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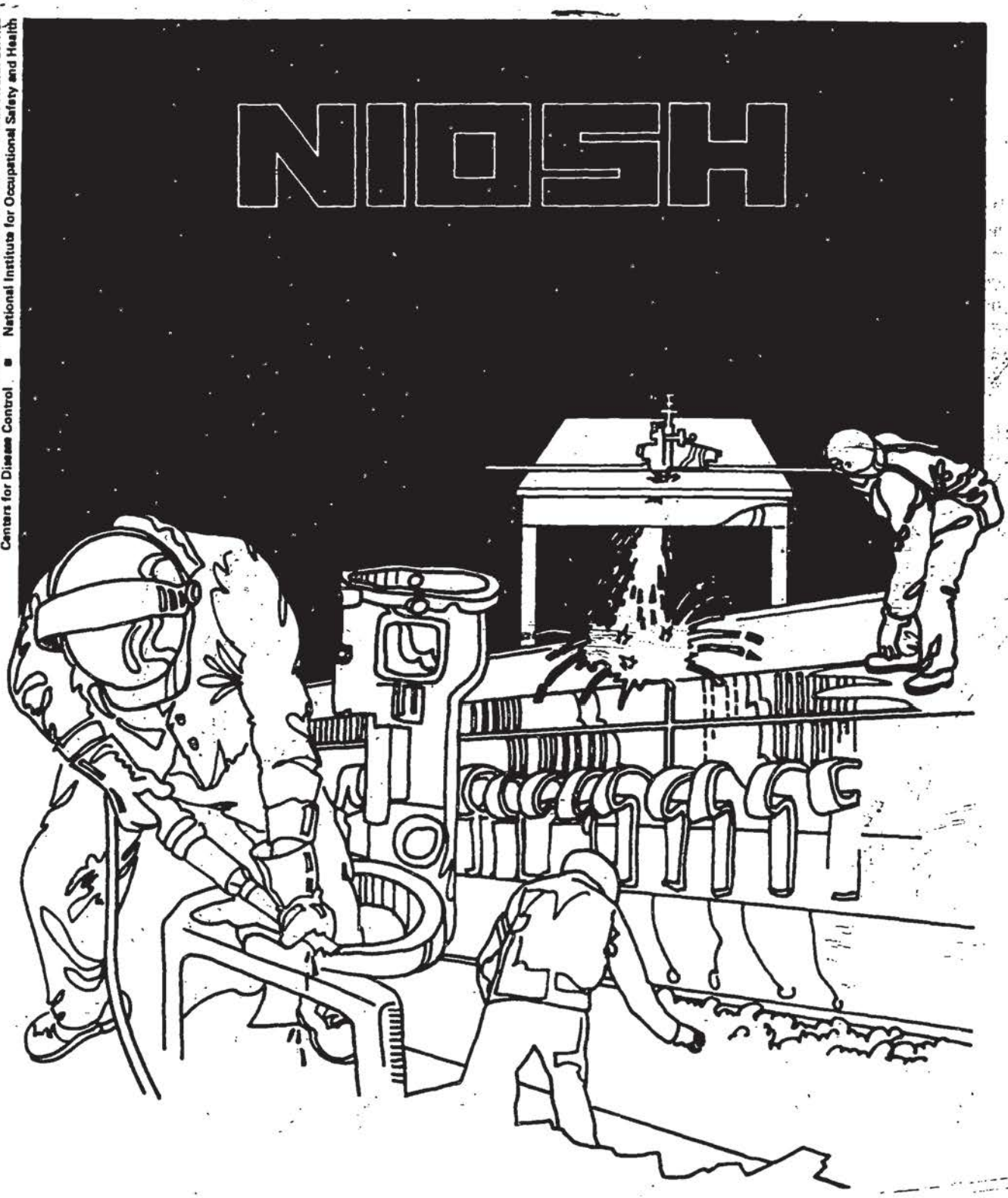
NIOSH



Health Hazard Evaluation Report

HETA 81-388-1129
SANTA CRUZ METROPOLITAN
TRANSIT DISTRICT
SANTA CRUZ, CALIFORNIA

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.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 81-388-1129
June, 1982
SANTA CRUZ METROPOLITAN
TRANSIT DISTRICT
SANTA CRUZ, CALIFORNIA

NIOSH INVESTIGATORS:
Pierre L. Belanger, I.H.
Molly J. Coye, M.D., M.P.H.

