U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION REPORT HE 78-138-580

TECUMSEH PRODUCTS COMPANY
900 NORTH STREET
GRAFTON, WISCONSIN 53024

April 1979

I. TOXICITY DETERMINATION

Employees of the Engine and Carburetor Assembly Areas of Tecumseh Products Company were not believed to be exposed to a health hazard from chemical contaminants during the survey on October 19 and 20, 1978. Engine Assembly employees in past episodes possibly were exposed to concentrations of carbon monoxide (CO) sufficient to cause some of the reported symptoms. This is based on measurements obtained by other previous investigators and is consistent with the medical opinion based on employee interviews and review of reported symptoms.

During the survey, employees of the Carburetor Assembly Area were experiencing an episode of mass psychogenic illness brought on by heightened anxiety to what was perceived to be a health threathening situtation in an adjacent similar operation. This is supported by the absence of any documented toxic exposure and the pattern of results, obtained from a detailed questionnaire, which are indicative of stress-induced mass psychogenic illness.

This conclusion in no manner implies that the affected employees were not ill. The workers were sick and the symptoms were real. The same logic applies to the fact that there is often a strong psychological or stress component in the etiology of a peptic ulcer, but this does not minimize the seriousness of the condition. Moreover, the present results do not suggest an abnormal group of workers at this plant. On the contrary, previous investigations of mass psychogenic illness have characterized the illness as occurring in a psychologically normal workforce which is temporarily experiencing high levels of stress.[13] Those workers who became affected by the illness did not show consistent personality traits which distinguish them from nonaffecteds.

The conclusion of psychogenic illness must be tempered by the fact that carboxyhemoglobin levels in two nonsmoking Carburetor Assembly workers were determined to 11.5% and 13.5% respectively, which is above the NIOSH criteria document recommendation of 5% (corresponding to an environmental CO level of 35 ppm). For reasons outlined further in this report, interpretation of those values is difficult. However, in the absence of clear reasons for discarding them entirely it is recommended that either environmental or biological CO monitoring of employees complaining of symptoms compatible with CO exposure be initiated. Other recommendations to improve the aesthetics of the work place, and to reduce potential exposure to employees to various chemicals used in the work place, are presented.

II. DISTRIBUTION AND AVAILABILITY

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22151. 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:

a. Tecumseh Products Company
b. Local 1326, International Association of Machinists and Aerospace Workers
c. International Office, International Association of Machinists and Aerospace Workers
d. U.S. Department of Labor, OSHA, Region V
e. NIOSH, Region V

For the purpose of informing the approximately 160 affected employees, copies of the report shall be posted in a prominent place accessible to the employees, for a period of 30 calendar days.

III. INTRODUCTION

Section 20 (a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669 (a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by any employee or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

On September 26, 1978, the authorized representative of employees submitted such a request. The request stated that unknown toxic substances were causing employees to become ill and pass out. On October 6, 1978, at the suggestion of the Area Director for the Occupational Safety and Health Administration, the personnel director of Tecumseh Products Company requested NIOSH to provide technical assistance concerning the same situation.

An NIOSH interim report, dated October 24, 1978, was provided to the company. This report provided the results of environmental measurements for CO, 1,1,1-TCE, phosgene, and ozone. Recommendations were also presented to correct the causes of mass illness. These recommendations are presented again in this report.

IV. HEALTH HAZARD EVALUATION

A. Chronology of Events

On Thursday, November 17, 1977, at approximately midday, an employee in the engine assembly area reported to the nurse's station complaining of dizziness and nausea which she attributed to fumes in her work area. Subsequently, several more employees reported to the nurse's station with similar complaints. Examination by the company nurse revealed only mild increase in heart rate (tachycardia). Affected employees were sent home.

During the early afternoon of November 18, 1977, employees in the same area again noticed a "gassy" odor. Symptoms reported to the nurse were dizziness, nausea, weakness and flushed sensation. Again affected employees were sent home.

Plant officials inspected the area on both occasions and could find no apparent source of the odors. However, detector tube measurements for carbon monoxide (CO) revealed concentrations up to 25 parts carbon monoxide per million parts air. Suspected sources of CO were the recently installed deburring and washing machine with gas-fired dryer for metal parts in the adjacent work area, the gas-fired oven in the engine assembly area, the gas-fired heaters and the propane powered forklift trucks. The Wisconsin Gas Company inspected for leaks and a private contractor inspected the heating units. A leak was found in the heating unit and was repaired. Also, an engineer for the Wisconsin State Division of Health Planning inspected the plant.

On November 23, employees again complained of "gassy" odors. One employee became ill and was taken to the hospital, complaining of dizziness, nausea, weakness and dry mouth. Pulmonary and neurological examinations, complete blood count, arterial blood gases, urinalysis and electrolytes were normal.

The health planning engineer returned to the plant the next week to conduct tests. He advised that there was poor air exchange in the engine assembly area and that roof stacks of the washer and adjacent degreaser be raised. These recommendations were followed. He also measured airborne concentrations of the solvent used in the degreaser (1,1,1-Trichloroethane or 1,1,1-TCE). Values for 1,1,1-TCE were less than 60 ppm. CO levels were also measured. Values were between 20 and 30 ppm.

On December 6, 1977, the Occupational Safety and Health Administration(OSHA) inspected the plant, measured CO levels (results indicated approximately 25 ppm) and concluded "no apparent health hazard existed".

On December 12, 1977, odors were again detected in engine assembly and 36 employees reported to the nurse's station complaining of dizziness, nausea and headaches. This resulted in the work area being shut down for the remainder of the day and the employees sent home. The employees reporting ill reported to work the next day. Also on December 12, OSHA again inspected the facility but found no violations of health standards.

During the week of December 13, 1977, a private industrial toxicologist obtained several environmental and breathing zone samples for CO and 1,1,1-TCE. CO breath levels averaged 26 ppm for 5 nonsmokers and 50 ppm for 5 smokers (3 were above 50 ppm). Carboxyhemoglobin (COHb) in one nonsmoking worker was determined; the value was 3%. Ambient CO concentrations ranged from 10 to 38 ppm. Ambient 1,1,1-TCE concentrations ranged from 3 to 800 ppm in certain locations. The consultant also experimented with the potential sources of CO and 1,1,1-TCE and found that when the air supply units were shut off, levels of CO rose above 50 ppm (current federal standard) rapidly. Levels of 1,1,1-TCE were also seen to rise. The consultant recommended that all sources of CO (washers, ovens, fork lifts) be checked for excessive CO emission and corrected if necessary, personal monitoring for toxic substance exposure, covering open solvent containers, and enclosing the engine "blow off" area and providing exhaust ventilation to reduce high concentrations of 1,1,1-TCE.

Changes were made in the plant soon after the last illness episode - the entrances to overhead conveyors that carried assembled engines into the degreaser and then through the paint booth were enclosed from the engine assembly area, roof stack height was increased, an exhaust plenum was installed in the center of engine assembly, leakes in the degreaser were repaired, engine blow-off stage was enclosed, an exhaust hood installed in the adjacent engine test area, forklifts were checked for CO emission and exhaust hoods were installed in the engine masking area. Illness episodes declined in frequency and magnitude.

