HETA 89-335-2041
MAY 1990
SHEFFIELD LAKE SERVICE DEPARTMENT
SHEFFIELD LAKE, OHIO

NIOSH INVESTIGATOR:
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I. SUMMARY

On August 3, l989, the National Institute for Occupational Safety and Health (NIOSH) received a management request from Sheffield Lake Service Department, Sheffield Lake, Ohio, to evaluate employee exposure to diesel exhaust, and complaints of nausea from diesel exhaust odors which occur in the office areas. The facility houses a garage and shop for road maintenance vehicles, and administrative offices.

An environmental evaluation was conducted on October 30-31, l989. Long-term (6-7 hour) area samples were collected at three locations in the facility, and one outdoor location (to determine background concentrations) for selected constituents of diesel exhaust: total particulates, sub-micron particulates, benzene-soluble particulates, formaldehyde and nitrogen dioxide. Short-term detector tube samples were collected at the same locations several times during the day for nitrogen oxides, carbon monoxide, sulfur dioxide, and carbon dioxide.

Levels of benzene-soluble particulates, total particulates, and sub-micron particulates were highest in the maintenance shop (0.12, 0.68, and 0.19 milligrams per cubic meter, respectively), about 50% less in the truck parking bay area, and only slightly above outdoor levels and analytical detection limits in the office (detection limits were 0.035, 0.01, and 0.007 milligrams per cubic meter, respectively). The primary source for these contaminants appeared to be diesel exhaust, and exposures to diesel exhaust in these areas would be expected to be proportional to these measurements.

Short-term measurements were either below applicable health criteria or none detected. In the office area carbon dioxide levels increased from 820 to 1500 parts per million during a six-hour period of the day, suggesting that the area is underventilated, and that complaints regarding indoor air quality are likely even in the absence of diesel exhaust exposure.

On the basis of data obtained in this investigation, NIOSH determined that a potential health hazard existed among workers in the maintenance shop and parking bay areas due to exposure to diesel exhaust. A lack of ventilation in areas were diesel trucks are periodically run resulted in exposures to diesel exhaust. Recommendations for improved ventilation in the office, maintenance shop, and parking bay areas are discussed.

KEYWORDS: SIC 1611 (Highway and street construction), diesel exhaust, maintenance shops, indoor air quality.

II. INTRODUCTION

On July 31, l989, a representative of Sheffield Lake Service Department requested that NIOSH conduct a health hazard evaluation (HHE) to evaluate employee exposure to diesel exhaust. The request stated that diesel exhaust from vehicle start up in the service garage permeates the office area of the building, causing clerks and customers to become nauseated.

On October 30-31, l989 NIOSH investigators conducted an initial survey and environmental sampling for selected constituents of diesel exhaust at the facility. Initial industrial hygiene results and recommendations resulting from that visit were provided to the requestor in a letter dated November 17, 1989.

III. BACKGROUND

Sheffield Lake Service Department has used the present location for service of municipal vehicles, mostly diesel-powered trucks, since approximately 1966. The single-story 60 by 120 ft building is constructed of concrete block with a pitched corrugated metal roof. A number of ceiling fans have been installed to circulate air and improve heating and cooling effectiveness. Since about 1982, 3 to 11 administrative employees of the department have been located in the northeast corner of the building, in an office approximately 20 by 40 feet, separated from the garage bays by a concrete block wall with two door openings. The office was heated with electric baseboard heaters, and cooled with four window air conditioners. Outside air is provided to the offices by operating window air conditioners on the vent setting, and when the front door is opened. Smoking was permitted in the offices and other work areas. The building floor plan is shown in Figure 1.

On a daily basis, diesel trucks are driven into the maintenance shop, consisting of a single service bay located in the southwest corner of the building. It is periodically necessary to run the truck engines in the maintenance shop during servicing. During the winter months, diesel-powered trucks are parked in the five garage bays overnight to keep the engines somewhat warmer than outside conditions. From 7:00 to 7:30 am, trucks to be used that day are started and run for 1 to 2 minutes, then pulled outside. The running time in the building reportedly is necessary to allow for the air brakes to become pressurized, and for the older-model truck engines to briefly warm up. Ventilation consists of a wall fan on the south wall and two overhead ceiling vents which must be opened manually.

