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IN DEPTH SURVEY REPORT
OF
P*I*E NATIONWIDE, INC.
Jacksonville, Florida

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16. Abstract (Limit: 200 words) A study was conducted at the P-I-E Nationwide terminal, Jacksonville, Florida as part of a larger effort to determine whether persons exposed to diesel aerosol as part of their job continued to have an elevated risk of contracting lung cancer after controlling for tobacco smoking and to determine relative exposures to diesel aerosol among the four major presumably exposed job groups: road drivers, local drivers, dock workers, and mechanics. This dock operated 24 hours a day on three shifts. Seven tow motor trucks were located on the dock, six diesel powered, one propane powered. Sampling conducted at the site indicated that most jobs had low level exposures on the order of 6 micrograms/cubic meter (microg/m3). Geometric mean exposures to submicrometer elemental carbon (7440440) ranged from a low of 4.1microg/m3 in mechanics working primarily in the repair shop to 25.4microg/m3 in the dock workers driving diesel powered lift trucks. Only the dock workers had exposures to elemental carbon which were substantially above the concentrations determined from highway area samples. The principal source of the dose workers' exposures was diesel emissions from the fork lift trucks operated on the docks.

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PURPOSE:	To conduct an in depth survey of workers' exposures to diesel exhaust. The survey was conducted as part of the Industrywide Studies Branch case control mortality and industrial hygiene study of truck drivers, dock workers and mechanics presumably exposed to diesel exhaust aerosol.
DATE OF SURVEY:	April 19-22, 1988
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SIC CODE:	4231 - Freight Trucking Terminals, with or without maintenance facilities

DISCLAIMER

Mention of facility names or products in this report does not constitute endorsement by the National Institute for Occupational Safety and Health.

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Abstract

The Industrywide Studies Branch of NIOSH is currently conducting a combined case-control and industrial hygiene study of members of the International Brotherhood of Teamsters. The purposes of the study are: 1) to determine whether persons exposed to diesel aerosol as a part of their job continue to have an elevated risk of contracting lung cancer after controlling for tobacco smoking, and 2) to determine relative exposures to diesel aerosol among the four major presumably exposed job groups (road drivers, local drivers, dock workers, and mechanics) identifiable from Teamsters union records. The second objective was accomplished by conducting a series of industrial hygiene surveys at seven U.S. truck terminals. During each of these surveys, personal and area sampling were conducted to evaluate exposures to submicrometer elemental carbon (used as the principal surrogate marker of exposure), submicrometer organic carbon, and several other particulate components of diesel exhaust, including gravimetrically determined respirable and submicrometer dust.

Elemental carbon sampling results at the P*I*E Nationwide terminal in Jacksonville, FL during mild weather indicate low-level exposures (similar to background highway concentrations - on the order of 6 ug/m^3) in most jobs. Geometric mean exposures to submicrometer elemental carbon ranged from a low of 4.1 ug/m^3 in mechanics working primarily in the repair shop, to 25.4 ug/m^3 in dock workers driving diesel-powered lift trucks. Other job exposure means were intermediate to these. Only the dock workers had exposures to elemental carbon substantially above concentrations determined from highway (area) samples. The principal source of the dock workers' exposures appeared to be diesel emissions from the diesel-powered fork lift trucks operated on the dock.

INTRODUCTION

NIOSH researchers are conducting a study to characterize the current and historical diesel exhaust exposures of trucking industry employees, with the objective of ranking jobs by exposure within the industry. The rankings will be used subsequently in a case-control mortality study to help interpret the results of the study in terms of dose-response, and to correctly classify the study participants by the level of their diesel exhaust exposure. The purpose of the mortality study is to determine if workers in certain jobs in the trucking industry have experienced an increased risk of developing lung cancer compared to others, after controlling for smoking. The study includes men who died in 1982-83, and applied for a Teamsters pension. Thus all persons in the study are long term Teamsters Union members.

One of the difficulties in determining relative exposures to diesel exhaust is deciding what substance or substances to measure. Whole diesel exhaust cannot be measured directly since it is a complex mixture of chemical substances. In addition, many other combustion or pyrolysis products, such as tobacco smoke, industrial aerosols, and wood smoke, contain many of the same components. Several components or fractions of diesel exhaust for which measurement methods have been established include respirable particulate, total airborne particulate, and oxides of nitrogen, sulfur, and carbon (1). In this study, measurement of the elemental carbon content of airborne submicrometer particulate was used as the primary marker of exposure to diesel exhaust.

This report describes the results of an in-depth industrial hygiene survey conducted at P.I.E. Nationwide's break-bulk terminal in Jacksonville, Florida during the period April 19-22, 1988. During the survey, 84 personal samples were obtained for evaluation of workers' exposures to elemental and organic carbon in airborne "submicrometer" aerosol (particles generally smaller than one micrometer in aerodynamic diameter). Additional area samples were obtained for evaluation of concentrations of airborne respirable dust and submicrometer dust. This report describes the terminal and its workforce, the toxicity of diesel exhaust and applicable exposure criteria, the methods used during the survey to evaluate diesel exhaust exposures, the results of the sampling, and preliminary conclusions and recommendations.

TRUCK TERMINAL DESCRIPTION

The terminal, located on Kings Road in Jacksonville, Florida, is one of the P.I.E. Nationwide company's largest. The site currently includes some corporate offices, and the break-bulk (or hub) terminal, which consists of terminal offices and truck/driver dispatching area, a 104-door dock, a wash rack, and a truck repair shop. Appendix A is a simplified site layout diagram, and it illustrates the general traffic flow at the terminal. Both line-haul (over the road) and local drivers operate to and from this terminal.

The terminal began operations as the Great Southern Trucking Company in the early 1940's. A 60-door dock was built in 1952, and was expanded to its present size in 1979. In 1953, the company was renamed the Ryder Trucking

Company after a merger with that company. In 1983, the name changed again to Ryder-P.I.E. Nationwide after a merger with the P.I.E. Nationwide Company. The name was changed again in 1985, and the company is now called the P.I.E. Nationwide Company.

Dock Operations

The dock is typical of truck docks at this type of terminal. The floor of the dock consists of an elevated (approximately 3 feet off the ground) concrete slab that allows easy loading and off-loading of truck trailers. The dock building itself is an open-sided covered structure with a total of 104 open doors placed along both sides and the west end of the building (terminal offices are adjacent to the east end). Each door is sized larger than the open end of most truck trailers, again to allow easy access to the interior of the trailer. The doors do not have closures, but during normal dock operations, trailers are parked at most of the door openings. Ventilation conditions on the dock are essentially the same during both warm or cool weather; i.e., dock doors remain open to the same degree during all weather, and the dock is not heated.

The floor of the dock is an open space, but most of it, except for the tow-motor (forklift) driving lanes, is normally taken up with materials, hand carts and other moving equipment, and other stock being transferred from one trailer to another within the dock.

The dock operates twenty-four hours per day on three shifts. There are seven tow-motor trucks on the dock. Six of the seven tow-motors are 1984 model Toyota diesel-powered vehicles, and one is a 1982 model Clark propane-powered vehicle. The P.I.E. Nationwide company has been gradually converting to diesel powered tow-motors since 1981. Currently, almost all tow-motors owned company wide are diesel powered.

Repair Shop Operations

The repair shop at this site consists of four repair bays and one service lane, plus shop offices, parts storage, and a tool crib. Each bay (running east-west) is approximately 200 feet long and about 18-20 feet wide, with large overhead bay doors at each end. Minor and medium level repairs are done in the four repair bays, while routine safety checks and services are done in the service lane. All arriving trucks are routed through the service lane. These trucks are driven into the service/safety check bay, parked, and the engine turned off. If the engine must remain running while in the service bay area, a local exhaust hood is attached to the exhaust stack of the truck. The mechanics in charge of this lane run through a checklist of service/safety items (oil, brakes, grease, tires, lights, wipers, etc.) to determine the operating condition of the vehicle.

The repair shop does most tune-ups, and mechanical, tire and wheel, and electrical repair, but does not do major jobs such as major engine or transmission overhauls. During the survey, the large bay doors on all bays were kept open at both ends due to the warm (greater than 50-degree daytime highs) ambient temperatures. Other than the local exhaust systems for the truck stacks, no ventilation systems were in place in the shop area.

Truck Fleet Description

This terminal employs both Line-haul (long-distance) drivers, and short-haul (city only or local) drivers. Twenty-two road tractors (used in line-haul) are housed at this terminal. These include both Freightliner and Kenworth: 1) conventional design single axle tractors (in which the engine is situated in front of the cab), which can haul up to 20,000 lbs. weight; and 2) "Cabover" designs (in which the cab is situated directly over the engine compartment), which can haul up to 34,000 lbs. with a conversion for a tandem axle. All line haul tractors used by P.I.E. are configured with vertical stack exhausts on the right (opposite from the driver) side of the cab. Since 1958, all of the line haul tractor cabs (but none of the city cabs) have been either bought or retrofitted with air-conditioning units.