I. SUMMARY

On July 3, 1981 the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from the vehicle maintenance supervisor at the Santa Cruz Metropolitan Transit District (SCMTD) Operations Facility. The requestor was concerned that employees (utility sweepers, cleaners, washers and fuelers) may be exposed to excessive levels of diesel and gasoline bus exhaust fumes while servicing the buses. Several employees have complained of dizziness, headaches, and nausea.

On August 19-20, 1981 environmental and medical surveys were conducted at the SCMTD operations facility during diesel and gasoline bus servicing. Environmental air samples (personal and area) were collected during diesel servicing for carbon monoxide (CO), carbon dioxide (CO_2), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), formaldehyde and total particulate (soot). Measurements were made during engine start-up and while the engines were idling. CO levels ranged from 2-8 ppm which is well below the NIOSH recommended criteria of 35 ppm. CO_2 levels were below the limit of detection (0.1 percent). NO_2 levels were nondetectable except for two measurements which peaked at 0-1 ppm. The NIOSH recommended criteria for NO_2 is 1 ppm. No sulfur dioxide was detected. Total particulate concentrations ranged from 0.03-1.12 mg/m^3 which is below the California-Occupational Safety and Health Administration (CAL-OSHA) standard of 10 mg/m^3 for nuisance dust. Fifteen air samples for formaldehyde were collected for sampling periods ranging from 45 minutes to 3 hours. Four of the formaldehyde samples ranged from 0.5 ppm to 1.4 ppm. This did not exceed the CAL-OSHA standard of 2 ppm, however, NIOSH recommends that formaldehyde be controlled to the lowest feasible limit. CO levels were measured during gasoline bus start-up and while idling. Peak CO levels reached 500 ppm and decended to 5 ppm after about 10 seconds. None of these levels exceeded the NIOSH recommended criteria of 35 ppm time weighted average.

A questionnaire was administered to determine relevant past medical history, symptoms of headache, eye, nose, throat and/or lung irritation, and the temporal pattern of symptoms. Carboxyhemoglobin levels were estimated by sampling of expired air for carbon monoxide content before and after shifts. The reported symptoms were consistent with exposure to diesel fume exposure, and to a lesser extent with gasoline exhaust exposure; the symptoms were not explained by smoking habits, and were associated with hot, stagnant air conditions in the work area. None of the workers demonstrated a significant change in carboxyhemoglobin levels pre- to post-shift; in some cases these results were obscured by cigarette smoke inhalation prior to the tests.

Based on the environmental air samples collected during the dates of the survey, overexposure to CO, CO_2, SO_2, NO_2, total particulate did not exist. However; significant short term exposures to formaldehyde were measured depending on workers job task, the time of the shift and the mechanical condition of the bus. The symptoms reported and/or experienced by the workers are generally consistent with formaldehyde exposure and diesel fume exposure. Recommendations are included in the body of the report to help reduce diesel exhaust fume exposure.

KEYWORDS: SIC 4172 (Maintenance and Service Facilities for Motor Vehicle Passenger Transportation), diesel and gasoline fume, carbon monoxide, carbon dioxide, nitrogen dioxide, sulfur dioxide, total particulate (soot) formaldehyde.

II. INTRODUCTION

On July 3, 1981 a request for a health hazard evaluation was submitted to NIOSH by the vehicle maintenance supervisor for the Santa Cruz Metropolitan Transit District (SCMTD). The supervisor was concerned that employees (utility sweepers, cleaners, washers and fuelers) may be exposed to carbon monoxide and carbon dioxide (components of diesel and gasoline exhaust fumes) when the buses are serviced. Several employees had complained of dizziness, headaches and nausea.

