

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

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 77-27-437

KELLER ALUMINUM FURNITURE OF INDIANA
LINTON, INDIANA 47441

OCTOBER 1977

I. TOXICITY DETERMINATION

A combined environmental, medical and behavioral Health Hazard Evaluation was conducted by NIOSH at Keller Aluminum Furniture of Indiana on January 31 and February 2 and 7, 1977. The environmental and medical studies discovered no definite evidence that toxic substances caused the outbreaks of illness on November 19, 24 and 29, 1976.

Numerous environmental conditions (e.g. ventilation, noise, dry air, diesel exhaust, etc.) were identified which could have contributed to the outbreaks of illness. Also, a natural gas leak was discovered that may have been the source of the "gas odor" complaints. Whatever the precipitating cause of the outbreak, no environmental toxins were discovered that could totally account for the continuing outbreaks of illness.

Behavioral factors may have been involved in propagating the outbreaks. NIOSH investigators from the Division of Biomedical and Behavioral Science found some significant psychological differences between affected and non-affected workers.

Recommendations are included for improvement of the occupational environment.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this determination report are currently available upon request from NIOSH, Division of Technical Services, Information and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. 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) Keller Industries Inc., Miami, Florida
- b) Keller Aluminum of Indiana, Linton, Indiana
- c) Authorized Representatives of Employees, Local 647, Linton, Indiana
- d) Upholsterers' International Union of North American - AFL-CIO
- e) U.S. Department of Labor - Region V
- f) NIOSH - Region V

For the purposes of informing the approximately 357 "affected employees", the employer shall promptly "post" for a period of 30 calendar days the Determination Report in a prominent place(s) near where exposed employees work.

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 an employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an employer, Keller Industries, Inc. regarding the unknown cause of production line employee illness outbreaks at Keller Aluminum Furniture of Indiana, Linton, Indiana. The outbreaks of illness occurred on November 19, 24 and 29, 1976, and affected approximately 96 employees. A similar incident in December, 1971 had been attributed to carbon monoxide. The source was identified as the fork-lift trucks which operated by propane gas. These vehicles have since been equipped with catalytic converters. In addition, the plant purchased a carbon monoxide (CO), detector for daily monitoring of CO levels after that incident.

IV. HEALTH HAZARD EVALUATION

A. Facility and Process Description

The Keller Aluminum Furniture Company Indiana, Linton, Indiana, is a division of Keller Industries, headquartered in Miami, Florida. The plant occupies approximately 80,000 square feet and employes 357 people (22% male, 78% female). The production workers are represented by the United Upholsterer's Union and work an eight hour day, (7:30 a.m. - 4:00 p.m.), forty hour week. The work is seasonal with the plant usually being operated from mid-October to mid-May.

The plant is exclusively involved in an assembly operation of constructing aluminum lawn furniture from fabricated aluminum tubing and plastic webbing. No manufacturing is performed in the plant, nor are any chemicals used in the assembly process. Work begins in the spinning and fabrication department located at the west end of the building. Here aluminum tubing is received at the loading dock, is contoured (ends spin tapered) and cut into various lengths for the different models. The aluminum tubes are then punch pressed to form holes for attaching the plastic webbing. Plastic and redwood arm rests are drilled and attached to the aluminum tubes and plastic caps are put onto the end pieces. From here, the aluminum tubes are sent to one of four assembly lines.

Immediately adjacent to the spinning and fabrication department is the webbing department. Here long rolls of plastic webbing are received, cut to specification for the various models, and eyeletted for attachment to the aluminum frames. The webbing moves from this department to the four assembly lines.

The four model assembly lines are located adjacent to the webbing department and run parallel to each other. The pre-cut aluminum tubes are shaped and assembled to form the various model frames (e.g. chair, lounge, or rocker model). Webbing is then attached (rivited) to the frames as the product moves down the assembly line towards the packers located at the end of each model line.

B. Chronology of Events

On Wednesday morning, November 24, 1976, a woman in the webbing department became ill with symptoms of headache, nausea, dizziness, burning throat and general weakness. She complained of a strange odor prior to the onset of her illness, which she felt was due to exhaust fumes from diesel trucks idling at the loading dock at the west end of the building. Within minutes, three other employees of the department became ill with similar symptoms. All four women were taken to the first aid room where they rested for 5-10 minutes before returning to work.

Within half an hour of the first incident, six more women from the same department reported to first aid with the same subjective, non-specific symptoms. The company's carbon monoxide monitor, located just north of the webbing department, indicated only 3-5 ppm CO during the outbreak and the dock doors at opposing ends of the building were open and exhaust fans were turned on.

Despite these precautions, individuals in the plant continued to develop symptoms. By 9:30 a.m. 29 people (all women) were taken to the local hospital and the plant was closed. Twenty-two of these individuals were treated for anxiety and hyperventilation and released. Seven were admitted: one person was released later the same day, five were released the following day, and one was released after five days. Medical examinations revealed no abnormalities in chest x-rays, hematology, serology, urinalysis or blood gases.

Environmental testing within the plant was conducted by Indiana OSHA (I-OSHA) representatives and an industrial hygienist from the Naval Weapons Support Center - Crane Medical Department. Sampling on November 24, 1976 throughout the plant indicated no detectable CO, 20-22% oxygen and 0.1% carbon dioxide. The plant remained closed over the Thanksgiving weekend. Operations resumed on Monday, November 29, 1976. By approximately 8:45 a.m. a female worker on the lounge assembly line became ill with symptoms of nausea, dizziness and headache. She was seen by a local physician (in attendance for the resumption of plant operations), treated in the first aid room and sent home at her request. Between 9:15 a.m. and 10:15 a.m., nine additional workers from various areas of the plant sought treatment in the first aid room for similar symptoms. All affected workers and some nonaffected workers complained of gas fumes, however environmental sampling by a consultant industrial hygienist failed to identify any toxic agents. All exhaust fans were in operation and the dock doors were kept open for the entire day.

