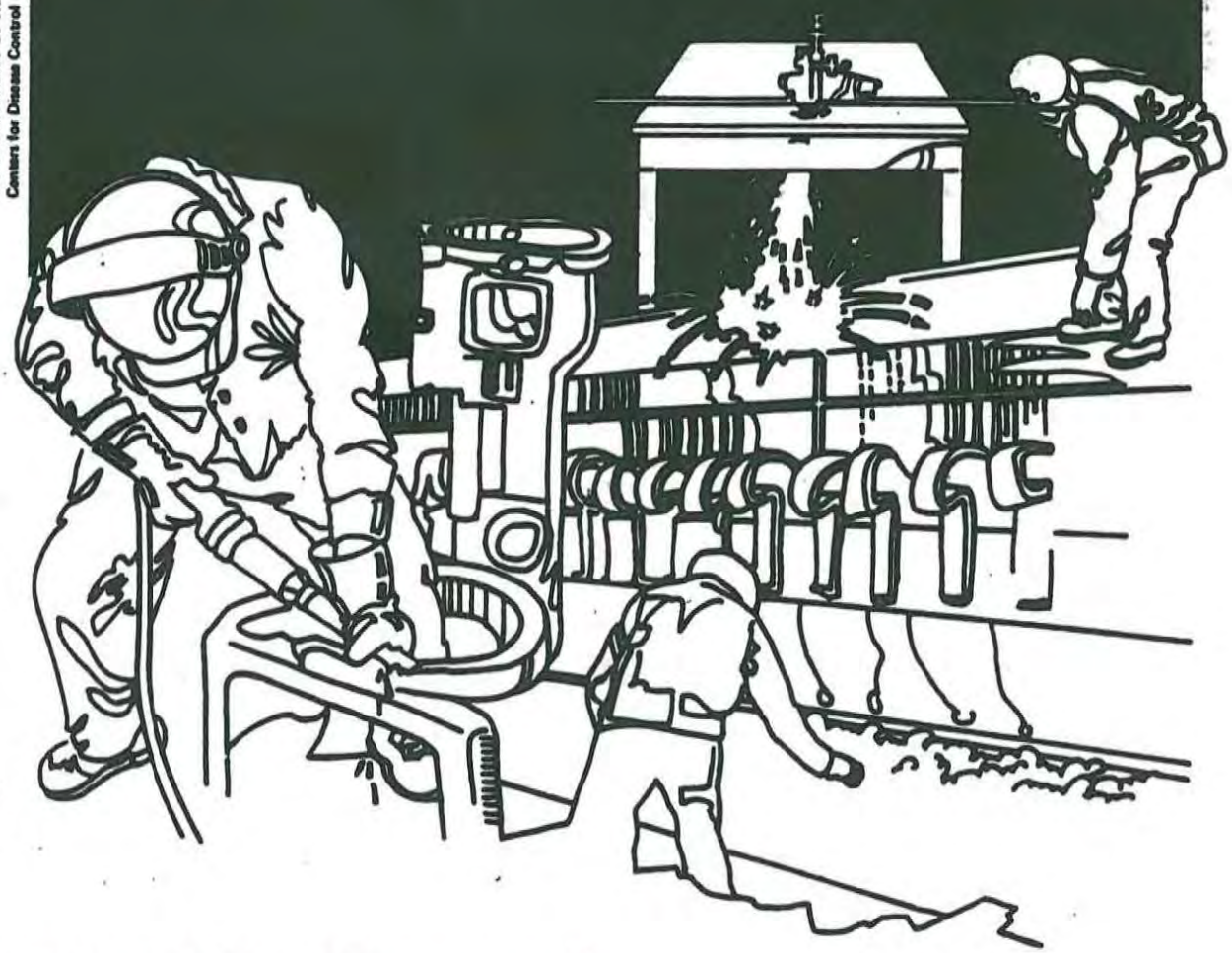
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

HETA 83-116-1570
ESSEX GROUP, INCORPORATED
VINCENNES, INDIANA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 83-116-1570
MARCH 1985
ESSEX GROUP, INCORPORATED
VINCENNES, INDIANA

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I. SUMMARY

In January 1983, NIOSH received a request to evaluate reported skin and upper respiratory tract problems at Essex Magnet Wire and Insulation, Vincennes, Indiana. In March and September 1983, NIOSH industrial hygienists and epidemiologists visited the plant to collect environmental samples, review company environmental data, and interview workers.