On August 19-20, 1981 NIOSH conducted an environmental and medical study at SCMTD. Environmental air samples were collected for several components of gasoline and diesel exhaust engines which include: carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), formaldehyde and total particulate (soot). NIOSH was requested to present their preliminary findings at the Santa Cruz City Board of Supervisors meeting the following day. Environmental air sampling results which were not immediately available were telephoned to the supervisor at a later date.

III. BACKGROUND

NIOSH was requested to conduct a health hazard evaluation based on workers complaints and reported symptoms from exposure to exhaust fumes. A California-Occupational Safety and Health Administration (CAL-OSHA) consulatant previously (April, 1981) conducted an environmental survey of the vehicle maintenance facility. Personal breathing zone air samples were collected for several components (carbon monoxide, carbon dioxide, nitrogen dioxide, sulfur dioxide and formaldehyde) of gasoline and diesel exhaust; however, none of the contaminants exceeded the CAL-OSHA permissible exposure limit.

Work Process

Fourteen people, employed by the SCMTD, work an 8-hour day five days per week in the vehicle maintenance facility. Nine of the 14 employees work the evening

shift which is staggered and begins at 7 p.m., 8p.m., and 10p.m. Approximately 65 buses (54 diesel, 6 gasoline, and 5 propane) are serviced nightly. Buses are moved from the adjacent parking area to either side of the fuel pump island to be fueled, check and service engine fluids, swept and washed on alternate evenings. Engines are shut off during servicing which takes 15-20 minutes. Propane buses are serviced from 7 p.m.-8 p.m., diesel buses are serviced from 8 p.m.-4:30 a.m. and gasoline buses are serviced from 4:30 a.m. to 6 a.m. The remainder of the shift is spent cleaning up the area.

The fuel island previously had a roof; however it has been temporarily removed because workers thought the bus exhaust fume collected under the roof especially on hot stagnant days.

IV. HAZARD EVALUATION DESIGN

A. Evaluation Criteria and Health Effects

Occupational exposure criteria have been developed to evaluate worker's exposure to chemical substances. Two sources of criteria were used to assess the workroom concentrations: (1) NIOSH Criteria for a Recommended Standard and a Current Intelligence Bulletin, and (2) California Occupational Safety and Health Administration (CAL-OSHA) Standards. These values represent concentrations to which it is believed that nearly all workers may be exposed for an 8-hour day, 40-hour work week throughout a working lifetime without experiencing adverse health effects.

TABLE A

Substance	Time Weighted Average (TWA)	Ceiling Value
Carbon Monoxide (NIOSH)	35 ppm	200 ppm
Carbon Monoxide (CAL-OSHA)	50 ppm	400 ppm
Carbon Dioxide (NIOSH)	10,000 ppm	30,000 ppm (10 min)
Carbon Dioxide (CAL-OSHA)	5,000 ppm	-
Nitrogen Dioxide (NIOSH)	-	1 ppm (15 min)
Nirogen Dioxide (CAL-OSHA)	5 ppm	5 ppm
Sulfur Dioxide (NIOSH)	0.5 ppm[b]	-
Sulfur Dioxide (CAL-OSHA)	5.0 ppm	-
Formaldehyde (NIOSH)	Lowest Feasible limit	-
Formaldehyde (CAL-OSHA)	2 ppm	2 ppm
Total Particulate (NIOSH)	-	-
Total Particulate (CAL-OSHA)	10 mg/m^3[c]	-

(a) TWA - NIOSH exposure is based on a work day up to 10 hours long, whereas CAL-OSHA Standard is based on an 8-hour work day.

(b) ppm - Parts of a vapor or gas per million parts of contaminated air by volume.