Workers from scattered areas of the plant filtered into the first aid room throughout the day and a total of twenty-seven employees, (five males and 22 females, eight of whom had previously been affected on November 24), were treated in the first aid room on November 29. On Tuesday, November 30, operations were normal and no dramatic outbreaks of illness occurred in the plant. There were isolated complaints of headache and nausea, but environmental sampling throughout the day did not find sufficient concentrations of toxic agents capable of producing the observed symptoms.

In addition to the previously mentioned industrial hygienists, a representative of the Bureau of Mines was on site November 29 and 30 to sample for methane gas possibly arising from coal deposits under the plant. No traces of methane were found.

Water for the Keller plant is supplied by the same wells which furnish the city of Linton and there were no indications of townspeople developing symptoms similar to those of the Keller employees. In addition, the Keller plant does not provide cafeteria services and employees bring their own lunches or eat out. Candy and soft drink machines are present in the plant but there was no consistent relationship between usage of these machines and illness.

From November 30, 1976 to January 21, 1977, the date when NIOSH investigators arrived, there were no major outbreaks of illness, nonetheless, there were daily complaints of odors and isolated cases of first aid visits by employees with symptoms of nausea, headaches, burning of the throat, etc.

C. Evaluation, Progress and Methods

1. Progress

On January 31, 1977, NIOSH investigators conducted a walk-through survey to familiarize themselves with the plant and its operations. On February 1, 2 and 7, 1977, environmental sampling, medical examinations, and behavioral studies were conducted. During the survey dates, no toxic materials were observed being used. The only potential sources of toxic gases were the heating units and diesel exhaust gases. Some dusts (aluminum and wood) could be generated by saws and drills.

2. Methods

a. Environmental

Measurements for carbon monoxide (CO) and oxides of nitrogen (NO_x) were made with Drager* indicator tubes.

General area samples for Nitrogen Dioxide (NO₂) and Sulfur Dioxide (SO₂) were obtained utilizing MSA* model G personal sampling pumps and midget impingers containing 15 milliliters (ml) of adsorption solution. The pumps were operated at airflows of approximately 0.2 liters per minute (lpm) for NO₂ and 1.2 lpm for SO₂. Personal samples for total dust and oil mist were obtained with MSA model G pumps and 0.8u Millipore* AA filters operated at airflows of approximately 2.0 lpm. Ventilation measurements were made utilizing a Sierra* hot wire anemometer.

The SO₂ samples were analyzed by titration according to NIOSH P&CAM #163. Nitrogen dioxide samples were analyzed according to a method described in American Industrial Hygiene Association Journal, Vol. 34, pp. 390-395, 1973. The oil mist samples were analyzed by chloroform extraction and flourimetry. The dust samples were weighed on a Perkin-Elmer* balance.

Noise measurements were made with a General Radio* sound level meter.

Measurements for organic vapors were made with a Organic Vapor Analyzer (OVA) and a combustible gas indicator.

*Mention of manufacturer's name does not constitute a NIOSH endorsement.

Work practices and general housekeeping were also observed. No toxic agents were observed being used at the time of the survey.

b. Medical

Medical questionnaires were compiled and blood pressure and pulse measurements were obtained from thirty-three employees, (nine male, twenty-four female) whom had complained of becoming ill on November 19, 24 and 29, 1976. In addition, release consent signatures were obtained from these individuals for purposes of obtaining and reviewing their medical records at Green County Hospital.

c. Behavioral

A total of 48 people had been identified by company records as receiving treatment on at least one of the two occasions involving mass illness at the Keller plant. Of these, approximately 40 were available on January 31 to receive the questionnaire developed by the Behavioral and Motivational Factors Branch, NIOSH, for previous investigations of this nature. In addition, a random sample of 140 workers who had not received medical treatment on either of these two occasions received questionnaires. Thus of the 357 workers employed by Keller, 180, or approximately 50%, received a questionnaire. Participating workers were asked to take the questionnaires home, fill them out, and return them to a collection point in the plant the next day. On the following day, February 1, the completed questionnaires were collected and non-respondents were requested, via a general announcement over the plant public address system, to bring their completed survey forms with them on their return to work February 2. A total of 94 questionnaires were returned on these two days.

D. Evaluation Criteria

1. Environmental Criteria

The following occupational exposure criteria were used in evaluating the environmental contaminants found in this survey: (1) National Institute for Occupational Safety and Health (NIOSH), Recommended Criteria for Occupational Exposures, (2) American Conference of Governmental Industrial Hygienists (ACGIH), Threshold Limit Values for Substances and Physical Agents in the Workroom Environment and supporting documentation, and (3) U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), Standards (29CFR1910.1000, Table Z-1 and Z-2).

<u>Substance</u>	<u>(1) NIOSH</u>	<u>(2) ACGIH</u>	<u>(3) OSHA</u>
Carbon Monoxide	35*	50*	50*
Sulfur Dioxide	5**		
Nitrogen Dioxide	1***	5***	5***
Nuisance Particulate	-	10**	10**
Oil Mist	-	5**	5**
Noise	85dBA****	85dBA****	90dBA**

*Parts per million for an eight or ten hour Time Weighted Average (TWA) daily exposure.

**Milligrams per cubic meter air for an eight or ten hour TWA.

***Ceiling Value in ppm not to be exceeded.

****Sound pressure level A weighted network with slow meter response. Value represents an 8-hour TWA.

Appendix A, Figure I, contains a chart for determining permitted duration times for exposure to noise versus the effective noise level.