P.I.E. Nationwide began conversion of the road tractor fleet from gasoline engines to diesel engines in the mid- 1950's, and the conversion was completed in 1958. Reliable non-asbestos composition brake linings became available in 1986, and since that time, all tractor wheels have been relined with the non-asbestos linings.

WORKFORCE DESCRIPTION

As of the date of the survey, approximately 110 persons were on the seniority list at this terminal. These included about 50 "checkers" (dock workers), 11 city truck drivers, 16 "hostlers" (yard operators), and 5 tow-motor (lift truck) drivers. An additional 25 workers were on layoff at the time of the survey. The terminal also employed 10 office clerks, and 13 management personnel. The management personnel included one terminal manager, one office manager, one city truck dispatcher, two dock superintendents, and eight dock supervisors. The terminal personnel (exclusive of office, managerial, and road drivers) were all male, and approximately 33% were black or Hispanic.

In addition to the terminal personnel, 47 road drivers were employed at this terminal, about 22 of whom were dispatched from this terminal. All of the drivers were males, seven were black, and one was Hispanic. In 1965, the terminal employed about 100 road drivers. The number has steadily decreased to 47 at the time of the survey.

MEDICAL, SAFETY, AND INDUSTRIAL HYGIENE PROGRAMS

Safety and Hygiene Programs

The company has no formal in-house industrial hygiene program, but P.I.E. Nationwide has a well developed safety program, with a safety supervisor located in Charlotte, N.C. The program includes extensive new-employee and periodic training programs in safety and hazardous materials, and an incentive awards program. On-site safety coordination and implementation is the responsibility of managers and supervisors. Safety meetings are held irregularly as time permits, and safety and hazardous materials topics are covered regularly in "breakfast" meetings.

Medical Programs

There is no on-site medical clinic or nurse's station, but there is a first aid station. The company has no specific arrangement for medical or emergency care, but the city emergency response system is reportedly excellent. At the time of the survey, the company had no policy or program for training personnel in C.P.R.

For drivers, the Department of Transportation requires a pre-employment physical and a periodic physical every two years. The physical is a limited one and includes a medical history, vision tests, hearing and audiometry, and urine analyses which include specific gravity, albumin, and sugar. The examination also includes an EKG and a chest X-ray. Appendix B is a copy of the blank form used for the examination.

DIESEL AEROSOL TOXICOLOGY AND EXPOSURE CRITERIA

Toxic and Carcinogenic Effects

Three characteristics of diesel exhaust particles (DEP) are important when considering the toxicity of diesel exhaust. First, the particles are small and readily inhalable and therefore can reach the lower respiratory system, where they are retained (2). Second, at least several thousand organic compounds can be adsorbed onto the surface of the carbon particle aggregates, many of which are cytotoxic, carcinogenic or mutagenic (3). These adsorbed compounds can include polynuclear aromatic hydrocarbons (PAHs), and nitro-substituted PAHs such as 1-nitropyrene and 2-nitrofluorene (4). Third, diesel particles consist largely of carbonaceous material which is relatively stable in biological media. Thus, inhaled diesel particles tend to be retained for long periods in the lower respiratory tract and can accumulate, favoring induction of chronic pulmonary effects such as respiratory impairment and carcinogenesis (4).

Whole diesel exhaust also includes a number of toxic gases or vapors (i.e., various oxides of nitrogen and sulfur, aldehydes, etc.), which appear to play a major role in effects such as acute respiratory irritation. However, it is conceivable that these gases, or the organic material adsorbed on deposited particles, may play an additive or synergistic role in reducing ciliary clearance as well, perhaps through direct chemical cell toxicity (2).

In a major chronic inhalation study conducted by the Lovelace Institute, rats exposed at a concentration of 350 ug/m^3 DEP for 7 hr/day, 5 days/wk for up to 2 years did not have clearance rates that were significantly different from controls (5). However, rats similarly exposed at a concentration of 7000 ug/m^3 did show clear evidence of pulmonary accumulation of DEP after only 12 months, indicating impaired particle clearance. Rats exposed at concentrations of 3500 ug/m^3 did not demonstrate impaired clearance until after 18 months of exposure. These data suggest that (at least in rats) impairment of pulmonary clearance is a function of both concentration and duration of exposure, and that significant impairment of pulmonary clearance and subsequent accumulation of DEP begins somewhere between a concentration of 350 and 7000 ug/m^3 of DEP. However, substantial differences in lung clearance rates between test animals and humans make these data difficult to interpret in terms of human risk assessment (2).

NIOSH recently published a current intelligence bulletin (1) which concluded that "...whole diesel exhaust be regarded as a potential occupational carcinogen in conformance with the OSHA Cancer Policy (29 CFR 1990)". This conclusion was based on the results of recent animal and human epidemiology studies. The studies in rats and mice confirmed the association between induction of lung tumors and exposure to whole diesel exhaust, and especially the particulate phase (5-9). Several recent human epidemiology studies also consistently suggested an association between occupational exposure to whole diesel exhaust and lung cancer (10-12).

The most recent and thorough epidemiological studies were done by Garshick et al. (11,12) in railroad workers. In both of these case control studies, significant excesses of lung cancer were identified in certain age groups of exposed railroad workers, after controlling for tobacco smoking and asbestos exposures. Classification of the workers into exposed and unexposed groups was confirmed using adjusted respirable particulate (ARP) exposure measurements in 39 representative jobs from four U.S. railroads over a 3-year period. The measurements were adjusted by analyses for nicotine from composited filters obtained from each job group (13). Geometric mean exposures to ARP ranged from 17 ug/m^3 for clerks to 134 ug/m^3 for locomotive shop workers. Differences in climate, facilities, equipment, and work practices were found to affect exposures to diesel exhaust (14).

Exposure Criteria

Permissible exposure limits (PELs) promulgated by the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA) and NIOSH recommended exposure limits (RELs) exist for a number of gas/vapor species present in whole diesel exhaust (Table I, reproduced from NIOSH's Current Intelligence Bulletin No. 50 (1). There are essentially no exposure limits (either promulgated as standards or recommended) directly applicable to evaluation of diesel aerosol (particulate phase) exposures. Both OSHA and MSHA have promulgated exposure limits for respirable nuisance (inert or nontoxic) dust for general occupational (5 mg/m^3) and coal-mine environments (2 mg/m^3). However, neither of these standards were intended to apply to diesel exhaust particulate. These standards are roughly comparable to the medium (3.5 mg/m^3) and high (7 mg/m^3) exposure concentrations used in the animal studies reported by Mauderly et al. (5). Thus it is unlikely that these concentrations represent reasonable exposure limits for human exposure to diesel aerosol. There are also no existing exposure limits for specific PAHs or N-substituted PAHs. Similarly, the OSHA PEL for coal tar pitch volatiles (measured by solvent extraction of collected particulate) is not considered relevant to diesel emissions.

Measurements of the specific compounds mentioned above (and relating the results to published standards and recommendations) will not serve as adequate surrogates for diesel exhaust exposure nor do they allow an accurate assessment to be made of the effects of factors such as climate, facility design, work practices, and tractor/tow-motor configuration, type, or age. The measurement of submicrometer elemental carbon, which was used in this survey, appears to be a more sensitive and specific surrogate for diesel exhaust than other previously used surrogates. Currently there are no promulgated standards or recommended exposure limits for exposure to submicrometer elemental carbon in whole diesel exhaust.

METHODS

Background

Characterizing worker exposure to diesel exhaust is difficult because of the complex nature of diesel engine emissions. One of the chief difficulties is determining which of the thousands of compounds best serves as an index at diesel exhaust exposure and as an indicator for the expression of adverse health effects. Since measuring each of the compounds in diesel exhaust is obviously impossible, it is necessary to identify a component of whole exhaust which is thought to be related to the health effect of interest. In this study the health effect of interest is lung cancer.

One of the many problems associated with choosing an appropriate air sampling method for the carcinogenic component of diesel exhaust is the uncertainty about which specific agent or agents are responsible for its mutagenic and carcinogenic properties. It has been established in previous research that whole diesel exhaust has low in-vitro mutagenic potency and low in-vivo carcinogenic potency in rats and mice (15). At present, the role of individual diesel components in the etiology of human lung cancer is unknown. However, it has been established that 90% of the mutagenic potency of diesel exhaust appears to be limited to the particulate phase (16). In addition, although a few animal studies indicate that filtered diesel exhaust (i.e. the gaseous phase) may also be carcinogenic, lung tumor induction in animals has been primarily associated with exposure to the particulate fraction (1). Therefore, it is reasonable to use an index directly related to the particulate, and not gaseous phase, of diesel aerosol.