Employees in the office area have reported persistent diesel exhaust odors, especially during the winter months, and occasional symptoms of nausea..

IV. EVALUATION DESIGN

On the day of sampling, October 31, l989, winter conditions at the maintenance garage were duplicated to the extent possible. The parking bay garage doors were kept closed except when opening was necessary to move trucks, roof vents were closed, and the wall-mounted fan was turned off. Windows and doors in the office areas were closed, and the window air-conditioners were off. Several trucks were started and warmed up for about 2 minutes in the parking bays, then pulled out. In the maintenance shop, trucks were pulled in periodically for routine servicing.

To characterize airborne concentrations of diesel exhaust, long-term (6-7 hour) area samples were collected at four locations: middle office, parking bays, road department shop, and outdoors (to determine background concentrations). Sampling locations are shown in Figure 1. These samples were collected for selected constituents of diesel exhaust: total particulates, sub-micron particulates, benzene-soluble particulates, formaldehyde, and nitrogen dioxide (NO_2). The samples (except those for NO_2) were collected using personal air sampling pumps with various sampling media, and calibrated to certain flow rates. NO_2 samples were collected with

passive monitors (Palmes Tubes). The flow rates, sampling media, and analytical techniques by constituent are shown in Table 1.

Short-term samples were collected with detector tubes at the same four locations for NO_2, nitrogen oxides (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2), and carbon dioxide (CO_2).

V. EVALUATION CRITERIA

Sources of evaluation criteria are the NIOSH Recommended Exposure Limits, the Occupational Safety and Health Administration (OSHA) enforceable Permissible Exposure Limits (PELs), and the American Conference of Governmental Industrial Hygienists' (ACGIH) recommended Threshold Limit Values (TLVs).

NIOSH recommends that diesel exhaust be regarded as a potential occupational carcinogen, and that exposures be reduced to the lowest feasible limits [1]. The recommendation is based on carcinogenic and tumorigenic responses in rats and mice exposed to whole diesel exhaust. OSHA and ACGIH do not have evaluation criteria for whole diesel exhaust.

Evaluation criteria are available for some of the individual components of diesel exhaust measured, such as CO_2, CO, NO_2, SO_2, formaldehyde, and total particulates, which are intended to suggest levels of exposure up to which workers may be exposed for 8-10 hours/day, 40 hours/week for a working lifetime without adverse health effects. Where applicable, these criteria are shown for long-term measurements in Table 2.

However, the combined effects of components in complex mixtures such as diesel exhaust are not considered in these individual evaluation criteria. It is important to note that a small percentage of workers may experience adverse health effects at exposure levels below the criteria because of individual susceptibility, a pre-existing medical condition, or hypersensitivity (allergy).

VI. RESULTS AND DISCUSSION

Long-term sample results are shown in Table 2. Both long-term and short-term results are discussed in the following subsections.

A. Benzene-soluble, Total, and Sub-Micron Particulates

Concentrations of benzene-soluble particulates, total particulates, and sub-micron particulates measured were highest in the maintenance shop, about 50% less in the bay area. Benzene-soluble particulate concentrations were only slightly above outdoors (or detection limit) in the office. Total and sub-micron particulates were an order of magnitude higher than outdoors in the maintenance shop, and about 50% less than the bay area. Since the primary source for these contaminants appeared to be diesel exhaust (with some contribution from cigarette smoke, especially in the office), potential exposures to the exhaust in these areas of Sheffield Lake Service Department building would be expected to be proportional to the measurements.

The concentration of benzene-soluble particulates in the maintenance shop on the day of the survey was 0.12 milligrams per cubic meter (mg/m^3). Although there is no evaluation criteria directly applicable to this measurement, it exceeds the NIOSH REL of 0.1 mg/m^3 for coal- tar pitch volatiles which may be used as a guideline for comparison. Diesel exhaust particulate emissions are similar to coal-tar pitch materials in that both are carbonaceous and known to contain carcinogenic polycyclic hydrocarbons [5]. NIOSH investigators conclude that there is a potential for long-term health effects at the facility, primarily due to the carcinogenic risk of exposure to diesel exhaust.