These criteria are designed to protect the average worker for an eight or ten hour day, forty-hour week, during a normal working lifetime. However, there are numerous factors that may influence an individuals response to a particular agent such as age, sex, health status, smoking habits, etc. Also, effects from exposures to combinations of agents may be additive or synergistic when the agents elicit similar physiological responses.

2. Medical Criteria

a. Toxic Substances Data¹⁻⁴

(1) Carbon Monoxide

Carbon Monoxide (CO) is an odorless, tasteless, nonirritating gas produced by incomplete combustion of organic materials. The gas enters the body via inhalation and combines with the blood hemoglobin, forming carboxyhemoglobin. The carboxyhemoglobin interferes with the oxygen carrying capacity of the blood resulting in a decreased concentration of available oxygen to the body tissues. The effects of CO exposure on man are enhanced by many environmental factors, such as individual smoking habits, cardiopulmonary status, the level of physical activity and altitude. The symptoms most commonly associated with CO toxication are headache, nausea, vomiting, dizziness, fatigue, drowsiness and finally collapse and death due to asphyxiation.

(2) Nitrogen Dioxide

Nitrogen Dioxide (NO₂) is one of several oxides of nitrogen. It is formed by the spontaneous oxidation of nitric oxide in air at ordinary temperatures.

The gas enters the body by inhalation and diffuses into the blood. Some of the gas combines with hemoglobin forming methemoglobin, which reduces the blood's oxygen carrying capacity. In addition, the gas is irritating to the mucous membranes and respiratory system. The effects commonly associated with exposure to NO₂ are coughing, eye and throat irritation; breathlessness, headache, vomiting, giddiness, stupefaction, cyanosis, delirium, fainting, unconsciousness and death. Delayed pulmonary edema results from acute exposures to high concentrations of NO₂. Chronic exposures to low levels of the gas may result in decreased pulmonary functions.

b. Physical Agent⁵

(1) Noise

Noise is any unwanted sound. It can produce a variety of effects on man, both physical and behavioral. Unwanted sounds can be mentally irritating resulting in personality changes, increased stress and task performance dysfunctions and inefficiency.

Physically, acute noise levels above 122dBA may cause immediate pain, disorientation, and hearing loss. Chronic exposures to lower levels may cause hearing impairment and increase stress conditions. The behavioral response to the increased stress may be exhibited in a variety of ways.

3. Behavioral Criteria

The survey questionnaire had been specifically developed for investigations of apparent mass psychogenic illness. In addition to sociodemographic (age, sex, level of education, marital and parental status, etc.), and epidemiological information (date and time of illness, symptomatology, location of workplace at time of illness onset, etc.), the questionnaire contained items designed to measure perceived job stress along a variety of dimensions (unwanted overtime, role ambiguity, boredom, etc.). Five standardized personality/psychodiagnostic questionnaires were also included in the study protocol. These were:

a. The Work Environment Scale

This scale measures ten dimensions of the social structure operating in the workplace which are believed to be predictive of worker satisfaction or adjustment. These are: 1) Involvement - the extent to which workers are enthusiastic or committed to their jobs; 2) Peer Cohesion - the extent to which workers are mutually supportive; 3) Staff Support - the extent to which management is

perceived as supportive by the workers; 4) Autonomy - the extent to which the 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. Rotter's Internal-External Control Scale

This is an 11 item scale designed to measure the extent to which an individual attributes causation for his experiences to internal vs. external sources. For example, it was felt that individuals experiencing vague, psychosomatic symptoms might attribute them to internal factors (stress, anxiety, fatigue) or external factors (a gas leak, a virus, etc.).

c. The Eysenck Personality Inventory (EPI)

This scale measures personality in terms of two pervasive, independent dimensions: extroversion-introversion and neuroticism-stability. There is some evidence to indicate that clinically diagnosed hysterics score lower on the extroversion scale than normals.

d. The Mini-Mult of the MMPI

This is a factor-analytically derived scale of the Minnesota Multiphasic Personality Inventory. Three subscales from this questionnaire 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 somatizes emotional or psychogenic strain or tension.

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

e. The Holmes-Rahe Recent Life Events Scale

This is a 43 item scale which measures the number of stress-inducing events which the individual has experienced in the recent past. This scale has been shown to be predictive of psychosomatic illness.

E. Results and Discussion

1. Environmental Results and Discussion

The personal sample results for total dust and oil mist are presented in Table V. As the results indicate, the operators of the band saw, redwood drill, spinner machine and press were not exposed to concentrations of nuisance dusts or oil mists which would adversely affect their health. On the other hand, noise levels in the operator's working area, as well as throughout the plant, were of a sufficient magnitude and duration to adversely affect their hearing, thus a potential health hazard from noise did exist (see Table VI).

Indicator tubes for carbon monoxide and the plant's continuous CO meter indicated that CO was present at approximately 5-7 parts per million. This was well below the health criteria and did not pose a health hazard at the time of the survey.

The results of the general area samples for sulfur dioxide (SO₂) are contained in Table IV. As indicated, the concentrations of SO₂ were very low and of no health significance. (The values obtained were lower than that found in many urban environments.)

Indicator tubes for oxides of nitrogen ranged from not detectable to 5ppm. The results of the general area samples for nitrogen dioxide, one of the oxides of nitrogen, are presented in Table III. These results indicate that the average concentration for the day were approximately one-half of the NIOSH recommended exposure criteria, which is based on fifteen minute ceiling concentration. Thus, it is difficult to determine whether or not being exposed for eight hours to an average concentration of NO₂ at half the concentration recommended for a fifteen minute exposure is such that the health of an individual would be adversely affected. It is quite likely that peak concentrations, at or above the criteria level, could have occurred for short periods of time but that the eight hour average not indicate such peaks. (In order to measure each fifteen minute period to determine the peak values, a minimum of 32 consecutive fifteen minute samples are required.) The potential for the "peaks" however exists, in that the main source of the NO₂ is diesel exhaust gases and potentially the gas fired air make-up units. The concentration of NO₂ will thus vary according to how long trucks idle at loading docks and air makeup units are operated.