Personal breathing zone monitoring of workers in the Enamel Department revealed no time-weighted average (TWA) exposures in excess of recommended criteria. Toluene diisocyanate (TDI) exposures ranged from nondetectable to 35 ug/m^3 (NIOSH recommended exposure limit: 36 ug/m^3). Cresol exposures ranged from 0.4 to 2.2 mg/m^3 (NIOSH recommended exposure limit: 10 mg/m^3). Phenol exposures ranged from 0.3 to 1.5 mg/m^3 (NIOSH recommended exposure limit: 19 mg/m^3). No dimethyl terephthalate was detected.

Symptoms reported by questionnaire included shortness of breath, chronic cough, chronic phlegm production, wheezing, eye and throat irritation, stuffy nose, lightheadedness, dizziness, and headache. The prevalence of symptoms, however, was not statistically significantly greater in workers exposed to emissions from enameling ovens than in unexposed workers.

Exposures in excess of currently acceptable limits were not documented. Respiratory and other non-dermatologic symptoms were frequent, but could not be epidemiologically associated with specific workplace exposures or work areas.

Recommendations for better work practices are presented in Section VII of this report.

KEYWORDS: SIC 3643 (Current-Carrying Wiring Devices), wire enameling, isocyanates, TDI, cresol, phenol, respiratory symptoms.

II. INTRODUCTION

A. Background

On January 19, 1983, the National Institute for Occupational Safety and Health received a request from the International Union of Allied Industrial Workers for an evaluation of skin and upper respiratory tract problems experienced by employees at the Essex Magnet Wire and Insulation Division of United Technologies, Inc., in Vincennes, Indiana.

On March 7-9, 1983, a NIOSH industrial hygienist and epidemiologist visited the facility and conducted a walk-through inspection, collected environmental data, reviewed company environmental data, and interviewed first shift workers with a standardized questionnaire. This information was used to design the protocol for the follow-up evaluation.

An interim report issued in June 1983 presented the results of the initial visit and outlined the follow-up study protocol.

A follow-up visit was made on September 9-13, 1983. This visit consisted of more comprehensive and specific environmental sampling, and interviews with a larger worker population.

B. Process Description

Essex manufactures copper and aluminum insulated wire for a variety of electrical uses. The process of interest in this evaluation is best described by departments. Testing/Quality Control and Shipping/Receiving functions are ordinary processes and will not be discussed here.

1. Concast Department

The Concast (an abbreviation for continuous casting) Department adds bulk copper sheets, called cathodes, in the top of a furnace. The molten copper extrudes from the bottom and is quenched and shaped eventually to 3/8" rod. The copper rod is then relocated to the roof of the building, where it is fed downward into the Rod and Wire Mill Department. The coolant used in Concast is an alcohol/water solution. The personnel operational titles are A operator (responsible for the operation of the casting machine) and B operator (responsible for the feed rate of the cathodes and truck loading of the rod as it exits from the casting machine).

2. Rod and Wire Mill Department

The 3/8" rod is first passed through a shaving machine which removes burrs and any material left from Concast. The rod is then passed through increasingly smaller wire mills until the desired gauge is obtained. An oil-based lubricant is used for copper wire while a water-based lubricant is used for aluminum. Personnel operational titles are simply operator; e.g., shaver operator.

3. Enameling Department

There are three enameling departments, so designated by the gauge of wire coated: 200, 300, and 400. The process is basically the same in both the 200 and 300 departments: wire from a spool is fed through either a trough filled with liquid enamel or enamel-soaked pads, and then fed vertically into a drying oven which vaporizes the volatile components of the enamel compound and leaves the solid material on the wire. The number of passes a section of wire makes through this arrangement determines the thickness of the coating. Once coated to specifications, the wire returns to a spool. The 400 series enameling process was not in operation; its principle is the same except that the material flow is horizontal rather than vertical.

Personnel operational titles in this department are operator and rover. Both are responsible for the operation of the enameling machines, referred to generally as ovens. This work involves setting up the wire for the correct number of passes through the process, changing the type of enamel to be applied, and repairing "wrecks" - a broken wire or a wire that has run outside its guides. The distinction between operator and rover is mainly one of title since they both do the same tasks. However, an operator may be responsible for one bank of four ovens, while a rover may be a helper on more than one (usually eight ovens).

