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SUMMARY

A management request was received from the Corporate Medical Consultant to Thomson Consumer Electronics in Marion, Indiana, for a Health Hazard Evaluation (HHE) of an illness outbreak among workers of the facility. The consultant reported an increasing number of symptomatic workers reporting to the company dispensary from various departments located throughout the plant. Approximately 1900 workers were employed at Thomson in the production of television picture tubes at the time of the investigation.

Industrial hygiene sampling was conducted by researchers from the National Institute for Occupational Safety and Health (NIOSH) during April 9-12, 1990, at three locations of the Thomson facility: (1) Q-set/Mask Forming, (2) Frit Seal, and (3) Cathodes and Heaters; NIOSH researchers concentrated their activities primarily in Q-set/Mask Forming Department. A variety of industrial hygiene methods were used to collect both personal breathing zone and area air samples. These methods included the use of charcoal tubes and personal sampling pumps to collect airborne organic vapors, short-term detector tubes to estimate air concentrations of trichloroethylene (TCE), and a Miran gas analyzer and a photoionization air analyzer in combination with radio telemetry to provide instantaneous TCE concentrations. In addition, air samples from two separate locations of the in-house compressed air system and bulk liquid samples (a TCE bulk and a TCE bulk containing butylene oxide stabilizer) were collected to determine if contamination existed which might contribute to the workers' reported illnesses.

A questionnaire was distributed to each worker present during the first shift on April 11, 1990, to determine the extent and severity of symptoms among the work force. Workers provided demographic and job information, whether or not they were experiencing any of 16 symptoms (based on those symptoms most often reported on the clinic log), and when these symptoms first began. Workers who reported to the clinic at Thomson with complaints of chest tightness during the week of the survey were asked to perform pulmonary function tests.

Charcoal tube sampling indicated the presence of acetone, n-amyl acetate, n-butyl acetate, isoamyl acetate, toluene, 1,1,1-trichloroethane, and TCE. Personal breathing zone and area air samples collected for TCE in the vicinity of the degreasers located in the Q-set/Mask Forming Department were at concentrations similar to those reported to be associated with the development of acute symptoms, but were less than established exposure limits for TCE. All of the remaining concentrations for the other chemicals of interest were much lower than their established exposure limits.

No contaminants were detected in the bag samples of air collected from the in-house compressed air system. The primary component of a TCE bulk sample was TCE. Small amounts of carbon tetrachloride and perchloroethylene were also present. TCE was also the primary component of the bulk liquid with stabilizer. The stabilizer expected to be present (butylene oxide) was also identified. Minor components were ethyl acetate, 1,1,2-trichloroethane, and C_8H_{16} aliphatic hydrocarbons.

Seven hundred and twenty-one workers completed and returned their questionnaires. Six hundred and sixty-seven of these respondents were first-shift employees resulting in a first-shift participation rate of 78%. One or more symptoms were reported by 593 workers (82%). The most commonly reported symptoms were: headache (67%), sore throat (53%), fatigue (51%),

eye irritation (50%), itchy skin (47%), irritated nose (45%), dizziness (45%), unusual taste in mouth (45%), unusual smell (41%), and cough (41%). On average, symptomatic employees reported seven symptoms each (range: 1-23 symptoms). One-hundred and twenty-eight persons reported having no symptoms (18%).

Symptomatic employees were categorized into one of three groups. No association could be established between inclusion in a symptom group and job title, work station location, years of employment, or years worked in present position. Floor plan diagrams suggested that symptoms were widely dispersed throughout the plant with no discernable pattern or common factor such as ventilation/air flow, chemical waste disposal canals, sanitary sewerage, or traffic patterns. Departments with a high prevalences of symptoms were located directly adjacent to other departments with low symptom prevalences.

Twenty workers complained of chest tightness during the site visit, and they were all asked to perform pulmonary function tests. Nineteen of the twenty workers tested had normal pulmonary function tests.

Industrial hygiene sampling conducted in three departments of the Thomson Consumer Electronics facility did not reveal exposure concentrations of any chemical or set of chemicals that would be expected to produce the widespread effects observed at Thomson Consumer Electronics. Symptomatic workers were widely dispersed throughout the facility. Exposures to trichloroethylene (TCE) near the degreasers in the Q-set/Mask Forming Department, while not exceeding established exposure limits, may have been associated with the development of acute symptoms by some workers. For this reason, and because TCE is considered by the National Institute for Occupational Safety and Health to be a potential occupational carcinogen, a recommendation was made that the TCE degreasing units be replaced with equipment that uses a less toxic degreasing agent. Because of the large work force and extensive number of operations at Thomson, a second recommendation was made that a full-time industrial hygienist (preferably a Certified Industrial Hygienist) be hired to conduct evaluations of worker exposures and work conditions, and to recommend and implement health and safety improvements. Symptoms were suggestive of those observed elsewhere as being secondary to anxiety, and the vast majority of health problems experienced by employees were in no way inconsistent with stress-related health complaints seen in other occupational settings.

Keywords: SIC 3673 (Manufacturing of Electron Tubes), CAS number 79-01-6, trichloroethylene, work-related stress.

INTRODUCTION

On March 8, 1990, a request for a Health Hazard Evaluation (HHE) was received from the International Brotherhood of Electrical Workers Local 1160 to evaluate the Q-set/Mask Forming Department of Thomson Consumer Electronics in Marion, Indiana, where workers had experienced transitory symptoms including headache, skin rash, sore throat, burning eyes and nose, fatigue, and dizziness. During the site visit in March 1990, four degreasing machines using trichloroethylene (TCE) were observed in the Q-set/Mask Forming Department and the odor of TCE was detected. Because the symptoms reported by workers in the Q-set/Mask Forming Department were similar to the symptoms generally associated with exposure to TCE vapor, recommendations were provided to control escaping TCE from the degreasers through improved local exhaust ventilation, and to reduce the likelihood of reentrainment of exhausted vapors to work areas by removing weather caps and increasing the heights of exhaust stacks. A recommendation was also made that an industrial hygiene sampling survey be conducted after implementation of corrective measures to ensure that exposures to TCE had been reduced to the lowest feasible limit. The closeout letter for the HHE was dated March 28, 1990.[1]

On April 6, 1990, a telephone call was received by the National Institute for Occupatonal Safety and Health (NIOSH) from the Corporate Medical Consultant to Thomson Consumer Electronics who reported that an increasing number of symptomatic workers were reporting to the dispensary, not only from the Q-set/Mask Forming Department, but also from other departments located throughout the plant. The consultant requested assistance from NIOSH on behalf of Thomson Consumer Electronics in determining the cause of the widespread illnesses. Site visits were conducted by NIOSH researchers April 9-12, and April 16-18, 1990.

BACKGROUND

Approximately 1900 workers are employed in the production of television picture tubes at the Thomson Consumer Electronics facility. At the time of this investigation, production occurred over three shifts, six days per week. The complex covers 62.5 acres (23 acres under roof) and encompasses an area of almost one million square feet. Approximately 8500 picture tubes are manufactured each work day with the majority shipped to the Thomson facility in Bloomington, Indiana for installation in televisions.