The exhaust and makeup air ventilation in the facility was not properly balanced for the different possible combinations of exhaust fans and air makeup units. As indicated in Table VII, the exhaust ventilation fans could set up a negative pressure effect and draw additional airborne contaminants, (e.g. oxides of nitrogen from diesel engine emissions), into the plant when either all the fans are operating at once as was the case on the dates of the outbreaks, or when one or more of the air intake units is turned off. (Any airborne contaminant drawn into the building will be superimposed on the airborne contaminants already present in the plant.) The air intake units also dry out the air as it is heated, so that the heated air blown over the employees is extremely dry. This creates an uncomfortable and unhealthy burden on the body which contributes to

the overall stress experienced by the individual. (The NIOSH investigators experienced dry eyes and lips after a few hours in the plant.) The air intake units are also very noisy and are the main source of background noise in the plant. The complaints of "gas odors", which has been a daily occurrence for months, were found to be due to a propane gas leak in the gas line supplying the middle air intake unit. The leak was located with the OVA and the concentration of the gas was approximately 0.2% (but less than the lower explosion limit).

Although there were candy and soft drink machines located in the plant, there was no area designated as a lunch room. Thus employees milled around the work areas on breaks and at lunch time and had no place to eat or find relief from the noise.

2. Medical Results and Discussion

A total of 33 employees were interviewed. This group included nine(9) males and twenty-four(24) females. (See Table I for Demographic Data). Those interviewed were persons who had complained of becoming ill on November 19, 24 or 29, 1976. Three of the employees who were interviewed had become ill on November 19, 1976. All complained of burning eyes, shortness of breath, chest pains, and dizziness. One employee fainted and was treated in the plant's first aid station. The remaining two employees required no treatment. All three employees stated that on the morning they became ill, they could smell fumes from a truck that was parked in the loading dock with its motor running. On November 24, 1976, 32 employees became ill; 25 of these employees were interviewed. Twenty employees became ill at the plant and 5 became ill after leaving the plant. All had complained of symptoms of lightheadedness, weakness, shortness of breath, headaches, chest pains, and dizziness. Some also complained of a bad smell in the plant, and mentioned that they also had noticed a truck parked in the loading dock with its motor running. They reported that a blue haze of exhaust fumes had been hanging over the working areas. Twenty were treated at the local hospital emergency room for possible carbon monoxide (CO) exposure. Seven were admitted to the hospital. Six were hospitalized overnight and one was hospitalized for 5 days. All were released in good condition. Those employees admitted to the hospital were treated for anxiety and hyperventilation. In addition, a number of biomedical evaluations were performed. A review of the medical records received from Greene County General Hospital concerning those employees admitted to the hospital revealed no abnormalities in chest x-ray, hematology, serology, urinalysis, electrocardiogram, or blood gases.

On November 29, 1976, 27 employees became ill and all were treated by the Company Doctor in the plant first aid station. Four out of this group who were interviewed by the NIOSH medical investigator, complained that on the morning on which they became ill, they had had symptoms of lightheadedness, weakness, shortness of breath, headaches, chest pains and dizziness. They were unable

to identify any precipitating cause for illness on this day and no exhaust fumes were reported to have been present.

All employees interviewed were found to be in excellent health, with the exception of several employees under treatment by private physicians for hypertension and one employee under treatment for hyperglycemia.

3. Behavioral Results and Discussion

a. Statistical Procedures

Results from the questionnaire were analyzed by treating "affected" (three or more symptoms) vs. "nonaffected" (two or less symptoms) as a categorical outcome variable. The various response alternatives to each questionnaire item were treated as categorical predictor variables. A k (number of response categories) \times 2 (affected vs. nonaffected) contingency table was constructed for each questionnaire item. Kendall's τ coefficients were then computed for each of the resulting bivariate distributions providing a measure of the degree of relationship between each variable (questionnaire item) and health status (affected vs. nonaffected). For purposes of interpretation, the absolute value of τ provides a measure of the extent to which the response tendencies of affecteds and nonaffecteds differ on that item (assuming statistical significance). This approach was used rather than a chi-square analysis because the large number of empty cells in the k (response alternatives) \times 2 (affected vs. nonaffected) contingency tables constructed for the various questionnaire items prohibited the use of a chi-square test of independence.

An initial problem in analyzing data collected in incidents of this nature is that of defining who was, and was not, affected by the outbreak of illness. From interview and survey responses obtained from the plant employees, it was apparent that receiving medical treatment for expressed symptomatology was not a valid criterion for identifying the affecteds. As a result of the general confusion present in the plant on the days of the outbreak, medical treatment was administered on a first-come, first-serve basis. Thus individuals with pre-existing, unrelated complaints may have been included among those receiving treatment for symptoms directly associated with the outbreak. Conversely, other workers experiencing a greater range of symptoms (e.g., headache, nausea, weakness, etc.) went undetected (as determined by interview and questionnaire responses) and therefore do not appear on any official list of affected employees. It was therefore decided for purposes of data analysis, to define affected in terms of the number of self-reported symptoms obtained via the questionnaire. For the purposes of this report, individuals reporting two or less symptoms are termed "nonaffecteds, while those indicating three or more symptoms are considered to be "affecteds." Using this criterion the sample consisted of 42 affecteds (4 males and 38 females) and 52 nonaffecteds (9 males, 43 females).

