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MARCH 1987
CONTINENTAL REFRIGERATION CORPORATION
EXTON, PENNSYLVANIA

NIOSH INVESTIGATORS:
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I. SUMMARY

In January 1986, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation at the Continental Refrigeration Corporation, Exton, Pennsylvania. NIOSH was requested to evaluate workers' exposures to welding fumes and other substances used in the foam-filling, assembly and crating operations. On March 29, 1986, a NIOSH industrial hygienist conducted an initial site visit of the production complex, followed by an environmental evaluation on October 28-29, 1986.

Personal exposure to iron oxide fume (2 samples) were 0.1 and 0.7 milligrams per cubic meter (mg/m^3); the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV*) is 5 mg/m^3. Personal exposure to aluminum oxide fume (2 samples) were less than the limit of detection and 0.4 mg/m^3. The ACGIH TLV* is 5.0 mg/m^3. Personal exposures to zinc oxide (2 samples) were 0.1 and 0.2 mg/m^3. The Occupational Safety and Health Administration's (OSHA) 8-hour time-weighted average (TWA) permissible exposure limit (PEL is 5 mg/m^3). Two personal samples to total particulate were 0.4 and 3.54 mg/m^3. The ACGIH TLV* is 10 mg/m^3. Six personal samples for methylene chloride ranged from 29 to 213 mg/m^3; NIOSH recommends that methylene chloride be regarded as a "potential occupational carcinogen" and be controlled to the lowest feasible level. The current OSHA standard for methylene chloride is 500 ppm 8 hour TWA. Three personal samples for airborne methylene bisphenyl isocyanate (MDI) were less than the limit of detection. Two personal samples for toluene were 4 and 10 mg/m^3. NIOSH recommends TWA exposure for toluene not to exceed 375 mg/m^3 with a ceiling limit of 750 mg/m^3 for a 10 minute sample. Two personal samples for petroleum distillates were 31 and 80 mg/m^3; NIOSH recommends a TWA exposure for petroleum distillates not to exceed 350 mg/m^3, with a ceiling limit of 1800 mg/m^3 for a 15 minute sample. One personal sample for methyl ethyl ketone (MEK) was 124 mg/m^3; NIOSH recommends a TWA for MEK not exceed 590 mg/m^3.

Long-term indicator tube samples for carbon monoxide (CO) were collected on two fork truck operators. The 8-hour TWA CO levels were 20 and 25 parts per million (ppm). The OSHA 8-hour TWA permissible exposure limit (PEL) is 50 ppm, while the NIOSH recommended exposure limit is 35 ppm (8-hour TWA). The source of the CO was two propane forklift trucks which were in need of fine tuning (through carbon monoxide analysis of exhaust gases).

Based on the environmental sample results and available toxicological information, the NIOSH investigator concluded that a potential health hazard existed from exposure to methylene chloride. Employees' exposures to welding fumes, solvents, methylene bisphenyl isocyanate, and carbon monoxide were not toxic in the concentrations measured during the evaluation performed on October 29, 1986. Recommendations to aid in providing a safe and healthful working environment are presented in Section VIII of this report.

KEYWORDS: SIC 3585 (commercial and industrial refrigeration equipment) methylene chloride, welding fumes, toluene, petroleum distillate, methyl ethyl ketone, methylene bisphenyl isocyanate, carbon monoxide.

II. INTRODUCTION

In January 1986, NIOSH received a request for a Health Hazard Evaluation at the Continental Refrigeration Corporation, Exton, Pennsylvania. The primary concern was workers' exposures to welding fumes and other substances used in the foam filling, assembly and crating operations, solvents, and carbon monoxide.

On March 29, 1986 a NIOSH industrial hygienist conducted an initial site visit of the production complex. Preliminary findings of the evaluations were reported in an interim report on September 8, 1986 to the requestor and management. On October 28-29, 1986 NIOSH conducted an environmental evaluation.

III. BACKGROUND

Continental Refrigeration produces refrigerators/freezers for commercial and government applications. The workforce consists of approximately 80 production workers, mostly men in their twenties. The work encompasses metal working, welding, foam-filling, assembly and crating operations.