METHODS

Industrial Hygiene

Industrial hygiene sampling was conducted by NIOSH researchers April 9-12, 1990, at three locations of the Thomson facility: (1) Q-set/Mask Forming, (2) Frit Seal, and (3) Cathodes and Heaters. NIOSH researchers concentrated their activities primarily in Q-set/Mask Forming with the expectation that if a likely cause or set of circumstances for workers' illnesses could be identified in this area, then a similar cause or set of circumstances might also be common to the other areas of the facility where workers had also experienced adverse health effects.

A variety of industrial hygiene methods were used to collect both personal breathing zone and area air samples. Sampling for organic vapors was conducted using a sampling train consisting of a 100-milligram (mg)/50-mg charcoal tube (SKC Lot 120) connected by flexible tubing to a sampling pump operated at a flow rate of 200 cubic centimeters per minute. Three charcoal tube samples, representing each of the three locations of the Thomson facility where sampling was conducted, were analyzed qualitatively by gas chromatography/mass spectrometry (GC/MS). Each qualitative charcoal tube sample was desorbed for 30 minutes with 1 milliliter (ml) of carbon disulfide and screened by a gas chromatograph with a flame ionization detector (GC/FID) using a 30-meter DB-1 fused silica capillary column in the splitless mode. Each sample was analyzed by GC/MS to identify detected peaks.

Eleven charcoal tubes and three field blanks were analyzed quantitatively based upon the results of the qualitative analyses. Because of the varying chemical structures of the components to be evaluated, a general combination and modification of NIOSH analytical methods 1003,[2] 1300,[3] 1400,[4] 1450,[5] 1500,[6] and 1501[7] were employed for the analyses. The front and back sections of the sample tubes and the front sections of the corresponding field blank samples were desorbed separately for 30 minutes in 1 ml of carbon disulfide. Each section was then analyzed for the components of interest by GC/FID, using a HP 5890 Series II gas chromatograph equipped with a 30-meter DB-1 fused silica capillary column in the splitless mode.

Dräger colorimetric detector tubes were also used to collect short-term air samples to estimate the concentrations of TCE escaping from the four degreasers located in the Q-set/Mask Forming area. In addition, a Miran gas analyzer (model 1B) was operated continuously to provide instantaneous estimates of TCE exposures for workers located near the degreasers. The Miran was used to provide information concerning any extreme peak concentrations of TCE that would not be available from charcoal tube sampling results. A photoionization air analyzer in combination with radio telemetry was also used to provide instantaneous estimates of TCE concentrations in the same area.[8]

Two samples of air were collected in Teflon® bags at two separate locations of the in-house compressed air system to determine if contamination existed that might contribute to the workers' illnesses. Upon delivery of the bag samples to the NIOSH laboratory in Cincinnati, Ohio, a 20 microliter (µl) aliquot from each bag was injected for analysis directly by GC/MS in the split mode.

Two bulk liquid samples (a TCE bulk and a TCE bulk containing butylene oxide stabilizer) were collected to determine if contamination existed. Soon after being received in the NIOSH laboratory, a 0.1 µl aliquot of each bulk liquid was injected for analysis directly by GC/MS in the split mode.

Finally, a NIOSH industrial ventilation engineer conducted a detailed evaluation of the four TCE degreasers and blackening ovens in the Q-set/Mask Forming area, and made visual evaluations of the ventilation systems in other areas of the plant where workers had experienced adverse health effects.

Medical

Prior to the NIOSH site visit, a detailed record was maintained at the plant Medical Department of each visit that an employee made to the clinic, which included a narrative statement describing the reason for the visit. This log noted the symptoms reported by the workers and indicated the department where each one worked. However, this record system did not provide a representative sampling of the entire work force. Therefore, a questionnaire was distributed to each worker present during the first shift on April 11, 1990, to determine the extent and severity of symptoms among the work force. Workers provided demographic and job information, whether or not they were experiencing any of 16 symptoms (based on those symptoms most often reported on the clinic log), and when these symptoms first began.

Workers who reported to the clinic with complaints of chest tightness during the week of April 9, 1991, were asked to perform pulmonary function tests. Pulmonary function tests were conducted by NIOSH investigators using Ohio Medical model 822 dry rolling seal spirometers, equipped with a Codonics graphics terminal 1550 and a HF4 microprocessor. Pulmonary function test procedures conformed with the American Thoracic Society's criteria for screening spirometry.[9] One-second forced expiratory volume (FEV_1) and forced vital capacity (FVC) were measured, and the ratio FEV_1/FVC was calculated for each participant. Each individual's observed pulmonary function values were compared with predicted values (derived from Knudson's equation[10]) to determine if observed values were within the normal range for age, height, sex, and ethnic background. In clinical situations, the lower limits of normal have typically been taken as an FEV_1/FVC of 70% (<70% suggests possible obstructive lung disease) and/or 80% of the predicted value for FVC (<80% suggests possible restrictive lung disease).[11]

EVALUATION CRITERIA

General Guidelines

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH investigators employ environmental evaluation criteria for assessment 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/day, 40 hours/week for a working lifetime without experiencing adverse health effects. It is important to note; however, not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the levels established by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus the overall exposure may be increased above measured airborne concentrations. Evaluation criteria typically change over time as new information on the toxic effects of an agent become available.

The primary sources of evaluation criteria for the workplace are: NIOSH Criteria Documents and Recommended Exposure Limits (RELs),[12] the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs),[13] and the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[14] These values are usually based on a time-weighted average (TWA) exposure, which refers to the average airborne concentration of a substance over an entire 8- to 10-hour workday. Concentrations are usually expressed in parts per million (ppm), milligrams per cubic meter (mg/m^3), or micrograms per cubic meter ($\mu g/m^3$). In addition, some substances have a short-term exposure limit (STEL) or ceiling limit, which is intended to supplement the TWA limit where there are recognized toxic effects from short-term exposures.

For specific substances NIOSH recommendations or the ACGIH TLVs may be lower than the corresponding OSHA standards, as they are based primarily on the prevention of occupational disease. In contrast, OSHA PELs and other standards are required to take into account the economic feasibility of reducing exposures in affected industries, public notice and comment, and judicial review. In evaluating worker exposure levels and NIOSH recommendations for reducing exposures, it should be noted that employers are legally required to meet the requirements of OSHA standards.

