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GTE PRODUCTS CORPORATION
WILLIAMSPORT, PENNSYLVANIA

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I. SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) received a request dated April 15, 1987, from GTE Products Corporation, Electronic Components Division, Williamsport, Pennsylvania, concerning employee exposures to rosin pyrolysis products, Freon*, methylene chloride, and other materials used in the Standard Electronic Module (SEM) assembly and testing area. Reported employee health effects included dizziness, headache, eyes, nose and throat irritation, memory loss, and mood changes. A similar request was submitted by the Business Director, District 98, International Association of Machinists (IAM), York, Pennsylvania on behalf of the local union. Both pertained to the same plant operations and employee health problems.

NIOSH investigators conducted a site visit to the GTE Williamsport plant on July 13 and 14, 1987. Personal and area air samples collected in the SEM assembly areas for formaldehyde, a pyrolysis product of colophony soldering flux, were below the limit of detection (LOD) of 2 micrograms (ug) per sample. Area air samples for total aldehydes (qualitative screen) revealed no significant differences between samples and blank tubes, or any extra chromatographic peaks in field samples vs. blanks. The LOD for this sample set was 1 ug/sample. Carbon dioxide (CO_2) concentrations ranged from 600 to 1200 parts per million (ppm) in the SEM solder touch-up and the wave-solder areas, respectively, compared to an outside CO_2 concentration of 400 ppm. Carbon dioxide levels were measured since the SEM assembly areas were air-conditioned and, at the time of this NIOSH evaluation, 100% of the air was recirculated. These CO_2 concentrations are near the upper limit for acceptable indoor air quality (more than 1000 parts per million (ppm), which is 3 to 4 times the outside level). These levels suggest deficiencies in the ventilation system. Carbon monoxide was not detectable in samples collected in the SEM areas.

Nine site visits to the SEM areas were made by a GTE-contracted industrial hygiene evaluation service between October 22, 1986 and April 30, 1987. Monitoring data for methylene chloride, Freon*, cellosolve acetate, toluene, xylene, methyl alcohol, total aldehydes, formaldehyde, 1,1,1, trichloroethane, lead, toluene diisocyanate, cyclohexanone, and isopropyl alcohol were below Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PEL's) and American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's).
One area air sample collected by GTE's industrial hygienist on the morning of February 11, 1987 for methylene chloride measured a concentration of 110 ppm. A subsequent sample taken on the same date, however, indicated only 2.6 ppm methylene chloride. Other methylene chloride samples, collected on different dates in the SEM areas, measured concentrations less than 1 ppm. Because this solvent has been shown to cause cancer in laboratory animals, NIOSH recommends that methylene chloride be considered a potential human carcinogen in the workplace and personal exposures reduced to the lowest feasible limit.

On only one occasion did the GTE industrial hygienist measure aldehyde levels elevated to the extent that the potential for precipitating symptomatology among exposed employees was evident. Initial tests for total aldehydes measured concentrations ranging from 0.17 to 0.27 mg/m^3. The ACGIH TLV for rosin core solder pyrolysis products (measured as formaldehyde) is 0.1 mg/m^3, 8-hour TWA.

Clinical interviews were conducted with 23 persons who work or have worked in the SEM department. Symptoms reported by these individuals include those related to irritation and neurobehavioral disturbances. Persons who no longer worked in SEM noted that their symptoms improved.

The NIOSH investigators determined that a potential health hazard from inadequate ventilation existed among workers in the GTE Products Corporation SEM assembly areas. Clinical symptoms reported by employees during medical interviews are consistent with exposure to agents with neurotoxic and irritant characteristics. Chemicals presently used in SEM processes are capable of precipitating these symptoms. Recommendations for ventilation improvements and work practice changes are included in Section VIII of this report.

Key Words: SIC 3674 (Semiconductors and Related Devices), ventilation, carbon dioxide, carbon monoxide, temperature, relative humidity, methylene chloride, toluene, xylene, formaldehyde, aldehydes, cellosolve acetate, personal protective equipment.

II. INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) received a request, dated April 15, 1987, from GTE Products Corporation, Electronic Components Division, Williamsport, Pennsylvania, concerning employee exposures to rosin pyrolysis products, Freon*, methylene chloride, and other materials used in the Standard Electronic Module (SEM) assembly and testing area. Reported employee health effects included dizziness, headache, eyes, nose and throat irritation, memory loss, and mood changes. A similar request, submitted by the Business Director, District 98, International Association of Machinists (IAM), York, Pennsylvania on behalf of the local union, pertained to the same plant operations and employee health problems.

According to GTE officials, employees in the SEM manufacturing areas began to complain of dizziness, headache, and eye, nose and throat irritation in October 1986. Wood paneling on interior SEM walls was removed in December 1986 and replaced with drywall under the assumption that residual formaldehyde may be present in the paneling.

At GTE's request, nine industrial hygiene (IH) evaluations of the SEM areas were conducted by their private IH and loss control provider between October 22, 1986 and April 30, 1987. Extensive air sampling for methylene chloride, Freon*, cellosolve acetate, toluene, xylene, methyl alcohol, total aldehydes, formaldehyde, 1,1,1 trichloroethane, lead, toluene diisocyanate, cyclohexanone, and isopropyl alcohol was performed and results were below applicable OSHA PEL's and ACGIH TLV's except for one area air sample for methylene chloride and several personal and area air samples for total aldehydes. These results are discussed in greater detail in Section VI.

On July 13, 1987, NIOSH investigators held an opening conference with management representatives. Due to a schedule conflict, an opening conference was held with the president of IAM Local 140 on July 14, 1987. Following these meetings a walk-through of SEM operations was conducted which included parts preparation, surface mount, solder assembly, solder touch-up and repair, quality assurance, and final inspection. Material safety data sheets, along with IH data and medical information from prior environmental and medical investigations conducted in the SEM areas, was supplied to NIOSH by GTE.

III. BACKGROUND

GTE Electronic Components Division designs and develops custom products for the computer and communications industries. SEM modules are designed and built for private system contractors and the U.S. Navy for use in ships, submarines, and airborne and ground support installations. GTE manufactures over 460 different module types in designs ranging from simple, discrete components to complex memory, microprocessor types.

A. SEM Operations

The approximately 8800 square foot SEM operation includes part preparation, surface mounting, solder assembly, solder touch-up and repair, quality assurance, and final inspection. SEM operations which have the greatest potential for generating airborne contaminants are wave soldering, automatic (belt-fed) vapor degreaser (using Freon* 113), and numerous manual solder touch-up stations.

All SEM operations, except final inspection, are separated from remaining plant operations by paneled walls. In December 1985, a suspended ceiling, along with air-conditioning, were installed in the SEM areas. The air-conditioning system, designed to maintain relative humidity between 40 to 60%, was necessary for product quality. Prior to this NIOSH investigation, direct steam injection was also utilized in the SEM (and office) areas for humidification during the winter. Steam injection to the SEM operations ended in February 1987. The steam humidification did not appear related to the health effects experienced by SEM workers.

B. Ventilation

The SEM areas are supplied by 20 separate air conditioning units mounted on the roof of the plant. These

units, several of which supply the front offices and fiber optic areas in the building, have dedicated returns. The units vary in capacity from 4.5 to 25 tons, and steam coils, located in supply ducts, supplement ceiling-mounted space heaters in providing heat.

An 18-inch wave solder machine (manufactured by Detrex) and a belt-fed vapor degreaser (using Freon* 113) were relocated to the SEM area in April 1986. Previously, these operations were performed near, but still outside, the main SEM assembly, touch up, and inspection areas. The solvent 1,1,1 trichloroethane had been used as a degreaser until April 1986. The wave solder and degreaser machines were locally ventilated by one system with an estimated flow of 3000 cubic feet per minute (CFM).