(c) mg/m^3 - Milligrams of a substance per cubic meter of air.

B. Materials and Methods

1. Environmental

Environmental air samples were collected for carbon monoxide, carbon dioxide, nitrogen dioxide, sulfur dioxide and formaldehyde using Drager gas detector tubes.

Five air samples (personal and area) were collected for total particulates using a MSA vacuum pump operating at 1.5 liters per minute, and a two piece, 37-millimeter, closed face cassette and filter (M-5). The filters were subsequently analyzed in the laboratory by gravimetric method.

Fifteen personal air samples were collected for formaldehyde using a specially impregnated charcoal tube (chromosorb 102) which was connected to a vacuum pump operating at 50 cubic centimeters per minute. The chromosorb tubes were subsequently analyzed in the laboratory according to NIOSH

Physical and Chemical Analytical Method 318 with minor variations.

A direct reading CO analyzer (ECOLYZER) was used during servicing of gasoline buses to determine peak CO exposures when the buses were driven up to the fuel island. Also a direct reading NO_2 Ecolyzer was used to measure NO_2 levels during servicing of the diesel buses. Air samples were randomly collected during the shift as buses were being started and while idling.

2. Medical Monitoring Design and Methods

On Wednesday and Thursday, August 19 and 20, 1981, informal interviews were conducted and a questionnaire completed by eleven night shift workers in the administrative offices and maintenance areas. Questions were asked regarding history or recent symptoms of headache, eye, nose, throat, and/or lung irritation. Workers also were asked about what concerns they had related to diesel and gasoline fumes and smoke. A brief questionnaire was administered both for irritative and central nervous system symptoms and as part of the carboxyhemoglobin breath test.

Carbon monoxide was monitored throughout the survey with a portable direct-reading CO analyzer. Breath samples were taken by having the workers blow an inhalation held for 20 seconds into a sample bag, which was then evacuated into a carboximeter ecolyzer. The CO concentration of the samples was determined on the carboximeter, and the amount of CO in the sample was converted to percent COHb in the workers' blood. Both pre- and post-shift levels were taken, and smokers were asked not to smoke for the last (four) hours before coming to work and before coming off shift. Workers were also asked not to drink any alcoholic beverages for four hours before the shift because alcohol interferes with the Ecolyzer analysis.

C. Toxicological Effects

Gasoline Exhaust

There are many components in gasoline exhaust. Carbon Monoxide (CO) is the main component of concern as a potential health hazard when it is in high concentrations.

Carbon Monoxide (CO)

The signs and symptoms of carbon monoxide poisoning may include headache, nausea, vomiting, dizziness, drowsiness, and collapse. In the bloodstream carbon monoxide rapidly binds to the oxygen-carrying molecule hemoglobin, forming "carboxyhemoglobin" (COHb). When carbon monoxide binds with hemoglobin to form COHb, it reduces the oxygen-carrying capacity of the blood. The more COHb is formed, the more significant the symptoms. Heart disease may be made worse in workers who have coronary heart disease and are exposed to carbon monoxide concentrations high enough to produce a COHb level greater than 5%. There is also evidence that exposure to lower carbon monoxide concentrations, producing COHb levels at or slightly below 5%, may affect the nervous system and causes changes in visual alertness, response time, and fine judgement.(2)

Non-smoking, non-exposed persons have an average COHb level of 1%. Cigarette smokers usually have an average COHb level of 2 to 10%. Non-smokers exposed to 50 ppm of CO for six to eight hours have COHb levels of 8 to 10%. Symptoms such as headache and nausea may be seen above 15%, but usually not at lower levels. At 25%, there may be electrocardiographic evidence of heart effects, and 40% usually results in collapse.