B. Formaldehyde

The long-term measurement for formaldehyde was slightly higher in the office area than in the bay area or maintenance shop. Formaldehyde levels are often higher indoors than outside because the compound is released from building materials such as plywood, particle board, carpeting and office furniture (materials that were more prevalent in the office area), and it is a constituent of cigarette smoke. The indoor:outdoor ratio for the formaldehyde measurements was approximately 8:1. Formaldehyde levels were within the range typical of modern office areas; less than 0.10 ppm [2].

The OSHA PEL for formaldehyde is 1.0 ppm for an 8-hour TWA. The ACGIH TLV-TWA for formaldehyde is 1.0 ppm, with a notation that it is a suspected human carcinogen, and exposures should be controlled to levels as low as reasonably achievable. ACGIH has also given notice that it intends to change the TLV to a 0.3 ppm ceiling limit. NIOSH policy states that formaldehyde is a suspect human carcinogen, and that exposures should be reduced to the lowest feasible level.

C. Carbon Dioxide

Short-term detector-tube measurements for carbon dioxide (CO_2) taken in the office and parking bay areas on the day of the survey are listed below. The outdoor, ambient concentration of CO_2 measured on that day was 350 parts per million (ppm).

CO_2 MEASUREMENTS (PPM)

Time	Office Area	Parking Bays
08:30	-	425
10:15	820	-
12:10	1000	-
12:25	-	580
15:05	1250	-
16:15	1500	-

- (indicates no measurement taken)

CO_2 is often monitored as a screening technique to evaluate whether adequate quantities of fresh outdoor air are being introduced into a work area within a building [3]. Usually CO_2 levels are higher inside occupied buildings than outside, because CO_2 is a normal constituent of exhaled breath. Indoor CO_2 concentrations greater than 1000 ppm indicate a lack of ventilation, which can allow concentrations of other contaminants to increase and lead to complaints such as headaches, fatigue, and eye and throat irritation. CO_2 levels measured in the parking bay area were well below 1000 parts per million (ppm), however in the office area CO_2 readings increased from 820 ppm to 1500 ppm during the day.

D. Other Measurements

With the exception of the following, detector tube results for NO_2, NO_x, CO, and SO_2 were none detected or trace (non-quantifiable) amounts:

1. In the bay area, seven minutes after truck warm-up began at 08:30, 25 ppm CO, and 1 ppm NO_x were measured.

2. In the office area, at 09:20 6 ppm CO was detected.

All the other long-term and short-term measurements on the day of the survey were well below the established criteria for individual compounds.

VII. RECOMMENDATIONS

1. CO_2 measurements suggest that the office area is underventilated, and that complaints regarding indoor air quality are likely even in the absence of diesel exhaust exposure. As stated in the November 17, 1989 letter, NIOSH recommends that conditioned outdoor air be supplied and adequately distributed to all office areas during times they are occupied. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) in Standard 62-1989 [4], recommends guidelines for indoor ventilation. The AHRAE-recommended rate for office areas is 20 cubic feet per minute (cfm) per person. A ducted system for supply and return air provides the best mixing for thermal comfort and contaminant control. The office area should be positively pressurized with respect to the parking bay and maintenance areas. Ventilation as described should do this. Providing this additional ventilation should ensure that exposures to diesel exhaust in the office areas are reduced to outdoor background levels, and that diesel odors and normal indoor contaminants are diluted and exhausted.