On September 21, 1978, six employees from engine assembly reported to the nurse's station complaining of dizziness, light headedness and headache due to exposure to fumes. Examination revealed mild tachycardia and tremor. One employee fainted and was sent via ambulance to the hospital. The other two were sent to a local emergency room. COHb levels obtained at the respective treatment centers were 3.6% and 10.2% and 3.0%. Later in the evening shift, three other employees reported ill, complaining of smelling fumes. One complained of dizziness, one of dizziness and tremor and one was hyperventilating. These employees eventually returned to work. The union filed a request for a health hazard evaluation on September 26, 1978.

Consequently an OSHA inspector was called to the plant. He sampled for CO, CO_2, formaldehyde and nitrogen dioxide. All values obtained were below exposure standards.

B. Description of Process/Operation

Tecumseh Products Company manufactures and assembles two stroke internal combustion engines and compressors for air conditioners. The work force totals approximately 1000 people. Figure I depicts the general layout of the facility at the time of the survey. Note the location of the two areas of concern, engine assembly and carburetor/stator assembly area and their relation to the deburring and washing machine, 5-stage washer and dryer, paint booth and storage room, degreaser and engine test facilities.

1. Engine Assembly Area

The engine assembly area is a somewhat crowded room of approximately 4940 ft^2 with a ceiling height of approximately 18 ft. It contains two conveyor lines. Parts to be assembled are brought in through double doors on the south wall. After passing through a gas-fired "expansion" oven (used to expand the bearing so that it fits with the crankshaft easier), the bearing is put on the crankshaft and it in turn is placed on the shroud base and put in the uniblock. The rod and piston assembly are then installed in the uniblock. The cylinder head and reed plate are then installed. This completes the powerhead assembly. The powerhead assembly is then placed on the moving conveyor line.

The assembly, now a complete two cycle engine, is placed in the overhead conveyor and taken into the test room. After testing, the engine continues via overhead conveyor, through a vapor degreaser. After that, the engine is blown dry, using high pressure air, and masking tape placed over areas not to be painted. The engine is then spray painted, dried in an oven, and boxed for shipment.

The "expansion" oven has local hood exhaust ventilation to trap any combustion products (grease, gas, etc.). The gasket assembly table is ventilated with a canopy hood. On the gasket assembly table the following chemical compounds are used: varnish (Glystal 1202) thinner (xylene or GE 1500), grade A locklight blue, and pre-tube 280,- a lubricant, CRC 3-36,- a thinner, and kerosene.

The general room ventilation is 100% nonrecirculating, supplied at a rate of 2700 CFM and heated by gas-fired furnaces.

Propane powered forklifts were used in the area to bring in pallets of ports. This practice is no longer allowed, although they are still used in other areas within the building.

There are approximately 40 employees in each of two shifts in the engine assembly area. Almost all are female. The work is manual (some assistance from pneumatic tools) and repetitive.

2. Carburetor Assembly Area

The carburetor assembly area is approximately 9600 ft^3 with a ceiling height of approximately 16 ft. It contains thirteen conveyor lines on which the carburetor is assembled. In order, the installation process is: idle needle installed on casing, the the welch plug, 2 steel balls, fuel inlet fitting, main fuel pickup tube, identification number stamped on, float sub assembled, float level set, leak test performed, throttle assembly and choke assembly. The crack screw is then set and the completed unit is inspected and boxed for shipment or used in the engine assembly room.

The room is ventilated with 100% outside makeup air. Makeup air is provided at a rate of 15,000 CFM. This air is heated after introduction into the room by two ceiling-mounted, gas-fired space heaters located at opposite ends of the room.

There are approximately 80 employees, all women in the carburetor assembly area. There is only one shift. Like engine assembly, the work is manual and repetitive.

C. Evaluation Design and Methods

Since other consulting groups previously had investigated the problem and had not been able to remedy the problem, it was decided that NIOSH would consider the problem from three approaches: environmental, medical and behavioral.

1. Environmental

From information gathered preliminarily, it was indicated that the most likely toxic substances in the workplace were CO and 1,1,1-TCE. Other chemicals used in the workplace - kerosene, xylene, toluene, etc.- were not considered likely to cause the health effects due to the small amount used.

Personal breathing zone sampling for 1,1,1-TCE and general organics was conducted on engine assembly and carburetor assembly workers. Their samples were obtained with vacuum pumps calibrated to pull 200 cubic centimeters of breathing zone air per minute through an activated charcoal sampling media. Analysis in the laboratory was done by gas chromatography and mass spectroscopy.

At various times during the survey and during periods of mass illness, an Ecolyzer* was used to measure ambient CO concentrations. Selected employees, after becoming ill, were asked to provide a breath sample for analysis. This analysis was performed with this Ecolyzer.

Various detector tube measurements were taken during the course of the survey: phosgene- a decomposition product of 1,1,1-TCE, CO^2, and ozone- from electric forklift trucks.

In addition, a Wilks Miran IA infrared spectrophotometer was used in the scan mode in an attempt to document the presence of a contaminant in the subject work areas not found in a control or clean area.

The ventilation system and work practices were reviewed. Potential sources of fumes and odors were investigated.

2. Medical

The NIOSH medical personnel obtained a detailed chronology of illness events most of which has been presented in the section entitled "Introduction". The data obtained resulted from review of medical records and questioning management and employees. Attachment I is the questionnaire quide followed in gathering this information.

Since the focus of investigation shifted from the engine assembly to the carburetor assembly area, the medical team was afforded the opportunity to interview 22 of 25 workers during their episode of illness. Partial physical examinations were performed on ten of these. Carboxyhemoglobin levels were determined on three of the affected employees. Because reported environmental sampling at that time did not indicate significant CO contamination, carboxyhemoglobin levels in subsequent workers were not determined.

*Mention of trade names does not constitute an endorsement by NIOSH.

Twenty engine assembly workers who had been affected in previous episodes were also interviewed.

3. Behavioral

A detailed questionnaire was distrubuted to 150 employees covering both the engine assembly and carburetor assembly area. The original study protocol was to consider only the engine assembly area employees since all past reports of mass illness had been confined to that area. It was only during the week of the NIOSH visit that similar problems surfaced in the carburetor assembly area. Individuals from both areas were asked to take the survey form home, complete it, and return it to the plant the following day or, if they wished, mail it in the postage-paid envelopes provided. This questionnaire was specifically designed for investigations where there is no apparent environmental condition that could be related to documented health effects and where conditions predisposing to stress induced mass psychogenic illness might prevail. In addition to social, demographic (age, sex, level of education, marital and parental status, etc.) and epidemiological information (date and time of illness, symptomatology, location of workplace at the timeof the onset of illness, etc.) the questionnaire contained items designed to measure perceived job stress along a variety of dimensions (unwanted overtime, role ambiguity, job boredom, role conflict, etc.). Three standardized personality/psycho-diagnostic instruments were also included in the survey protocol. These were:

a. The Work Environment Scale[4] - This scale measures ten dimensions of social climate of the workplace which are believed to be predictive of work satisfaction of adjustment. These are: 1) Involvement - extent to which workers are enthusiastic or committed to their jobs; 2) Peer Cohesion -the extent to which workers are mutally supportive; 3) Staff Support - the extent to which management is perceived as supportive by the workers; 4) Autonomy - the extent to which workers feel self-sufficient and independent; 5) Task Orientation - the extent to which the climate emphasizes productivity and efficiency; 6) Work Pressure - the extent to which workers perceive pressure to produce; 7) Clarity - the extent to which workers know what is expected of them in the performance of their jobs; 8) Control - the extent to which management imposes rules and regulations on the workers; 9) Innovation -the extent to which variety and new approaches are emphasized in the workplace; and 10) Physical Comfort - the extent to which the physical surroundings contribute to a pleasant work environment.

b. The Eysenck Personality Inventory (EPI)[5] - This scale measures personality in terms of two pervasive, independent dimensions: extroversion-introversion and neutoticism-stability. There is some evidence to indicate that clinically diagnosed hysterics score lower on the extroversion scale than normals.

c. The Mini-Mult of the MMPI[6] - This is a factor-analytically derived scale of the Minnesota Multiphasic Personality Inventory. Three subscales from this instrument were included in the present survey protocol. These were:

1) The Hysteria Scale - Measures the extent to which the individual exhibits behavioral patterns characteristic of the hysteria-prone personality: excitability, emotional instability, self-dramatization.