Several methods have been used previously to measure worker exposures to diesel exhaust. Measurement of ARP (respirable particulate adjusted for the contribution of tobacco smoke by quantitation of nicotine extracted from the same filters) was used in a recently completed exposure study in railroad workers (14). MSHA, the Bureau of Mines (BOM), and NIOSH have measured exposures to diesel aerosol in coal mines by gravimetric determination of submicrometer particulate, using a custom-designed "dichotomous" sampling cassette (17).

The major problems associated with the use of these methods in the trucking industry include: 1) the relative insensitivity of the gravimetric method (as high as 200 mg/filter), and 2) lack of specificity, since tobacco smoke produces an unknown and potentially large positive bias.

Exposure to submicrometer elemental carbon (Ce) was chosen as the principal marker of exposure to whole diesel exhaust in this study because: 1) it has a 100-fold greater sensitivity over the gravimetric method (the limit of detection is on the order of 2 ug/filter); 2) diesel particulate is typically 60-80% elemental carbon by weight (thus the major component of diesel exhaust is measured); and 3) tobacco smoke is almost entirely organic carbon, and should not produce a significant positive bias.

Sampling Strategy

Approximately 6 to 10 personal samples for submicrometer Ce and organic carbon (Co) were obtained on each of the two shifts sampled each day. Generally, 3 to 5 personal samples were obtained from both mechanics and road drivers during the second shift, and an equivalent number of personal samples were obtained from dock workers (both tow-motor drivers and non-driver dock workers), and local drivers during the day shift. Sampling was conducted for three days (six shifts).

Additional area sampling was conducted during the survey to measure respirable airborne particulate, and submicrometer airborne particulate (both gravimetric analyses). These methods were used for comparison to the results from other recently completed research, specifically Woskie et al. (railroad workers) (14), and additional exposure assessments currently being conducted in coal and metal/nonmetal mines by NIOSH, BOM, and MSHA. Two samples of each type were obtained on each shift, one in each of the two areas sampled; i.e., on the dock and in city tractor cabs during the day shift, and in the repair shop and road tractor cabs during the second shift. In the case of the tractor cabs, the sampling pumps were placed on the floor of the cab driven by the person (road or city driver) on whom personal samples were obtained for submicrometer elemental carbon. The sampling cassettes were attached to an appropriate location near the dashboard. In the case of the dock and repair shop, the samplers were placed at one strategic location in each area.

Methods and Materials

Worker exposures to submicrometer Ce were determined by obtaining full shift personal samples using a modified dichotomous sampling cassette developed by NIOSH's Division of Respiratory Disease Studies (DRDS) (17), but containing 37 mm Pallflex Corporation QAOT quartz fiber filters instead of 37 mm PVC filters. Battery-operated personal sampling pumps were used to draw air through these cassettes at a flowrate of 4 Lpm. The modification to the DRDS design entailed resizing the inlet diameter to approximately 0.0520" in order to preserve the impaction characteristics (>1 um aerodynamic diameter) when operating the sampler at 4 Lpm instead of 2 Lpm.

The dichotomous cassette is essentially a single-stage personal cascade impactor, designed to collect submicrometer particles, and to reject supermicrometer (those larger than 1 um) particles. The dichotomous cassette was used in order to exclude, to the extent possible, non-diesel particulate, since almost all diesel particles (about 95%) are smaller than one micrometer (18). All of these samples were obtained for a full shift, since the main problem is sensitivity, not overloading. The limit of detection is about 2 ug/filter, which translates to a concentration of about 1 ug/m^3, assuming a 2 cubic meter air volume. Subsequent to the survey, the sample filters were submitted to a laboratory for thermal-optical quantitation of elemental and organic carbon. The method used is capable of accurate speciation of elemental and organic carbon fractions in deposits on the filter.

Defining the nature of elemental carbon is not simple. Most researchers define it entirely in terms of the method of analysis. However, elemental (as opposed to "organic") carbon has certain fundamental properties which allow its separation and quantitation. These properties include:

- nonvolatility even at high temperature in an oxygen-free atmosphere,
- small particles which absorb light of any wavelength,
- chemically inert to most acids at room temperature,
- insolublility in all solvents, and
- electrical conductivity.

The thermal-optical determination (19-20) makes good use of the first two of these properties. In this analysis, a portion of the filter (i.e., a "punch") is removed and placed in a furnace. During each of the two major phases of the analysis, the furnace temperature is increased in a stepwise manner several times to drive off the various carbon species in stages, resulting in a carbon species profile, or thermogram.

In the first major phase of the analysis, the temperature in the furnace is stepped from 250° to 680° C, in the absence of oxygen, to drive off organic carbon compounds. In the second major phase, the furnace temperature is reduced slightly, and stepped from 525° to 750° C., in a 2% oxygen atmosphere to oxidize elemental carbon to carbon dioxide. Quantitation is accomplished during both phases by catalytic reduction of carbon dioxide to methane, and detection using flame ionization. During the first phase, the transmission of a helium-neon laser beam through the filter is monitored to correct for inadvertent pyrolysis (charring) of organic carbon species to elemental carbon.

Similar dichotomous samplers were used (but at a flowrate of 2 Lpm) to collect submicrometer aerosol using pre-weighed 5 um pore-size polyvinyl chloride filters. Subsequent to the survey, these filters were reconditioned to constant temperature and humidity and reweighed to determine the net weight of collected submicrometer particulate.

Respirable dust samples were obtained using NIOSH method 0600 (21). This method measures the mass concentration in air of any nonvolatile respirable dust, as specified by the American Conference of Governmental Hygienists

(22). The samples were collected using a preweighed 37 mm Millipore 5 um pore-size polyvinyl chloride filter held in a polystyrene cassette. The cassette was placed in a 10 mm nylon cyclone, which separates the particles into respirable and non-respirable fractions. Air is drawn through the cyclone/filter at a flowrate of 1.7 Lpm. The filter is post weighed after reconditioning in the laboratory to determine the net weight of particulate collected on the filter.

RESULTS

Tables II and III present statistical summaries, by job categories, of personal samples used to evaluate time weighted average exposures to elemental and organic carbon. Tables IV and V contain statistical summaries of respirable dust and submicrometer dust concentrations by job or area. Tables 1, 2, and 3 in appendix C contain the individual personal, eight-hour time weighted average exposures to elemental and organic carbon, respirable dust, and submicrometer dust samples. Figures 1 and 2 are bar charts of the geometric mean elemental carbon concentrations, by job, including the results of the background highway and residential area samples. In the following discussion, the terms "average" and "mean" denote geometric means (not arithmetic), unless otherwise indicated.

Submicrometer Elemental and Organic Carbon

As shown in Table II, the geometric mean submicrometer elemental carbon exposures of personnel sampled at this facility ranged from a low of 4.1 ug/m^3 in mechanics to a high of 25.4 ug/m^3 in dock tow motor operators. The exposure means in other jobs were (see Figure 1): road drivers (5.5 ug/m^3), local drivers (7.1 ug/m^3), hostlers (7.5 ug/m^3), and dock workers (16.3 ug/m^3). By contrast, Ce concentrations measured on a local freeway near Jacksonville averaged 5.7 ug/m^3 (range: 3.9 to 8.6 ug/m^3 in three samples), and in a residential area (at least one mile from the nearest highway or freeway), averaged 1.2 ug/m^3 (range: 0.9 to 1.6 ug/m^3 in three samples).

Inspection of Figure 1 shows that exposures in most jobs (with two exceptions, dock workers and dock tow-motor operators) were of the same order of magnitude as highway background concentrations. The 95% upper confidence limit of the highway concentrations, was, in fact, greater than the 95% lower confidence limit of any of the other job means, suggesting that none of the true job means were significantly higher than local highway concentrations of submicrometer elemental carbon. However, it is possible that the number of samples within individual jobs (N ranging from 2 to 15) were too small to detect a true significant difference. Thus final judgement on this conclusion (using factorial analysis of variance) will be reserved until the data from all seven surveys have been pooled and analyzed together.

The principal source of dock workers' exposures to diesel aerosol was diesel-powered lift trucks on the dock. However, an unknown proportion of the dock workers' exposures was undoubtedly due to road, local, and switching tractors operating in the yard adjacent to the dock. The fact that the hostlers' (working mainly in the yard) mean exposures were substantially lower than the dock workers' exposures supports the conclusion that the primary source of diesel aerosol was the diesel-powered tow-motors.