2. To reduce employee exposure to diesel exhaust in the bay and maintenance shop areas, supplement or replace the wall-mounted propeller fan and passive roof openings used for dilution ventilation. The effectiveness of the propeller fan and roof openings appears to be subject to outside wind/weather conditions, and at times they would be rendered ineffective. A more efficient system, capable of coping with fluctuating airflow conditions, would provide local exhaust ventilation to the diesel truck exhaust tailpipes/stacks. The system should include a suitable exhaust fan, such as a centrifugal fan combined with overhead rigid and flexible ductwork to the tailpipe/stacks. As a general guideline for design purposes, enclosed are "Service Garage Ventilation Overhead," and "Exhaust System Requirements for Typical Diesel Engines Under Load" from the ACGIH's Industrial Ventilation, 19th Edition, A Manual of Recommended Practice (pages 5-106,5-107, and 5-109).

VIII. REFERENCES

1. NIOSH Current Intelligence Bulletin 50. "Carcinogenic Effects of Exposure to Diesel Exhaust." DHHS (NIOSH) Publication No. 88-116. NIOSH, Cincinnati, Ohio. August 1988.

2. National Research Council, Building Research Board. "Policies and Procedures for Control of Indoor Air Quality." National Academy Press, Washington, D.C. 1987.

3. NIOSH Division of Standards Development and Technology Transfer. Indoor Air Quality-Selected References. NIOSH, Cincinnati, Ohio. September l989.

4. ASHRAE Standard 62-1989. Ventilation for Acceptable Indoor Air Quality. ASHRAE Publications, Atlanta, Georgia. 1989.

5. ACGIH. Documentation of the Threshold Limit Values and Biological Exposure Indices. Fifth Edition. ACGIH, Inc., Cincinnati, Ohio. 1986, page 143.

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 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. NIOSH Cincinnati Region
2. OSHA, Region V
3. Sheffield Lake Service Department, Sheffield Lake, Ohio

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

Summary of Long-term Sampling and Analytical Methods
Sheffield Lake Service Dept.
Sheffield Lake, Ohio
HETA 89-335
October 31, 1989

Contaminant	NIOSH Method Number [3]	Collection Medium	Volumetric Air Flow Rate (L/min) Used	Desorbing Solvent or Solution	Type of Analysis Used
Formaldehyde	3500	Impinger - aqueous 1% sodium bisulfite solution	1.0		Chromotropic acid reaction, spectrophotometry
Nitrogen Dioxide (NO_2)	6700	Palmes tube-passive diffusion	**		Trienthanolamine reaction, Spectrophotometry
Total particulate	0500	Filter - poly-vinyl chloride (PVC) membrane	2.0		Gravimetric
Sub-micron particulate	***	Filter - PVC-membrance	2.0		Gravimetric
Benzene-soluble fraction of particulate	5023	Filter - Polutetraflouro-ethylene (PTFE) membrance	3.5	Benzene	Gravimetric

** Passive diffusion rate of 2.3 nanomoles/ppm-hr.
*** Identical to NIOSH Method 0500 except for size selector.

Table 2

Long-Term Sample Results
Sheffield Lake Service Dept.
Sheffield Lake, Ohio
HETA 89-335