2) The Hypochondriasis Scale - Measures the extent to which the individual somaticizes emotional or pyschogenic strain or tension.

3) The Depression Scale - Measures the extent to which the individual experiences feelings of dejection, hopelessness, worthlessness, etc.

D. Evaluation Criteria

In this study, three sources of environmental exposure criteria were used to evaluate a worker's exposure to toxic chemicals in an occupational setting. These exposure limits are derived from existing human and animal data, and industrial experience, to which it is believed that nearby all workers may be exposed for an 8-10 hour day, 40-hour work week, over a working lifetime with no adverse effects. However, due to variations in individual susceptability, a small percentage of workers may experience effects at levels at or below the recommended exposure limit; a smaller percentage may be more seriously affected by aggravation of a pre-existing condition or by development of an occupational illness.

The three sources of criteria for this study are: 1) Criteria for a Recommended Standard[7] by the National Institute of Occupational Safety and Health; 2) Occupational Safety and Health Standards[8] for General Industry by the Department of Labor's Occupational Safety and Health Administration; and 3) Threshold Limit Values (TLVs) and their supporting documentation[9] by the American Conference of Governmental Industrial Hygienists.

Since past study indicated CO and 1,1,1-TCE to be the major potential sources of toxic exposure, the toxicological summary will be confined primarily to their substances.

1. Carbon Monoxide

CO is a colorless, odorless, tasteless, and nonirritating gas, resulting from the incomplete combustion of organic matter. CO combines with hemoglobin (Hb) in the blood to form carboxyhemoglobin (COHb). CO has a greater affinity for the Hb molecule than does oxygen, even though the molecule/molecule ratio of CO/Hb is the same as O_2/Hb. In addition, COHb reduces the rate of release of oxygen from oxyhemoglobin. These two functions serve to reduce the amount of oxygen available to the tissues, resulting in oxygen starvation or tissue hypoxia.

There is a great variation in individual susceptibility to CO, and a number of factors affect the rate of an individual's uptake of CO.

- concentration of CO in inspired air
- duration of exposure
- exercise or work rate
- cardiac, respiratory and metabolic rate
- Hb concentration in the blood

Table I relates levels of CO exposure and expected resultant symptoms. CO in inspired air is related to COHb levels according to the following equation:

$$\%\ COHb = 0.5 + \frac{\text{Biological concentration of CO (ppm)}}{5}$$

The percentage satuation of carboxyhemoglobin indicated in Table I should be regarded as approximate values since the table does not state the duration of exposure. As the CO concentration increases in ppm, the time it takes to achieve the level of satuation decreases. While values at the top of the table are essentially for 8-hour exposures, it takes only 1/2 the exposure time to achieve the maximal satuation of 1000 ppm.

NIOSH has recommended[7] that no employee be exposed to concentrations greater than 35 ppm based on an 8-hour time-weighted-average concentration. Moreover, no employee shall be exposed to concentrations greater than 200 ppm at any time. This 35 ppm recommendation is based on a COHb level of 5%. Literature has documented the initiation or enhancement of deleterious mycardial alterations in individuals with chronic heart disease who are exposed to CO concentrations sufficient to produce a COHb level greater than 5%. Since tissue hypoxia causes the heart rate to increase in order to supply more oxygen to the tissues, increased levels of COHb cause strain on a heart already weakened by disease. Therefore, COHb concentrations below 5% should prevent heart stress in all but the most sensitive worker.

This recommended exposure criteria does not take into account smoking habits of the worker since the level of COHb in chronic cigarette smokers has generally been found to be in the 4 to 5% range prior to CO exposure. Goldsmith[10] has estimated that a smoker is exposed to 475 ppm CO for six minutes per cigarette.

The ACGIH and OSHA cite 50 ppm as the 8-hour TWA exposure limit. The OSHA standard is listed here only as a reference. Enforcement of OSHA standards is the responsibility of the U.S. Department of Labor - OSHA.

2. 1,1,1-Trichloroethane

Also know as methyl chloroform, 1,1,1-TCE is used mainly as an industrial solvent and degreasing agent. Its odor threshold varies according to the literature cited (American National Standards Institute[11] 10 ppm, Littel[2] - 16 ppm, May[13] - 400 ppm). The toxic effects of 1,1,1-TCE exposure are manifested as central nervous system disorders. These include impairment of perceptual speed, reaction time, manual dexterity and equilibirium, dizziness, and drowsiness. Acute exposure can cause unconsciousness and death. The liquid and vapor are irritating to the eyes on contact; repeated skin contact may produce dermatitis. Stewart[14] found that 7-hour exposure per day for 5 days at 500 ppm caused mild sleepiness, headache, light headedness, eye, nose and throat irritation. Salvini et al[15] found that 8-hour exposure to 450 ppm caused decreased perceptive capabilities under stress conditions and eye, nose and throat irritation. Gamberale et al[16] found that 2-hour exposure to 350 ppm reduced perceptual speed, reaction time and manual dexterity.

The NIOSH recommended exposure limit[17] is 350 ppm ceiling based on a 15-minute period. The ACGIH and OSHA also endorse the 350 ppm limit.

More recent information contained in a NIOSH Current Intelligence Bulletin (No. 27)[18] indicates that related chlorinated ethane compounds have been shown by the National Cancer Institute to be carcinogenic in laboratory animals. Therefore NIOSH recommends that, due to the similarity in structure of 1.1.1-TCE to these compounds, 1,1,1-TCE be treated as a potential human carcinogen. Safe exposure levels to carcinogens have not been demonstrated, but lower exposure to carcinogens decrease the probability of cancer development.

3. Other Toxic Chemicals

a. Xylene and Toluene

Both of these solvents are central nervous system depressants, eliciting symptoms similar to 1,1,1-TCE. NIOSH recommended exposure limits[19,20] are 100 ppm respectively.

b. Ozone and Phosgene

Ozone can be formed around electrical sources such as electrically powered forklifts. It has a characteristic pungent odor, and causes irritation to the eyes and upper respiratory passages. NIOSH does not currently have a recommendation regarding ozone exposure; the ACGIH recommends 0.1 ppm[9] and the OSHA standard[8] is also 0.1 ppm.

Phosgene has a sweet, not unpleasant odor in low concentrations. It is a respiratory irritant and can cause severe pulmonary edema even when not overly irritating to the upper respiratory tract. NIOSH recommends an exposure limit[21] of 0.1 ppm; as does ACGIH. The OSHA standard is also 0.1 ppm.