Raw materials (aluminum, steel, insulation, foam tanks) are stored in Bay #1 and are brought by fork-lift trucks to the machine line where steel parts are fabricated then returned to storage. Metal parts are cleaned in Bay #3 with toluene, methyl ethyl ketone (MEK), and petroleum distillates at various degreasing tanks. Bay #2 involves painting, welding, foaming, assembly and coating operations. There are sixteen paint bases which use a lacquer and thinner (toluene). Aluminum and stainless steel welding is used to construct the refrigerator frame, body and doors. A foaming unit (methylene chloride and methylene bisphenyl diisocyanate) produces the foam insulation which is installed in the inner wall and doors of the refrigerator. The cooling coils are wound and brazed together for connection to the compressor and motor units and then installed in the refrigerator chassis. Silicone caulking is used to fill the refrigerator seams using a caulking gun. The cleaning solvents are applied manually using cloth rags. The crating department uses lemon oil, toluene, petroleum distillates, and MEK for cleaning and finishing purposes.

IV. EVALUATION DESIGN AND METHODS

Environmental

Personal breathing zone air samples for total particulate, aluminum, iron, and zinc were collected on pre-weighed FWSB filters using a battery-powered vacuum pump at a flow rate of 1.7 liters per minute (LPM). The total weight of each sample was determined by weighing the sample plus the filter on an electrobalance and subtracting the previously determined tare weight of the filter. The tare and gross weighings were done in duplicate. The samples were analyzed for iron, aluminum, and zinc by means of atomic absorption spectroscopy. The samples were ashed with nitric and perchloric acids (NIOSH Method 7300) and diluted to 25 milliliter (ml). The analyses were then completed according to NIOSH Method P & CAM 173.

Two personal air samples for toluene and petroleum distillate were collected on 150 mg activated charcoal sorbent tubes, using a vacuum pump operating at a flow rate of 0.05 LPM. The charcoal tube samples were desorbed with 1 ml carbon disulfide and were analyzed by gas chromatography and flame ionization detector.

Six personal air samples for methylene chloride were collected on 150 mg activated charcoal sorbent tubes, using a vacuum pump operating at a flow rate of 0.02 LPM. The charcoal tube samples were desorbed with 1 ml carbon disulfide and were analyzed by gas chromatography and flame ionization detector.

Two personal air samples for methyl ethyl ketone were collected on ambersorb XE 347 sorbent tubes, using a vacuum pump operating at a flow rate of 0.05 LPM. Each sample was analyzed according to NIOSH Method 2500.

Three personal air samples for methylene bisphenyl diisocyanate (MDI) were collected on glass fiber filters impregnated with nitro reagent using a vacuum pump operating at a flow rate of 1.7 LPM and analyzed for MDI, according to NIOSH Method P & CAM 326.

Personal and area air samples for carbon monoxide were collected with long and short-term indicator tubes.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).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 (TLVs), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLVs are usually 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 exposure limits, 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 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. The environmental criteria for the substances evaluated are listed at the end of Tables 1 through 3.

B. Physiological Effects

1. Total Particulate

In contrast to fibrogenic dust which, when inhaled in excessive amounts, cause scar tissue to be formed in the lungs, so called "nuisance" dusts are stated to have little adverse effects on lungs and do not produce significant organic disease or toxic effects when exposures are kept under reasonable control. The "nuisance" dusts have also been called (biologically) "inert" dusts, but the latter term is inappropriate to the extent that there is no dust which does not evoke some cellular response in the lungs when inhaled in sufficient amount. However, the lung tissue reaction caused by inhalation of "nuisance dusts" has the following characteristics: 1) the architecture of the air sources remains intact; 2) collagen (scar tissue) is not formed to a significant extent; and 3) the tissue reaction is potentially reversible.

Excessive concentrations of dusts in the work room air may seriously reduce visibility; may cause irritation of the eyes, ears, and nasal passages; or cause injury to the skin or mucous membranes by chemical or mechanical action per se, or by the rigorous skin cleansing procedures necessary for their removal.[1]

2. Zinc Oxide

Overexposures to zinc oxide may produce metal fume fever, also known as brass chills, welders' ague, copper fever, zinc fever, and Monday morning fever. Metal fume fever is a syndrome that arises after respiratory exposure to the fume of any of several metals. Fume is generated when a metal is heated to above its melting point, typically in such settings as brass foundry work, welding, galvanized steel, and acetylene or plasma arc cutting. Exposure to fumes of zinc, copper, and magnesium are the most common causes. Symptoms, such as thirst, metallic taste, dry mouth, and headache, occur about four to eight hours after fume exposure. Cough, chills with irregular fever, dyspnea, muscle pain, and a sense of weakness and fatigue may develop over the subsequent few hours. The illness is self-limited and usually resolves within 24-48 hours. Illness can occur after an individual's first exposure to fume. Exposure to fume within a day or so of initial exposure tends to elicit less severe symptoms, but repeated exposure after having avoided metal fume for a longer period makes the individual susceptible again to the initial symptoms. The name "Monday morning fever" is used among workers with Monday through Friday fume exposure who become ill after a Monday exposure, feel well for the rest of the work week, and become ill again the next Monday.[2,3,4]