4. Clean Room

Machine parts are cleaned of enameling materials and other compounds in degreasing tanks located in the Clean Room. The job title for this operation is Clean Room mechanic.

There have been no major production changes since 1967. It is a 24 hour/day, 7 day/week operation employing approximately 200 workers at the time of the survey. Due to economic conditions this number has varied.

III. STUDY DESIGN

A. Environmental

1. Initial Visit (March 1983)

The purpose of the initial survey was to become familiar with the operation and to collect air and bulk liquid samples to be used in identification of potential contaminants which might be related to the health complaints reported on the medical questionnaire. Area samples were collected in locations considered to be the most likely to yield high concentrations of airborne contaminants (at the rod extrusion point in the Concast pit, over the enamel application point, and in the plume at the top of the enameling ovens). Personal breathing zone samples were collected also.

2. Follow-up Study (September 1983)

Based on the results of the initial medical questionnaire, a follow-up study was designed to evaluate worker exposure to substances in the Enamel Department potentially causing respiratory problems. These substances fell into two categories: (1) those reported to cause pulmonary sensitization, such as isocyanates [TDI and methylene bisphenyl isocyanate (MDI)], and (2) those reported to cause respiratory irritation, such as isocyanates, phthalates, phenol, cresol, and anhydrides. However, the enamel containing anhydrides was not in use during the September survey. Since these potential exposures would be expected to occur primarily to the Enamel Department, sampling was confined to this department.

Table 1 details the substance sampled for and the sampling and analytical method employed in both visits.

B. Medical

1. Initial Visit (March 1983)

During the initial visit a medical and occupational history questionnaire was administered to all employees from one shift. The departments interviewed included Concast, Rod and Wire Mill, Enameling, Shipping/Receiving, and Office. The questionnaire collected information concerning demographic data, occupational history at Essex Group, Inc., respiratory symptoms, smoking history, and health conditions, particularly skin conditions. After obtaining informed consent, hair and nail samples for copper analysis were collected from employees in the Concast and Rod and Wire Mill areas.

2. Follow-Up Visit (September 1983)

During the follow-up visit the identical questionnaire, with very minor revisions, was administered to employees from all four shifts in the Enamel and the Concast Departments. (The minor revisions consisted, for example, of eliminating some of the health conditions which were reported by very few workers during the initial visit.)

IV. EVALUATION CRITERIA

A. General

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

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of

occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

B. Specific Substances

1. Copper[1]

Health effects resulting from exposure to copper fume in excess of recommended exposure levels consist of irritation of the upper respiratory tract, metallic or sweet taste, nausea metal fume fever (a syndrome consisting of fever, chills, throat dryness, shortness of breath, weakness, fatigue, and muscle and joint pain occurring four to twelve hours after exposure), and in some instances discoloration of the skin and hair. Copper salts can act as skin irritants, producing itching and dermatitis; and on the eye, conjunctivitis or even ulceration and clouding of the cornea. The TLV and OSHA standard for copper fume are 0.1 mg/m^3 8-hour TWA, and for copper dusts and mists, 1.0 mg/m^3 TWA 8-hour TWA.

2. Aluminum[1]

Aluminum is considered to be an "inert" particulate, for there has been no documentation that aluminum causes either irritation or lung disease in man. Airborne concentrations should be kept below the TLV and OSHA standard of 10 mg/m^3 8-hour TWA to prevent excessive accumulations of dust causing safety (vision, slipping) and housekeeping problems.

3. Cresol[2] (all isomers)

Cresol is not volatile enough to constitute a respiratory hazard under normal conditions, but it is a strong irritant and can cause dermatitis. If large areas of the skin become wet with cresol and are not washed off immediately, serious poisoning can result. The NIOSH recommended standard is 10 mg/m^3 10-hour TWA. The OSHA standard is 22 mg/m^3 8-hour TWA.

4. Phenol[3]

Phenol is similar to cresol in both chemical characteristics and health effects, i.e. low volatility, skin absorption and irritation. The NIOSH recommended standard is 20 mg/m^3. 10-hour TWA, while the OSHA standard is 19 mg/m^3, 8-hour TWA. These levels are identical except for the time-weighted period.