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Three full-shift personal air samples for formaldehyde, a possible pyrolysis product of colophony soldering flux, were collected in the SEM area on July 14, 1987 on the wave-solder machine operator, a touch-up solderer, and a quality assurance inspector. Air samples were collected on solid sorbent tubes (ORBO-22) using low-flow air sampling pumps. The samples were analyzed by gas chromatography (flame ionization detector, FID) using a 30 meter fused silica capillary column. This analysis followed NIOSH Method No. 2502 (with modifications).[1]

Three full-shift area air samples were collected in SEM areas for the qualitative determination of aldehydes. These samples were collected on solid sorbent tubes (ORBO 23) also using low-flow air sampling pumps. Lab anaylsis consisted of desorbing the samples with 1 milliliter of toluene in an ultrasonic bath for 60 minutes. Aliquots of the sample extracts were then screened by gas chromatography (FID) using a 15-meter DB-1301 column. This is a modification of NIOSH Method 2501 for acrolein.[1] Colorimetric detector tubes were used to measure carbon dioxide (CO_2) and carbon monoxide levels in the SEM solder assembly and parts preparation areas.

Also examined were the extensive IH data collected for GTE prior to this NIOSH investigation for methyl alcohol, Freon* 113, methylene chloride, lead, total particulate, cellosolve acetate, toluene, xylene, toluene diisocyanate, total aldehydes, formaldehyde, 1,1,1 trichloroethane, isopropyl alcohol, and cyclohexanone. In these studies, the sampling and analytical procedures were in accordance with accepted industrial hygiene procedures. All solvent samples were collected on charcoal tubes (ethyl alcohol samples were collected on silica gel tubes) using flow rates ranging from 0.05 to 0.1 liters per minute (lpm). Analysis was by gas chromatography. Total aldehyde air samples were collected in two midget impingers (connected in series), containing 10 milliliters of a 1 percent sodium bisulfite solution, at a flow rate of 1 lpm. Analysis was by a titration method. Formaldehyde samples were collected on ORBO 22 sorbent tubes with analysis by gas chromatography (FID) based on NIOSH Method No. 2502. Particulate samples were collected on pre-weighed polyvinyl chloride filters and gravimetrically analyzed. Atmospheric lead samples were collected on mixed cellulose ester filters, then analyzed using atomic absorption spectrophotometry.

B. Ventilation

Information was collected on the ventilation systems in the SEM areas, and the materials used in the electronic assembly operation. Ventilation measurements were made on the local exhaust systems at the SEM solder touch-up and final inspection areas using a velometer. Smoke tubes were used to evaluate the

effectiveness of the exhaust systems supplying the wave-solder and freon degreasing machines and the solder touch-up and final inspection operations. A list of solvents used in the SEM assembly and inspection areas are shown in Table 1.

C. Medical

The intent of the initial medical evaluation, consisting of interviews, was to identify the range of symptoms experienced primarily by those persons identified by management as having work-related (SEM-related) health concerns, past and/or present. The NIOSH physician interviewed 23 GTE employees regarding work history and symptoms experienced while performing work related activities. Fifteen of 23 SEM employees interviewed by NIOSH investigators had reported symptoms in October 1986 when GTE management solicited complaints. All fifteen persons claimed to have experienced symptoms since January 1986, 75% claiming original onset between April and November 1986. The remaining 8 employees were randomly selected from employees that performed SEM-related activities, with attention to proportionate representation of geographic areas within the SEM rooms.

The 23 workers interviewed represented 51% of the 45 persons either presently working in SEM, performing SEM-related activities at work stations that were moved to another area of the plant since November 1986, or were employed in the SEM area as of January 1986 but have transferred to other jobs. Interviews consisted of an informal discussion and a systematic review of biological systems.