Table III contains comparable summary statistics for the same samples analyzed for organic carbon. As indicated, geometric mean exposures to submicrometer organic carbon ranged from 32.8 ug/m^3 in road drivers to 76.6 ug/m^3 in dock tow-motor operators. Other job means (Table III and Figure 2) were intermediate. Highway background concentrations averaged 16.8 ug/m^3, and residential concentrations averaged 11.5 ug/m^3. Again, the 95% UCL for the highway samples (38.2 ug/m^3) was greater than the 95% LCL for all other job means, with the exception of the dock workers. Inspection and comparison of Figures 1 and 2 suggests the same relative levels of exposures between the jobs. However, the substantially higher concentrations of organic carbon also suggest that other, non-diesel aerosol may have contributed to total carbon exposure. These sources may have included tobacco (cigarette, pipe, and cigar) smoke as well as industrial emissions.

Respirable and Submicrometer Dust

Table IV is a summary of concentrations of respirable dust obtained in specific areas of the repair shop, dock, and in local and road truck tractors. Respirable dust concentrations in two areas of the repair shop averaged 19.3 and 49.3 ug/m^3 , 40 to 44.3 ug/m^3 on the dock, 26 to 47.6 ug/m^3 in local tractor cabs, and 51.0 ug/m^3 in road tractor cabs. In general, concentrations of respirable dust were of the same order of magnitude in all areas sampled, approximately 40-50 ug/m^3.

Table V summarizes concentrations of submicrometer dust obtained in the same areas as were the respirable dust concentrations. Geometric mean concentrations of submicrometer dust ranged from 14.76 ug/m^3 (N=2) on the dock near the foreman's desk, to 37.4 ug/m^3 (N=2) in the repair shop (garage) near the north repair bay. Intermediate means were found in the road tractor cabs (17.3 ug/m^3, N=2) and in the local tractor cabs (33.7 ug/m^3, N=3). Individual samples also indicated concentrations of 12.9 ug/m^3 and 24.6 ug/m^3 in the south end of the repair shop and the dock near the billing desk, respectively.

CONCLUSIONS

1. Based on measurements of personal, breathing zone concentrations of elemental carbon at this terminal, it appears that only the dock workers' exposures to diesel aerosol were elevated significantly above background highway concentrations found in the Jacksonville area. However, this conclusion is not a rigorous one, since the small sample sizes generated necessarily wide confidence limits around the geometric means. Firmer conclusions must await analysis of this data in conjunction with data collected during the remainder of the surveys at other terminals. It appears that the substantially greater exposures of dock workers were due primarily to emissions from diesel-powered fork lift trucks operated on the dock.

2. Geometric mean organic carbon concentrations were substantially higher than elemental carbon concentrations in all jobs and areas sampled at this terminal, suggesting the presence of non-diesel aerosols, such as tobacco smoke, in the samples. Again, however, the small overall sample sizes preclude firm conclusions.

3. Additional data collected during this survey regarding the environmental factors such as temperature, and factors such as tractor configurations, age, and weight, will be consolidated with similar data collected at other terminals and used to help determine their significance. The data reported here were collected in relatively mild conditions (approximately 70 degrees F. daytime highs), and represent (with a few exceptions) tractors with vertical (stack) exhaust systems, and conventional (not cab-over) tractor designs.

RECOMMENDATIONS

With the exception of dock workers (and particularly those spending the majority of their shift driving tow-motors), exposures to elemental carbon were relatively low during the survey. However, in view of the potential human carcinogenicity of whole diesel exhaust (NIOSH 1988) the following recommendations are prudent.

Exposures to diesel exhaust should be reduced to the lowest feasible limit using one or more of the following techniques: source controls, changes in work practices, substitution, and engineering controls such as local and general exhaust ventilation. Source controls include careful, continued engine maintenance and tune-ups, particularly in tow-motors, but also in tractors and switching vehicles, as well as use of direct exhaust controls such as ceramic filters. Changes in work practices include planned rotation of workers between jobs to minimize exposures (between work on the dock and driving tractor cabs, for instance). Local exhaust techniques include flexible-duct, vehicle exhaust removal systems in buildings or other enclosed or semi-enclosed spaces such as the repair shop. General (dilution) exhaust and makeup systems can be useful in controlling exposures in enclosed spaces such as the repair shop, particularly in cold weather, or where it is not possible to effectively control exposure using only local exhaust systems. Substitution would include replacement of older or malfunctioning tow-motors with newer, more efficient models, or substituting gasoline, propane, or electric powered vehicles for diesel powered vehicles.

REFERENCES

1. Current Intelligence Bulletin No. 50. Carcinogenic Effects of Exposure to Diesel Exhaust. National Institute for Occupational Safety and Health, Cincinnati, OH, July 1988.

2. McClellan, R.O., D.E. Bice, R.G. Cuddihy, N.A. Gillett, R.F. Henderson, R.K. Jones, J.L. Mauderly, J.A. Pickrell, S.G. Shami, and R.K. Wolff. Health Effects of Diesel Exhaust. To be published in the Proceedings of the U.S. - Dutch International Symposium on Aerosols held in Williamsburg, VA, May 19-24, 1985.

3. Pierson, W.R., R.A. Gorse Jr., A.C. Szkariat, W.W. Brachaczek, S.M. Japar, and F.S.-C. Lee. Mutagenicity and Chemical Characteristics of Carbonaceous Particulate Matter from Vehicles on the Road. Environmental Science and Technology 17:31, 1983.

4. Wolff, R.K., R.F. Henderson, M.B. Snipes, J.D. Sun, J.A. Bond, C.E. Mitchell, L.L. Mauderly and R.O. McClellan. Lung Retention of Diesel Soot and Associated Organic Compounds. To be published in Carcinogenicity and Mutagenicity Effects of Diesel Engine Exhaust, Proceedings of the Symposium on Toxicological Effects of Emissions from Diesel Engines held in Tsukuba City, Japan, July 26-28, 1986.

5. Mauderly, J.L., R.K. Jones, W.C. Griffith, R.F. Henderson, R.O. McClellan. Diesel Exhaust is a Pulmonary Carcinogen in Rats Exposed Chronically by Inhalation. Fund. Appl. Toxicol. 9:208-221.

6. Heinrich, U., H. Muhle, S. Takenaka, H. Ernst, R. Fuhst, U. Mohr, F. Pott, W. Stober. Chronic Effects on the Respiratory Tract of Hamsters, Mice, and Rats after Long-term Inhalation of high concentrations of filtered and unfiltered diesel engine emissions. J. Appl. Toxicol. 6(6):383-395, 1986.

7. Brightwell, J., X. Fouillet, A-L Cassano-Zopi, R. Gatz, F. Duchosal. Neoplastic and Functional Changes in Rodents After Chronic Inhalation of Engine Exhaust Emissions. In: Ishinishi, N., A. Koizumi, R.O. McClellan, W. Stober eds. Carcinogenic and Mutagenic Effects of Diesel Engine Exhaust. Proceedings of the Symposium on Toxicological Effects of Emissions from Diesel Engines, Tsukuba City, Japan, July 26-28, 1986. New York, NY: Elsevier Science Publishers, pp. 471-487, 1986.

8. Ishinishi, N., Duwabara, N., Nagase, S., Suzuki, T., Ishiwata, S., Kohno, T. Long-term Inhalation studies on Effects of Exhaust from Heavy and Light Duty Diesel Engines on F344 Rats. In: Ishinishi, N., A. Koizumi, R.O. McClellan, W. Stober eds. Carcinogenic and Mutagenic Effects of Diesel Engine Exhaust. Proceedings of the Symposium on Toxicological Effects of Emissions from Diesel Engines, Tsukuba City, Japan, July 26-28, 1986. New York, NY: Elsevier Science Publishers, pp. 329-348, 1986.

9. Iwai, K., Udagawa, T., Yamagishi, M., Yamada, H. Long-term Inhalation Studies of Diesel Exhaust on F344 SPF rats. Incidence of Lung Cancer and Lymphoma. In: Ishinishi, N., A. Koizumi, R.O. McClellan, W. Stober eds. Carcinogenic and Mutagenic Effects of Diesel Engine Exhaust. Proceedings of the Symposium on Toxicological Effects of Emissions from Diesel Engines, Tsukuba City, Japan, July 26-28, 1986. New York, NY: Elsevier Science Publishers, pp. 349-360, 1986.

10. Edling, C., C-G Anjou, O. Axelson, H. Kling. Mortality Among Personnel Exposed to Diesel Exhaust. Int. Arch Occup. Environ. Health 59:559-565, 1987.

11. Garshick, E., M.B. Schenker, A. Munoz, M. Segal, T.J. Smith, S.R. Woskie, S.K. Hammond, F.E. Speizer. A Case-control Study of Lung Cancer and Diesel Exhaust Exposure in Railroad Workers. Am. Rev. Respir. Dis. 135(6):1242-1248, 1987.