5. Polynuclear aromatic hydrocarbons (PAHs or PNAs)

PAHs are a class of compounds consisting of various arrangements and substitutions of multiple benzene rings. PAHs result mainly from the combustion or high-temperature treatment of coal-derivatized materials. PAHs have been shown to cause skin cancer in laboratory animals. Epidemiological studies of the cancer mortality rates among steel workers, roofers and gas workers indicate that high PAH exposure is associated with increased mortality from lung and kidney cancer.[4,5,6,7] Consequently, NIOSH recommends that exposure to PAHs be reduced to the extent feasible by engineering control and personal protective equipment.

6. Nitrosamines[8,9,10,11]

Nitrosamines are substances which have a N-N=O linkage. The vast majority of direct biological evidence reported for the carcinogenicity of nitrosamines has been gathered using laboratory animals. The evidence of carcinogenicity in man is only indirect. Studies have shown nitrosamines to be versatile in their induction of organ tumors with practically all locations reported as the target of at least one compound. In keeping with general policy regarding potential human carcinogens, NIOSH recommends that exposure to nitrosamines be reduced to the lowest extent feasible by engineering control and personal protective equipment.

7. Isocyanates[12]

Isocyanates, in particular, toluene diisocyanate (TDI) and diphenylmethane diisocyanate (MDI), cause sensitization of the respiratory tract, a severe immunotoxicologic reaction usually beginning after a latent period with repeated exposures. Another type of respiratory response, especially with TDI, is irritation of the nose and throat and a choking sensation. The OSHA standard for TDI is 0.14 mg/m^3 and 0.2 mg/m^3 for MDI. Both are ceiling concentrations. On the other hand, NIOSH recommends that TDI exposures be limited to .036 mg/m^3 8-hour TWA with a 0.14 mg/m^3 ceiling, and MDI exposures be

limited to 0.05 mg/m^3 8-hour TWA with a 0.2 mg/m^3 ceiling. However, persons sensitized or believed to have been sensitized should not be exposed to any concentrations of isocyanates.

8. Chlorobenzene[1]

Chlorobenzene has the characteristic odor of mothballs, which is reported to be noticable at approximately 1.0 mg/m^3. Health effects from exposure in excess of the TLV and OSHA standard of 350 mg/m^3 8-hour TWA are headache, dizziness, digestive disorders, and numbness and tingling in the hands and fingers.

9. Xylene[13]

The three isomers (o-, m-, and p-) are indistinguishable in terms of health effects. Commerical xylene is usually a mixture of all three isomers. Xylene is a skin, eye, and upper respiratory tract irritant. Xylene exposure in excess of the NIOSH recommended standard of 425 mg/m^3 10-hour TWA may cause nervous system depression, headache, fatigue, irritability, and gastrointestinal disturbances (nausea, anorexia). The OSHA standard is 435 mg/m^3 8-hour TWA.

10. n-Hexane[1]

n-Hexane is a skin and eye irritant, inhalation hazard (causing euphoria, dizziness, numbness of limbs, respiratory tract irritation) and ingestion hazard (causing nausea, vertigo, general intestional irritation and central nervous system depression). Moreover, n-hexane causes motor neuropathy. The TLV is 180 mg/m^3 8-hour TWA and the OSHA standard is 1800 mg/m^3 8-hour TWA.

11. Ethanol[1]

The main occupationally related health effects due to exposure to ethanol vapor are irritation of the eyes and upper respiratory tract. The effects from ingestion are widely documented and understood. The TLV and OSHA standard for ethanol are 1900 mg/m3 8-hour TWA.

12. n-Butanol[1]

n-Butanol vapor causes mild eye irritation and can be absorbed through the skin. The TLV and OSHA standard are 300 mg/m^3 8-hour TWA.

13. Dimethyl Terephthalate[14]

Dimethyl terephthalate has a low acute oral toxicity, is not absorbed through the skin, and is not a skin irritant or sensitizer. It is an isomer of dimethyl phthalate, but apparently is not as toxic. The TLV and OSHA standard for dimethyl phthalate are 5 mg/m^3 8-hour TWA with a short-term exposure limit of 10 mg/m^3. Maintaining exposures of dimethyl terephthalate below these levels should adequately protect workers.