V. RESULTS AND CONCLUSIONS

A. Environmental

Sixteen personal breathing zone samples for 1,1,1-TCE and identification of general organics were taken. Seven employees sampled were from engine assembly, eight were from carburetor assembly and one was from the engine masking area. In addition, one area sample was taken. As an initial screening procedure, four samples which would, in some combination, represent each day of the survey, each shift, and be the best possible chance to document an exposure: i.e., most likely to show the greatest results, were chosen for gas chromatography/mass spectroscopy analysis for qualitative identification. Four main compounds were discovered and these were then quantitated for each sample. The results are presented in Table II. All results were below NIOSH criteria used in this study. Some values obtained by sampling, even though below exposure criteria, are at or above published odor thresholds. The odor threshold for 1,1,1-TCE has been mentioned previously; the odor threshold for xylene is 0.08 ppm and for toluene is 0.17 ppm.[22] This could account for the odors detected by employees which seemed to precipitate the illness episodes.

Since numerous changes were instituted to reduce the amount of solvent vapors (1,1,1-TCE) prior to NIOSH's visit, it is possible that there were greater airborne concentrations of solvents in the past than were detected by NIOSH sampling. Potential exposure operations are the employee working in the engine blow off area and secondarily the employees in the engine masking area. Using high pressure air to evaporate residue solvent is a significant source of airborne vapors, especially in the absence of a proper hood to collect these vapors.

The amounts of kerosene, xylene and toluene used in the assembly process are too small to cause health problems; this is substantiated by the low levels of these compounds detected by air sampling. However, care should be exercised to reduce skin contact to these chemicals and to use only that amount necessary to do the job.

Ambient CO concentrations in both the engine assembly and carburetor assembly areas never exceeded 10 ppm during the times sampled. CO monitoring was conducted in the general area when employees became ill. This would seem to indicate that CO was not the causal agent during these episodes. However, past CO sampling by other consultants indicated levels up to 30 ppm in engine assembly. In hypersensitive individuals, these levels could be the cause of mild headaches and nausea. Further, since there were significant sources of CO near the work stations in engine assembly, propane powered forklifts and possibly maladjustment of gas-fired ovens, dryers, and recently utilized space heaters resulting in incomplete combustion and physical changes not yet made ("expansion" oven still in use and the wall separating the engine assembly area from the main corridor was still in place), it is possible that levels of CO could have risen past exposure criteria. This is borne out by the experiment of one consultant when he found that levels of CO in the engine assembly area rose above 50 ppm when the ventilation system was shut down and the gas-fired dryer in the 5-stage washer continued to run.

Detector tube measurements for phosgene were below 0.09 ppm. This measurement was taken as far inside the degreaser as the industrial hygienist could safely reach. Since phosgene is a possible decomposition product of 1,1,1-TCE, it was judged that concentrations of phosgene would be greatest inside the degreaser. Since phosgene levels were below 0.09 ppm, it can be concluded that phosgene is an unlikely cause of symptoms experienced by employees.

Ozone measurements in the carburetor assembly area were below 0.05 ppm. Ozone is an unlikely cause of symptoms in this situation. However, since it will be recommended that electric forklifts be used in place of propane powered forklifts indoors, the potential for exposure above the recommended 0.1 ppm limit will increase.

A Wilks Miran IA infrared spectrophotometer was run in scan mode in a control area (personal director's office) and in both the engine assembly area and the carburetor assembly area. All three scans of the infrared spectrum were identical which would seem to indicate the absence of an unknown infrared absorbing compound in the work areas in question. However, this technique must be interpreted with caution. Water vapor and carbon dioxide (compounds naturally present in air) absorb strongly in the infrared region and it is possible that the broad peaks representing water vapor and CO_2 masked the presence of a compounds(s) absorbing at a similar wavelength.

The 2-stage and 5-stage washers were inspected. Contact with the manufacturer revealed that the cleaning solutions used were either diluted with water 1 to 50 or 1 to 100, and were nontoxic. It was judged that the washers were not a source of chemical contaminants, other than possibly CO. Inspection of the roof stacks revealed that their height had been raised. One previous consultant had suggested that the source of odors could be from reentrainment of exhausted contaminants in the fresh air intake portals. Another consultant had verified large amounts of CO being exhausted from the 5-stage washer. It is possible, subject to weather conditions, that contaminants could re-enter the workplace. Proof that outside contaminants can be brought in to the building was exhibited on the second day of the survey. Transportation workers were tarring the road outside and employees and NIOSH personnel were able to detect the odors quite readily indoors. Raising the stack heights should prevent reintroduction of exhausted contaminants.

The engine test facilities were not extensively looked at. However, it is possible for exhausted combustion gases to be reintroduced into the workplace. Increased stack height again should remedy the problem.

B. Medical

1. Carburetor Assembly area

Twenty-two employees from the carburetor assembly area who reported to the nurse's station were interviewed. All but one were female. Their average age was 37.2 years, and they had worked at the plant an average of 9.7 years. Past medical problems in two employees appeared unrelated to present complaints. Fourteen of the 22 noted smelling an unusual odor prior to becoming ill, usually characterizing it as similar to "exhaust" fumes. Common complaints included dry throat (15/22), headache 11/22), dizzinesss (10/22), light headedness (7/22), weakness (7/22), nausea (7/22), chest pain or pressure (6/22), and tingling (6/22). This data is reflected in Table III. Three had palpitations and four appeared normal except for occasional mild tachycardia. No cyanosis was observed. Limited physical exams on 10 employees revealed no pulmonary, cardiac or neurological abnormalities. All recovered within 40 to 45 minutes. Some returned to work while others went home. Follow up interview with some employees the next day revealed headache and a fatigued feeling as sequelae. Carboxyhemoglobin levels were drawn at the time of symptoms in three carburetor assembly employes. These results were 11.5%, 13.3%, and 13.3%. One was a smoker (13.3%) and two were not. No information was given regarding the time of the last cigarette smoked. Also, CO breath analysis was performed on selected employees reporting ill. Values were less than 10 ppm, indicating a COHb level less than 5%.

No specific conclusions concerning the cause of the illness episodes in the carburetor assembly area were presented in the medical report. There is no significant source of chemical odors in this work area. No forklift trucks are used, the area is well separated from degreasers and washers, there are no ovens. Possible sources are inflow from adjacent areas (note concentrations of 1,1,1-TCE found in carburetor assembly workers, Table II), entrainment from intake ducts, and evaporating solvent from felt pad tables. However it is felt that these sources, singly or combination, are not enough to cause the problems encountered.

Three carboxyhemoglobin levels in excess of 5% (11.5, 13.3, and 13.3%) are cause for concern. However, the small number of samples taken in a biased population (i.e., only affected workers), possible sampling or analytical error, and lack of data on when the last cigarette was smoked in one individual, all tend to lessen degree of confidence placed in this data. According to Table I, for employees to exhibit CoHb levels of approximately 10%, ambient concentrations of CO would have to be near 70 ppm. Ambient CO levels measured were less than 10 ppm. This discrepancy might be explained by the quick uptake and long half-life of CO in humans. The blood samples may represent exposure occurring prior to the sampling period.

