ABSTRACT

HEALTH HAZARD EVALUATION DETERMINATION

REPORT NO. 73-89

Toxic Substances: Diesel exhaust gases (oxides of nitrogen, acrolein, aldehydes)

Industry: Manufacturing/Automobile Hardware

Study Data: Employee interviews
Professional judgement of NIOSH investigators

Study Date: September 6, 1973

Study Results: The hazard evaluation request concerned the alleged exposure to diesel exhaust gases of employees in an automobile hardware manufacturing plant. The alleged hazard was stated to be caused by a tractor used to move equipment inside of the building used to manufacture the automobile hardware. The hazard was eliminated to the satisfaction of the union and management by requiring the tractor operator to turn off the tractor engine when the tractor was not being used to move heavy equipment (not permitted to idle). Seven machine operators and one tractor operator were interviewed to determine if they felt they had any health problems related to their work. All gave negative responses.

Toxicity Determination: Based upon information obtained from employee interviews, existing ventilation systems, and the professional judgement of NIOSH investigators, no health hazard exists from operation of the diesel powered equipment under present operating procedures. It was suggested that safe working conditions could be maintained if equipment is not permitted to run at idle while inside buildings, employees may leave the immediate area while equipment is being moved, the diesel engine is properly tuned, and the environment is periodically monitored to determine the air concentrations of the toxic contaminants mentioned in this report are being maintained at safe levels for all employees including the tractor operators. The company had indicated that it was not practical to use electrical forklift trucks since the tractors are used on upper floors which the company felt would not support the weight of the battery powered unit.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 73-89

FISHER BODY
GENERAL MOTOR'S CORPORATION
FLINT, MICHIGAN
OCTOBER 1973

I. TOXICITY DETERMINATION

It was determined by NIOSH investigators that no health hazard exists from exposure to diesel exhaust gases as long as present operating procedures are followed. It should be pointed out however, that hazardous concentrations of diesel exhaust gases could result if a tractor were operated for any reason in a confined space, or for a prolonged period of time at one location. The long term health effects from exposure to diesel exhaust gases and particulate are not fully understood at the present time.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are available upon request from the Hazard Evaluation Services Branch, NIOSH, U.S. Post Office Building, Room 508, 5th and Walnut Streets, Cincinnati, Ohio 45202. Copies have been sent to:

(a) Fisher Body, Flint, Michigan
(b) Authorized Representative of Employees
(c) U.S. Department of Labor - Region V
(d) NIOSH - Region V

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

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by any 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 authorized representative of employees to evaluate the potential hazards associated with the alleged exposure to diesel exhaust gases produced inside a building by a tractor used to move equipment. Before our arrival at the plant the company had agreed to require the tractor operator to turn off the engine when the tractor was not being used to move equipment (not permitted to idle). Both the company and the union agreed this had reduced exposure to diesel exhaust gases to satisfactory levels.

IV. HEALTH HAZARD EVALUATION

A. Conditions of Use

The Fisher Body Plant of the General Motor's Corporation is engaged in the manufacture of automobile hardware. In the area where the hazard evaluation request was made, an Allis Chalmers HD-6, 4 cycle, 4 cylinder, 50 horse power, diesel fueled tractor is used to move heavy equipment. About 5000 employees work in the entire plant and about 150 on the second shift in the area specified in the request. The plant covers an area of several blocks. The tractor is not used in one location but is used to move equipment at a number of areas which helps reduce exposure of an individual employee, except for the tractor operator who must stay with the equipment.

Supply air is provided by several 20,000 cubic feet per minute air ducts and it was estimated that the air was changed at the rate of about 4 or 5 air changes per hour.

B. Worksite Evaluation

On Thursday, September 6, 1973, Messrs. Larsen and Burton conducted an evaluation of alleged exposure to diesel exhaust gases at the Fisher Body Plant. Eight employees were interviewed in a non-directive manner.

At the completion of the plant site evaluation an exit interview was held with management and union representatives to discuss potential hazards and control measures.

C. Evaluation Methods

No samples were collected during the survey, the determination was based upon information obtained from employee interviews and the professional judgement of the NIOSH investigators. Seven machine operators and one tractor operator were interviewed to

determine if they felt they had any health problems related to their work. Some workers complained of the odor of diesel exhaust, but none had health effects related to diesel exhaust gases.