V. RESULTS AND DISCUSSION

A. Environmental

1. Initial Visit (March 1983)

The data have been presented in an interim report dated June 1983, and are summarized below:

a. Worker exposure to copper dust in the Concast and Wire and Rod Mill Departments (4 samples) ranged from 0.02 to 0.14 mg/m^3 8-hour TWA. The recommended exposure limit is 1.0 mg/m^3.

b. Organic solvent exposure (8-hour TWA) to two Enamel Department operators and one Clean Room mechanic were: chlorobenzene, 0.1-0.3 mg/m^3; xylene, 3.4-15.5 mg/m^3; ethanol, 0.2-14.1 mg/m^3; n-hexane, 0.1-1.4 mg/m^3; n-butanol, non-detectable - 0.3 mg/m^3. The recommended exposure limits are 350, 435, 1900, 180, and 150 mg/m^3, respectively.

c. PAHs detected in the oil-based rod and wire mill lubricant were: fluoranthrene (<4.2 ppm), pyrene (non-detectable), benzo(a)anthracene (<5.2 ppm), benzo(e)pyrene (22 $\pm$ 2 ppm), and benzo(a) pyrene (<4.0 ppm).

d. Nitrosamines were not detected in either the Concast quench liquid or the water-based rod and wire mill lubricant.

2. Follow-up visit (September 1983)

Personal breathing zone air sampling was conducted on three shifts covering 24 hours of production. Twelve samples for TDI, 4 samples for phenol, 6 samples for cresols, and 6 samples for phthalates were collected. These data are presented in Table 2 through 5.

a. One of 12 personal samples had detectable TDI - 35 ug/m^3, 8-hour TWA obtained from a 300 series Rover (Table 2). This exposure is 97% of the NIOSH recommended exposure limit of 36 ug/m^3.

   Six of 12 samples for isocyanates indicated that there was exposure to some substance(s) other than monomeric TDI which reacted with the sampling reagent [1(2-methoxyphenyl)piperazine] in a similar fashion. This sampling and analytical method is designed to evaluate exposure to monomeric (MDI, TDI) as well as polymeric forms of isocyanates. However, it is suspected that substances such as polyester intermediates and blocked TDI (monomeric TDI reacted with compounds containing a reactive hydrogen atom in order to reduce the hazard of TDI) may act as positive interferences. Therefore, we cannot conclude that the additional exposure is due to polymeric TDI or other isocyanates such as MDI. It is possible that the sample results reflect polymeric TDI exposure since TDI is in the enamel formulation used; however, laboratory evaluation of the reactivity of blocked TDI and polyester intermediates with the piperazine reagent would be necessary before this could be confirmed.

b. Cresols exposures ranged from 0.4 to 2.2 mg/m^3 8-hour TWA, which is at most only 22% of the recommended exposure limit (10 mg/m^3) (Table 3).

c. Phenol exposures ranged from 0.3 to 1.5 mg/m^3, 8-hour TWA, which is only 8% of the recommended exposure limit (19 mg/m^3) (Table 4).

d. All samples for dimethyl terephthalate were below the limit of quantitation (20 ug/m^3) (Table 5).

If the three substances detected - TDI, cresol, and phenol - are considered as upper respiratory tract irritants, their combined or additive exposure must be considered. Assuming a worst case, that is, if the highest concentration for each individual substance for each job classification are added together, the combined exposure, for that job classification, is estimated. These data are presented in Table 6. A job classification would be considered overexposed if the combined exposure exceeded 100% of that allowed. Combined exposures ranged from less than 50 to 111% of the combined exposure limit. This combined substance exposure occurred in the 300 series rover classification.

B. Medical

1. Initial Visit (March 1983)

During the initial visit the questionnaire was administered to 41 employees from one shift: six from Concast, eight from the Rod and Wire Mill, 15 from Enamel, and 12 from Shipping/Receiving and the Office.

Ten (67%) of 15 workers in the Enamel Deppartment, and five (83%) of six workers in the Concast Department, reported chronic cough, compared to two (17%) of 12 workers from Shipping/Receiving and Office. These differences are statistically significant ($X^2 = 4.88$, $p<0.05$; and $p = 0.01$, Fisher's exact test, two-tailed, respectively). In addition, eight (57%) of 14 workers in the Enamel Department reported wheezing most days at work, compared to none of 12 Shipping/Receiving and Office workers. This difference is also statistically significant ($p = 0.002$, Fisher's exact test, two-tailed). Smoking could not account for all of these differences; current and former smokers constituted 83%, 73%, and 58% of the Concast, Enamel, and Shipping/Receiving/Office groups, respectively, and current smokers constituted 16%, 47%, and 33%, respectively.