Acetone

Acetone (CAS number 67-64-1), a widely used industrial solvent and chemical intermediate, is a colorless, highly volatile, flammable liquid with an aromatic odor. The fast evaporation rate of acetone makes it useful for cleaning and drying precision parts. Inhalation of acetone vapors in high concentrations produces dryness of the mouth and throat, dizziness, nausea, uncoordinated movements, loss of coordinated speech, drowsiness, and in extreme cases coma. Inhalation of low concentrations over long periods causes irritation of the respiratory tract, coughing and headache.(15) In addition exposures to concentrations of acetone below 1,000 parts per million (ppm) have been associated with eye, nose, and throat irritation.(16) The odor threshold of acetone has been reported to be 13 ppm.(17)

The Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) and the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) for acetone are 750 ppm as an 8-hour (8-hr) time-weighted average (TWA) concentration, and the OSHA and the ACGIH Short Term Exposure Limits (STEL) are 1000 ppm for any 15-minute sampling period.(13, 14) NIOSH has established a Recommended Exposure Limit (REL) for acetone of 250 ppm as a TWA concentration.(12)

n-Amyl Acetate, n-Butyl Acetate, and isoamyl Acetate

n-Amyl acetate (CAS number 628-63-7), n-butyl acetate (CAS number 123-86-4), and isoamyl acetate (123-92-2) are colorless liquids with fruity odors. Overexposure to these chemicals causes irritation of the eyes, nose, and throat, as well as headache, weakness, drowsiness, and unconsciousness. These substances are defatting agents, and prolonged overexposure causes irritation of the skin. No chronic systemic effects have been reported in humans for these chemicals.(18) The odor thresholds of these chemicals have been reported to be 0.05 ppm for n-amyl acetate, 0.4 ppm for n-butyl acetate, and 0.02 ppm for isoamyl acetate.(17)

The OSHA PELs and the ACGIH TLVs for n-amyl acetate and isoamyl acetate are 100 ppm as an 8-hr TWA concentration. The OSHA PEL and the ACGIH TLV for n-butyl acetate are 150 ppm as an 8-hr TWA concentration; the OSHA and the ACGIH STELs are 200 ppm for any 15-minute sampling period.(13, 14)

Toluene

Toluene (CAS number 108-88-3) is a flammable, colorless liquid with a typical aromatic hydrocarbon odor. It is present in gasoline and many petroleum solvents. Toluene can cause irritation of the eyes, respiratory tract, and skin. It can also cause fatigue, weakness, confusion, headache, dizziness, drowsiness, numbness and peripheral sensory effects such as dysesthesia (a "pins and needles feeling"). Repeated or prolonged exposure to liquid toluene can cause drying and cracking of the skin.(18) The odor threshold of toluene has been reported to be 3 ppm.(17)

The OSHA PEL and the ACGIH TLV for toluene are 100 ppm as an 8-hr TWA; the OSHA and the ACGIH STELs are 150 for any 15-minute sampling period.[13, 14] NIOSH has established a REL for toluene of 100 ppm as a TWA concentration, with a 10-minute ceiling concentration of 200 ppm.[12]

1,1,1-Trichloroethane

1,1,1-Trichloroethane (methyl chloroform) (CAS number 71-55-6) is a colorless, nonflammable liquid with a mild chloroform-like odor. The major usage of this chemical is as a cleaning solvent. Exposure to 1,1,1-trichloroethane vapor can cause headache, dizziness, drowsiness, unconsciousness, and irregular heart beat. Prolonged or repeated skin contact with liquid 1,1,1-trichloroethane can cause irritation of the skin.[18] It has been reported that anesthetic effects may begin to occur at concentrations approaching 500 ppm. Deaths from central nervous system depression and/or cardiac sensitization have been noted in employees working in confined areas.[16] Reproductive abnormalities have been noted in studies of animals exposed to high concentrations of 1,1,1-trichloroethane.[18] The odor threshold of 1,1,1-trichloroethane has been reported to be 120 ppm.[17]

The OSHA PEL and the ACGIH TLV for 1,1,1-trichloroethane are 350 ppm as an 8-hr TWA; the OSHA and the ACGIH STELs are 450 for any 15-minute sampling period.[13, 14] NIOSH has established a REL for 1,1,1-trichloroethane of 200 ppm, with a 15-minute ceiling concentration of 350 ppm.[12]

Trichloroethylene

Trichloroethylene (TCE) (CAS number 79-01-6) is a colorless, nonflammable, noncorrosive liquid with the sweet odor characteristic of some chlorinated hydrocarbons. It used for vapor degreasing and as a solvent. Exposure to TCE can cause drowsiness, dizziness, headache, blurred vision, incoordination, mental confusion, flushed skin, tremors, nausea, vomiting, fatigue, and cardiac arrhythmia. Irritation of the skin, mucous membranes, and eyes can also occur.[19] The effects of TCE appear to be enhanced in some individuals by simultaneous exposure to caffeine, alcohol, and other drugs. "Degreasers flush," a reddening of the skin, has been observed in some persons who ingest alcohol after exposure to TCE.[15]

The OSHA PEL and the ACGIH TLV for TCE are 50 ppm as an 8-hr TWA; the OSHA and the ACGIH STELs are 200 for any 15-minute sampling period.[13, 14] The OSHA PELs for TCE were established to reduce the significant risk of adverse central nervous system effects that are associated with exposure to TCE at the former OSHA limits. OSHA found that it was premature to establish a PEL for TCE based on evidence of its carcinogenicity, because (in their judgement) there are uncertainties associated with the evidence.[16]

The ACGIH TLVs for TCE are to control subjective complaints such as headaches, fatigue and irritability, and to protect against incoordination and other beginning anesthetic effects from TCE. The ACGIH documentation for TCE contains a reference to a study which reported that workers exposed to concentrations averaging 10 ppm (12% of the tests showed values about 40 ppm) complained of headache, dizziness, and sleepiness.[20] The odor threshold of TCE has been reported to be 21.4 ppm[21] and 28 ppm.[17] Therefore, the sense of smell would be a poor indicator of exposure at this level. The ACGIH documentation also contains the statement that there is no evidence in three epidemiological studies completed to date to suggest that TCE has increased cancer in man.[22-24]

NIOSH recommends that TCE be controlled and handled as a potential human carcinogen in the workplace, and that exposure be minimized to the lowest feasible limit.[19] NIOSH concluded that the results of a study by the National Cancer Institute, which reported an increase in liver tumors in mice, but not rats, indicated TCE to be a potential human carcinogen, although NIOSH noted that TCE was not considered to be a potent carcinogen.[16] The NIOSH REL is based partly upon past health hazard evaluations involving workers who experienced symptoms of dizziness, fatigue, nausea, headache, sensory irritation, and difficulty breathing. The REL is also based upon NIOSH reports showing that degreasing operations, including those using open-top tanks, are able to achieve 25 ppm uniformly by the use of engineering controls.[16]

Exposure limits for the seven chemicals described above are summarized in Table I.