October 31, 1989

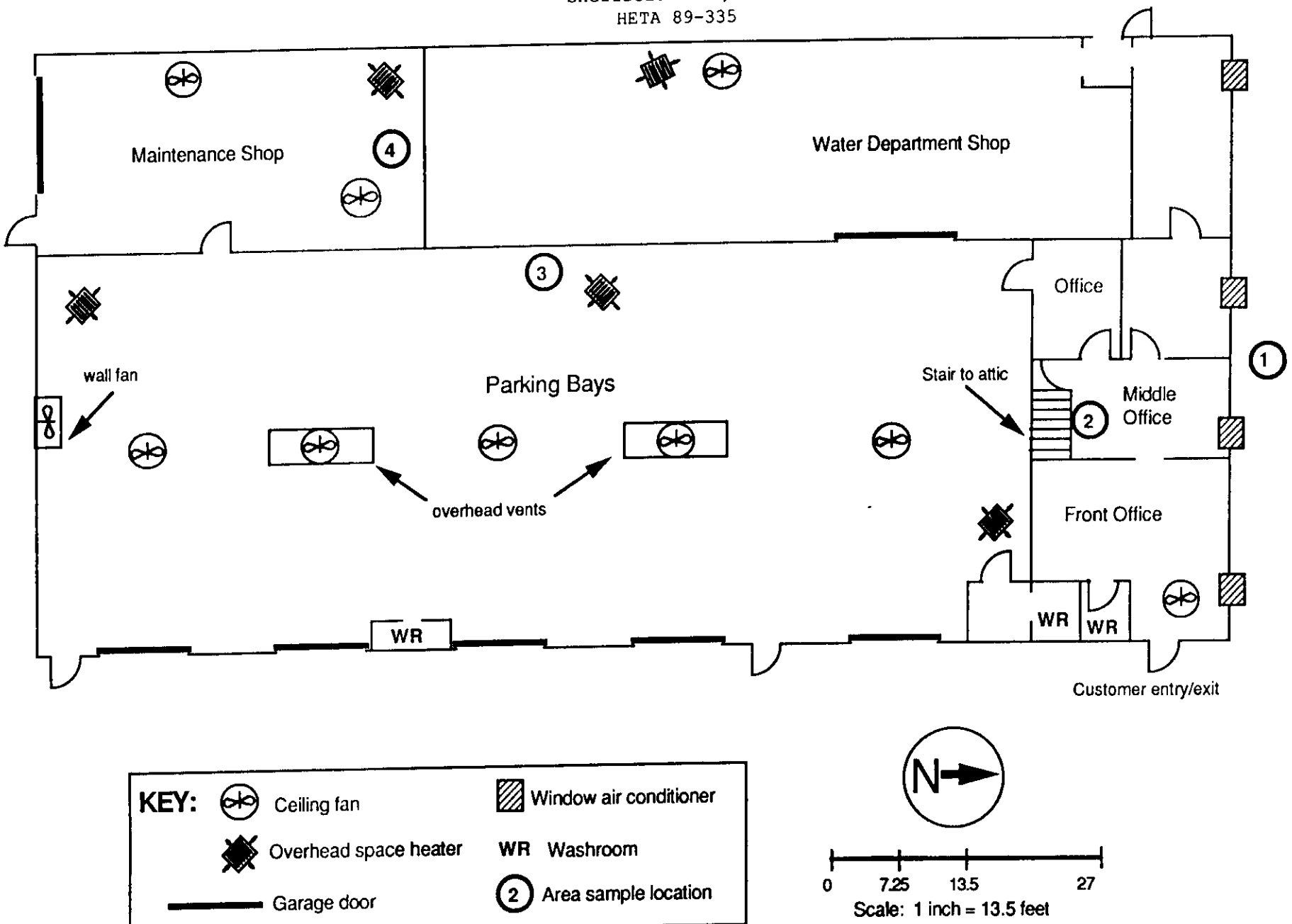
Sample Location	Sampling Time (minutes)	Benzene-Soluble Part. (mg/m^3)	Total Part. (mg/m^3)	Sub-Micron Part. (mg/m^3)	Formaldehyde (mg/m^3)	Nitrogen Dioxide (ppm)
1. Outdoors	353	N.D. <0.035	N.D. <0.01	0.007	0.0030	(0.031)
LOD		0.035	0.01	0.007	0.00057	0.031
LOQ		N/A	N/A	N/A	0.0011	0.054
2. Office	412	0.036	0.097	0.030	0.026	(0.048)
3. Parking Bays	431	0.066	0.28	0.075	0.023	0.096
4. Maintenance Shop	419	0.12	0.68	0.19	0.024	0.093
EVALUATION CRITERIA:						
NIOSH REL		N/A	N/A	N/A	LFL	1 ppm
ACGIH TLV		N/A	10 mg/m^3	N/A	1.5 mg/m^3	3 ppm
OSHA PEL		N/A	15 mg/m^3	N/A	1.5 mg/m^3	5 ppm