2. Engine Assembly Area

Twenty employees from the engine assembly area were interviewed. All were female employees who had reported to the nurse's station complaining of illness from "fumes" in one or more of six distinct episodes. Some had reported there on more than one occasion, but this was uncommon. Since some of the incidents had occurred several months earlier, the recall of the sequence of events was not always good. The average age of these workers was 35.9 years. Their average tenure with the company was 6.7 years. Past medical illness or current medication taken by two interviewees appeared unrelated to symptomatic complaints. Predominant symptoms included weakness (15/20), headache (12/20), dry throat (10/20), and light headedness (7/20).

Nine of the twenty reported smelling some unusual odor, characterized as "gassy" or "exhaust" prior to the illness. One employee complained of palpitations, and three noted that they were quite tremulous. Two reported fainting in the work area. Vital signs on all were normal except for some who had mild tachycardia. Eleven of the twenty were sent home or returned to work. Nine of twenty had been transported to local emergency rooms on either of two occasions. All 9 had carboxyhemoglobin levels drawn at the E.R. with results ranging from 1.2 to 10.2%. (See Table V). However, these values are suspect since normal first aid procedure is to administer O_2 during transport. The two values above 5% were in the two heaviest smokers.

Based on previous industrial hygiene measurements, medical data and consultant reports, and the correlation of symptom descriptions obtained with the clinical picture, the acute and recurrent complaints in the engine assembly area are consistent with low level CO intoxication. Clustering of cases near midday (95 to 118 cases occurred between 11:00 a.m. and 2:00 p.m.) suggests the symptoms may be the result of a cumulative toxic exposure. Such effects may also manifest itself by occurrence of symptoms at the end of the workday or workweek.

It has been suggested that exposure to CO at low levels in the ambient air can act synergistically with low level solvent exposure producing a mixed syndrome of mild CO intoxication and mild narcotic effects. However, at the present time, such interactions are not well investigated or documented.

C. Behavioral

Of the 150 questionnaires handed out, 65 were returned resulting in a response rate of approximately 43%. The confusion in the plant arising from the illness episode is likely to have impeded both the distribution and return of the questionnaires.

The questionnaire results for the demographic and epidemiological information are presented in statistical summary form. The individual job stress and psychological scale data were analyzed by computing Pearson product moment coefficients ($\underline{r}$) between each of these variables and the number of reported symptoms. This test measures the degree to which there is a linear relationship between two measures. Thus the larger the value of the correlation coefficient ($\underline{r}$), the stronger the relationship between measures. The probability ($\underline{p}$), that the correlation or relationship between the measures occurred just by chance is also indicated. The smaller the value for $\underline{p}$ the lower the possibility the correlation occurred by chance.

1. Demographic Factors

The average age of the 65 respondents was 32 years of age. They had worked for Tecumseh for an average of approximately 6 years. Eighty-seven percent (57 respondents) of the sample were female.

2. Symptoms

Twenty-five symptoms, identified in the literature as often characteristic of mass psychogenic illness were listed. Each respondent was requested to check which, if any, of the symptoms he/she experienced during the outbreak periods. Of the 65 respondents, 49 (approximately

Of the 65 respondents, 49 (approximately 75%) reported experiencing at least one or more symptoms during one of the illness outbreaks. Table VI presents the 25 symptoms rank-ordered in terms of incidence rate for the entire sample (n=65). The five most prevalent symptoms were: (1) headache (67%), (2) dry mouth (63%), (3) lightheadedness (51%), (4) sleepiness (35%), and (5) bad taste in mouth (34%). For the purpose of this report, the number of symptoms reported is used as an index of symptom severity and as a criteria for the classification of workers as "affected" by the illness outbreaks or "inaffected". "Affected" workers indicated one or more symptoms. "Unaffected" workers reported zero symptoms.

3. Work Satisfaction Measures

The small number of respondents limits the confidence that can be placed on any one specific finding with respect to sources of work dissatisfaction. Nevertheless, the overall trend indicated a consistent relationship between work dissatisfaction and symptom frequency. Specifically, the following results were obtained:

a. Dissatisfaction with supervisor was related to numbers of reported symptoms. ($r=.19$, $p<.07$). The more dissatisfaction reported by the workers with their supervisor, the more frequent the reported symptoms.

b. Dissatisfaction with the amount of freedom to make decisions was correlated with numbers of reported symptoms ($r=.23$, $p< .05$). The less freedom perceived by the workers, the greater the number of reported symptoms.

c. These workers expressing frequent feelings of having to push themselves to get their work done, reported greater numbers of symptoms ($r=.20$, $p=<.01$).

d. The greater the dissatisfaction with the work schedule, the greater the number of reported symptoms ($r=.29$, $p<.01$).

e. Those workers reporting the most symptoms indicated the greatest concern about possible job layoffs ($r=.23$, $p<.03$).

4. Social Patterns

There was a tendency for those workers reporting more symptoms to report greater dissatisfaction with the amount of social support they received from family and coworkers. Those workers expressing the greater number of symptoms:

a. reported that their job more often resulted in problems with their husband/wife ($r=.31$, $p<.01$).

b. reported that their job more often resulted in problems children ($r=.33$, $p<.01$).

c. reported that their coworkers were often not as helpful as they could be $r=.31$, $p<.01$).

5. Health Factors

Analysis of those items dealing with general health status (excluding the outbreaks) indicated that those individuals reporting more symptoms at the times of the outbreak also reported more health problems in general. Specifically:

a. Those workers reporting higher numbers of symptoms reported poorer overall health ($r=.25$, $p<.02$).

b. Workers reporting more symptoms during the outbreaks more frequently used cold and cough medication ($r=.22$, $p<.04$).

c. Workers reporting more symptoms during the outbreaks reported more frequent use of "pep medication" ($r=.28$, $p<.05$).

d. Individuals most affected during the illness outbreaks also reported more frequently being bothered by headaches ($r=.26$, $p<.02$) and spells of exhaustion/fatigue ($r=.23$, $p<.03$).

6. Personality Factors

There was a moderately strong correlation between symptom frequency and scores on the hysteria scale of the MMPI ($r=.23$, $p<.05$). This scale measures the degree to which an individual exhibits excitability, emotional insecurity and self-dramatization.

The findings of the behaviorial factors evaluation indicate that workers who were affected during the illness outbreaks showed a pattern of elevated job and life stress and more frequent health complaints than did nonaffecteds. Specific factors include less autonomy, more feelings of production pressure, and job interference with home interactions. Affected workers also reported ill more frequently than did nonaffected; also more use of medication.

D. Summary

The environmental aspect of this hazard evaluation determined that measureable levels of 1,1,1-TCE and other organic compounds were in both the carburetor and engine assembly areas. These values in some cases were above the odor threshold for that particular chemical. Measurable levels of CO were also recorded in both areas. However, in all cases, the values were below the exposure criteria listed in this report. The "gassy", "exhaust" or unidentifiable odor reports could be attributed to concentrations of chemicals at the odor threshold. This unidentifiable odor may represent a "triggering mechanism" responsible for the subsequent outbreaks of mass illness.

The sources of CO in the workplace are engine testing facilities, gas-fired ovens, washers and heaters, propane forklifts, and reentrainment of exhausted gases from the above. The changes made prior to NIOSH's visit preclude anything but speculation as to what the situation may have been. Employees in the engine assembly room may or may not have been exposed to excessive amounts of airborne contaminants. Clustering of cases near midday in the engine assembly room suggests the symptoms may have been the result of a cumulative toxic exposure. Documentation by other consulting groups indicates exposure to CO to have been likely on one or more previous occasions in the engine assembly area. Since problems in the engine assembly area have declined to zero, the changes instituted may have remedied the situation; or it may be that the right set of physical and emotional circumstances has failed to present itself again.