A summary of the most frequently reported symptoms can be found in Table 2. Four or fewer persons also reported tremulousness, feelings of abdominal fullness, nausea, difficulty sleeping, occasional palpitations, circumoral (around the mouth) and digital parasthesias, and perceived changes in short term mental capacity. There were no reports of changes in gross motor coordination or fine motor skills. Persons who had changed jobs claimed that symptoms abated after their job change.

V. EVALUATION CRITERIA

A. Environmental Criteria

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

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and Recommended Exposure Limits (REL's), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often NIOSH REL's and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLVs usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH REL's, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels, and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet levels specified by an OSHA standard.

B. Aldehydes (Formaldehyde)

Formaldehyde can be found as a pyrolysis product of colophony soldering flux.[2] Formaldehyde gas may cause severe irritation to the mucous membranes of the respiratory tract and eyes.[3] The aqueous solution splashed in the eyes may cause eye burns. Urticaria (hives) has been reported following inhalation of gas. Repeated exposure to formaldehyde may cause dermatitis either from irritation or allergy. Systemic intoxication is unlikely to occur since intense irritation of upper respiratory passages compel workers to leave exposure areas. If workers do inhale high concentrations of formaldehyde, coughing, difficulty in breathing, and pulmonary edema may occur.

In bacterial studies, formaldehyde has been consistently shown to be a weak mutagen.[2] At this time, the data are inadequate to demonstrate whether or not formaldehyde is teratogenic (causes birth defects). Formaldehyde has induced a rare form of nasal cancer in two test animals as reported by the Chemical Industry Institute of Toxicology. Formaldehyde has also been shown to be a mutagen in several test systems. Based on this information, NIOSH recommends that formaldehyde be handled in the workplace as a potential occupational carcinogen and exposures be reduced to the lowest feasible level.[4] The recently amended OSHA PEL for formaldehyde is 1 ppm for an 8-hour TWA.[5]

C. Methylene Chloride

Methylene chloride, or dichloromethane, is a chlorinated organic compound that is commonly used as a solvent, paint remover, and degreaser. It may be absorbed into the body by inhalation of vapors and by absorption of liquid through the skin. Rats and mice have developed tumors and cancers after exposure to methylene chloride under specific experimental conditions.[6] NIOSH recommends that methylene chloride be regarded as a potential occupational carcinogen and that exposure be controlled to the lowest feasible level.[6] The various published exposure limits are summarized in Table 3.

If inhaled in high concentrations, methylene chloride may affect the nervous system, leading to symptoms such as mental confusion, light-headedness, nausea, vomiting, and headache.[7] Continued exposure to very high concentrations may cause increased light-headedness, staggering, unconsciousness, and death.[8] High vapor concentrations may also cause irritation of the eyes and respiratory tract. There have also been reports of chronic (long-term) neurotoxic (nervous system) effects among workers who have been exposed to methylene chloride for several years. Symptoms reported from chronic exposure have included forgetfulness, insomnia, headaches, fatigue, and hallucinations.[9] Exposure to methylene chloride may aggravate the symptoms of angina pectoris (heart pain), which may be accompanied by feelings of suffocation and palpitations. If the liquid is held in contact with the skin, it may cause irritation or skin burns. Splashes of the liquid into the eyes may cause irritation.

D. Cellosolve Acetate

Cellosolve acetate (2-ethoxyethyl acetate, 2EEA), an acetate ester of 2-ethoxyethanol (2EE), is commonly used as a solvent in many production facilities of the electronic component manufacturing industry. Cellosolve acetate has caused male reproductive toxicity in male mice equivalent to the glycol ethers 2-methoxyethanol and 2EE.[10] 2EEA also appears to have fetoxicity and teratogenicity effects in rats.[10] Based on these findings, NIOSH recommends that exposure to glycol ethers be reduced to the lowest extent possible and that employers voluntarily assess how their workers may be exposed to these substances. The ACGIH TLV for cellosolve acetate is 5 ppm, 8-hour TWA, a limit selected to prevent systemic effects.[11] The OSHA PEL is 100 ppm, 8-hour TWA.[12]