The current CAL-OSHA standard for carbon monoxide is 50 ppm. Exposure at this level for 90 minutes may cause chest pain for persons with angina (chest pain related to heart disease); exposure for 2 hours may make leg cramps worse

for persons who have leg cramping associated with vascular disease. The effects of carbon monoxide exposure, including the more common symptoms of headache, dizziness, and nausea, are made worse by heavy labor and a high temperature in the work area. (1)

In 1972, after considering all of these factors, NIOSH recommended an exposure limit of 35 ppm for an 8-hour time-weighted average, and a ceiling limit of 200 ppm. This recommendation is based on the concentration necessary to produce a COHb level of not more than 5%. The recommendation does not consider the smoking habits of workers since the COHb levels in smokers has generally been in the 4 to 5% range, but may run as high as 10 to 15% in heavy smokers. Therefore, smokers who already have a blood level of 5%, and are then exposed in a work place with an average concentration of 35 ppm will have a total COHb of about 10%. (2,5)

CAL-OSHA standard: 50 ppm. NIOSH recommendation: 35 ppm.

Diesel Exhaust

Diesel exhaust contains several thousand different chemicals and materials, not all of which have been analyzed. A few of these chemicals are most likely to cause immediate irritation to people who breathe them while working.

Short Term Effects

(1) Formaldehyde and other aldehydes:
Formaldehyde is best known for its use by embalmers and morticians to preserve dead bodies and tissues. It has a sharp odor which can be smelled at very low levels (less than 1 ppm). At levels between 1-5 ppm, formaldehyde makes the eyes water and sting. At 20 ppm, many people notice stinging or prickling in the throat and nose. Low levels -

0.3 to 2.7 ppm - have also been found to disturb sleep and to be irritating to some people (3) (4)
Formaldehyde has caused nasal cancer in animal testing as reported by the Chemical Industry Institute of Toxicology. Formaldehyde has also been shown to be a mutagen (cause genetic changes) in several test systems.

Based on these finds, NIOSH recommends that formaldehyde be handled in the workplace as a potential occupational carcinogen and occupational exposures be controlled to the lowest feasible limit.

Other aldehyde - such as acrolein - also cause irritation to the nose, throat, eyes and lungs at even lower levels of air concentrations.

CAL-OSHA standard: 2 ppm.
NIOSH recommendation: lowest feasible limit.

(2) Nitrogen dioxide (NO_2)

NO_2 is well known as the gas which makes smog over large cities like Los Angeles turn yellow or yellow brown. This gas also causes irritation of the nose, throat. and lungs at low levels (5 ppm). It may cause persistent cough and phlegm (mucous) at these levels. At higher levels, 50 ppm or more, NO_2 will cause serious swelling in the lungs, and in some cases permanent lung damage. (4,8)

CAL-OSHA standard: 5 ppm.
NIOSH recommendation: 1 ppm (15 min)

(3) Carbon monoxide (CO)

Refer to gasoline exhaust

(4) Soot (Total particulate)

Diesel engines produce 30 - 50 times as much smoke particulates as gasoline engines. This smoke is easily breathed in and becomes trapped in the lungs. There it causes cough and phlegm. (4)

CAL-OSHA standard: 10 mg/m^3

(5) Sulfur dioxide (SO_2)

SO_2 causes symptoms of irritation similar to those caused by NO_2 and formaldehydes. (1)
CAL-OSHA standard: 5 ppm.
NIOSH recommendation: 0.5 ppm.

Long Term Effects

(1) Polycyclic aromatic hydrocarbons (PAH's): these are organic chemicals found in very small quantities in diesel fumes. Several of these chemicals are known to cause cancer in laboratory animals. Whether or not they cause cancer in humans is not clear at this time, but it is a strong possiblity that cannot be ignored.(4)

(2) Smoke particles (soot): Just like cigarette smoke, these particles settle in the lung. Diesel soot is largely made up of carbon black particles. Although the long term effects of breathing diesel smoke are not known, it is known that workers in the carbon black industry suffer from emphysema, chronic bronchitis, and a lung disease similar to coal miner's lung (pneumoconiosis).(5)

In addition, diesel soot particles have been shown to have PAH's on their surface, and it has been suggested that soot particles carry these suspected carcinogens deep into the lungs.