Failure to document exposure to toxic substances in the carburetor assembly room during periods of mass illness suggests that there were no toxic substances present in sufficient concentrations to cause the effects seen. However, the high carboxyhemoglobin values in three carburetor assembly workers (two of which were nonsmokers), even though they do not correlate with other environmental measurements and observations, are still cause for concern. Unless there was some CO exposure prior to the work shift not reported by the subject workers or discovered by the medical team, there is no reason to discount the values. Accordingly, recommendations for continued CO monitoring are presented to document either that these levels could actually be reached or to prove that they cannot.

Regardless of the triggering mechanism responsible for the initial illness outbreak, there is evidence to suggest that stress may have played a contributing role in the recurrent episodes. Feelings of production pressure, concerns about job layoffs, dissatisfaction with supervisors, lack of social support, and a variety of other potential sources of stress may have sensitized the workers to odors in the work environment. The resulting psychological and physical strain, coupled with the anxiety produced by the original illness episode may have resulted in a contagious reaction.

Due to the small sample size, the data did not allow a comparison between the engine assembly and carburetor areas. It is the industrial hygienist's opinion that at one or more times in the past sufficient concentrations of CO probably existed to cause mild headache, nausea, and lightheadedness in the engine assembly employees. Susbsequent episodes in this area were possibly a result of heightened anxiety over potential exposure to an unknown toxic substance. The "transfer" of symptoms to the carburetor assembly employees is likewise a response to an unknown situation aggravated by the presence of outside investigators studying a group of fellow workers engaged essentially in the same task. That the presence of NIOSH had a negative effect on the carburetor assembly workers is unquestionable. Suggestion that the carburetor assembly employees were susceptible to anxiety reactions was observed in the "blacktop" episode. Once the source of the odor was identified to the employees, they became noticeably calmer.

Overall, the data reveals a pattern of results which is indicative of stress-induced mass psychogenic illness. Perhaps with more data it would be possible to separate those who actually were exposed to a toxic substance from those who were predisposed, by way of various factors, to believe they were so exposed. An outbreak of stress-induced mass psychogenic illness develops suddenly and spreads contagously, typically affecting a work force engaged in short-cycle, repetitive and usually boring jobs. So far experience indicates females have composed the majority of affected workers. Whether this is because women tend to predominate this type of job or whether the predisposing socio-economic stresses preferentially affect women, has yet to be determined. The outbreak is usually triggered by an external event, e.g. a strange odor, and spreads rapidly throughout the plant as others are observed to be affected or as word of someone becoming ill circulates. The specific symptoms may vary across cases but typically are vague and non-specific and include headache, lightheadedness, dizziness, weakness and dry mouth. Such outbreaks have occurred in a variety of organizational settings but all appear to have the above factors in common. This is in agreement with previous descriptions of mass illness having an apparent psychogenic component.

VI. RECOMMENDATIONS

The recommendations presented to the company in the Interim Report #1, dated October 24, 1978, are presented below, numbers 1 through 14. Most of these had been implemented prior to this report.

1. Expand the assembly lines out to give employees more room. Especially in the engine assembly room, spread the two assembly lines apart to allow more room.

2. Clear out unnecessary boxes and waste cans from the aisles between the assembly lines and under the assembly tables.

3. Keep the fresh air make-up systems on at all times during the working hours. If employees are cool, have them don sweaters. The employees seem to like the temperature somewhat cool rather than warm.

4. Reopen the elevated assembly line openings in the carburetor assembly area to allow more air to circulate.

5. Cut off the wall mounted fans in the engine assembly area. Their use interferes with the exhaust funtion of the hood over the gasket table.

6. Lower the hood over the gasket assembly table. In its present location, it is not capturing contaminants at table level.

7. Place an exhaust hood over the felt storage area in the carburetor assembly if it is necessary to leave the felt pads out in the open. Even though they are essentially dry, they are still a source of odor. People handling these felt pads should also wear impervious gloves.

8. Increase the ventilation in all paint and solvent storage rooms. If possible, combine all storage rooms in a single room. Keep the duct openings clear of paint cans or other material which would obstruct airflow.

9. Cover all solvent cans and other chemical containers and keep them covered during intermittent use to prevent the escape of chemical vapors and odors.

10. Conduct personnel monitoring of the spray painters for exposure to solvent vapors and mist. It may be necessary to have the painters wear NIOSH approved respirators with organic vapor cartridges if they are being excessively exposed (until the necessary engineering controls are implemented.)

11. Connect the exhaust hood with the drain table at the engine blow off area of the degreaser. It may also be necessary to further enclose this work area or alter the work procedure if this employee is exposed to solvent vapors.

12. Ascertain that all gas-fired heaters, ovens and forklifts are operating efficiently. These significant sources of CO can be adjusted so the CO output is as low as possible.

13. On a calm day, run smoke bomb tests to determine if the proximity of the intake and exhaust stacks on the roof allow discharged contaminants to be reintroduced into the workplace. The elevating of the exhaust stacks may have remedied this problem; however, if not, various filtering techniques (e.g., charcoal) may have to be used in the exhaust systems to remove the contaminants before they are discharged.

14. Train selected employees in first aid. Once these people are trained, they should be the ones to respond when someone becomes ill. When numbers of people respond to help a sick person, it creates confusion and excites the patient unnecessarily which may worsen the symptoms.

15. Electric forklifts should be used indoors in place of propane powered forklifts.

16. Employees should be kept informed of the intent and reasons for testing or investigation, and the reasons behind changes and adjustments in the environment. Such information may reduce anxiety and provide reassurance that efforts to correct potential health problems are being carried out.

17. Because of the discrepancy between two COHb levels in the Carburator Assembly Area and ambient CO levels measured, it is recommended that Tecumseh Products Company institute a program of either environmental surveillance or biological monitoring, especially in employees complaining of symptoms of CO intoxication, until it is satisfactorily resolved that no significant levels of CO are being generated.

18. If it is determined that there are significant levels of CO being generated even after engineering controls have been instituted, it may be necessary to install ambient CO monitors equipped with a warning system to alert employees when ambient CO concentrations approach 35 ppm.

VII. REFERENCES

1. Kerckhoff, A.C. et al. The June Bcig. New York: Appleton-Century-Crofts, 1968.

2. Kroes, W. H. et al. "Report of an Investigation at the James Plant." Unpublished Report. NIOSH (1975).

3. Stahl, S. M. et al. "Mystery Gas: An Analysis of Mass Hysteria." J. of Health and Social Behav 15:44-50, 1974.

4. Moos, R. et al. Family, Work and Group Environment Scales Manual. Palo Alto. Ca: Consulting Psychologists Press, 1974.

5. Eysenck, H.J., et al. Eysenck Personality Inventory. San Diego, Ca.: Educational and Industrial Testing Service, 1968.

6. Kincannon, J. C. "Prediction of the Standard MMPI Scale Scores from 71 Items; The Mini-Mult"., J of Consulting and Clinical Psychology, 32:319-325, 1968.

7. "Criteria for a Recommended Standard . . . Occupational Exposure to Carbon Monoxide", DHEW, NIOSH Pub No. HSM 73-11000 (1972).