E. Toluene and Xylene

Toluene is often used as a solvent in varnish formulations.[2] These varnishes are used in the electronic component manufacturing industry. Inhalation of toluene vapors at very high concentrations produces a state of euphoria.[3] Several cases of toluene abuse and habituation have been reported and long-term abuse of toluene can lead to permanent central nervous system damage.[3] The ACGIH TLV for either toluene or xylene is 100 ppm, 8-hour TWA.[11] The OSHA standards for toluene and xylene are 100 and 200 ppm, respectively.[12] The NIOSH REL's for toluene and xylene are 100 ppm, averaged over a work shift of up to 10 hours per day, with acceptable ceiling levels of 200 ppm averaged over a 10-minute exposure.[13,14]

F. Fluorocarbons (Freons)

Fluorocarbons have the potential to produce bronchoconstriction, reduce pulmonary compliance, depress respiratory minute volume, reduce mean blood pressure, and accelerate the heart rate in dogs.[2] Freon* 11 was found to be the most toxic fluorocarbon tested.[2] Many halogenated organic solvents can cause the heart to become sensitized to epinephrine. However, little or no problems seem to exist in the electronic component manufacturing industry with regard to cardiac sensitization because exposure levels of halogenated hydrocarbons are usually well below the high levels used in these experiments.[2]

Freon* 113 (1,1,2-trichloro-1,2,2-trifluoroethane), used in the Detrex model belt-fed vapor degreaser situated in the SEM parts assembly area, is a central nervous system depressant and a mild mucous membrane irritant.[3] The ACGIH TLV and OSHA PEL for Freon* 113 are both 1,000 ppm, 8-hour TWA.[11,12] These exposure limits were selected primarily for good hygiene control for substances of low toxicity. There is no NIOSH REL for Freon 113.

G. Lead

Inhalation of lead dust and fume is the major route of lead exposure in industry. A secondary source of exposure may be from ingestion (swallowing) of lead dust deposited on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood forming organs.[15] Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.[15]

The revised OSHA lead standard is 50 ug/m^3 as an 8-hour TWA.[16]. The ACGIH TLV for lead is 100 ug/m^3; the NIOSH REL is less than 100 ug/m^3 for up to a 10-hour TWA.[11,17]

I. Flux Fumes

Many solders and fluxes are used in the electronics industry and many of the health problems associated with soldering are caused by inhalation of colophony fumes. Colophony consists of about 90% resin acid (which is mostly abietic acid) with 10% neutral materials such as stibine and various hydrocarbons.[2] Pyrolysis products include aliphatic aldehydes such as formaldehyde. When colophony fumes are inhaled, the exposed person may develop an allergic sensitivity. Colophony sensitization and its symptoms develop over a period that varies from a few months to 16 years.[2] The mean exposure period before symptoms develop is 4 years.

The ACGIH TLV for rosin core solder pyrolysis products (measured as formaldehyde) is 0.1 mg/m^3, 8-hour TWA.[11]

VI. RESULTS

A. Environmental

1. NIOSH Evaluation

All formaldehyde samples were below the limit of detection (LOD) of 2 micrograms (ug) per sample. No significant differences between samples and blank tubes were observed in the qualitative aldehyde screening samples, nor were any extra chromatographic peaks detected in the field samples vs. blanks. The LOD for formaldehyde for the aldehyde sample set was 1 ug/sample.

Carbon dioxide is a normal constituent of exhaled breath, and, if monitored, can be used as a screening technique to evaluate whether adequate quantities of fresh outdoor air are being introduced into a work area. The CO_2 concentrations in the SEM areas ranged from 600 to 1200 parts per million (ppm) for the solder touch-up and the wave-solder areas, respectively (outside CO_2 concentration was 400 ppm). These CO_2 concentrations are near the upper limit for acceptable indoor air quality (more than 1000 parts per million (ppm) and 3 to 4 times the outside level) and suggest deficiencies in the ventilation system. Carbon monoxide was not detectable in samples collected in the SEM areas.