(3) NO_2 and SO_2 and formaldehyde: years of exposure to these irritants may cause or speed up the development of upper respiratory illnesses or chronic bronchitis. Formaldehyde has been reported to cause nasal cancer in experimental animals. (7,8,9)

V. RESULTS AND DISCUSSION

Environmental

No carbon monoxide, sulfur dioxide, nirogen dioxide or formaldehyde was detected on the appropriate colorimetric detector tubes during diesel start-up and while idling. Carbon dioxide was detected at concentrations below the lowest limit of detection (0.1 percent).

Carbon monoxide levels were also measured during bus (diesel and gasoline) start-up and while idling. Peak CO concentrations measured during diesel engine operation at random intervals in the evening ranged form 2-8 ppm. Peak CO levels measured for all gasoline buses during engine start-up and while idling ranged from 5-500 ppm. Carbon monoxide levels normally peaked at 500 ppm during start-up and descended to 5 ppm during idle.

Nitrogen dioxide levels measured during diesel engine start-up and while idling indicated several peak concentrations of 0.1 ppm.

No sulfur dioxide levels were detected.

Five environmental air samples were collected for total particulate (Table 1). The air sample concentrations ranged from 0.03 - 1.2 mg/m^3 which is below the CAL-OSHA standard of 10 mg/m^3.

Fifteen personal air samples were collected for formaldehyde (Table II). Four samples measured concentrations which ranged from 0.4-1.5 ppm. These concentrations are below the CAL-OSHA standard of 2 ppm; however, NIOSH recommends that formaldehdye be controlled to the lowest feasible limit. Although no specific bus numbers could be linked with the formaldehyde exposure, the workers indicated that some of the buses ran rougher, produced more smoke and stronger diesel odors than others.

It is not clear that removing the roof from the fuel island has significantly improved the previously existing exhaust fume problem since most of the complaints were associated with periodic hot stagnant climatic conditions. Furthermore, most of the buses have exhaust systems which discharge on top of the bus well away from the workers breathing zone and outside the perimeter of the roof line.

Medical

Vehicle service operators reported occasional symptoms of eye, nose, throat and lung irritation which are consistent with those reported in the medical literature for diesel fume exposure in particular, and to a lesser extent with gasoline exhaust exposure. Presence of these symptoms was reported to be associated with hot, stagnant air conditions in the work area.

Table III below shows the number of workers reporting symptoms associated with workplace exposures, among the eleven workers surveyed. Six of the eleven workers are smokers, and as a group were responsible for 33% of the total symptoms reported. No marked difference in pattern between smokers and non-smokers was found for type of symptoms reported.

Carboxyhemoglobin (COHb) levels were measured pre- and post-shift for 10 workers (see Table IV). None of the workers demonstrated a significant change in COHb, indicating that the workers had not been exposed to CO in excessive concentrations during this shift (average shift differential was a decrease in COHb of 1.45%).

VI. CONCLUSIONS

No overexposures to carbon monoxide, carbon dioxide, nitrogen dioxide, sulfur dioxide or total particulates were measured; however, there were significant exposures to formaldehyde vapors. Vehicle service operators reported symptoms of eye, nose, throat and lung irritation which are consistent with those reported in the medical literature for formaldehyde and diesel fume exposure. These symptoms are not explained by smoking habits, and they are reported to be aggravated by hot stagnant air.

VII. RECOMMENDATIONS

1. An educational program should be developed to inform workers about the hazardous materials present in their workplace, specifically diesel fumes and gasoline vapors.

2. Buses which are serviced with fuel should continue to be turned off.

3. Buses which appear to be running rough should be reported to the supervisor so that these buses can be checked by the vehicle service department.