b. Symptoms

Twenty-five physical symptoms, identified from the literature as often characteristic of contagious psychogenic illness, were contained on the questionnaire. Each respondent was requested to check which, if any, of the listed symptoms she/he experienced during the outbreak. Table II presents the 25 symptoms rank-ordered in terms of incidence rate for the entire sample. The seven principal symptoms were : 1) "headache" (37.2%), 2) "bad taste in mouth" (33%), 3) "dry mouth" (31.9%), 4) "dizziness" (28.7%), 5) "lightheadedness" (26.6%), 6) "tightness in chest" (26.6%) and 7) "convulsions" (25.5%).

c. Socio-Demographic Factors

There were no noticeable differences between affecteds and nonaffecteds in terms of age, sex, level of education, marital or parental status. There was evidence to indicate that the affecteds were more dependent upon their job and income for total family support than noneffecteds. The results of the survey revealed that:

(1) The affecteds had a lower total family income ($\tau = -.33$, $p < .001$) and lower personal income ($\tau = -.29$, $p < .003$) than the nonaffecteds.

(2) The nonaffecteds had more people in the household presently employed ($\tau = -.22$, $p .01$) than the affecteds.

d. Psychological Stress Factors

The affecteds indicated a higher overall level of perceived stress than nonaffecteds due to combined job and life stress factors. Compared to nonaffecteds, affecteds:

(1) reported experiencing greater pressure at work than nonaffecteds ($\tau = .30$, $p < .001$).

(2) experienced more role ambiguity, indicating an uncertainty about what was expected of them in the performance of their job, as shown by the clarity scale of the Work Environment Scale ($\tau = -.21$, $p < .02$).

(3) were more frequently bothered by noise ($\tau = .16$, $p < .05$), irritating smells ($\tau = .30$, $p < .001$), and variations in temperature ($\tau = .29$, $p < .001$) in the workplace.

(4) reported experiencing more life stresses (e.g., death of family member, divorce, etc.) on the Life Events Scale over the past year, ($\tau = .15$, $p < .04$).

e. General Health Factors

Although there was no difference between the affected and nonaffected workers in their response to an item asking them to evaluate their general health, the affected workers reported being bothered more frequently by: 1) feelings of nervousness or tension ($r = .17$, $p < .04$), 2) sneezing spells ($r = .31$, $p < .001$), 3) colds ($r = .18$, $p < .03$), and 4) spells of exhaustion ($r = .20$, $p < .03$). The affected workers also reported taking more sick days during an average month than nonaffecteds ($r = .17$, $p < .05$).

f. Personality Factors

The affected workers scored significantly higher on the "Hysteria" scale of the Minnesota Multiphasic Personality Inventory (MMPI) than the unaffecteds ($r = .30$, $p < .003$). This scale is designed to assess the individual's tendency to express psychological stress or conflict through somatic complaints or ailments.

The findings of the present investigation are in general agreement with previous reports of mass illness having an apparent psychogenic component (Kerckhoff and Back, 1968; Kross and Shepard, 1975; Stahl and Lebedun, 1974). These studies have suggested that stress-induced behavioral contagion affects primarily women engaged in a predominantly female workforce who are collectively experiencing considerable job stress and concomitant physical strain. The specific symptoms may vary across incidents, but typically consists of subjective somatic complaints (e.g., headaches, nausea, chills, etc.) which the affected individuals experience in response to job or life stresses. The actual outbreak of illness is usually triggered by a physical stimulus (e.g., an odor, a bug bite, etc.) which is perceived by one or more workers and which is believed to be the source of their experienced discomfort. As the rumor begins to spread that workers are becoming ill because of a physical hazard in the workplace, the overall anxiety may reach such a point as to necessitate a plant shutdown.

The present study indicated that, compared to nonaffected workers, the affected workers were more often bothered by physical (noise, variations in temperature, and irritating odors) and psychological (production pressures, role ambiguity) stressors on the job. The impact of these job stresses may have been exacerbated by the affecteds' feeling of being "locked into" the job due to their dependency on their employment for personal and family financial support. It should also be noted that although the affecteds and nonaffecteds did not differ in terms of self-reported estimates of general health, the affecteds reported experiencing more transient complaints of a psychogenic nature (e.g., feelings of tension, sneezing spells, spells of fatigue or exhaustion) during an average month, and took more sick days per average month than the nonaffecteds. This is consistent with the findings that the affected workers scored higher on the "Hysteria" scale of the MMPI than nonaffecteds, indicating a tendency for affecteds to

somatize psychological stress or conflict. This is not intended to imply that the affected workers did not experience "real" symptoms, but rather suggests that the symptoms experienced by the affected workers may have been in part, induced by combined job and life stresses. Given this setting, it is possible that the presence of a strange odor (as reported by a number of employees) or witnessing others become ill, may have provided the affected workers with an explanation for the physical ailments they were experiencing and triggered a contagion reaction.

F. Conclusions

Based on all the information gathered, there is no definite evidence that a toxic substance, in the workplace, caused the episodes of illness experienced by the employees of Keller Aluminum Furniture of Indiana. However, there is considerable evidence that a potential health hazard situation could develop, but did not on the dates of the NIOSH survey. The combination of inadequate ventilation, truck loading docks on the prevalent wind side of the building, noise, dry air, etc. are such that, at times, environmental contaminants and/or conditions could develop to a point where employees are unable to cope, either physically or behaviorally. The symptomatology of the employees who became ill, is consistent with the toxicological effects of oxides of nitrogen even though, at the time of the survey, environmental sampling did not establish toxic concentrations. The affected employees' tolerance to environmental stresses could be lower however because of the additional stresses they must cope with (e.g., noise, dry air, variable temperatures, gas odors, etc.), on a daily basis while performing their work functions.