8. "Occupational Safety and Health Standards for General Industry" (29 CFR Part 1910) U. S. Department of Labor - OSHA (January 1, 1978).

9. Documentation of Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1978." American Conference of Governmental Industrial Hygienists, 1978.

10. Goldsmith, J. R., et al. "Evaluation of Fluctuating Carbon Monoxide Poisoning." Arch Environ. Health, Vol. 7, pp. 647-663, 1973.

11. American National Standard Acceptable Concentrations of Methyl Chloroform (1,1,1-Trichloroethane), 237.26-1970. New York, American National Standards Institute, Inc., 1970.

12. Arthur D. Little, Inc. "Parameters Affecting the Determination of Odor Thresholds" - Report to the Manufacturing Chemists Association, Inc. C68988, August 26, 1978.

13. May, J. "Odor Thresholds of Solvent for Assessment of Solvent Odors in the Air." Staub-Reinhalt Luft 26:34-38, 1966.

14. Stewart, R. D. et al. "Experimental Human Exposure to Methylchloroform Vapor." Arch Environ. Health 19:467-72, 1969.

15. Salivini, M., et al, "Evaluation of the Psychophysiological Functions In Humans Exposed to the Threshold Limit Value of 1,1,1-Trichloroethane." Br. J. Ind Med 28:28692, 1971.

16. Gamberale, F. et al. "Methyl Chloroform Exposure - II Psychophysiological Function." Arbete Och Halsa 1:29:50, 1972.

17. "Criteria for a Recommended Standard . . . Occupational Exposure to 1,1,1-Trichloroethane (Methyl Chloroform) DHEW, NIOSH Pub No. 76-184 (July, 1976).

18. "Chloroethanes: Review of Toxicity". Current Intelligence Bulletin #27. DHEW (NIOSH) Pub. No. 78-181. (August 21, 1978)

19. "Criteria for a Recommended Standard . . . Occuaptional Exposure to Xylene" DHEW, NIOSH Pub. No. 75-168. (1975)

20. Criteria for a Recommended Standard . . . Occupational Exposure to Toluene"(DHEW, NIOSH Pub. No. HSM 73-11023 (1973).

21. Criteria for a Recommended Standard . . . Occupational Exposure to Phosgene" DHEW, NISOH Pub No. 76-137 (1976).

22. Heillman and Small, Journal of Air Pollution Control Association, Vol. 24 (10): 979-82, 1974.

ACKNOWLEDGEMENTS

Report Written By:

Clifford L. Moseley
Industrial Hygienist
Hazard Evaluation and Technical Assistance Branch
Cincinnati, Ohio

Michael Colligan, Ph.D.
Motivation and Stress Research Section
Behavioral and Motivational Factors Branch
Cincinnati, Ohio

Linda Murray, M.D.
James Melius, M.D.
Timothy Bridge, M.D.
Division of Occupational Medicine
Cook County Hospital
Chicago, Illinois

Originating Office:

Jerome P. Flesch
Acting Chief
Hazard Evaluation and Technical Assistance Branch
Cincinnati, Ohio

Survey Assistance:

Paul Johnson
Industrial Hygienist
Hazard Evaluation and Technical Assistance Branch
Cincinnati, Ohio

	Mayme Culver Motivation and Stress Research Section Behavioral and Motivational Factors Branch Cincinnati, Ohio
Laboratory Analyses:	Measurement Support Branch NIOSH Cincinnati, Ohio
Typist:	Linda Morris Clerk-Typist Industrial Hygiene Section Hazard Evaluations and Technical Assistance Branch Cincinnati, Ohio
	Rita Connor Medical Section Industry-wide Studies Branch Cincinnati, Ohio

TABLE I

LOW LEVEL CARBON MONOXIDE EXPOSURE AND EFFECTS

TECUMSEH PRODUCTS COMPANY
GRAFTON, WISCONSIN

HE 78-138

CO Concentration in Inspired Air, %	PPM	% Saturation in Blood (COHb)	Signs and Symptoms
0.0035	35	5	None, except in hypersensitive individuals
0.005	50	7	Slight headache
0.007	70	10	No appreciable effect; shortness of breath on vigorous exertion, possible tightness across forehead, dilatation of cutaneous blood vessels; increased headache.
0.012	120	20	Shortness of breath on moderate exertion, occasional headaches with throbbing in temples
0.022	220	30	Definite headache; irritability, easy fatigue judgment disturbed, possible dizziness, visual disturbance.
0.04	400	40	Headache (frontal) and nausea after 1-2 hours. Occiptal headache after 2½ to 3½ hours.
0.05	500	45	Severe headache, increased respiratory rate, chest pain, confusion, impaired judgment, possibility of syncope or collapse.

Partially adapted from International Labor Organization, Encyclopedia of Occupational Safety and Health, Page 254 and Hamilton and Hardy, Industrial Toxicology, third edition, Page 240.

TABLE II

PERSONAL ENVIRONMENTAL SAMPLES FOR AIRBORNE CONTAMINANTS

TECUMSEH PRODUCTS COMPANY
GRAFTON, WISCONSIN

HE 78-138

October 19-20, 1978

Location	Time Sampled (minutes)	Concentration (ppm) 1,1,1-Trichloroethane	Toluene	Xylene	Total Kerosene
Carburetor Assembly	35	1.7	ND*	ND	1.4
Carburetor Assembly (area sample)	40	2.2	ND	ND	1.4
Carburetor Assembly	24	1.3	ND	ND	ND
Carburetor Assembly	25	1.5	ND	ND	ND
Carburetor Assembly	414	2.2	0.1	0.1	0.5
Carburetor Assembly	419	2.1	0.2	0.1	0.5
Carburetor Assembly	420	3.4	0.1	0.2	2.2
Carburetor Assembly	148	3.8	0.1	0.1	0.5
Carburetor Assembly	416	0.9	0.1	0.0	0.2
Engine Masking Area	440	7.7	0.2	0.2	2.2
Engine Assembly	427	4.2	0.1	0.5	1.9
Engine Assembly	430	3.8	0.1	0.2	1.8
Engine Assembly	92	0.4	ND	ND	ND
Engine Assembly	121	2.2	0.1	0.1	1.0
Engine Assembly	118	2.1	0.1	0.1	1.4
Engine Assembly	105	3.1	0.3	0.2	1.4
Engine Assembly	95	2.3	0.1	0.2	1.0
Exposure criteria		350 (15 min exposure)	100	100	14

*ND - not detectable

TABLE III

INTERVIEW SUMMARY OF EMPLOYEES FROM CARBURETOR ASSEMBLY AREA
REPORTING TO FIRST AID STATION 10/19 & 20/78

TECUMSEH PRODUCTS COMPANY
GRAFTON, WISCONSIN

HE 78-138

Symptomatic Complaint	Frequency
Dry throat or mouth	15
Dizziness	10
Headache	11
Lightheadedness	7
Nausea	7
Weakness	7
Flushed feeling	6
Chest pain or pressure	6
Tingling	6
Palpitations	3
Tremors	4
Complained of odor at time of symptoms	14
Syncope	0
Sequelae of headache	4
Number interviewed	22
Smoking behavior	
current smokers	15
nonsmokers	7