3. Iron Oxide

Arc welders, especially those who work in welding shops with poor ventilation, may develop a condition called siderosis after 5 to 15 years as a welder. A worker with siderosis presents an abnormal chest X-ray that shows fine modular stipling in both lung fields. Animal experiments suggest that the X-ray pattern is due to groups of lung macrophage cells that are filled with iron oxide. It is not clear if the iron oxide causes adverse health effects but epidemiological studies suggest that arc welders (perhaps because of exposures to many noxious gases and fumes present in a welding shop) may be at increased risk for development of chronic pulmonary impairment especially if they smoke.[5]

4. Aluminum

Aluminum is a light, silvery-white, soft, ductile, malleable amphoteric metal, soluble in acids or alkali, insoluble in water. The primary sources are the ores cryolite and bauxite; aluminum is never found in the elemental state.

The effect on the human body caused by the inhalation of aluminum dust and fumes is not known with certainty at this time. Present data suggest that pneumoconiosis might be a possible outcome. In the majority of cases investigated, however, it was found that exposure was not to aluminum dust alone, but to a mixture of aluminum, silica fume, iron dusts, and other materials.[6]

5. Diisocyanates

Occupational exposure to diisocyantes has well-recognized adverse health effects; the most common compound is toluene diisocyanate (TDI). The isocyanates have been described as irritants of the skin and conjunctiva (surface of the white part of the eye). The main effects are on the respiratory system. Acutely, in high concentrations, these materials are severe irritants of the upper and lower respiratory tract. Second, and of additional concern, is the potential development of sensitization to diisocyanates in which some individuals may have asthma-like reactions (immediate, delayed or both) at concentrations much lower than those producing irritation. Chronic effects that have been reported include excess declines in the forced expiratory volume in 1 second (FEV_1) and the forced vital capacity (FVC), increased prevalence of bronchitis and dyspnea and possibly, hypersensitivity pneumonitis.[7,8,9,10]

6. Solvents

Solvents have been noted to be associated with liver damage in the past. A number of solvents are used at various times in the chemical processes, including methyl ethyl ketone, toluene and petroleum distillate. Exposure to organic solvents can cause varying degrees of anesthesia, headaches, lightheadedness, "drunkenness" and even unconsciousness. They may have a disagreeable odor and can be irritating to the eyes and upper respiratory tract (nose and throat). Skin contact with solvents can, if prolonged, remove the natural oil from the skin causing dryness and cracking.

7. Methylene Chloride

NIOSH estimates that 1 million workers are potentially exposed to methylene chloride during its manufacture and use; as a solvent, aerosol propellant or fumigant, and as a blowing agent in flexible urethane foams. In 1976, NIOSH published a document entitled Criteria for a Recommended Standard....Occupational Exposure to Methylene Chloride. In that criteria document, NIOSH recommended a 10-hour time-weighted average (TWA) occupational exposure limit of 75 parts per million (ppm) in order to prevent interference by methylene chloride with delivery of oxygen to tissues, and impairment in functions of the central nervous system (CNS). Since 1976, the carcinogenicity of methylene chloride has been documented in several studies of chronic effects in animals. On the basis of carcinogenic and tumorigenic responses in rats and mice, and in accordance with the Cancer Policy of the Occupational Safety and Health Administration (OSHA) ("Identification, Classification, and Regulation of Potential Occupational Carcinogens," 29 CFR 1990), NIOSH recommends that methylene chloride be regarded as a "potential occupational carcinogen". Although the potential for methylene chloride-induced cancer in humans has not been determined, the probability of a population of exposed workers developing cancer could be decreased by reducing exposure. Therefore,

NIOSH recommends that occupational exposure to methylene chloride be controlled to the lowest feasible limit.

8. Carbon Monoxide

Carbon monoxide (CO) combines with hemoglobin in the blood reducing the oxygen carrying capacity of the blood. Symptoms of CO poisoning are headache, dizziness, drowsiness, nausea, vomiting, collapse, coma, and death. Long-term low level exposure to CO can increase the risk of heart attack for some people.