The NIOSH investigators' hypothesis is that, a number of employees were exposed to levels of CO and NO₂, resulting from diesel emissions and inadequate ventilation, and developed signs and symptoms of intoxication to those substances. These employees were in turn observed by other employees, who responded to the situation in a "hysteria" manner. The knowledge of the similar gas experience of 1971, was probably also a contributing factor in the development of the "contagion reaction."

V. RECOMMENDATIONS

1. The plant's continuous CO monitor should be calibrated daily.
2. The sources of noise should be confined or isolated, possibly by building booths around them. (Particularly the radial saw). In addition, the radial saw, spinner machine and rivet gun operators should be provided with approved hearing protectors. These employees should also have yearly audiometric exams (some choice in the type of hearing protection equipment should be available so that proper fitting comfortable equipment is obtained). The use of the protectors should be mandatory for those jobs whose noise levels are excessive. Also, rotation of employees could reduce the individuals daily dose.

3. Some form of humidification should be considered. (See Appendix A, Figure II for a chart of air comfort, determined by relative humidity and temperature.) This would help to reduce the body stress and cost of temperature control. Relative humidity measurements were not directly performed. The subjective determination were inferred by 2 impinger samples evaporating to dryness in a very short time in the area where the air intake ducts blow air into the plant. Also, the investigators experienced dry eyes and lips within a few hours in the plant and employees complained of feeling "dried out".

4. Trucks should not be allowed to idle while at the loading docks unless appropriate controls are provided. However, since diesels are hard to start on extremely cold days, there should be some type of flexible exhaust stacks. These could then be positioned such that the exhaust gases are emitted further from the building, thus much less likely to be drawn or blown into the building.

5. An area should be set aside for a lunch room. This area should be kept clean and quiet.

6. Coveralls or jumpsuits could be provided so that the employees do not get oil on their clothes. (All the aluminum tubing has been pretreated with oil.) The clothes provided could be laundered by an outside contractor or the facility could install its own industrial washer and dryer. This could greatly improve morale and productivity.

7. The ventilation system should be reevaluated so that the appropriate balance of exhaust fans and air makeup units are used for each operating condition. (e.g. For each air makeup unit operated, a different number of exhaust fans will be required.) Also, the air makeup units need to be insulated with a noise attenuating material to reduce their noise output which is the main source of the plant's background noise.

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TABLE I
 KELLER ALUMINUM PLANT
 LINTON, INDIANA
 HHE 77-27

DEMOGRAPHIC DATA
 FEBRUARY, 1977

<u>Number Assigned to Department</u>		<u>Number Interviewed by NIOSH</u>	
Eyelet Department			
M	F	M	F
2	43	1	10
Spinning Department			
M	F	M	F
15	35	2	6
Lounge Line 1			
M	F	M	F
10	37	3	1
Lounge Line 2			
M	F	M	F
10	39	1	2
Chair Line 1			
M	F	M	F
6	83	1	1
Chair Line 2			
M	F	M	F
7	56	0	4
Maintenance Department			
M	F	M	F
8	0	1	0
TOTAL			
M	F	M	F
58	293	9	24

TABLE II

Symptoms rank-ordered in terms of frequency of occurrence
for the entire sample (N=94)
Keller Aluminum Industries
Linton, Indiana
February, 1977

<u>Symptom</u>	<u>n affected</u>	<u>% of total sample having symptom</u>
1. Headache	35	37.1%
2. Bad taste in mouth	31	33%
3. Dry mouth	30	31.9%
4. Dizziness	27	28.7%
5. Lightheadedness	25	26.6%
6. Tightness in Chest	25	26.6%
7. Convulsions	24	25.5%
8. Nausea	20	21.3%
9. Abdominal pain	17	18.1%
10. Ringing in ears	17	18.1%
11. Watery eyes	17	18.1%
12. Sleepiness	15	16%
13. Blurred vision	13	13.8%
14. Racing heart	10	10.6%
15. Difficulty swallowing	10	10.6%
16. Passed out	9	9.6%
17. Numbness	9	9.6%
18. Tingling feeling	7	7.4%
19. Vomiting	7	7.4%
20. Chest Pain	5	5.3%
21. Fever	4	4.3%
22. Muscle soreness	4	4.3%
23. Weakness	4	4.3%
24. Diarrhea	2	2.1%
25. Couldn't catch breath	2	2.1%

TABLE III
 Results of Air Sampling for Nitrogen Dioxide
 Keller Aluminum Industries
 Linton, Indiana
 February 7, 1977

<u>Sample Description</u>	<u>Sample Time</u>	<u>Concentration Nitrogen Dioxide (ppm)*</u>
#1 General Area-Section A1 (Spinner Machines)	8:22-16:47	0.53
#2B General Area-Section C1	12:30-16:50	0.40
#3 General Area-Section D2	8:27-16:52	0.43
#4 General Area-Section D5	8:29-12:30	0.57
#4B General Area-Section D5	12:33-16:53	0.41 --- .49 ave.
#5 General Area-Section A7	8:36-12:38	0.56
#6 General Area-Eyelet Dept.	8:34-16:53	0.21
#7 General Area-S.W. (Lounge Chair Line #1)	8:40-16:54	0.48
#9 General Area-S.E.	8:41-12:43	0.62
#9B General Area-S.E.	12:55-16:54	0.34 --- .48 ave.
#10 General Area-Offices	8:07-16:46	0.17

* parts per million

TABLE IV
 Results of Air Sampling for Sulfur Dioxide
 Keller Aluminum Industries
 Linton, Indiana
 February 7, 1977

<u>Sample Description</u>	<u>Sample Time</u>	<u>Concentration Sulfur Dioxide (mg/M³)**</u>
A. General Area-Section C12 (Redwood Chair Line)	8:46-16:53	0.08
B. General Area-Section A7	8:36-16:52	0.08
C. General Area- (Chair Line #2)	8:43-16:52	0.06
D. General Area-Section C1	8:25-16:50	0.08
E. General Area-Section D5	8:29-16:50	0.06
F. General Area-Section A1	8:22-16:47	0.09

The NIOSH Recommended Standard for Occupational Exposure to Sulfur Dioxide is 5 mg/M³ as an 8 or 10 hour Time Weighted Average (TWA) daily exposure.