TABLE IV

INTERVIEW SUMMARY OF EMPLOYEES FROM ENGINE ASSEMBLY AREA REPORTING TO FIRST AID STATION SINCE EPISODES BEGAN 11/77

TECUMSEH PRODUCTS COMPANY
GRAFTON, WISCONSIN

HE 78-138

Symptomatic Complaints	Frequency
Dry throat or mouth	10
Headache	12
Dizziness	4
Lightheadedness	7
Nausea	2
Weakness	15
Flushed feeling	2
Chest pain or pressure	0
Tingling	3
Palpitations	1
Tremors	3
Complained of odor at time of symptoms	9
Syncope	2
Sequelae of headache	4
Fatigue	2
Transported to emergency room	9
Admitted to hospital	1
Number interviewed	20
Smoking behavior	
current smokers	10
nonsmokers	10

TABLE V

PAST CARBOXYHEMOGLOBIN LEVELS IN ENGINE ASSEMBLY WORKERS

TECUMSEH PRODUCTS COMPANY
GRAFTON, WISCONSIN

HE 78-138

Date	Level (%)	Smoking Packs Per Day
9/21/78	10.2	1
9/21/78	3.0	½
9/28/78	3.6	½
10/13/78	3.8	1
10/13/78	6.1	1½
10/13/78	4.9	1
10/13/78	1.2	NS*
10/13/78	1.6	NS
10/13/78	1.5	NS

*NS - non smoker

TABLE VI

FREQUENCY AND PERCENT OF SAMPLE (n=65)
REPORTING EACH SYMPTOM

TECUMSEH COMPANY PRODUCTS
GRAFTON, WISCONSIN

HE 78-138

Symptom	n Reporting Symptom	% of Sample
Headache	43	66%
Dry Mouth	41	63%
Lightheadedness	33	51%
Sleepiness	23	35%
Bad taste in mouth	22	34%
Weakness	20	31%
Watery eyes	17	26%
Nausea	15	23%
Dizziness	14	22%
Tingling feeling	13	20%
Difficulty swallowing	12	18%
Numbness	9	14%
Tightness in chest	7	11%
Blurred vision	5	8%
Racing heart	5	8%
Muscle soreness	4	6%
Couldn't catch breath	4	6%
Fever	3	5%
Chest Pains	3	5%
Ringing in ears	2	3%
Diarrhea	1	2%
Passed out	1	2%
Vomiting	1	2%
Abdominal pain	0	0%
Convulsions	0	0%

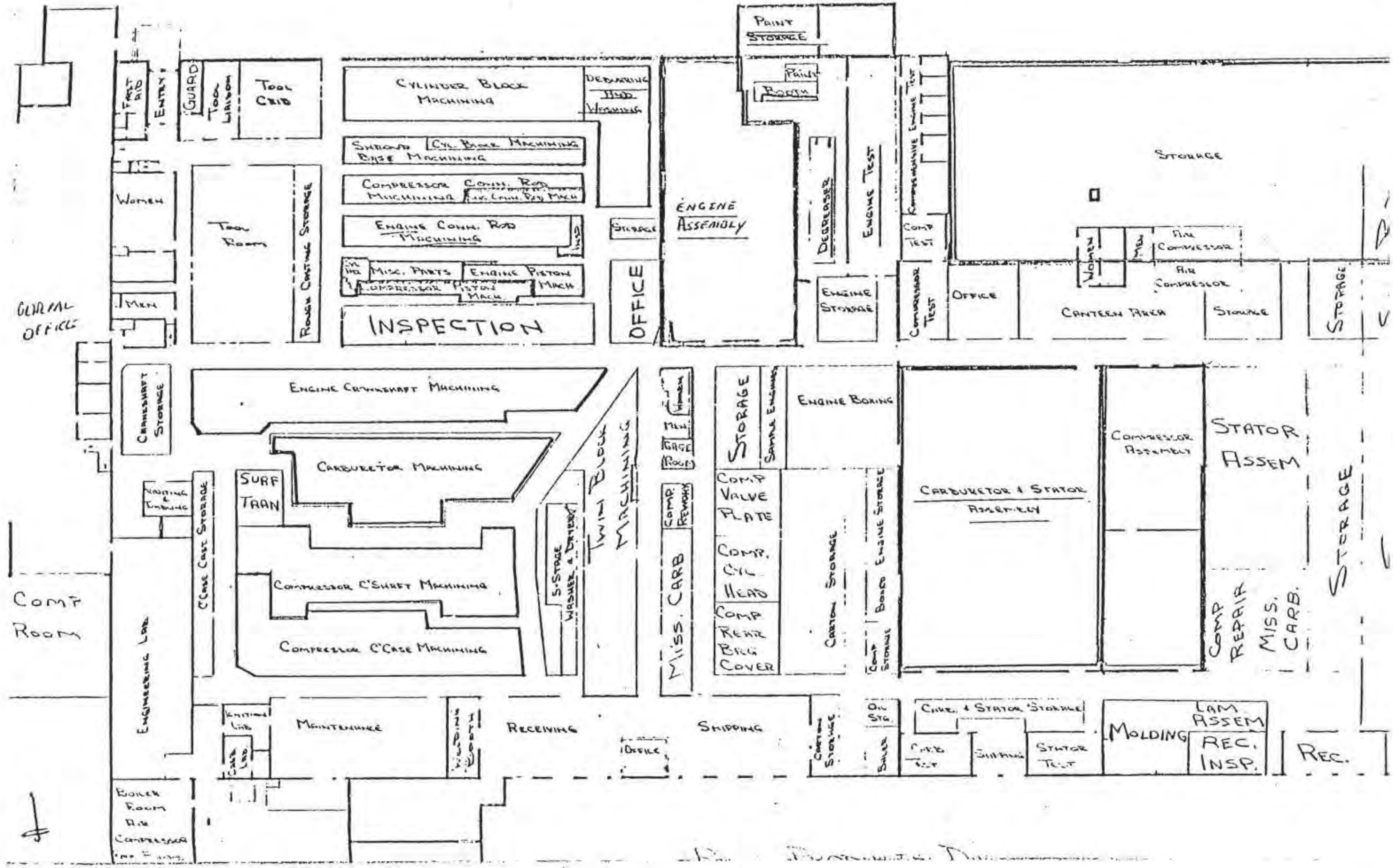

Figure I
Tecumseh Power Products Company
Grafton, Wisconsin
HE 78-138
October 18-20, 1978

Consent #____________

HE 78-138

Attachment I

INTERVIEW QUESTIONNAIRE
TECUMSEH PRODUCTS COMPANY
GRAFTON, WISCONSIN

INTERVIEW:

1. Name: ________________________ Age: __________

   Address: ________________________ Phone: __________

2. Present Job/Shift: ________________________

   Transportation to Work: ________________________

3. Job History: ________________________

4. Medical History:

   Hospitalizations: ________________________

   Medications: ________________________

   Chronic Illnesses: Hypertension____ Heart Disease____

   Epilepsy____ Pulmonary____

   Other____

   History of

   Smoking Hx: ________________________

Consent #____________

INCIDENTS

A. Time:____________________ Day of Week____________________

Place:____

Job at Time:______________________________________

Preceding Action:__________________________________

Unusual Conditions that Day:____________________________

State of Heating/Ventilation System:________________________

Odors/Source:______________________________________

B. Symptoms: Time Course (description):________________________

Hospitalized/Seen by M.D.: (where, when, released):________________

Recurrence/Sequelae:__________________________________

Time off work:______________________________________