RESULTS

Industrial Hygiene

A total of seventeen charcoal tube samples and three field blanks were collected with the majority of samples collected in the Q-set/Mask Forming area. Information concerning sample type (personal breathing zone, area, or field blank), sampling location, and duration for each charcoal tube are presented in Table II. Three charcoal tube samples (03, 12, and 13) were analyzed qualitatively. Acetone was the major peak of qualitative charcoal tube sample 03, a personal breathing zone sample collected during unloading at degreaser #4 in the Q-set/Mask Forming area. Minor peaks included methanol, ethanol, 1,1,1-trichloroethane, TCE, toluene, n-butyl acetate, isoamyl acetate, and n-amyl acetate. Ethanol was identified as the major peak of charcoal tube sample 12. (The source of ethanol did not originate within the work environment.) Minor peaks were identified as Methanol, acetone, isopropanol, chloroform, 1,1,1-trichloroethane, TCE, toluene, isoamyl acetate, and n-amyl acetate were identified on charcoal tube sample 12, a personal breathing zone sample collected during frit seal loading. TCE was identified as the major peak of charcoal tube sample 13, an area sample collected in the coating room of the Cathodes and Heaters area. Minor peaks identified were acetone, isopropanol, 1,1,1-trichloroethane, toluene, n-undecane, n-dodecane, and ethanol.

Results of the eleven charcoal tubes analyzed quantitatively are presented in Table II for the following chemicals: acetone, n-amyl acetate (AAc), n-butyl acetate (BuAc), isoamyl acetate (IAAc), toluene, 1,1,1-trichloroethane (1,1,1-TCE), and trichloroethylene (TCE). The sampling results presented in Table II consist generally of concentrations which are much lower than the applicable exposure limits for the chemicals summarized in Table I. Exceptions deserving comment are the TCE concentrations for samples 05, 06, 07, and 09. Samples 05 (46 ppm) and 06 (50 ppm) were collected side-by-side directly above the open area between degreaser #4 and its blackening oven, and therefore they do not represent concentrations to which a worker would be exposed for an extended period of time. However, the sample values do serve to identify a location where TCE is released to the general work environment. Samples 07 (9 ppm) and 09 (11 ppm) were personal breathing zone samples worn by workers at Master Frame #28 and Spring Clip Welding, respectively. Since symptoms have been reported among workers who were exposed to similar concentrations of TCE,[20] these two workers and the others in their immediate work area might also experience symptoms related to their exposure.

The TCE concentrations measured using short-term detector tubes at various locations around the degreasers in the Q-set/Mask Forming area ranged from 2 to 20 ppm. TCE concentrations ranging from 1 to 16 ppm were measured using the Miran gas analyzer, which operated continuously. No excursions above this range of concentrations were observed during the entire testing period. Similar levels were measured by the photoionization air analyzer. The use of this device in combination with radio telemetry demonstrated that higher concentrations of TCE occurred under the "fresh" air showers (located at the worker positions at both ends of degreaser #4) than outside the air showers.

No contaminants were detected in the bag samples of air collected from the in-house compressed air system. The primary component of the TCE bulk sample was TCE. Minor constituents included carbon tetrachloride and perchloroethylene. TCE was also the primary component of the bulk liquid with stabilizer. The stabilizer expected to be present (butylene oxide) was also identified. Minor components were ethyl acetate, 1,1,2-trichloroethane, and C_8H_{16} aliphatic hydrocarbons.

The NIOSH evaluation of the local exhaust ventilation systems resulted in the conclusion that while improvements could be made to the ventilation systems in the Q-set/Mask Forming Department, that the systems were somewhat effective in controlling exposures. Problems with the ventilation system were judged to not be associated with the widespread occurrence of ill workers throughout the Thomson facility. The complete report of the ventilation engineer is attached as Appendix A (see pages 18-20).

Medical

Seven hundred and twenty-one workers completed and returned questionnaires distributed during the first work shift on April 11, 1990. Six hundred and sixty-seven of these respondents were first-shift employees, resulting in a first-shift participation rate of 78%. Respondents had a mean age of 42 years (range: 20 years - 63 years), had worked at this plant for a mean of 19 years, and had worked at their present job for a mean of 7 years.

One or more symptoms were reported by 593 workers (82%). The most commonly reported symptoms were: headache (67%), sore throat (53%), fatigue (51%), eye irritation (50%), itchy skin (47%), irritated nose (45%), dizziness (45%), unusual taste in mouth (45%), unusual smell (41%), and cough (41%). On average, symptomatic employees reported seven symptoms each (range: 1-23 symptoms). One-hundred and twenty-eight persons reported having no symptoms (18%).

Symptomatic employees were categorized into one of three symptom groups:
(1) Solvent Symptom Group (SSG), which included symptoms compatible with solvent exposure (nausea, dizziness, fatigue, unusual taste in mouth, rash, chills, and tingling lips or tongue); (2) Irritant Symptom Group (ISG), which consisted of irritant-related symptoms (sore or itchy nose, sore throat, unusual taste in mouth, itchy skin, or rash); and (3) Objective Sign Symptom Group (OSSG), which included physical signs that can be observed or measured, such as a rash or hives. To be included in one of the symptom groups, a worker had to report experiencing two or more of the symptoms listed in the Solvent Symptom Group or Irritant Symptom Group, or one or more symptoms listed in the Objective Sign Symptom Group.

Three-hundred and eighty workers (57%) were included in the Solvent Symptom Group, 373 workers (56%) were included in the Irritant Symptom Group, and 276 workers (41%) were included in the Objective Sign Symptom Group. Job titles and work station locations, years of employment, and years worked in present position were examined statistically to evaluate if any of these factors were associated with a symptom group. No association was established between inclusion in a symptom group and job title, work station location, years of employment, or years worked in present position.

Prevalences of symptoms groups were transferred graphically to a floor plan of the plant to investigate if patterns or common elements could be observed between departments and specific symptom groups. Floor plan diagrams suggested that symptoms were widely dispersed throughout the plant with no discernable pattern or common factor such as ventilation/air flow, chemical waste disposal canals, sanitary sewerage, or traffic patterns. Departments with high prevalences of symptoms were located directly adjacent to other departments with low symptom prevalences.

Twenty workers complained of chest tightness during our site visit, and they were all asked to perform pulmonary function tests. Nineteen of the twenty workers tested had normal pulmonary function tests. A mild obstructive lung function pattern was found with only one of the twenty workers tested. This worker had a mild restrictive lung function pattern as well.

DISCUSSION AND RECOMMENDATIONS

A meeting was held at Thomson on April 12, 1990, to discuss preliminary recommendations. The nineteen individuals attending the meeting included six NIOSH researchers, nine representatives of Thomson Consumer Electronics, and four representatives of the International Brotherhood of Electrical Workers Local 1160. Two recommendations were made by the NIOSH researchers based upon the results of industrial hygiene sampling with direct reading instruments and upon observation of work practices. The first recommendation was that the TCE degreasing units in the Q-set/Mask Forming Department be replaced with equipment that uses a less toxic degreasing agent.

Because of the large work force and extensive number of operations at Thomson, the second recommendation was that a full-time industrial hygienist (preferably a Certified Industrial Hygienist) be hired to conduct evaluations of worker exposures and work conditions, and to recommend and implement health and safety improvements.