** milligrams per cubic meter air

TABLE V
 Results of Air Sampling for Total Dust and Oil Mist
 Keller Aluminum Industries
 Linton, Indiana
 February 7, 1977

<u>Sample Description</u>	<u>Sample Time</u>	<u>Total Weight (mg/M³)*</u>	<u>TWA**</u>
G. Spinner Operator	8:08-15:45	0.56 ¹	0.53
J. Press Operator	8:15-15:49	0.20 ¹	0.19
H. Redwood Drill Operator	8:05-15:45	0.42 ²	0.40
I. Radial Saw Operator	8:10-15:45	0.61 ²	0.58

1. The ACGIH Threshold Limit Value, (TLV) for Occupational Exposure to Oil Mist particulates is 5 mg/M³ for an 8-hour TWA daily exposure.
2. The ACGIH Threshold Limit Value for Occupational Exposure to Nuisance Dust is 10 mg/M³ for an 8-hour TWA daily exposure.

* milligrams per cubic meter air
 ** eight hour Time Weighted Average

TABLE VI
 Results of Noise Measurements
 Keller Aluminum Industries
 Linton, Indiana
 February 7, 1977

<u>Area of Measurement</u>	<u>Time of Measurement</u>	<u>Noise Level in dBA*</u>	<u>Peak</u>
1. Spinner Machine Operator	10:05	96-103	
2. Redwood Drill Operator	10:06	87-93	
3. Radial Saw #1 Area	10:08	92-104	109
4. Radial Saw #2 Area	10:10	88-94	105
5. Area between Spinners and Wooden Arm Rest Drills	10:20	102-108	
6. Radial Saw for Aluminum Braces	10:25	90-91 (Background)	122 (When Cutting)
7. Support Rod Cutting	10:30	85-95	
8. Drill-Plastic Arm Rests	10:40	97-105	
9. Leg Capper	10:45	92-97	
10. Punch Machine #1	10:50	96-106	
11. Punch Machine #2	10:55	98-104	
12. Press-Lounge Chair Line #1	10:57	87-90	102
13. Redwood Line Rivet Machine	11:05	83-88 (Background)	112
14. Chair Line #2 Area	11:15	84-86	
15. Lounge Chair Line #1 Area	11:25	88-92	
16. Eyelet Department	13:58	81-89	
17. Press Lounge Chair Line #1	14:40	81-87 (Background)	
18. Rivet Gun	14:42		117

* Slow response scale

TABLE VII
 Results of Ventilation Measurements
 Keller Aluminum Industries
 Linton, Indiana
 February 1-2, 1977

A. Gas Fired Air Makeup Units¹
Intake (CFM)*

Unit # 1 15,700
 Unit # 2 48,500
 Unit # 3 14,500

Total approximate Intake 78,700 (CFM)*

B. Wall Exhaust Fans²
Exhaust (CFM)*

#1 7,718
 #2 Not Operating
 #3 7,397
 #4 10,073
 #5 Not Operating
 #6 9,215
 #7 Not Operating
 #8 7,718
 #9 Not Operating
 #10 Not Operating
 #11 Not Operating

Total approximate Exhaust 42,121 (CFM)*

1. Units operated as needed for Temperature Control. The number of units operated at any given moment is highly variable and depends on how cold it is and how much heating is required.
2. If the six fans not operating, as indicated, are as effective as the average of the other fans then an additional 58,969 (CFM) could be exhausted. This additional exhaust would create even a greater negative pressure if one or more of the air makeup units was not operating. The company indicated that on the dates of the outbreaks all the exhaust fans were on, but that they didn't know how many, if any, of the air makeup units were operating. The converse is depicted in the tables when a positive pressure system was in effect due to the three makeup units being operated and only five of the eleven exhaust fans operating.