4. The fuel island roof design should be open at the ends to allow good air movement during hot stagnant days.

VII. REFERENCES

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IX. AUTHORSHIP

Report Prepared By:

Pierre L. Belanger
Industrial Hygienist
NIOSH - REGION IX
San Francisco, California

Molly J. Coye, M.D., M.P.H.
Medical Investigative Officer
NIOSH - REGION IX
San Francisco, California

ACKNOWLEDGEMENTS

Melvin T. Okawa
Regional Program Consultant
NIOSH - REGION IX
San Francisco, California

Stephanie Alpert
Medical Student

Analytical Laboratory Service — Measurement Service Section, Measurement Support Branch, NIOSH

Report Typed By — Sally A. Niehaus, Hazard Evaluations and Technical Assistance Branch

X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22216.

Copies of this report have been sent to:

1. Santa Cruz Metropolitan Transit District
2. United Transportation Union, Local #23
3. CAL-OSHA
4. U.S. Department of Labor - Region IX

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

TABLE I
ENVIRONMENTAL AIR SAMPLES
COLLECTED FOR TOTAL PARTICULATE
SANTA CRUZ METROPOLITAN TRANSIT DISTRICT
SANTA CRUZ, CALIFORNIA
AUGUST 19-20, 1981

Location	Sample Volume(Liters)	Sample Period	Concentration (mg/m)
Fuel Island, on top of paper towel tray	705	1915-0305	0.06
Fuel Island, on top of unleaded fuel pump	705	2015-0305	0.03
Personal, vehicle service operator	532	2030-0007 0053-0315	0.04
Personal, vehicle service operator	600	2030-0310	1.2
Personal, vehicle service operator	450	2210-0310	0.33

1. mg/m^3 - milligrams of a substance per cubic meter of air by volume.

TABLE II
ENVIRONMENTAL AIR SAMPLES
COLLECTED FOR FORMALDEHYDE
SANTA CRUZ METROPOLITAN TRANSIT DISTRICT
SANTA CRUZ, CALIFORNIA
AUGUST 19-20, 1981

Location	Sample Volume(Liters)	Sample Period	Concentration (ppm)
Vehicle Service Operator(A)	2.4	1915-2005	N.D.[2]
	4.3	2005-2127	N.D.
	5.8	2128-2330	N.D.
	8.3	2330-0205	N.D.
	3.6	0210-0315	N.D.
Vehicle Service Operator(B)	2.6	2025-2116	N.D.
	5.2	2117-2300	N.D.
	8.3	2305-0200	0.5
	3.7	0205-0320	N.D.
Vehicle Service Operator(C)	2.5	2030-2115	1.4
	5.9	2115-2305	0.8
	3.0	2305-0010	N.D.
Vehicle Service Operator(D)	3.2	2208-2315	N.D.
	8.8	2315-0210	0.4
	3.6	0210-0325	N.D.

1. ppm - Parts of a vapor or gas per million parts of contaminated air by volume.

2. N.D. None detected

TABLE III
SYMPTOMS REPORTED TO BE ASSOCIATED WITH
WORKPLACE EXPOSURES
MAINTENANCE WORKERS

Symptom	No. of Workers Reporting N=11	Smokers Reporting N=6
eye irritation	5	2
frequent cough	2	-
nausea	4	2
runny, itchy nose	4	1
headache	5	2
dizziness	6	2
fatigue	3	1
chest pain	2	1
chest tightness	1	-
phlegm production	1	-
decreased appetite	1	-

TABLE IV
CARBOXYHEMOGLOBIN LEVELS (%)
MAINTENANCE WORKERS

Worker Number	Smoker	Pre-shift	Post-shift
1	No	2.3	1.7
2	No	3.3	3.3
3	Yes	2.5	2.1
4	Yes	NA*	-
5	No	NA	-
6	Yes	6.1	6.1
7	Yes	3.3	-
8	Yes	NA	-
9	Yes	10.2	7.9
10	Yes	10.1	4.7

Average shift differential = -1.45% COHb

* 3 of the tests were invalid tests, listed as "NA".