Four NIOSH researchers visited the Thomson facility on May 16-17, 1990, and conducted eight informational meetings that were attended by a total of approximately 315 employees from the three work shifts. Workers attending were from areas of the plant designated Heaters/Cathodes, White Room, Rooms #2, #3, and #9, Frit Seal, PMI, and Q-set/Mask Forming. Each worker who attended these meetings received a one-page Fact Sheet which outlined the questionnaire results and a one-page summary of NIOSH industrial hygiene activities.

The summary of NIOSH industrial hygiene activities contained the statement that the sampling had resulted in the reporting of low levels of a few chemicals that were already known to exist in the particular area being sampled, and there were no unexpected exposures. The concluding statement of the summary was that while exposures experienced by employees of Thomson Consumer Electronics were not the sole cause of health problems, low level concentrations of chemicals might have acted in combination with other work-related factors to produce the observed effects.

The most important contributor to the "other work-related factors" was described in a report by a medical consultant to the company; the complete report is attached as Appendix B (see pages 21-28). The consultant concluded that symptoms reported by affected workers were compatible with those secondary to anxiety, and that the vast majority of the health problems experienced by employees at Thomson were in no way inconsistent with stress-related health complaints which have frequently been seen in other occupational settings, including electronics plants.[25, 26] The consultant based his judgement upon his observation that all of the symptoms seen were relatively minor in nature, transient, and not inconsistent with symptoms seen in typical anxiety states.

The consultant stated in his report that the major stressors at the time of his investigation were associated with working in a factory in which numerous people had become ill due to unknown causes, dealing with the uncertainty of the situation, dealing with conflicting opinions of consultants and changing opinions regarding the source of the problem, hearing of people becoming ill on a daily basis, reading newspaper accounts and listening to TV and radio accounts, and knowing that the incident had received national attention, including the involvement of a U.S. Congressman. It was stated further that given these profound stressors, it was quite natural, normal, and understandable for workers to respond with much anticipatory anxiety before entering the workplace, and to experience mounting anxiety as employees around them reported health complaints.[20] Ten recommendations are provided in the consultant's report for addressing the psychosocial aspects of this event.

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APPENDIX A: VENTILATION ENGINEER'S REPORT

Results of Ventilation Survey at Thomson Consumer Electronics

Thomson Consumer Electronics employs approximately 1900 workers in the production of television picture tubes. Production rate is approximately 8500 picture tubes per day. Workers in the mask forming area were complaining of headaches, burning eyes and noses, and dizziness.

Upon arrival at the plant it was learned that the worker complaints had increased in number and had spread to other areas of the plant. A detailed evaluation of the four TCE degreasers and blackening ovens in the mask forming area was made. In addition, a visual evaluation was made of the ventilation in other affected plant areas.

The mask forming area contains three annealing ovens. Mask blanks are annealed in a hydrogen and nitrogen atmosphere at approximately 1500 degrees to facilitate forming. There is no ventilation on the ovens. The hydrogen and nitrogen exit the oven at each end and are removed by the room general ventilation.

There are three trichloroethylene vapor degreasers in the area (No. 1, 2, and 3) and one in an adjoining room (No. 4). Annealed mask blanks, formed in a press near the degreaser, and frames are carried on a continuous chain belt through the degreasers and blackening ovens. The degreasers are covered and ventilated at both ends by a slot hood on both the top and bottom of an approximately 1 x 5 foot opening. In some cases the degreaser covers and hood slots are bent. The ducts are located at the end of the upper slot plenum. The lower slot is connected to the upper at the opposite end forming a "U" shape. The entry hoods are located at the degreaser entrance. There is a short tunnel between the degreaser and the discharge hoods. In some cases there is a gap between the hood plenum and the degreaser. This configuration is common for all hoods except the degreaser #4 discharge which was a slot located in the bottom of the discharge tunnel, approximately 2 feet from the tunnel exit. An air curtain from a compressed air jet was also located at the tunnel exit. Measurements indicated an air flow range of 150 to 220 cubic feet per minute (cfm) for degreasers 1, 2, and 3, and 400 cfm for degreaser 4.

The blackening ovens used an electrically heated mixture of carbon monoxide and carbon dioxide. They were ventilated with hoods located in the same manner as the degreasers, at the inlet and at the discharge of a short tunnel. The hoods for ovens 1, 3, and 4 essentially formed a canopy type hood with a 1 x 5 foot opening. A 2-inch slot was used for oven #2. In all cases the hoods were located next to the upper edge of the tunnel. Measurements showed an air flow range of 600 to 700 cfm.

A 34-inch circular air shower is located at each end of the #4 degreaser-blackening oven. The air is supplied by a 12-inch duct from the room air supply. There was not any baffling of any sort resulting in a "jet" of high velocity air directly on the worker. Air velocities of 400-500 feet per minute (fpm) were measured with the adjustment damper nearly closed.

General room ventilation for the mask forming area is supplied by four roof mounted air handling units (AHU) providing 100% outside air. The AHU intakes have recently been raised to eliminate reentrainment from roof level room discharge air. The discharge stacks from the degreaser TCE recovery units and the blackening ovens were raised, but are at the same height as the AHU inlets. The AHU's were inspected and found to be dry and clean. The room air is discharged at roof level.

In addition to the mask forming area, a visual inspection of the plant roof was made to determine if reentrainment could be a cause of the problem. There was no indication of any major problems, although there were a number of roof level discharge stacks.

CONCLUSIONS AND RECOMMENDATIONS

In general the ventilation system appeared to be well maintained and operating properly. While some changes should be made, it is not believed that the ventilation system was a primary cause of the reported problems. The plant areas where problems were reported were not served by a common ventilation system and reentrainment of exhaust air, while possible, did not seem to be a cause. In addition, these areas did not all use common chemical agents, although the problems reported were common to all areas. If sampling results should indicate a possible reentrainment problem, a more specific investigation of the system might be warranted.

The following recommendations contain descriptions of changes which will result in an increase in the overall ventilation system efficiency.

The blackening oven ventilation rate is approximately 120 cfm per square foot of hood face which is somewhat less than published criteria (200 cfm per square foot; Industrial Ventilation Manual, VS 602). Although there was not any indication of problems at the existing flow rate, increasing the flow rate to 200 cfm per square foot (approximately 1000 cfm per hood) should be considered.

The degreaser air flow seems low in view of the increased escape of TCE. The hood slots should be straightened and the air flow increased to 300 cfm per hood. Hood air flow distribution would be improved if the duct connection were moved to the connecting plenum between the upper and lower slot. It is, however, necessary to determine the effect of increased air flow and increased TCE levels on the TCE recovery units. In addition, the degreaser covers should be straightened to achieve a close fit. If the TCE recovery units could handle the additional load, 100 to 200 cfm from a duct attached to the center of the cover would create a slight negative pressure in the degreaser and would help in eliminating TCE escape.