*Approximate cubic feet per minute

Appendix A
Figure I

LINE A
FORMULA: $T = 16 + 2(L-80)/5$
RANGE: 80 to 115 dBA-Slow

LINE B
FORMULA: $T = 16 + 2(L-85)/5$
RANGE: 85 to 115 dBA-Slow

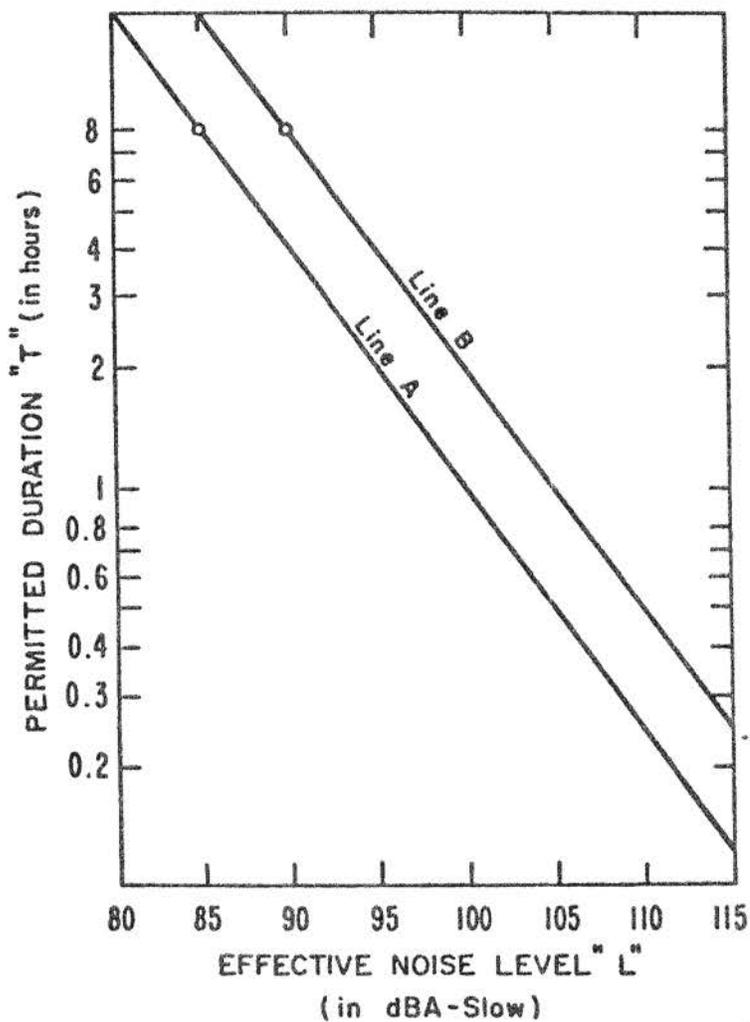
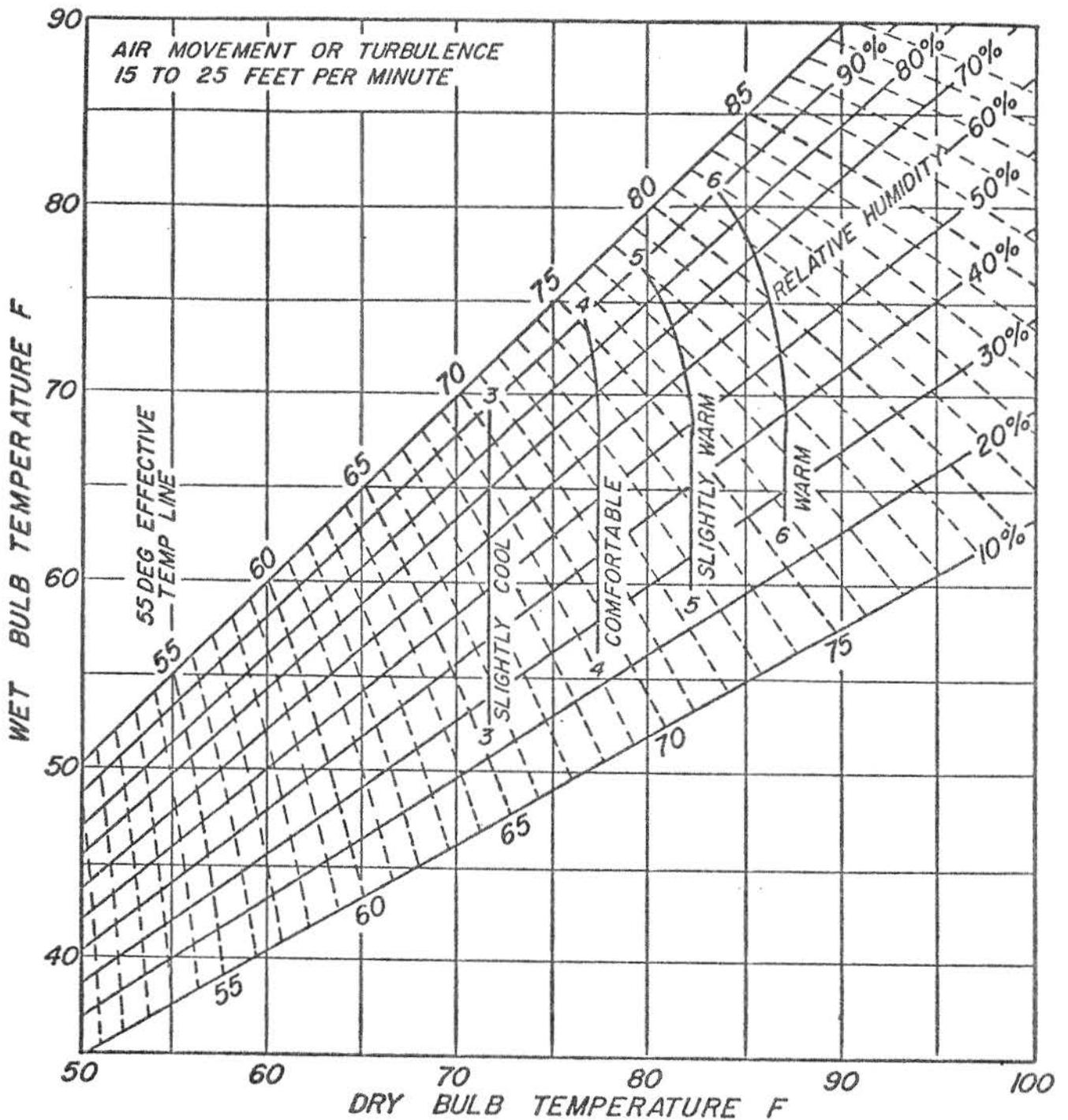


Figure I-1. Permitted duration vs. noise level.*

*The indicated duration limits which exceed 8 hours are to be used only for purposes of computing Daily Noise Dose and are not to be regarded as defining noise exposure limits for work days which exceed 8 hours.

Appendix A

FIGURE II



Notes

1. Effective Temperature (dashed) lines indicate sensation of warmth immediately after entering conditioned space.
2. Solid lines 3, 4, 5, and 6 indicate sensations experienced after three hour occupancy.
3. Both sets of curves apply to people at rest and normally clothed.

Fig. 3-3. Comfort chart for still air. Courtesy of the American Society of Heating, Refrigeration and Air Conditioning Engineers.