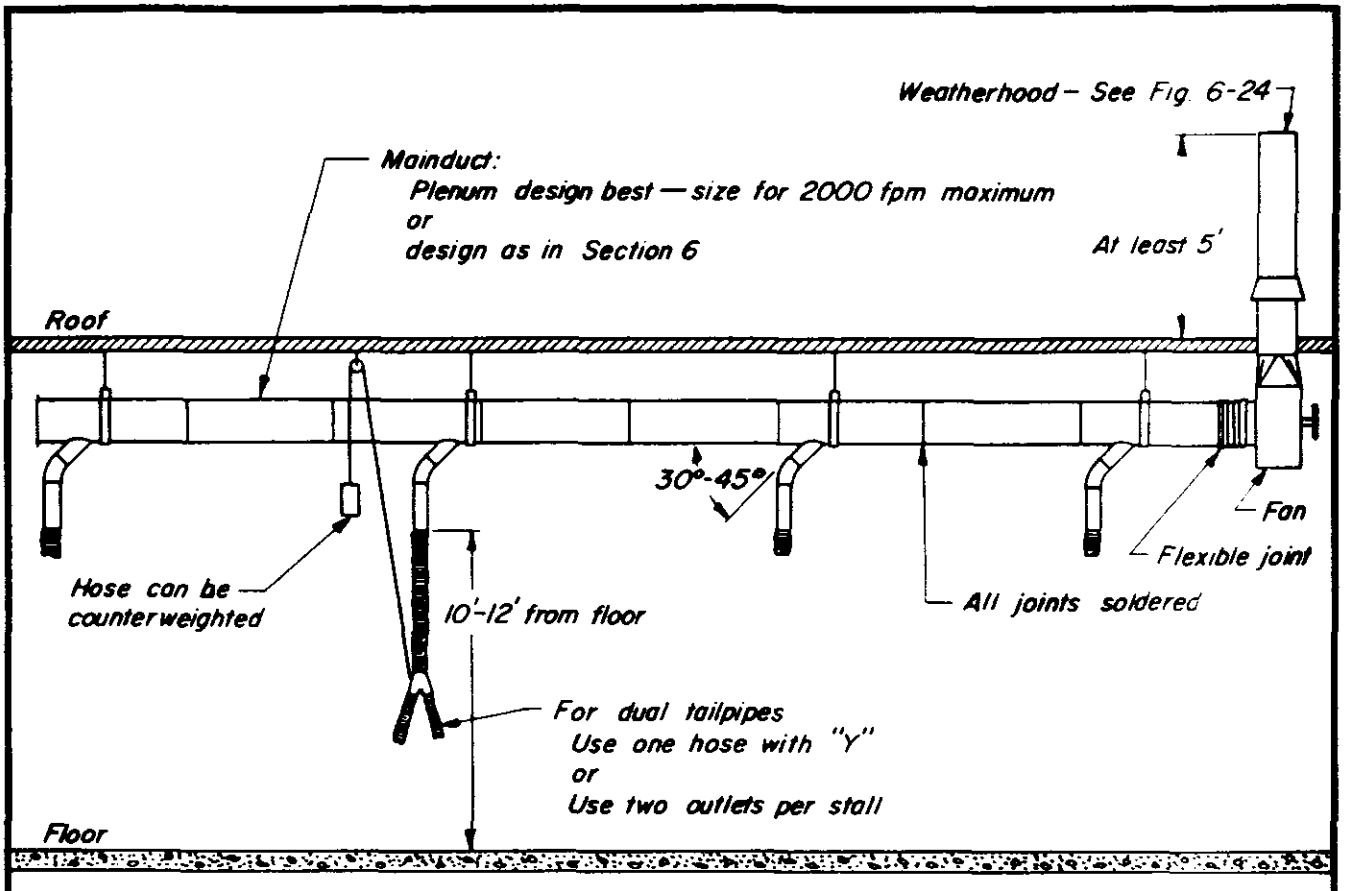
Key to Abreviations:

Part. - Particulate
LOD - Limit of detection
LOQ - Limit of quantitation

ppm - parts per million
mg/m^3 - milligrams per cubic meter
( ) - quantity measured is between LOD and LOQ
N/A - not applicable
LFL - lowest feasible level

Figure 1
Floor plan
Sheffield Lake Service Dept.
Sheffield Lake, Ohio
HETA 89-335