The air showers at degreaser-blackening oven #4 blow a narrow jet of high velocity air on the worker. To be effective, an air shower should cover as wide an area as possible and not have a high air velocity. The existing air shower should be modified by adding a perforated plate (approximately 40-50% open area) over the exit. In addition, a flat baffle approximately 14 inches in diameter should be located inside the shower enclosure and approximately 4 to 5 inches below the supply opening to assure good even air distribution from the shower.

The mask forming area AHU inlets and the degreaser and blackening oven discharge stacks have been recently extended. However, they are at the same height. It is also noted that the mask forming area room exhausts, as well as other area exhausts, are at roof level, some very near AHU intakes. Normal configuration is to keep air intakes close to the roof and extend exhaust stacks above the roof top recirculation region. It is recommended that the mask forming AHU inlets be lowered and the discharge stacks be further extended if required to preclude reentrainment of stack discharge. Other exhausts should also be extended. The ASHRAE 1989

Fundamentals Handbook (Chapter 14) provides the necessary information for determining stack height and location.

Robert T. Hughes

APPENDIX B: MEDICAL CONSULTANT'S REPORT

Investigation of Health Complaints at Thomson Consumer Electronics, Marion, Indiana, May 9, 1990

INTRODUCTION

In response to a request from Robert Walton, M.D., Medical Director of Thomson Consumer Electronics, I visited the Marion, Indiana facility on May 9, 1990. The purpose of this site visit was to review the history of health problems which have affected many employees at the plant, to interview some affected employees in the dispensary, and to make recommendations to management with regard to amelioration of the epidemic illness.

BACKGROUND INFORMATION

Thomson Consumer Electronics in Marion, Indiana, a large facility which manufactures color television picture tubes, employs approximately 2,200 workers. The workforce is predominantly female, with many long-term employees. The community of Marion is about 40,000, and the area has been losing a considerable amount of industry over the years. The workforce is rather stable, there have been no recent layoffs, and widespread concerns regarding job security are not apparent.

While there have been sporadic health complaints among workers at the plant over the past two years, the major problem, which began in the Q-Set and Mask Assembly departments, reached crisis proportions towards the end of January or the beginning of February of this year. Approximately one year ago, there had been a problem with elevated carbon monoxide levels in this area, though this problem had been quickly corrected, and was clearly not the cause of the ongoing health complaints. Health complaints among employees have spread to a large number of departments beyond the original focal area. During the three weeks prior to my site visit, 946 different employees presented to the dispensary. Over 200 employees had made three or more visits to the dispensary during this time period, and several had made up to 17 visits, meaning that they had essentially been to the dispensary on every work day. Immediately prior to my visit, the plant had been closed for four days for a cleanup of sewer lines, drains, trenches, and other general "housekeeping" activities.

Although detailed analysis of dispensary records was not available, it was the impression of the medical staff that the symptoms had initially been of a mild irritative nature, along with some rashes, which apparently were currently less of a problem. More recent problems have been headache, sore throat, hoarseness, and frequent complaints of weakness, lack of energy, difficulty concentrating, shakiness, multiple near syncopal episodes and a few actual episodes of syncope.

Prior to my site visit, numerous consultants, both private and governmental, had investigated the situation. In brief, industrial hygiene evaluations, while uncovering some problems with the handling of Trichlorethylene and minor ventilation problems, had not elicited any potential exposures which could explain the widespread nature of the illness. A dermatological consultant did observe come "flushing" reactions and non-specific rashes, whose etiology was unclear. A pulmonologist similarly noted a variety of non-specific symptoms, but pulmonary function test results were essentially normal. NIOSH consultants, who performed an industrial hygiene and a questionnaire survey (721 completed questionnaires), concluded that no chemical or microbiological exposures could explain employees' symptoms. During my visit, I was also informed that all chest x-ray results were within normal limits (I am not certain of the number of such x-rays), and that there were no known hospitalizations secondary to employee health problems, other than hospitalizations of several employees for clearly non-work-related problems, such as a cerebral hemorrhage.

SUMMARY OF FINDINGS

Evaluation consisted of detailed discussions with the Medical Director, brief interviews of seven ill employees in the dispensary, a limited walk-through evaluation, and several discussions with management representatives and NIOSH investigators. In addition, prior to my site visit, I reviewed extensive reports of consultants, including records of a dermatologist, pulmonologist, three private industrial hygienists and NIOSH investigators.

I performed limited evaluations of seven employees in the dispensary, the majority of whom had come from the "white room", since all 24 employees of the "white room" were seen in the dispensary during the first shift on May 9. Several employees described "fumes", by which they meant that they had either experienced a chalky or metallic taste (reports were inconsistent) or "a puff, like it hit me in my face and took my breath." While symptoms were variable from employee to employee, they consisted largely of lightheadedness, occasional numbness around the lips or extremities, "rubbery" feeling of the arms and legs, shakiness, weakness, occasional pounding heart and headache. Several employees had transient, minor elevations of the pulse and slight hand tremor. One employee described a fear of breathing deeply in the "white room", expressing concern that the fumes would enter her lungs if she inhaled deeply. Another employee became ill even before entering the work station. She stated that the problem "hit me as soon as I entered the plant." She described a high level of anticipatory anxiety as she approached the plant. All of the symptoms seen were relatively minor in nature, transient, and not inconsistent with symptoms seen in typical anxiety states.

Symptoms described by employees, including headaches, fatigue, throat irritation, dizziness, odors, abnormal tastes, and irritative symptoms, are all commonly seen in indoor air quality investigations. Headache, the number one complaint according to the NIOSH investigators, is typically the most prevalent complaint seen in these evaluations. Objective physical findings have been minimal. Rashes, blood pressure elevations, and elevated pulse, when detected, have been relatively mild and transient. According to the NIOSH investigators, who evaluated "attack rates" in different departments, symptoms were reported in widespread areas, with no clear "hot spots", no potential for chemical or microbiological exposure to explain the symptoms, and no ventilation patterns which could plausibly explain the epidemiologic features of the outbreak. Thus, based on the types of symptoms seen, the epidemiologic features of the outbreak, and the lack of plausible chemical or microbiological exposures to account for these types of symptoms and the pattern of attack rates, it is unlikely that any chemical or microbiological exposure in the workplace can explain the vast majority of symptoms currently being reported among Thomson employees. Rather, symptoms reported are compatible with those secondary to anxiety, commonly seen in workplaces with "high stress levels."

In looking at the stressors in this plant, the major current stressors are the very fact of working in a factory in which numerous people have become ill due to unknown causes, dealing with the uncertainty of the situation, dealing with conflicting opinions of consultants and changing opinions regarding the source of the problem, hearing of people becoming ill on a daily basis, reading about newspaper accounts and listening to TV and radio accounts, and knowing that the incident has now received national attention, including the involvement of a U.S. Congressman. Thus, given these profound stressors, it is quite natural, normal, and understandable for workers to respond with much anticipatory anxiety before entering the workplace, and to experience mounting anxiety as employees around them report health complaints.