However, it should be pointed out that conditions of use of the tractor had changed since the hazard evaluation request was made. The tractor was not operating in the building at the time of the survey. The diesel exhaust problem had been resolved to the satisfaction of union and management.

If the requestor or the company at any time considers toxic concentrations of air contaminants to exist under the revised operating procedures when the tractor is being used, another Health Hazard Evaluation Request should be made at that time.

D. Applicable Criteria

The OSHA Standards for the air contaminants of interest are taken from Part 1910 of Title 29 of the Code of Federal Regulations, Section 1910.93, Tables G-1 and G-2.[1]

Material	8-hour time weighted average	Acceptable ceiling concentration	Acceptable maximum peak above the acceptable ceiling concentrations for an 8-hour shift	
			Concentration	Maximum duration
Formaldehyde (Z37.16-1967)	3 p.p.m.	5 p.p.m.	10 p.p.m.	30 min.
Acrolein	0.1 p.p.m.			
Nitrogen Dioxide	5 p.p.m.			
Carbon Monoxide	50 p.p.m.			
Carbon Dioxide	5000 p.p.m.			

Threshold Limit Values adopted by the American Conference of Governmental Industrial Hygienists for these substances are as follows:[2]

Formaldehyde	2 ppm (ceiling level)
Acrolein	0.1 ppm
Nitrogen Dioxide	5 ppm (ceiling level)
Carbon Monoxide*	50 ppm
Carbon Dioxide	5000 ppm

*A recent NIOSH Criteria Document recommends a value of 35 ppm for Carbon Monoxide.

Table 2 provides information on Diesel Exhaust Output and Standards.

E. Evaluation Discussion

Table 1A lists the major vapor and gaseous components of diesel exhaust as identified in a recent Bureau of Mines investigation,[3] using a conventional kerosene fuel without additives. The carbon monoxide values originated from a study of diesel locomotive exhausts by the Pennsylvania Railroad in the 1950's.[4]

The toxic contaminants of diesel exhaust gases are generally considered to be aldehydes and oxides of nitrogen.

1. Aldehydes

(a) Formaldehyde

Formaldehyde is often measured to evaluate exposure to aldehydes.

According to the literature, formaldehyde has a pungent characteristically sharp irritating odor. Concentrations of 20 p.p.m. cause irritation of the eyes and upper respiratory tract, however, there are reports in the literature of eye irritation at concentrations as low as 5 p.p.m. occurring in "unacclimated" persons exposed. There have also been complaints of annoying odor, prickling irritation of the mucous membranes, and disturbed sleep, by workers exposed to concentrations of formaldehyde from 0.3 to 2.7 p.p.m.[5]

(b) Acrolein

Acrolein is one of the principle irritants in exhaust of internal combustion engines. Acrolein is an intense irritant to the mucous membranes of the eyes, nose, throat and respiratory tract, causing conjuctivitis, rhinitis, pharyngitis and bronchitis; 1 p.p.m. in air is detectable, while 5.5 p.p.m. causes a severe irritation, and 10 p.p.m. is lethal. The gas is so irritating that large or prolonged exposures will not be tolerated. In high concentrations it may cause severe edema of the lungs. However, an individual would have to be trapped and unable to escape for this to occur.[5]

2. Oxides of Nitrogen

Nitrogen Dioxide is the gas often measured to determine exposure to the oxides of nitrogen. Inhalation of small amounts of nitrogen dioxide may not be noticed, but inhalation of an atmosphere containing over 5 p.p.m. for even a few minutes may cause irritation of the upper respiratory tract. Continued exposure to high concentrations of nitrogen dioxide may result in a delayed, but slowly progressive, frequently fatal pulmonary edema. Characteristically, immediately after removal from the exposure, cough and chest symptoms subside and the individual,

feeling fine, claims to be fully recovered, yet 5,10,20, or even 36 hours later, a progressive, severe dyspnea may develop, with sudden pulmonary edema, fever, circulatory collapse and watery sputum. Death may follow in 2 to 3 days.[5,6]

Symptoms should not occur if air concentrations of contaminants are kept at or below the Criteria and Standards mentioned in this report.