Vehicle horsepower	cfm/vehicle	Flexible duct diam	Branch connection
Up to 200 hp	100	3"	4"
Over 200 hp	200	4"	4"
Diesel trucks	See VS-908.2		

On dynamometer test rolls

Automobiles and light duty trucks = 2 x cfm above

Heavy duty trucks = 1200 cfm minimum

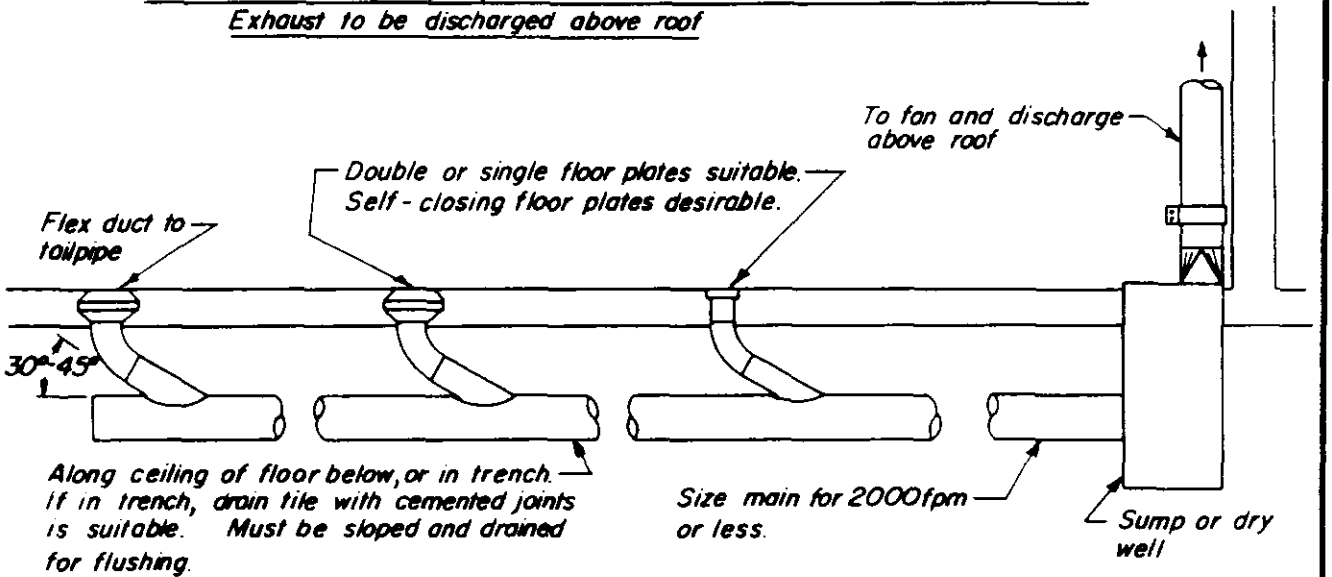
For friction loss of flexible duct; consult manufacturers' data

See VS-908 for additional details

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	
SERVICE GARAGE VENTILATION OVERHEAD	
DATE 1-82	VS-907

SPECIFIC OPERATIONS

Note: In ventilating a garage use either the overhead or under floor system. Exhaust to be discharged above roof



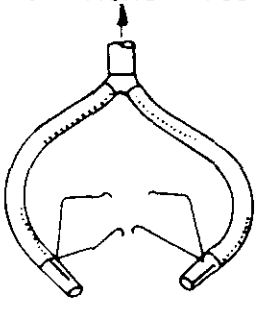
UNDER FLOOR SYSTEM

EXHAUST REQUIREMENTS *

Type	cfm per vehicle	Flex duct ID (min)
Automobiles and trucks up to 200 hp	100	3"
Automobiles and trucks over 200 hp	200	4" * *
Diesel	See VS-908.2	

* On dynamometer test rolls
Automobiles and light duty trucks = 2 x cfm above
Heavy duty trucks = 1200 cfm minimum.