The air-conditioning in the main SEM assembly room, installed in December, 1985, was estimated by GTE to introduce about 5% outside make-up air, a situation contributing to the gradual build-up of airborne contaminants in the work area. While a higher percentage of fresh outside air (20% or greater) should reduce the concentration of contaminants in the SEM assembly areas, the desirability of recirculating air from operations potentially generating known toxic materials (methylene chloride, formaldehyde, cellosolve acetate, etc.) is not recommended.

The feasibility of recirculating air from industrial exhaust systems depends on a number of industrial hygiene and engineering factors. These factors, outlined in Table 4, should be used to determine if recirculation is feasible and if adequate worker protection will be maintained. Since methylene chloride, a substance NIOSH considers to be a suspect carcinogen, is used at numerous SEM work stations, a recirculating ventilation system would not be recommended unless the system's design assured that no methylene chloride was reintroduced back into the work areas.

2. GTE Contracted Evaluation

The GTE contracted industrial hygiene evaluation included monitoring data collected from October 22, 1986 to April 30, 1987. In total, nine site visits were made and personal and area samples were collected for methylene chloride, Freon*, cellosolve acetate, toluene, xylene, methyl alcohol, total aldehydes, formaldehyde, trichloroethane, lead, toluene diisocyanate, cyclohexanone, and isopropyl alcohol.

The initial portion of their investigation was conducted before additional local exhaust ventilation was installed at SEM operations. One of the report's preliminary recommendations, that additional local exhaust ventilation on the wave solder machine and the individual solder touch-up stations be installed to control future problems, was implemented by GTE in December 1986.

All solvent concentrations from the GTE investigations were below OSHA PEL's and ACGIH TLV's except for one area air sample, collected on the morning of February 11, 1987 for methylene chloride. This area sample measured a concentration of 110 ppm TWA. A subsequent sample taken on the same date, however, indicated only 2.6 ppm methylene chloride. Other samples, collected on different dates in the SEM areas, measured concentrations less than 1 ppm.

On only one occasion did the GTE hygienist's sampling for aldehydes yield levels elevated to the extent

that the potential for precipitating symptomatology among the exposed was evident. Initial tests for total aldehydes measured concentrations ranging from 0.17 to 0.27 mg/m^3. The ACGIH TLV for rosin core solder pyrolysis products (measured as formaldehyde) is 0.1 mg/m^3, 8-hour TWA.

As pointed out in the GTE report, several factors may have influenced the total aldehyde levels measured. The levels were near the LOD for the analytical method. Some of the solvents used in the SEM areas are interferences in the analytical method and may have affected the accuracy of the results. The wood paneling on the walls of the SEM areas (paneling present when initial aldehyde samples were collected in October 1986 but subsequently removed) may have released residual formaldehyde, further affecting the results.

The GTE report concluded that a possible problem with total aldehydes may have existed which could have given rise to the symptoms and attitudes reported by employees in the SEM areas. The GTE report went on to state that some of the incidents of health effects may have been a "hysteria reaction" to odors (perceived or real) which certain employees believed to be the cause of their problems. The primary recommendation was ventilation improvements (since implemented by GTE) in the SEM areas to control future problems.

B. Medical

Probable work-related symptoms were reported by 20 of the 23 persons interviewed. In addition to symptoms noted in Table 2, four or fewer persons also reported tremulousness, feelings of abdominal fullness, nausea, difficulty sleeping, occasional palpitations, circumoral (around the mouth) and digital paresthesias, and perceived changes in short-term memory. There were no reports of changes in gross motor coordination or fine motor skills. Fifteen persons reported persistent daily or intermittent symptoms. Persons who have changed jobs claimed that symptoms abated after their job change. Five different job tasks were represented by the small number of persons interviewed. As such, additional statistical analysis of the data was inappropriate.