All six employees in the Wire Mill reported dermatitis (excluding burns) within the last month. Burns on the job within the past year were reported by five (83%) of six workers in the Concast Department and by 12 (80%) of 15 workers in the Enamel Department.

Hair and nail samples from 14 employees in Concast and the Rod and Wire Mill were not analyzed because of the low exposure levels of copper detected in the air samples from these departments.

2. Follow-up Visit (September 1983)

a. Enamel and Quality Control Departments.

During the follow-up visit, 108 workers from all four shifts from the Enamel, Quality Control, and Concast Departments were interviewed. Some employees in the Quality Control Department had work stations located in the Enamel Department. Therefore, all employees located in the Enamel Department were classified into a greater or a lesser exposure group: oven workers (44 workers) and non-oven workers (36), respectively. Oven workers included operators and rovers (Enamel Department) who worked in

proximity to the enameling ovens. Non-oven workers included production repair workers (Enamel Department) and inspector-packers and roving inspectors (Quality Control Department).

Table 7 first classifies workers by location within the Enamel Department (that is, as oven workers or non-oven workers) and by current smoking status. The two exposure groups has comparable proportions of current smokers, 30% in oven workers and 39% in non-oven workers. Although oven workers appeared to have higher prevalences of chronic cough, chronic phlegm, shortness of breath, and wheezing most days at work than did non-oven workers, none of the differences was statistically significant. The differences between the two exposure groups for the prevalences of chronic cough, chronic phlegm, and wheezing most days at work were also present in non-smokers, but the relatively few non-smokers reporting these symptoms precluded the differences from being statistically significant.

The six most commonly reported non-pulmonary symptoms are shown in Table 8. Although each had a greater prevalence among oven workers than among non-oven workers, none of the differences was statistically significant. (The probability that all six would be more prevalent in one group is only 0.016 if one makes the assumption that the symptoms are all independent, but this assumption is most likely wrong.)

b. Eleven workers in the Concast Department were interviewed (Table 9). The prevalences of some respiratory symptoms were higher than those of oven workers, and the prevalences of all five were higher than those of non-oven workers. None of these differences, however, was statistically significant, probably because of the relatively small number of Concast Department workers. (For the largest apparent difference, chronic cough in 10 of 28 non-oven Enamel workers and seven of 11 Concast workers, $p = 0.07$ by Fisher's exact test, two-tailed.) The prevalences of non-pulmonary symptoms among Concast workers were not, given the number of interviewees, remarkably different from those of either oven or non-oven workers in the Enamel Department area.

VI. CONCLUSIONS AND RECOMMENDATIONS

No exposures in excess of currently acceptable workplace limits could be documented. Respiratory and other non-dermatoligic symptoms were frequent but could not be epidemiologically assoicated with specific workplace exposures or work areas.

VII. RECOMMENDATIONS

The following recommendations are made in order to improve certain aspects of the work environment.

1. Employees should wear respirators during the brief times they must go above the ovens to work. A more formal program, with more support by management, might be helpful in winning worker acceptance of respirators.

2. Forklift trucks should be properly tuned to reduce carbon monoxide and other emissions.

3. Spills should be cleaned up as soon as possible to reduce the potential for the escape of volatile components of enamels.

4. Long-sleeve shirts and gloves should be used to reduce the possibility of wire burns and skin contact with enamel materials from wrecks.

5. PAHs were detected in the oil-based lubricant. Exposure by skin contact should be minimized by use of aprons and gloves. Inhalation exposure as a result of aerosolized droplets of lubricant is a possibility, so splash shields should be installed where needed and kept in place during machine operation. These protective measures should reduce the dermatitis reported in the Rod and Wire Mill Department.