12. Garshick, E., M.B. Schenker, A. Munoz, M. Segal, T.J. Smith, S.R. Woskie, S.K. Hammond, F.E. Speizer. A Retrospective Cohort Study of Lung Cancer and Diesel Exhaust Exposure in Railroad Workers. Am. Rev. Respir. Dis. 137:820-825, 1988.

13. Hammond, S.K., B.P. Leaderer, A.C. Roche, and M. Schenker. Collection and Analysis of Nicotine as a Marker for Environmental Tobacco Smoke. Atmos. Env. 21:457-462, 1987.

14. Woskie, S.R., T.J. Smith, S.K. Hammond, M.B. Schenker, E. Garshick, and F.E. Speizer. Estimation of the Diesel Exhaust Exposures of Railroad Workers: I. Current Exposures. Am. J. Ind. Med. 13:381-394, 1988.

15. McClellan, R.O. Health Effects of Diesel Exhaust: A Case Study in Risk Assessment. Am. Ind. Hyg. Assoc. J. 47(1):1-13, 1986.

16. Schuetzle, D. Sampling of Vehicle Emissions for Chemical Analysis and Biological Testing. Env. Health Perspectives 47:65-80, 1983.

17. McCawley, M., J. Cocalis, J. Burkhart, and G. Piacitelli. Identification and Measurement of Diesel Particulates. Interim Final Report, Contract No. J0145006. Prepared for the U.S. Dept. of Interior, Bureau of Mines. Division of Respiratory Disease Studies, Environmental Investigations Branch, NIOSH, 1988.

18. McCawley M., J. Cocalis. Diesel Particulate Measurement Techniques for Use With Ventilation Control Strategies in Underground Coal Mines. In: Wheeler, R.W., ed. International Conference on the Health of Miners. Annals of the American Conference of Governmental Industrial Hygienists 14:271-281, 1986.

19. Cadle, S.H., P.J. Groblicki, and D.P. Stroup. Automated Carbon Analyzer for Particulate Samples. Analytical Chemistry 52:2201-2206, 1980.

20. Johnson, R.I., J.S. Jitendra, R.A. Cary, and J.J. Huntzicker. An Automated Thermal-Optical Method for the Analysis of Carbonaceous Aerosol. In: ACS Symposium Series, No. 167, Atmospheric Aerosol: Source/Air Quality Relationships, E.S. Macias and P.K. Hopke, Eds., American Chemical Society, 1981.

21. NIOSH Manual of Analytical Methods, Third Ed., Vols. 1-3. DHHS (NIOSH) Publication No. 84-100. National Institute for Occupational Safety and Health, Cincinnati, OH. 45226, 1984.

22. Threshold Limit Values and Biological Exposure Indices for 1988-1989. American Conference of Governmental Industrial Hygienists, 6500 Glenway Ave., Bldg. D7, Cincinnati, OH. 45211-4438, 1987.

Table I.—Limits for occupational exposure to selected components of the gaseous fraction of diesel exhaust; OSHA, MSHA, NIOSH compared

Component	OSHA PEL	MSHA PELs* Underground coal mines	MSHA PELs* Metal and nonmetal mines	NIOSH REL
Carbon dioxide (CO_2)	5,000 ppm (9,000 mg/m^3), 8-hr TWA†	5,000 ppm (9,000 mg/m^3), 8-hr TWA; 30,000 ppm (54,000 mg/m^3), STEL§	5,000 ppm (9,000 mg/m^3), 8-hr TWA; 15,000 ppm (27,000 mg/m^3), STEL	10,000 ppm (18,000 mg/m^3), 8-hr TWA; 30,000 ppm (54,000 mg/m^3), 10-min ceiling
Carbon monoxide (CO)	50 ppm (55 mg/m^3), 8-hr TWA	50 ppm (55 mg/m^3), 8-hr TWA; 400 ppm (440 mg/m^3), STEL	50 ppm (55 mg/m^3), 8-hr TWA; 400 ppm (440 mg/m^3), STEL	35 ppm (40 mg/m^3), 8-hr TWA; 200 ppm (230 mg/m^3), ceiling (no minimum time)
Formaldehyde	1 ppm, 8-hr TWA; 2 ppm, 15-minute STEL	1 ppm (1.5 mg/m^3), 8-hr TWA; 2 ppm (3 mg/m^3), STEL	2 ppm (3 mg/m^3), ceiling	0.016 ppm (0.020 mg/m^3), 8-hr TWA; 0.1 ppm (0.12 mg/m^3), 15-min ceiling
Nitrogen dioxide (NO_2)	5 ppm (9 mg/m^3), ceiling	3 ppm (6 mg/m^3), 8-hr TWA; 5 ppm (10 mg/m^3), STEL	5 ppm (9 mg/m^3), ceiling	1 ppm (1.8 mg/m^3), 15-min ceiling
Nitric oxide (NO)	25 ppm (30 mg/m^3), 8-hr TWA	25 ppm (30 mg/m^3), 8-hr TWA	25 ppm (30 mg/m^3), 8-hr TWA; 37.5 ppm (46 mg/m^3), STEL	25 ppm (30 mg/m^3), 10-hr TWA
Sulfur dioxide (SO_2)	5 ppm (13 mg/m^3), 8-hr TWA	2 ppm (5 mg/m^3), 8-hr TWA; 5 ppm (10 mg/m^3), STEL	5 ppm (13 mg/m^3), 8-hr TWA; 20 ppm (52 mg/m^3), STEL (5 min)	0.5 ppm (1.3 mg/m^3), 10-hr TWA

*MSHA limits are based on threshold limit values (TLVs®) of the American Conference of Governmental Industrial Hygienists (ACGIH). 1973 TLVs® are used for metal and nonmetal mines. Current TLVs® are used for underground coal mines.
†Time-weighted average.
§Short-term exposure limit.
**Adapted from Reference 5

Table II
Exposures to Elemental Carbon
P*I*E Nationwide, Jacksonville, Florida
April 1988; (ug/m3)

Job or Area	N	Range Min	Range Max	Arith. Mean	S.E.	Geom. Mean	Geom. S.D.	95% Confidence Limit Lower	95% Confidence Limit Upper
Mechanic	11	0.5	44.8	7.4	3.8	**4.1**	2.8	2.0	8.2
Road Driver	15	3.2	9.0	5.8	0.5	**5.5**	1.4	4.6	6.6
Dock Worker	10	8.9	57.6	19.2	4.5	**16.3**	1.7	11.1	24.1
Dock Worker, TM *	5	13.2	43.9	27.3	5.0	**25.4**	1.5	14.8	43.8
Local Driver	10	3.5	48.1	11.1	4.4	**7.1**	2.5	3.7	13.4
Hostler	2	6.4	8.8	7.6	1.2	**7.5**	1.2	1.0	54.9
Non-highway	3	0.9	1.6	1.3	0.2	**1.2**	1.3	0.6	2.5
Highway	3	3.9	8.6	6.0	1.4	**5.7**	1.5	2.1	15.2

* Tow motor (fork lift) operator

Table III
Exposures to Organic Carbon
P*I*E Nationwide, Jacksonville, Florida
April 1988; (ug/m3)

Job or Area	N	Range Min	Range Max	Arith. Mean	S.E.	Geom. Mean	Geom. S.D.	95% Confidence Limit Lower	95% Confidence Limit Upper
Mechanic	11	26.0	109	40.3	7.1	**36.7**	1.5	28.0	48.1
Road Driver	15	2.4	143	44.2	9.4	**32.8**	2.5	20.0	54.0
Dock Worker	10	32.3	155	73.4	13.2	**64.4**	1.7	44.0	94.1
Dock Worker, TM *	5	36.8	239	95.7	36.6	**76.6**	2.0	32.3	182
Local Driver	10	10.1	70.5	38.3	5.7	**34.1**	1.7	23.2	50.2
Hostler	2	35.2	42.8	39.0	3.8	**38.8**	1.1	11.3	134
Non-highway	3	6.5	16.3	12.4	3.0	**11.5**	1.6	3.3	39.6
Highway	3	11.9	22.8	17.4	3.2	**16.8**	1.4	7.4	38.2