** 3" dia permissible for short runs with proper fan.
For friction loss of flexible duct; consult manufacturers' data.



Dilution ventilation is necessary for cars in motion or idling outside of stalls.

DILUTION RATES:

5000 cfm/running automobile
10,000 cfm (or more)/truck.
100 cfm/horsepower for diesel.

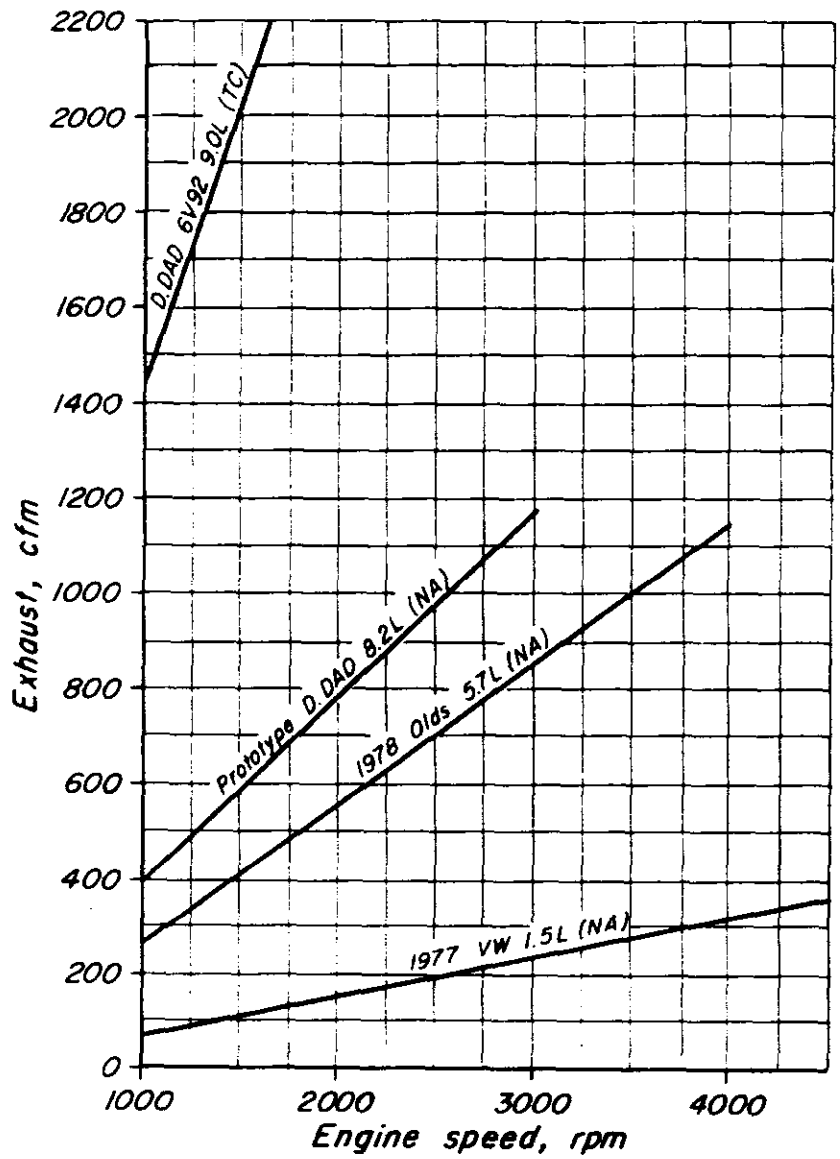
For parking garages, see Table 5-9-2

Use adapters on dual exhausts and special tailpipes.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	
SERVICE GARAGE VENTILATION UNDERFLOOR	
DATE 1-82	VS-908

ATTACHMENT II

SPECIFIC OPERATIONS



Note:
NA - normally aspirated
TC - turbo charged

Exhaust, cfm = acfm + 20% excess

For specific design information request manufactures 13 mode EPA engine bench test.

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EXHAUST SYSTEM REQUIREMENTS FOR TYPICAL DIESEL ENGINES UNDER LOAD

DATE 1-82 | VS-908.2