3. Other Gaseous Contaminants in Diesel Exhaust

Carbon monoxide (CO) and carbon dioxide (CO_2) are potential health hazards. The relative role of CO as a potential health hazard from diesel exhausts is small owing to the nearly complete combustion of the fuel to carbon dioxide if the engine is well maintained.[7] Carbon dioxide is not a problem if the oxygen content of the air does not fall below 18% by volume,[7] which should not occur at the Fisher Body Plant in the area where the hazard evaluation request originated because air is supplied to the work area and the work area has a large room volume.

Hydrocarbon content of diesel exhaust has not been well characterized in either kinds or amounts to allow more than a very general toxicologic evaluation of their effects on health. Hydrocarbons are considered to pose little threat to health per se, but have a potential for effecting health and well being by the production of odor and photochemical smog.[7]

"The important question of the presence of absorbed carcinogenic polycyclic aromatic hydrocarbons cannot be answered until special examination of diesel smoke has been made under varying operating conditions".[7]

4. Particulate Matter

Table 1B lists the particulate composition of diesel exhaust as determined by Frey and Corn.[8] The values for carbon smoke particulate are the combined data of McKee, et al,[9] Linnell and Scott,[10] and Frey and Corn.[8] (Tables 1A and 1B were compiled by Dr. Stokinger)[7]

The most prominent particulate in diesel exhaust is smoke. Pure carbon particles are non-injurious when inhaled. However, when inhaled with appreciable amounts of absorbed substances with toxic potential, the carbon particles can enhance the inherent toxicity of absorbed substances by carrying these materials to the more sensitive tissues of the respiratory tract where they would not ordinarily go by virtue of their solubility, volitility or other properties.[7]

Trimanganese tetroxide (Mn_3O_4), the combustion product of the smoke-reducing fuel additive, methyl manganese cyclopentadienyl tricarbonyl (MMCT), is currently undergoing toxicity tests and hence its toxic hazard has yet to be determined. Although MMCT is highly toxic, it decomposes rapidly in air at ordinary humidities to Mn_3O_4. Whether a hazard exists depends upon the amount of Mn_3O_4 emitted.

Barium compounds may be used as a smoke reducer in old diesel engines. What forms of barium appear in the exhausts depend on the amounts of sulfur and nitrates (cetane improvers) or nitrogen oxides relative to amounts of the barium additive. Barium sulfate would constitute no health hazard, but more soluble forms would have to be controlled to around 0.5 mg/M^3 of barium to prevent health effects.[7]

Long term health effects from exposure to particulate matter in diesel exhaust, and synergistic effects* from exposure to the various substances which occur in diesel exhaust needs further investigation.

V. REFERENCES

1. Federal Register: Wednesday, October 18, 1972.

2. American Conference of Governmental Industrial Hygienists: Threshold Limit Values for Chemical Substances and Physical Agents for 1972.

3. Marshall, W.F., Fleming, R.D.: Diesel Emissions Reinventoried, U.S. Bu. Mines Rept. Invest. 7530, 1971.

4. Private communication to Dr. Herbert Stokinger by James F. Morgan.

5. Rutherford, R.T. and Miller, S.E.: Occupational Diseases and Industrial Medicine. W.B. Saunders Company, Philadelphia, Penn., 1960, pp. 124-126, 135-136.

6. Sven, Moeschlin: Poisoning, First American Edition. Grune & Stratton, p. 186, New York, New York, 1965.

7. Stokinger, H.E.: From information presented by Dr. Stokinger at a Symposium of Diesel Powered Equipment in Underground Mining, January 30-31, 1973, Pittsburg, Penn.

*Synergism - Cooperative action of discrete agencies such that the total effect is greater than the sum of the two effects taken independently.

8. Frey, J.W., Corn, M.: Physical and Chemical Characteristics of Particulates in a Diesel Exhaust, Am. Ind. Hyg. Assoc. J., 28, 468 (1967).

9. McKee, H.C., Clark, J.M., Wheeler, R.J.: Measurement of Diesel Engine Emissions, J. Air Poll. Control Assoc. 12, 516, (1962).