* Tow Motor (forklift) operator

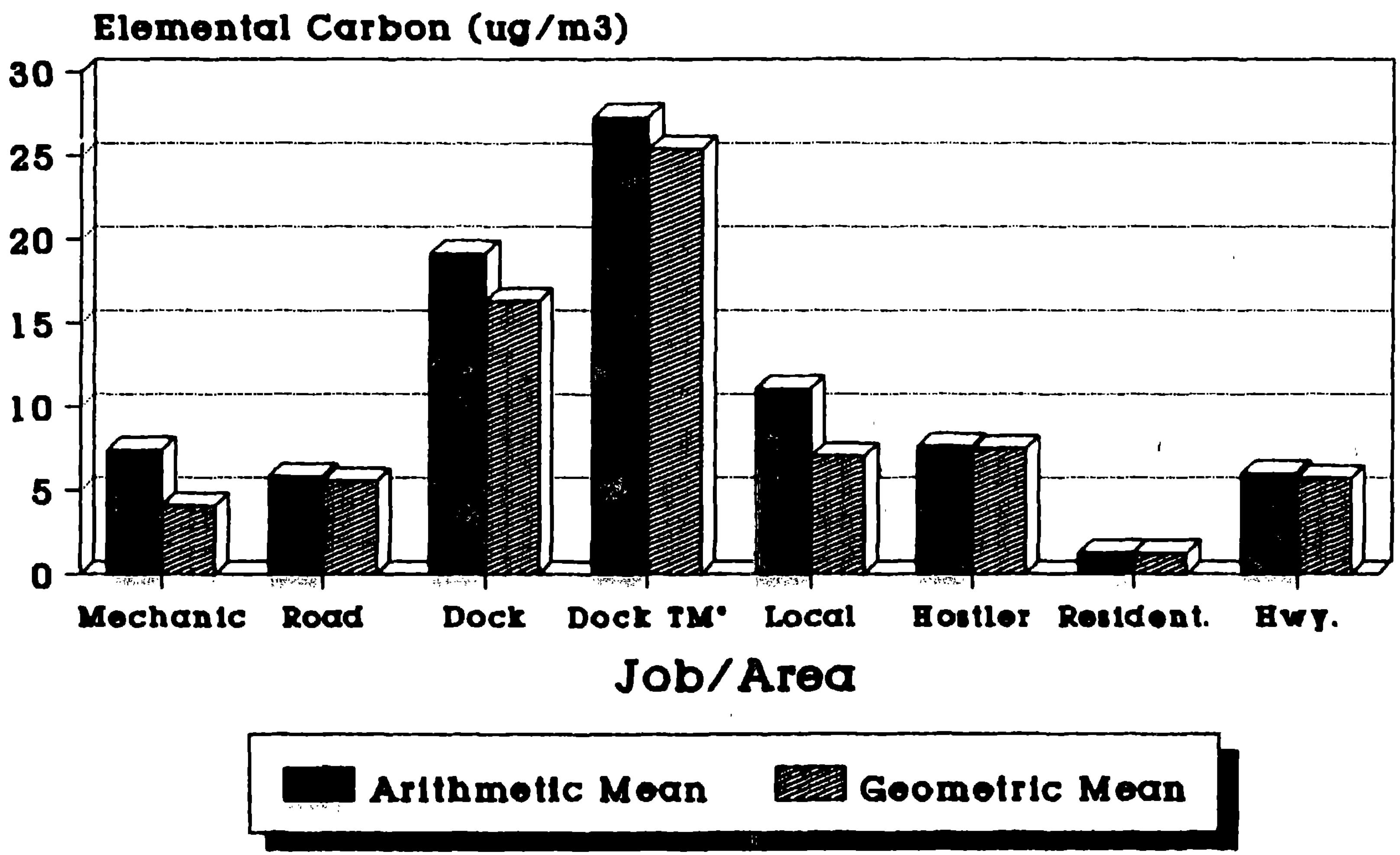
Table IV. Exposures to respirable dust
By Job or Specific Location
P*I*E Nationwide, Jacksonville, FL
April 1988; (ug/m3)

Job or Area	N	Range Min	Range Max	Arith. Mean	Stand. Error	Geom. Mean	Geom. S.D.	95% Confidence Limit Lower	95% Confidence Limit Upper
Garage, north bay	3	29.6	130.4	63.7	33.4	49.3	2.3	6.1	400
Garage, south end	3	<13	73.6	31.7	21.1	19.3	3.4	0.9	413
Dock, city bill desk	3	27.3	54.8	41.9	8.0	40.2	1.4	16.7	97
Dock, foreman's desk	3	26.7	58.1	47.0	10.2	44.3	1.6	14.9	132
Local cab, road tractor	1	26.2	--	--	--	--	--	--	--
Road tractor cab	4	36.8	98.0	55.7	14.5	51.0	1.6	24.5	106
Local cab	4	24.2	110.3	56.3	19.2	47.6	1.9	16.7	136

Table V. Submicrometer Dust Concentrations
P*I*E Nationwide, Inc.
April 1988
(ug/m3)

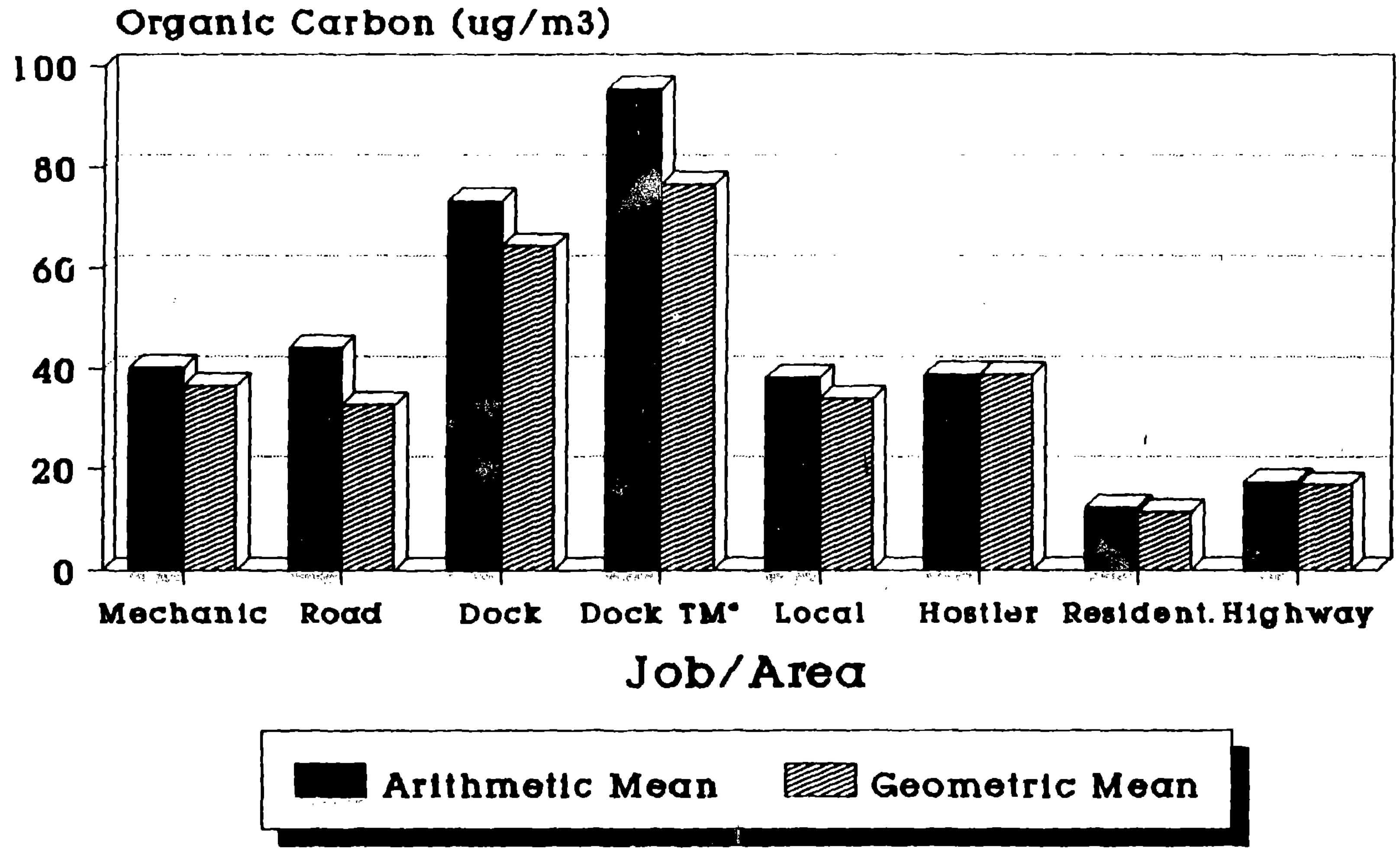
Area	N	Range Min	Range Max	Arith Mean	S.E.	Geom. Mean	Geom. S.D.	95% Confidence Limit Lower	95% Confidence Limit Upper
Dock; billing desk	1	24.6	--	--	--	--	--	--	--
Garage, south end	1	13.0	--	--	--	--	--	--	--
Dock; Foreman's desk	2	5.8	37.1	21.4	15.7	14.6	3.7	0.0	2024447
Road Tractor Cab	2	16.7	18.0	17.3	0.7	17.3	1.1	10.6	28.2
Local Cab	3	19.2	64.8	38.3	13.7	33.7	1.8	7.3	155
Garage, north bay	2	26.2	53.2	39.7	13.5	37.4	1.6	0.4	3322