Despite the similarity of this outbreak to other stress-related outbreaks in both industrial and nonindustrial occupational environments, it is not possible to state from this type of evaluation whether any particular worker is suffering from a stress-related problem. While the epidemiological, medical, and industrial hygiene data suggest that the bulk of the current health problems are stress-related, in a facility employing over 2,000 workers, one would expect that some of the employees will have non-work related illnesses. In addition, due to the potential chemical exposures which do exist in any industrial facility, a small number of individuals could experience work-related illnesses due to such exposure. Thus, there is no substitute for sound clinical judgment in determining each individual's problem. I would reiterate, however, that the vast majority of the current problems experienced are in no way inconsistent with stress-related health complaints which have frequently been seen in other occupational settings, including electronics plants.

RECOMMENDATIONS

Based on my review of consultants' reports, evaluations of employees, and detailed discussions with the Medical Director and other management representatives, the following are my recommendations for dealing with the psychosocial aspects of this outbreak, which currently appear to be the main problem.

1. Unless there is further definite evidence of unsafe working conditions, with substantiated concern that employees are being exposed to toxic materials, there is no medical indication for further temporary shutdowns of the plant. This recommendation remains in effect unless consultants, in the coming weeks, document a heretofore undetected physical, chemical, or biological source of the problem. Since such is deemed highly unlikely, based on investigations to date and the medical/epidemiological features of this outbreak, it is also recommended that additional industrial hygiene and medical consultants not be retained unless there is significant change in the nature of employees' symptoms. Unnecessary ongoing investigations will serve only to heighten anxiety levels of the workforce.

2. Affected employees need to be efficiently triaged in the dispensary. Clear-cut guidelines should be provided to the nursing staff as to which individuals are to receive more detailed examinations. In general, those individuals complaining of fatigue, mild irritative symptoms, shakiness, etc. can be quickly evaluated with regard to vital signs and brief, focused medical examinations, and returned to the work station promptly. This will relieve congestion in the dispensary, which only tends to aggravate the situation, as affected individuals congregate in small quarters.

   Based on the symptom pattern to date, it would appear reasonable to focus further attention on those employees with chest symptoms because of the potential that this could represent more serious illness, though there is no evidence to date that such is the case, and anxiety can certainly lead to chest pain so severe as to mimic a myocardial infarction. For those workers with significant pulmonary symptoms, one might want to run pulmonary function tests. Should a reasonable number of these tests come back essentially normal, there would be no need for ongoing use of pulmonary function testing. However, such would provide reasonable reassurance that no significant pulmonary effects are being detected.

With regard to blood and urine sampling, there is no reason to take such samples routinely, and such monitoring should be done on an individual case by case basis, depending on clinical judgment. Finally, no individual should be transported by wheelchair unless clinically necessary, as this can fuel anxiety among employees and will tend to exaggerate the magnitude of the health complaints.

3. In areas such as the "white room", where employees complain of "lack of adequate air", it might be reassuring to employees to have some visible sign of the quality of the air, for example, oxygen, carbon dioxide, and humidity levels prominently posted on a daily basis, with an explanation of desirable ranges.

4. It would be of interest to analyze the dispensary data with regard to the employees who most frequently visit the dispensary, particularly with regard to their work location. For those individuals who have made numerous dispensary visits, almost on a daily basis, one might want to consider scheduling regular brief visits to the dispensary for a two week period for a brief examination, in order to provide reassurance to the employee. These visits could then be dispensed with after two weeks, and follow-up over the next two weeks would indicate whether this technique has been effective in reducing the level of health complaints among these employees.

5. With regard to pregnant employees, unless strikingly different information is forthcoming from consultants in the future, there is no evidence in the material which has been presented to me to indicate that the workplace, at this time, presents a health hazard to pregnant employees. Those pregnant employees currently on leave should be returned to work. However, due to the special psychological needs of pregnant women, one should accommodate such needs with extreme sensitivity. I recommend that those pregnant women who feel too anxious to return to the workplace because of ongoing concern of possible teratogenic effects be allowed to go on unpaid leave for the duration of the pregnancy. All pregnant employees also need to be counseled regarding the high rate of spontaneous abortions and birth defects in the general population.

6. Mandatory group meetings should be held to include all employees, a maximum of 100 - 125 at a time. While this may be difficult to arrange logistically, the company might want to consider doing a cost benefit evaluation to determine whether it is worthwhile to conduct such meetings, which should last about one hour, during regular work shifts.

   One purpose of these meetings is educational. The employees need to understand in a clear, non-technical manner, the efforts of the company to date and the findings and recommendations of consultants. Employees need to be educated regarding the difference between odors and toxic effects and the difference between an odor threshold and a threshold for toxicity. This meeting should also provide some guidelines on safe aspects of handling chemicals. In addition, the session should provide time to deal with rumors and misinformation which undoubtedly are widespread in the workplace, for example, the issue of exposure to trichlorethylene. Finally, the employees need to understand that in a group as large as 2,200, a significant proportion of the workforce will have relatively minor health problems on any day. In this regard, it might be valuable to obtain information from the most recent HANES survey. The average employee will be astonished at the high prevalence of symptoms such as headache, fatigue, and insomnia among the general population.

An additional valuable aspect of group meetings is to provide for ventilation of feelings of anxiety, anger, frustration, uncertainty, and helplessness. Management, which is also experiencing these feelings, can honestly empathize with workers' feelings, as both management and labor would like to find "the culprit" to account for this outbreak, preferably a chemical exposure which could be easily monitored and remedied. It is difficult to deal with the fact that such an exposure will not likely ever be found.

The group meeting can then go on to describe how stress can lead to symptoms which have been seen among plant employees. Employees should be able to agree that the workplace is now a highly tense one. Though one may never know with certainty what triggered the outbreak of illness, it is clear at this point that much of the current problem is stress-related. Early on in the discussion of stress, one must forthrightly address the concerns of employees that they are being labeled as lying, faking illness, having it "all in their heads", being hysterical, or being blamed for illness. Management must make clear its position that it considers the symptoms to be real, legitimate, and serious (that is, from the point of view of the distress which they cause the individual employee, but not from the point of view of being medically serious physical symptoms).

When describing how stress can cause these symptoms, one should pick everyday examples. Such examples might include dry mouth and shaky knees which many people get when having to speak in public, fainting at the sight of blood, and the racing heart beat that most of us experience as the state patrolman turns on the sirens to give us a speeding ticket. In addition, one needs to explain how, in these tense workplace situations, many individuals become sensitized to odors, not in the allergic sense, but in the sense of becoming more aware of the odors and more concerned that the odors are connected with health effects.

With regard to how these problems spread, they are typically transmitted by sight and sound, that is, knowledge that other people are becoming ill or actually viewing such individuals becoming ill. Some individuals may be hyperventilating, and employees need to understand that hyperventilation is a well-recognized medical problem which can lead to symptoms affecting virtually every organ of the body (if you need references in this regard, please contact me). Also employees need to understand that one does not have to breathe rapidly in order to hyperventilate. For example, many individuals who sigh or yawn frequently are actually hyperventilating.