VI. AUTHORSHIP AND ACKNOWLEDGMENT

Report Prepared By: Lee B. Larsen
Industrial Hygienist
Hazard Evaluation Services Branch/SLC

Originating Office: Jerome P. Flesch, Chief
Hazard Evaluation Services Branch

Acknowledgments

Environmental Evaluation:
David J. Burton, HESB, DTS/SLC

TABLE 1A.--COMPONENTS OF DIESEL EXHAUSTS--VAPORS AND GASES

FROM BUREAU OF MINES, RI 7530 1971

VAPORS & GASES	PROPORTIONATE AMOUNTS IN EXHAUST (PPM) MEDIAN	RANGE	TLV[A] PPM	RELATIVE DILUTION TO MEET TLV[B]
CARBON MONOXIDE	400	100-3,600	50	8-75X
CARBON DIOXIDE	125,000	90,000-138,000	5,000	25-30X
HYDROCARBONS ('UNBURNED')	11,400	760-25,000	50[C]	230-500X
LIGHTER FRACTION (C_{1-12})	4,000	260-9,000	1,000	4-9X
NITROGEN OXIDES (NO, NO_2)	735	70-3,280	C 5	150-700X
ALDEHYDES (TOTAL)	30	3-97		15-50X
FORMALDEHYDE & ALIPHATICS	UNDETERMINED		C 2	
UNSATURATED (ACROLEIN?)	"		0.1	
AROMATIC?	"			
SULFUR DIOXIDE	NEGLIGIBLE		5	
	* * *			
	DI ODOR UNITS[D]			
MALODOR	3-4.5			

A) THRESHOLD LIMIT VALUE FOR AIR AT 1 ATMOSPHERE PRESSURE & 25° C

B) BASED ON MEDIAN & MAXIMUM AMOUNTS

C) TLV FOR HYDROCARBON, CUMENE

D) DIESEL INTENSITY ODOR UNITS

TABLE 1B.--COMPONENTS OF DIESEL EXHAUSTS--PARTICULATES

FROM FREY & CORN, AIHAJ 1967

PARTICULATES	PROPORTIONATE AMOUNTS[A] IN EXHAUSTS MG/M^3	TLV MG/M^3
SMOKE	30-75	
CARBON	20-45 (60%)	(3,5)
ETHER EXTRACTABLES	10-13 (30%)	
PARAFFINS	10-12	250 [F]
PARAFFIN ACIDS	0,1-1	250 [F]
NITROPARAFFINS	TRACE	25 PPM[D]
PAHC'S[G] (CARCINOGENS)?	?	
WATER EXTRACTABLES	0,3-2 (3%)	
PARAFFINIC ACIDS	0,1-0,6	
NITROPARAFFINS	0,03-0,1	
ALDEHYDES	0,03-0,1	
NITRITE	0,03-0,1	
SULFATE[B]	0,2-0,3	1[C]
HYDROCARBON 'HEAVY' FRACTION	69,000[E]	250[F]
BARIUM SALTS, SOLUBLE		0,5
TRIMANGANESE TETROXIDE (Mn_3O_4)		?

A) AS MEASURED 4 INCHES FROM EXHAUST PIPE
B) SULFUR CONTENT OF FUEL, 0,75%
C) AS SULFUR TRIOXIDE
D) AS NITROPROPANES
E) CALCULATED PARTICULATE AS 65% OF 'UNBURNED' HYDROCARBON OF AVERAGE MOLECULAR WEIGHT OF 226
F) TLV FOR CUMENE
G) POLYCYCLIC AROMATIC HYDROCARBONS

TABLE 2.--DIESEL EXHAUST OUTPUT & STANDARDS

FROM BUREAU OF MINES, RI 7530 1971

EXHAUST COMPONENT	BRAKE SPECIFIC EMISSION RATE G/BHP-HR[A]	ABOVE GROUND DIESEL EMISSION STANDARD[C] G/BHP-HR[A]
CARBON MONOXIDE	2-10	40
HYDROCARBONS	0.3-3	16[B]
NITROGEN OXIDES	6-20	
ALDEHYDES	0.1-0.5	

A) GRAMS PER BRAKE HORSEPOWER-HOUR

B) COMBINED STANDARD FOR HYDROCARBONS & NITROGEN OXIDES ASSUMING ULTRAVIOLET RADIATION EFFECTS

C) ENVIRONMENTAL PROTECTION AGENCY, FED'L REGISTER, VOL. 37 NO. 221 NOV. 15, 1972, P. 24,309.