Figure 1. P*I*E Elemental Carbon Personal Exposures by Job or Area



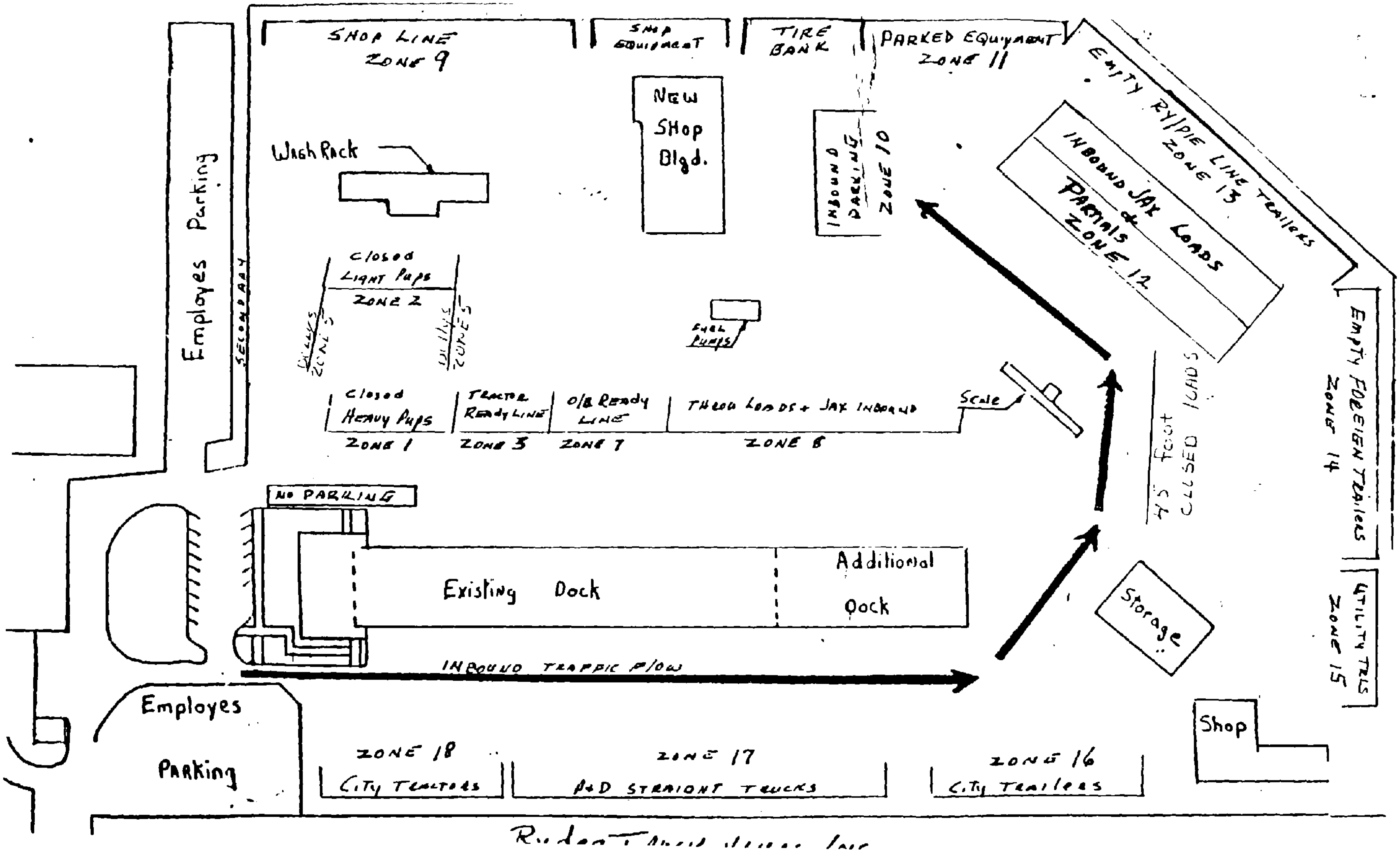
* Tow Motor (forklift operator)

Figure 2. P*I*E Organic Carbon Exposure Personal Exposures By Job or Area



* Tow Motor (forklift operator)

Appendix A
Site Plot Diagram
P*I*E Nationwide, Inc.
Jacksonville, FL
April 1988



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Appendix B
Medical Exam Form
P*I*E Nationwide, Inc.
Jacksonville, FL

Reproduced from best available copy.

PHYSICAL EXAMINATION REPORT

NOTE TO EXAMINING PHYSICIAN: BE SURE TO ANSWER EACH QUESTION AND SPECIFY STATUS OF ANY PHYSICAL DEFECT INJURY OR DISEASE. D.O.T. INSTRUCTIONS FOR PERFORMING AND RECORDING A PHYSICAL EXAMINATION ARE SHOWN ON THE REVERSE SIDE

PERSONAL HISTORY

NAME IN FULL | SOCIAL SECURITY NO | PRE-EMPLOYMENT ______

ADDRESS | DATE OF BIRTH | RECERTIFICATION ______

IF MASTER LEASE DRIVER SHOW OWNER'S NAME | HOME TERMINAL | DATE EMPLOYED

CHECK ONE

- P & D DRIVER ☐
- LINE DRIVER ☐
- LEASE DRIVER ☐
- DOCK WORKER ☐
- SHOP WORKER ☐

HEALTH HISTORY

HEAD OR SPINAL INJURIES	YES ☐	NO ☐	NERVOUS STOMACH	YES ☐	NO ☐
SEIZURES, FITS CONVULSIONS OR FAINTING	YES ☐	NO ☐	RHEUMATIC FEVER	YES ☐	NO ☐
EXTENSIVE CONFINEMENT BY ILLNESS OR INJURY	YES ☐	NO ☐	ASTHMA	YES ☐	NO ☐
CARDIOVASCULAR DISEASE	YES ☐	NO ☐	KIDNEY DISEASE	YES ☐	NO ☐
TUBERCULOSIS	YES ☐	NO ☐	MUSCULAR DISEASE	YES ☐	NO ☐
SYPHILIS	YES ☐	NO ☐	SUFFERING FROM ANY OTHER DISEASE	YES ☐	NO ☐
GONORRHEA	YES ☐	NO ☐	PERMANENT DEFECT FROM ILLNESS, DISEASE OR INJURY	YES ☐	NO ☐
DIABETES	YES ☐	NO ☐	PSYCHIATRIC DISORDER	YES ☐	NO ☐
GASTROINTESTINAL ULCER	YES ☐	NO ☐	ANY OTHER NERVOUS DISORDER	YES ☐	NO ☐

IF ANSWER TO ANY OF THE ABOVE IS YES, EXPLAIN

PHYSICAL EXAMINATION

GENERAL APPEARANCE AND DEVELOPMENT:
GOOD | FAIR | POOR | HEIGHT | WEIGHT

VISION:
FOR DISTANCE RIGHT 20/ | LEFT 20/
☐ WITHOUT CORRECTIVE LENSES | ☐ WITH CORRECTIVE LENSES IF WORN
EVIDENCE OF DISEASE OR INJURY: RIGHT | LEFT
COLOR TEST

HORIZONTAL FIELD OF VISION: RIGHT | LEFT

HEARING: RIGHT EAR | LEFT EAR | DISEASE OR INJURY

AUDIOMETRIC TEST (complete ONLY if audiometer is used to test hearing)
DECIBEL LOSS AT 500 HZ | AT 1,000 HZ | AT 2,000 HZ

THROAT:

THORAX:
HEART | IF ORGANIC DISEASE IS PRESENT, IS IT FULL COMPENSATED?
BLOOD PRESSURE SYSTOLIC / DIASTOLIC | PULSE BEFORE EXERCISE / AFTER EXERCISE | LUNGS

ABDOMEN:
SCARS | ABNORMAL MASSES | TENDERNESS
HERNIA YES ☐ NO ☐ IF SO WHERE? | IS TRUSS WORN?

GASTROINTESTINAL:
ULCERATION OR OTHER DISEASE YES ☐ NO ☐

GENITO-URINARY:
SCARS | URETHRAL DISCHARGE

REFLEXES:
RHOMBERG | PUPILLARY | LIGHT R | L | ACCOMMODATION RIGHT | LEFT
KNEE JERKS: RIGHT NORMAL | INCREASED | ABSENT
LEFT NORMAL | INCREASED | ABSENT

REMARKS

EXTREMITIES:
UPPER | LOWER | SPINE

LABORATORY AND OTHER SPECIAL FINDINGS:
URINE SPEC. GR | ALB | SUGAR | OTHER LABORATORY DATA (SEROLOGY, ETC.)