VI. RESULTS AND DISCUSSION

Results of the fifteen personal air samples collected on October 29, 1986 for iron oxide, aluminum oxide fume, zinc oxide, total particulate, methylene chloride, MDI, toluene, petroleum distillates, and methyl ethyl ketone are presented in Table 1 through 3.

Two personal samples from welders for airborne metals, including iron oxide, aluminum, zinc, plus total particulates, were well within the respective evaluation criterion.

Six personal air samples collected on the foam operators indicated exposures to methylene chloride ranged from 29 to 213 mg/m^3. Based on the animal studies, NIOSH recommends that methylene chloride be handled in the workplace as a potential occupational carcinogen and as a prudent public health measure suggests that effective engineering controls and stringent work practices be employed to reduce occupational exposure to the lowest feasible limit. The use of air-purifying respirators for protection from excessive methylene chloride levels is not advised due to the 1) very short respirator sorbent breakthrough times of methylene chloride and 2) lack of adequate olfactory warning properties (no distinct odor threshold). The recently published carcinogenicity research findings on methylene chloride dictate the use of the best respiratory protection available; in this case, supplied air respirators.

Three personal air samples for MDI were less than the limit of detection (0.3 micrograms/sample).

Two personal air samples indicated exposures to toluene ranged from 4 to 10 mg/m^3. NIOSH recommends that the TWA exposure for toluene not to exceed 375 mg/m^3 with a ceiling limit of 750 mg/m^3 for a 10 minute sample.

Two personal air samples for petroleum distillates ranged from 31 to 80 mg/m^3. NIOSH recommends a TWA exposure to petroleum distillates not to exceed 350 mg/m^3 with a ceiling limit of 1800 mg/m^3 for a 15 minute sample.

One personal air sample indicated that exposure to MEK was 124 mg/m^3. NIOSH recommends that the TWA exposure not to exceed 590 mg/m^3. A second personal air sample appeared to have been directly inserted or had fallen into some oil or solvent mixture during the sampling period, as there was liquid in both the front and back up sections of the tube. Therefore, no quantitative results could be obtained.

Long-term indicator tube samples for CO were collected on two fork truck operators. The 8-hour TWA CO levels ranged from 20 to 25 ppm. The OSHA 8-hour TWA PEL is 50 ppm, while the NIOSH recommended exposure limit is 35 ppm (8-hour TWA). The source of the CO was two propane forklift trucks which were in need of fine tuning (determined through carbon monoxide analysis of exhaust gases). Short-term indicator tubes measured airborne concentrations of CO directly behind the forklifts as high as 500 ppm. The lift trucks were shut down and given a tuneup by a contractor and the CO levels were reduced.

VII. CONCLUSION

Based on the environmental sample results, it is concluded that a potential health hazard existed from exposure to methylene chloride. Employees were not overexposed to welding fumes, solvents, MDI, and carbon monoxide during the evaluation performed on October 29, 1986.

VIII. RECOMMENDATIONS

1. Reduction of employee overexposures to methylene chloride should be accomplished by substitution with a less hazardous process materials, automation, ventilation, improved work practices or a combination of these.

2. To help lower CO levels the American Conference of Governmental Industrial Hygienists (ACGIH) Industrial Ventilation Manual should be consulted for fuel-powered lift truck ventilation design criteria and plant operations modified accordingly. The ACGIH guidelines are summarized below.

   BASIC DESIGN VENTILATION RATES

   - 5000 cfm per propane fueled lift truck
   - 8000 cfm per gasoline fueled lift truck

- A regular maintenance program incorporating final engine tuning through carbon monoxide analysis of exhaust gases must be provided. CO concentration of exhaust gases should be limited to 1 percent for propane fueled trucks, 2 percent for gasoline fueled trucks.

- Actual operating time of lift trucks must be 50 percent or less of total exposure time.

- A reasonably good distribution of air flow must be provided.
- The volume of space must amount to 150,000 cu. ft. per lift truck or more.

CORRECTIONS FOR CONDITIONS OTHER THAN THOSE ABOVE

- No regular maintenance program - multiply the basic design ventilation rate by three.

- Operating time greater than 50% - multiply the basic design ventilation rate by the actual operating time in percent divided by 50.

- Poor distribution of air flow - lift truck operation not recommended.

- Volume of space less than 150,000 cu. ft. per lift truck - multiply the basic design ventilation rate by a suitable factor based on the following:

  1.5 times design rate for 75,000 cu. ft.; 2.0 times design rate for 30,000 cu. ft. Lift truck operation in spaces of less than 25,000 cu. ft. is not recommended.