VII. DISCUSSION

Clinical symptoms reported by employees during medical interviews are consistent with exposure to agents with neurotoxic and irritant characteristics. Agents presently being used in SEM processes are capable of precipitating these symptoms. Additionally, many of the symptoms reported (past and persistent) may be found in instances of indoor air quality problems in which employee concern precipitates an increased sensitivity to the work environment. Air monitoring data generated by previous GTE-sponsored industrial hygiene evaluations, along with results from this NIOSH evaluation, suggest that exposure levels have diminished to the extent that biological monitoring of SEM employees for substances such as toluene, xylene, trichloroethylene, and cellosolve acetate was not appropriate. Because of potential acute and chronic health effects of several of the compounds in use, even in low doses, efforts should be made to maintain reduced exposures. In addition, since personal sensitivity is variable, symptomatic individuals should be encouraged to seek medical evaluation when needed.

VIII. RECOMMENDATIONS

1. Gloves used by SEM spray booth operators to clean spray equipment in methylene chloride (known by the employees as solvent M-17), should be replaced with gloves offering greater permeation protection and degradation resistance. The gloves currently used, Edmont Solvex (a nitrile rubber glove) and a 19 mil latex (manufacturer unknown), are not recommended when working with methylene chloride. Glove materials which offer a higher degree of protection include supported polyvinyl alcohol, Viton (a registered trademark of DuPont for its fluoroelastomer material), and Norfoil, a flexible laminate used in the Silver Shield glove manufactured by North Hand Protection. Please note that the mention of trade names or commercial products does not constitute endorsement or recommendation by NIOSH.

2. The 4 flexible exhaust hoses, located at the SEM final inspection area, should be lengthened to permit the exhaust opening to reach within 1 to 2 inches of the point of work. During our visit these hoses were 4 to 6 inches from the point where the electronic components were cleaned with solvent, soldered, and touched-up with a polyurethane sealer, a distance too great for the exhaust ventilation system to be effective. Similar exhaust hoses used in the solder touch-up area were sufficiently long to permit locating the exhaust within 2 inches of the point of work.

3. Good housekeeping should continue to be emphasized to prevent dust and fumes from soldering operations from accumulating on work surfaces. If allowed to build up, concentrations of these flux materials in the workroom air will increase because of air movement resuspending the particles.

4. The local exhaust system on the Detrex model degreaser should be reengineered to improve its efficiency. The current location of the exhaust duct more readily ventilates the general room air than the vapor degreaser.

5. Personal exposures to methylene chloride (solvent M-17) should be reduced to the lowest feasible level. If possible, this solvent should be substituted with a less toxic material.

6. Periodic surveillance for persistent and recurrent medical symptoms should be undertaken in the SEM areas until it is clear that the level of symptoms has diminished.

7. Industrial hygiene monitoring should continue in the SEM areas as outlined in the periodic monitoring schedule recommended by the GTE IH and loss control provider.

8. Recirculation of exhaust air from the SEM areas is not recommended considering the agents presently being used. Because of potential acute and chronic health effects of several of the compounds, even in low doses, efforts should be made to reduce exposures by eliminating the practice of air recirculation in the SEM department.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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

1. GTE Products Corporation, Williamsport, Pennsylvania.
2. International Association of Machinists, District 98, York, Pennsylvania.
3. The National Institute for Occupational Safety and Health (NIOSH) Cincinnati Region
3. The Occupational Safety and Health Administration (OSHA) Region III.