6. Preplacement and periodic medical evaluations, including pulmonary function tests, should be made available to all employees exposed to isocyanates.[12]

VIII. REFERENCES

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications 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, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Local 509, Allied Industrial Workers of America
2. International Union of Allied Industrial Workers of America
3. NIOSH, Region V
4. OSHA, Region V

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

Table 1

Sampling and Analytical Methodology

Essex Group, Inc.
Vincennes, Indiana
HETA 83-116

March and September, 1983

Substance	Sampling Method	Analytical Method[18]
Metals	AA filter, 2.0 Lpm	P&CAM#173 Copper, Aluminum: Flame AA lower limit of detection: Copper, 2 ug/sample, Aluminum, 15 ug/sample
Organic Solvents	Charcoal Tube, 0.2 Lpm	GC/MS bulks:CS_2 extn, GC-FID/MS, DB-1 cap column charcoal tube: MeCl desorption GC-FID/MS DB-1 cap column
Nitrosamines	N/A	GC/thermoenergy analyzer MeOH/MeCl extn, GC/TEA, 10% Carbowax 20 M/2%KOH, Temp. Program 130°-180° at 6° C/min lower limit of detection: 50 ng/sample
Polynuclear aromatic hydrocarbons	N/A	HPLC/UV (254 Nm), fluorescence (340, 425 Nm) Acetonitrile (H_2O (60/40) to 100% Acetonitile in 20 min, Supelco PAH (C18) column, Flow rate 1.0 ml/min, Lower limit of detection: Fluoranthrene, benzo(a)pyrene, 0.08 ug/ml pyrene, benzo(a) anthracene, Benzo(c)pyrene 0.1 mg/ml

Continued

Table 1
Continued

Substance	Sampling Method	Analytical Method[18]
Dimethyl terephthalate	AA filter, 1.5 Lpm	P&CAM#127 GC-FID, toluene extn, DB-5 cap column lower limit of detection: 0.01 mg/sample
Phenol	0.1N NaOH impinger, 1.0 Lpm	P&CAM#S-330 GC-FID, 5% Igepal on 40/60 chrom T 160°C oven, lower limit of detection: 0.01 mg/sample
Cresols	silica gel, 0.2 Lpm	P&CAM S-167 GC-FID, n-decane desorption, DB-5 cap column, 150°C oven lower limit of detection: 0.01 mg/sample
TDI	1-(2-methoxyphenyl)piperazine impinger, 1.0 Lpm	HPLC/UV(254 Nm) Acetonitrile/H_2O with acetate buffer, isocratic at 1.2 mL/min Supelco C8 column lower limit of detection: 15 ug/sample

Table 2

Worker Exposure to TDI and Substances Assumed to be Isocyanates

Essex Group, Inc.
Vincennes, Indiana
HETA 83-116

September 13-15, 1983

Job Description	Shift	Sampling Duration (min)	ug/m^3 TDI 8-hour TWA
200 series rover	8-4	442	<32
200 series operator	8-4	431	<32
300 series rover	8-4	436	35
300 series operator	8-4	436	<32
200 series rover	4-12	459	<32
200 series operator	4-12	438	<32
300 series rover	4-12	440	<32
300 series operator	4-12	448	<32
200 series rover	12-8	456	<32
200 series operator	12-8	455	<32
300 series rover	12-8	434	<32
300 series operator	12-8	442	<32
Recommended exposure limit			36 (NIOSH)
Limit of detection (air adjusted)			32

Table 3

Worker Exposure to Cresol

Essex Group, Inc.
Vincennes, Indiana
HETA 83-116

September 13-15, 1983

Job Description	Shift	Sampling Duration (min)	mg/m^3 Cresol 8-hour TWA
300 series operator	8-4	436	0.4
300 series rover	8-4	436	0.9
200 series operator	4-12	438	0.4
200 series rover	4-12	459	2.2
300 series operator	12-8	442	0.5
300 series rover	12-8	434	0.8
Recommended exposure limit			10 (NIOSH)
Lower limit of detection (air adjusted)			.03

Table 4

Worker Exposure to Phenol

Essex Group, Inc.
Vincennes, Indiana
HETA 83-116

September 13-15, 1983

Job Description	Shift	Sampling Duration (min)	mg/m^3 Phenol 8-hour TWA
200 series rover	4-12	459	1.5
200 series operator	4-12	438	0.3
300 series rover	12-8	434	1.0
300 series operator	12-8	442	1.0
Recommended exposure limit			19.0 (NIOSH)
Lower limit of detection (air adjusted)			0.03

