1	17.1
22,000-24,999	3.6	9.8
25,000-28,999	3.6	9.8
≥ 29,000	25.0	19.5

Personal income	% of Ill	% of Well
< $7000	0.0	12.2
7000-9999	40.0	28.6
10,000-12,999	40.0	40.8
13,000-15,999	16.7	6.1
16,000-18,999	0.0	4.1
19,000-21,999	3.3	2.0
≥ $22,000	0.0	6.1