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

TABLE 1

Solvents Used In Standard Electronic Module Assembly Areas
GTE Products Corporation
Williamsport, Pennsylvania
HETA 87-250

1. Conathane urethane prepolymer. Manufactured by Conap, Inc.
   - 25% cellosolve acetate
   - 15% xylene
   - 2% toluene diisocyanate (free residual)

2. Conathane CE-1155, Part B polyurethane curing agent. Manufactured by Conap, Inc.
   - 17.6% cellosolve acetate
   - 17.5% toluene

3. S-8 Solvent. Manufactured by Conap, Inc.
   - >45% toluene
   - <55% cellosolve acetate

4. M-17 Solvent. Manufactured by John B. Moore Corporation.
   - methylene chloride
   - trichloroethylene
   - tetrahydrofuran

5. No. 1587 rosin flux. Manufactured by Kester Solder Company.
   - 75% isopropyl alcohol
   - 24% rosin

5. Hollis 225 Soldering Fluid. Manufactured by Chevron.
   - 92.5% hydrocarbon base oil
   - 7.5% fatty acids and phenolic antioxidant (proprietary additives)

6. Freon "R" TMS Solvent. Manufactured by E.I. DuPont De Nemours and Company.
   - 94% trichlorotrifluoroethane
   - 5.7% ethyl alcohol
   - 0.3% nitromethane

TABLE 2

Frequently Reported Symptoms[a]
GTE Products Corporation
Williamsport, Pennsylvania
HETA 87-250

Symptom	No. of Persons
Headache	14
Nasal Irritation/Sinus Congestion	12
Eye Irritation	9
Throat irritation	9
Fatigue	9
Mood Alteration	8
Faintness	6
Disorientation	5
Dizziness	5
Difficulty Breathing	5

a Probable work-related symptoms.

TABLE 3

Published Airborne Exposure Limits for Methylene Chloride
GTE Products Corporation
Williamsport, Pennsylvania
HETA 87-250

OSHA Permissible Exposure Limits		500 ppm (TWA) l,000 ppm (Ceiling) 2,000 ppm (5-min Peak)
ACGIH Threshold Limit Values	Currently Currently l986 Proposed Change	l00 ppm (TWA) 500 ppm (STEL) CA/50 ppm (TWA)
NIOSH Recommended Exposure Limit	l976 proposal l976 proposal l986 proposal	75 ppm (TWA) 500 ppm (Ceiling) CA/LFL

ppm parts per million: parts of vapor per million parts of air (by volume)

TWA time-weighted average: average value over an 8-hour shift

STEL short-term exposure limit: highest allowable concentration for a l5-min. exposure

LFL lowest feasible limit: the lowest exposure that can feasibly be achieved.

CA carcinogen: substance suspected of carcinogenic potential

TABLE 4

Guidelines for the Recirculation of Air from Industrial Processes[a]
GTE Products Corporation
Williamsport, Pennsylvania
HETA 87-250

The following factors should be considered in determining the feasiblility of recirculation while maintaining adequate worker protection.

A. The chemical, physical and toxicological characteristics of the chemical agents in the airstream to be recirculated must be identified and evaluated. Exhaust air containing chemical agents whose toxicity is unknown, or for which there is no established safe exposure level, should not be recirculated.

B. All local, state and federal regulations regarding recirculation must be reviewed to determine if it is restricted or prohibited for the recirculation system under review.

C. The effect of a recirculation system malfunction must be considered. Recirculation should not be attempted if a malfunctiion could result in exposure levels that would cause serious workder health problems. Substances which can cause permanent damage or significant physiological harm from a short over-exposure shall not be recirculated.

D. The availability of a suitable air cleaner must be determined. An air cleaning device capable of providing an effluent airstream contaminant concentration sufficiently low to achieve acceptable workplace concentraions must be available.

E. Recirculation systems must incorporate a monitoring system that provides an accurate warning or signal and is capable of initiating corrective action or process shutdown before harmful concentrations of the recirculated chemical agents build up in the workplace. Examples include area monitoring for nuisance-type substances and secondary high-efficiency filter pressure drop and on-line monitors for more hazardous materials.

a This decision logic approach was obtained from page 7-17 of the 19th edition of the Industrial Ventilation Manual of Recommended Practice, published by the American Conference of Governmental Industrial Hygienists, Committee on Industrial Ventilation, Lansing, Michigan, 1986.