Table 5

Worker Exposure to Dimethyl Terephtahalate

Essex Group, Inc.
Vincennes, Indiana
HETA 83-116

September 13-15, 1983

Job Description	Shift	Sampling Duration (min)	ug/m^3 Dimethyl Terephthalate 8-hour TWA
200 series rover	8-4	442	<20
200 series operator	8-4	431	<20
300 series rover	4-12	440	<20
300 series operator	4-12	448	<20
200 series rover	12-8	456	<20
200 series operator	12-8	455	<20
Recommended exposure limit (for dimethyl phthalate)			5000 (ACGIH)
Lower limit of detection (air adjusted)			20

Table 6

Worker Combined Exposure to Substances Causing Respiratory Tract Irritation

Essex Group, Inc.
Vincennes, Inc.
HETA 83-116

September 13-15, 1983

Job Description	mg/m^3 Phenol	mg/m^3 Cresol	ug/m^3 TDI	Combined Exposure Level (percent)
200 series rover	1.5	2.2	16*	<74
200 series operator	0.3	0.4	16*	<50
300 series rover	1.0	0.9	35	111
300 series operator	1.0	0.5	16*	<55
Recommended exposure Limit	19	10	36	100 (ACGIH)

*Actually nondetectable. Sixteen ug/M^3 represents one-half of the lower limit of detection.

Table 7

Respiratory Symptoms, by Exposure and Current Cigarette Smoking Status,
Enamel Department Workers and Quality Control Workers
Located in the Enamel Department

Essex Group, Incorporated
Vincennes, Indiana
HETA 83-116

September, 1983

	Number and (Percent) of Workers with Symptom					
	Oven Workers*			Non-Oven Workers*		
Symptom	Non-smokers (16)	Smokers (29)	Total (45)	Non-smokers (22)	Smokers (14)	Total (36)
Chronic cough	4(25)	17(59)	21(47)[A]	2(9)	8(57)	10(28)[A]
Chronic phlegm	3(19)	15(52)	18(40)[B]	2(9)	5(36)	7(19)[B]
Shortness of breath	6(38)	19(66)	25(56)[C]	8(36)	7(50)	15(42)[C]
Ever Wheezed	4(25)	15(52)	19(42)	8(36)	5(36)	13(36)
Wheezing most days at work	3(19)	6(21)	9(20)[D]	2(9)	1(7)	3(8)[D]

* - See Text
A - $X^2 = 2.27$, $p>0.1$
B - $X^2 = 3.06$, $0.1>p>0.05$
C - $X^2 = 1.04$, $p>0.2$
D - $X^2 = 1.33$, $p>0.2$

Table 8

Non-pulmonary Symptoms among Enamel Department Workers
and Quality Control Workers Located in the Enamel Department

Essex Group, Incorporated
Vincennes, Indiana
HETA 83-116

September 1983

Symptom	Number and (Percent of Workers with Symptom		Difference	
	45 Oven Workers*	36 Non-oven Workers*	X^2	p
Eye irritation	38(84)	25(69)	1.81	>0.1
Stuffy nose	34(76)	20(56)	2.76	>0.05
Throat irritation	23(51)	15(42)	0.39	>0.5
Lightheadedness	18(40)	9(25)	1.41	>0.2
Dizziness	16(36)	7(19)	1.82	>0.1
Headaches ($\geq$ 2 per week)	16(36)	12(33)	0.0007	>0.5

* - See Text

Table 9

Symptoms, by Current Cigarette Smoking Status, among Concast Department Workers

Essex Group, Incorporated
Vincennes, Indiana
HETA 83-116

September 1983

Symptom	Number and (Percent) of Workers with Symptom		
	Non-smokers (6)	Smokers (5)	Total (11)
Chronic cough	4(67)	3(60)	7(64)
Chronic phlegm	3(50)	1(20)	4(36)
Shortness of breath	4(67)	2(40)	6(55)
Ever wheezed	3(50)	3(60)	6(55)
Wheezing most days at work	1(17)	2(40)	3(27)
Eye irritation			10(91)
Stuffy nose			7(64)
Throat irritation			4(36)
Lightheadedness			4(36)
Dizziness			3(27)
Headaches (≥2 per week)			2(18)