- Lift truck engine horsepower greater than 60 - multiply the basic design ventilation rate by the actual horsepower divided by 60.

3. Ventilated welding booths of sufficient size should be installed to accommodate refrigerator and freezer parts being welded. This should help to reduce the welding fumes in the welder breathing zone and the general area.

4. Oil and/or cutting fluid should be removed from parts to be welded prior to their arrival in the welding area so that the parts will not generate excessive smoke when they are welded.

5. Workers should be advised to avoid exposure to welding fumes and cautioned about the hazard of developing metal fume fever secondary to exposure to zinc oxide fumes that can be generated when welding galvanized metal.

6. An educational program should be instituted so that employees are made aware of the potential hazards associated with the chemicals used.

7. All containers of methylene chloride, MEK, toluene, and petroleum distillate should be properly labeled.

IX. REFERENCES

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. Continental Refrigeration Corporation
2. Teamsters Local 837
3. OSHA, Region 3

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 I

AIRBORNE CONCENTRATIONS OF METHYLENE CHLORIDE AND
METHYLENE BISPHENYL ISOCYANATE (MDI)
Personal Samples
CONTINENTAL REFRIGERATION CORPORATION
Exton, Pennsylvania
HETA 86-162
October 29, 1986

JOB	SAMPLE TIME	SAMPLE VOLUME (LITERS)	METHYLENE CHLORIDE mg/m^3*	MDI mg/m^3
Foam Operator (303)	0748-1250	7.1	209	-----
	1341-1545	3.1	134	-----
	0748-1545	811	---	L.D.**
Foam Operator (303)	0740-1250	6.3	213	-----
	1340-1545	2.6	138	-----
	0740-1545	824	---	L.D.
Foam Operator (302)	0802-1250	6.1	29	-----
	1333-1550	2.8	32	-----
	0802-1550	796	---	L.D.
Evaluation Criteria (mg/m^3)			Lowest Feasible Limit	0.05
NIOSH Ceiling Limit For MDI (10 Minute)			---	0.20
Limit of Detection (mg/m^3)			0.05	.0003

*mg/m^3 = Milligrams of substance per cubic meter of air sampled
**L.D. = Less than detectable limits

TABLE II

AIRBORNE CONCENTRATIONS OF TOLUENE, PETROLEUM DISTILLATE, AND METHYL ETHYL KETONE (MEK)
Personal Samples
CONTINENTAL REFRIGERATION CORPORATION
Exton, Pennsylvania
HETA 86-162
October 29, 1986

JOB	SAMPLE TIME	SAMPLE VOLUME (LITERS)	TOLUENE mg/m^3*	Petroleum Distillate mg/m^3	METHYL ETHYL KETONE mg/m^3
Crating (305)	0814-1540	23.8	10	80	---
Crating (305)	0813-1540	24.3	4	31	---
Crating (305)	0800-1540	23.9	--	--	invalid**
Crating (305)	0826-1540	23.2	--	--	124
Evaluation Criteria (mg/m^3)			375	350	590
NIOSH Ceiling Limit For Toluene (10 minute)			750	---	---
NIOSH Ceiling Limit For Petroleum Distillate (15 minute)			---	1800	---
Limit of Detection (mg/sample)			.009	.05	.17

*mg/m^3 = milligrams of substance per cubic meter of air sampled
**Invalid = it appears that the tube had been directly inserted or had fallen into some oil or solvent mixture during the sampling period as there was liquid in both the front and backup sections of the tube. Therefore, no quantitative results could be obtained.

TABLE III

AIRBORNE CONCENTRATIONS OF IRON, ALUMINUM, ZINC AND
TOTAL PARTICULATE
Personal Samples
CONTINENTAL REFRIGERATION CORPORATION
Exton, Pennsylvania
HETA 86-162
October 29, 1986

JOB	SAMPLE TIME	SAMPLE VOLUME (LITERS)	IRON mg/m^3*	Aluminum mg/m^3	TOTAL ZINC mg/m^3	PARTICULATE mg/m^3
Welder	0816-1555	780	0.1	L.D.**	0.1	0.4
Welder	0806-1555	797	0.7	0.4	0.2	3.54
Evaluation Criteria (mg/m^3)			5.0	5.0	5.0	10.0
Limit of Detection (mg/m^3)			0.0006	0.0005	0.0002	0.01

*mg/m^3 = milligrams of substance per cubic meter of air sampled
**L.D. = Less than detectable limits