The employees need to understand that the type of problems which they are experiencing, though quite dramatic, are not uncommon. Over 500 such investigations have been conducted by NIOSH alone, and certainly many thousands have been done by private organizations and other governmental agencies. Where no chemical or biological source of these problems is found, employees can be reassured that there is no evidence that the transitory type of symptoms which have been experienced in these types of outbreaks have had any long-term effects in terms of ongoing effects on major organ systems, carcinogenicity, or teratogenicity. While employees need to understand that much is unknown about the initiation and propagation of these outbreaks, in most cases there is a progressive return to "normal", with a lowering of the frequency of health complaints. However, a problem which has been ongoing for months will not be resolved within 24 hours, no matter what steps are taken by the company.

7. Employees need to be apprised of the company's plans to respond to future health problems. The company should make it clear that the investigation is not "closed", in the sense that symptomatic employees will continue to be seen at the dispensary as always. The company will remain on the alert for any potential exposure problems which need to be remediated via industrial hygiene activities. In a plant as large as the Marion facility, it is likely that there will be a need for ongoing industrial hygiene monitoring, as isolated problems inevitably do develop. The company should also reassure its employees that they will keep them apprised of any new developments.

8. It is my expectation that implementation of all of these recommendations will substantially resolve the problem. Looking at the plant as a whole, one would expect a considerable reduction in problems over a one month period. If such is not the case, then one might want to consider the possibility of more formal group counseling for certain subsets of the workforce. I would expect that a small fraction of employees will not respond to such activities. For those individuals who remain chronically "impaired" after the bulk of the epidemic has subsided, individual attention may need to be provided.

9. With regard to the news media, a proactive rather than a reactive approach should be taken. Regular press releases should be made available through the company spokesperson. Such releases will be the major source of information for employees, regardless of any newsletters which are published internally. However, I do recommend that a one to two page summary of the main points of the group meetings be provided to all employees after the meeting, in an attempt to minimize the inevitable distortions that will arise in any communication process.

10. Finally, while I cannot currently address this issue in detail, there is certainly some concern that the mandatory six day work week instituted one year ago may have contributed to the current widespread health complaints. Reportedly, some employees are now voluntarily working up to 80 hours a week. It would be of interest to see if there is any correlation between health complaints and the number of hours worked (though such correlation may end up turning out to be negative!). While the six day work week cannot be the sole problem at this time, in view of the fact that the "white room" is on a five day work week, one cannot rule out the possibility that it is a significant contributory factor. Further investigation of this subject may be fruitful.

Peter A. Boxer, M.D., M.P.H.

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Copies of this report were sent to:

1. Thomson Consumer Electronics (Marion, IN)
2. International Brotherhood of Electrical Workers (IBEW) Local 1160
3. IBEW (Washington, DC)
4. OSHA Region V (Chicago, IL)
5. USPHS Region V (Chicago, IL)

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

TABLE I

Summary of Exposure Limits
Thomson Consumer Electronics, Inc.
Marion, Indiana
April 9 - 12, 1990
HETA 90-223

Chemical [CAS No.]	OSHA PELS and 1991-92 ACGIH TLVs TWA (ppm)	STEL (ppm)	NIOSH RELs TWA (ppm)	Ceiling (ppm)
Acetone [67-64-1]	750	1000	250	NA
n-Amyl Acetate [628-63-7]	100	NA	---	----
n-Butyl Acetate [123-86-4]	150	200	---	----
Isoamyl Acetate [123-92-2]	100	NA	---	----
Toluene [108-88-3]	100	150	100	200 (10-min)
1,1,1-trichloroethane [71-55-6]	350	450	200	350 (15-min)
Trichloroethylene [79-01-6]	50	200	Ca 25*	NA

* Concentration achievable by the use of engineering controls
ACGIH: American Conference of Governmental Industrial Hygienists
Ca: potential occupational carcinogen
OSHA: Occupational Safety and Health Administration
PEL: Permissible Exposure Limit
ppm: parts per million
STEL: Short Term Exposure Limit
TLV: Threshold Limit Value
TWA: Time-weighted Average
NA: not applicable

TABLE II

Sampling Results for Charcoal Tube Sampling
Thomson Consumer Electronics, Inc.
Marion, Indiana
April 9 - 12, 1990
HETA 90-223

Sample Number	Sample Type	Sampling Location	Sampling Duration (minutes)	Concentration (parts per million) Acetone	AAc	BuAc	IAAc	Toluene	1,1,1-TCE	TCE
01	personal	Degreaser #4 (loading)	159	0.4	(0.01)	----	----	0.05	----	2
02	personal	Degreaser #4 (loading)	158	0.3	----	----	----	(0.04)	----	2
03	personal	Degreaser #4 (unloading)	156	Sample was analyzed qualitatively.						
04	personal	Degreaser #4 (unloading)	156	0.3	----	----	----	0.07	----	0.3
05	area	Degreaser #4 (middle)	162	0.3	----	----	----	0.08	----	46
06	area	Degreaser #4 (middle)	158	0.4	----	----	----	0.08	----	50
07	personal	Master Frame #28	161	0.4	----	----	----	(0.02)	(0.01)	9
08	personal	Master Frame #28	161	Sample was not analyzed.						
09	personal	Spring Clip Welding	152	1	(0.01)	----	----	(0.02)	(0.01)	11
10	personal	Spring Clip Welding	152	Sample was not analyzed.						
11	personal	Frit Seal Loading	202	2	0.8	----	0.4	----	0.2	(0.01)
12	personal	Frit Seal Loading	201	Sample was analyzed qualitatively.						
13	area	Coating Room (heaters)	183	Sample was analyzed qualitatively.						
14	area	Coating Room (heaters)	183	81	0.4	0.8	0.2	0.06	1	0.2
15	area	Degreaser #3 (unloading)	255	0.2	0.2	----	0.06	0.7	0.1	0.2
16	area	Degreaser #2 (unloading)	254	Sample was not analyzed.						
17	Area	Degreaser #1 (unloading)	252	0.3	0.2	----	0.07	0.8	0.1	0.3
18*	field blank									
19*	field blank									
20*	field blank									
		Limit of Detection (LOD):		0.01	0.006	0.007	0.006	0.009	0.006	0.006
		Limit of Quantitation (LOQ):		0.06	0.02	0.03	0.02	0.04	0.02	0.02

Note: Values in ( ) represent quantities of a chemical between its LOD and LOQ, and should be considered trace concentrations. LOD and LOQ concentrations were calculated for a sample volume of 30 liters.

* Analysis of field blank samples 18, 19, and 20 indicated that no components of interest were detected at levels equal to or greater than their respective limits of detection.

AAc: n-Amyl Acetate
BuAc: n-Butyl Acetate
IAAc: Isoamyl Acetate
1,1,1-TCE: 1,1,1-Trichloroethane
TCE: Trichloroethylene
----: not detected