RADIOLOGICAL DATA (ATTACH FINDINGS REPORT) | ELECTORCARDIOGRAPH | GENERAL COMMENTS

NOTE: THIS SECTION TO BE COMPLETED ONLY WHEN VISUAL TEST IS CONDUCTED BY A LICENSED OPTOMETRIST

DATE OF EXAMINATION | ADDRESS OF OPTOMETRIST

NAME OF OPTOMETRIST (PRINT) | SIGNATURE OF OPTOMETRIST

MEDICAL EXAMINER'S CERTIFICATE

I CERTIFY THAT I HAVE EXAMINED ______ Driver's Name (Print)

IN ACCORDANCE WITH THE MOTOR CARRIER SAFETY REGULATIONS (49 C.F.R. 391.41 - 391.49) AND WITH KNOWLEDGE OF HIS DUTIES. I FIND HIM QUALIFIED UNDER THE REGULATIONS ☐ QUALIFIED ONLY WHEN WEARING CORRECTIVE SPECTACLES

A COMPLETED EXAMINATION FORM FOR THIS PERSON IS ON FILE IN MY OFFICE

AT ______ ADDRESS

DATE OF EXAMINATION | NAME OF EXAMINING DOCTOR (Print) | SIGNATURE OF EXAMINING DOCTOR

SIGNATURE OF DRIVER | ADDRESS OF DRIVER

TERMINAL MANAGER'S CERTIFICATE

Examination of this form indicates that the driver meets the minimum requirements of D.O.T. On the basis of this information, medical examiner's certificate card has been issued

DATE | TERMINAL MANAGER'S SIGNATURE

FORM [illegible]

Appendix C
Tables 1-3
Individual Sample Results
P*I*E Nationwide, Inc.
Jacksonville, FL
April 1988

Table 1. Elemental & Organic Carbon Sample Results
P*I*E Nationwide, Inc., Jacksonville, FL
April 1988

Day-Shift	Sample Number	Job/Area	Ce Wt. (ug)	Co Wt. (ug)	Time (min)	Volume (L)	Ce Conc. (ug/m3)	Co Conc. (ug/m3)
19-2	PD2	Mechanic	5.4	54.8	467	1868	2.9	29.3
19-2	PD1	Mechanic	7.4	48.3	465	1860	4.0	26.0
19-2	PD3	Mechanic	8.7	55.9	468	1872	4.6	29.9
19-2	PJ4	Road Driver	7.3	4.6	480	1920	3.8	2.4
19-2	PJ5	Road Driver	8.5	89.1	478	1912	4.4	46.6
19-2	PJ6	Road Driver	9.7	105.9	480	1920	5.1	55.2
19-2	PJ7	Road Driver	14.9	39.8	480	1920	7.7	20.7
19-2	PJ8	Road Driver	6.9	68.0	480	1920	3.6	35.4
20-1	PJ9	Dock Worker	35.4	65.3	505	2020	17.5	32.3
20-1	PJ10	Dock Worker, Tow Motor	88.6	121.1	505	2020	43.9	59.9
20-1	PJ11	Dock Worker	32.0	273.9	443	1772	18.0	154.6
20-1	PJ12	Dock Worker	50.1	133.6	499	1996	25.1	66.9
20-1	PJ13	Dock Worker	14.7	121.4	410	1640	8.9	74.0
20-1	PJ14	Local Driver	7.9	135.3	480	1920	4.1	70.5
20-1	PJ15	Local Driver	6.7	58.1	480	1920	3.5	30.3
20-1	PJ16	Local Driver	92.4	19.4	480	1920	48.1	10.1
20-1	PJ17	Hostler	16.2	64.8	460	1840	8.8	35.2
20-1	PJ18	Mechanic	68.8	167.0	384	1536	44.8	108.7
20-1	PJ19	Local Driver	7.8	67.0	460	1840	4.2	36.4
20-1	PJ20	Non-highway	3.4	34.7	532	2128	1.6	16.3
20-1	PJ21	Highway	8.7	28.1	399	1596	5.4	17.6
20-2	PJ33	Highway	14.1	37.3	409	1636	8.6	22.8
20-2	PJ34	Non-highway	3.5	38.2	669	2676	1.3	14.3
20-2	PD25	Mechanic	5.5	44.5	411	1644	3.4	27.1
20-2	PJ24	Mechanic	8.7	60.6	397	1588	5.5	38.1
20-2	PJ22	Mechanic	4.8	57.2	407	1628	2.9	35.1
20-2	PJ26	Road Driver	15.7	214.8	480	1920	8.2	111.9
20-2	PJ29	Road Driver	11.7	61.1	480	1920	6.1	31.8
20-3	PJ30	Road Driver	14.4	57.9	480	1920	7.5	30.1
20-2	PJ27	Road Driver	14.5	70.1	480	1920	7.5	36.5
20-2	PJ28	Road Driver	10.6	50.4	480	1920	5.5	26.2
21-1	PJ35	Dock Worker, Tow Motor	47.0	74.7	507	2028	23.2	36.8
21-1	PJ36	Dock Worker, Tow Motor	53.3	128.0	505	2020	26.4	63.4
21-1	PJ37	Dock Worker	115.9	122.7	503	2012	57.6	61.0
21-1	PJ38	Dock Worker	29.1	272.3	494	1976	14.7	137.8
21-1	PJ39	Dock Worker	24.5	68.5	432	1728	14.2	39.7
21-1	PJ34a	Hostler	10.3	68.4	400	1600	6.4	42.8
21-1	PJ41	Local Driver	7.1	72.6	480	1920	3.7	37.8
21-1	PJ40	Local Driver	30.2	54.0	480	1920	15.7	28.1

Table 1 (Cont'd). Elemental & Organic Carbon Results
P*I*E Nationwide, Inc., Jacksonville, FL
April 1988

Day-Shift	Sample Number	Job/Area	Ce Wt. (ug)	Co Wt. (ug)	Time (min)	Volume (L)	Ce Conc. (ug/m3)	Co Conc. (ug/m3)
21-1	PJ42	Mechanic	6.7	60.2	367	1468	**4.6**	41.0
21-2	PJ43	Mechanic	6.3	48.3	400	1600	**3.9**	30.2
21-2	PJ44	Mechanic	0.4	36.2	194	776	**0.5**	46.6
21-2	PJ45	Mechanic	7.1	47.8	385	1540	**4.6**	31.0
21-2	PJ46	Road Driver	17.3	274.4	480	1920	**9.0**	142.9
21-2	PJ47	Road Driver	6.2	74.2	480	1920	**3.2**	38.7
21-2	PJ48	Road Driver	7.7	46.2	480	1920	**4.0**	24.1
21-2	PJ49	Road Driver	11.3	52.0	480	1920	**5.9**	27.1
21-2	PJ50	Road Driver	10.8	63.5	480	1920	**5.6**	33.1
21-2	PJ63	Highway	16.5	49.9	1053	4212	**3.9**	11.9
21-2	PJ65	Non-highway	3.7	26.6	1028	4112	**0.9**	6.5
22-1	PJ53	Local Driver	10.5	58.5	556	2224	**4.7**	26.3
22-1	PJ57	Dock Worker	17.8	63.4	467	1868	**9.5**	33.9
22-1	PJ54	Local Driver	13.3	72.7	540	2160	**6.1**	33.7
22-1	PJ58	Dock Worker	29.4	149.0	480	1920	**15.3**	77.6
22-1	PJ55	Dock Worker, Tow Motor	57.6	151.1	480	1920	**30.0**	78.7
22-1	PJ59	Dock Worker	20.7	107.7	480	1920	**10.8**	56.1
22-1	PJ51	Local Driver	33.5	124.1	480	1920	**17.4**	64.7
22-1	PJ62	Dock Worker, Tow Motor	25.3	459.8	480	1920	**13.2**	239.5
22-1	PJ52	Local Driver	5.4	67.7	378	1512	**3.6**	44.8

Table 2. Respirable Dust Concentrations
P*I*E Nationwide, Inc.
April 1988

Date	Sample Number	Job/Area	Weight (mg)	Time (min)	Volume (L)	Conc. (ug/m3)
Apr 19	FW.1016	Garage, north bay	0.1	451	766.7	130.43
Apr 19	FW.904	Garage, south end	<0.01	452	768.4	<13
Apr 19	FW.929	Dock, city bill desk	0.02	421	732.5	27.30
Apr 20	FW.967	Dock, foreman's desk	0.04	412	712.8	56.12
Apr 20	FW.968	Local cab, road tractor	0.02	451	762.2	26.24
Apr 20	FW.963	Garage, north bay	0.02	397	674.9	29.63
Apr 20	FW.978	Garage, south end	0.01	390	663.0	15.08
Apr 20	FW.972	Road tractor cab	0.08	480	816.0	98.04
Apr 20	FW.974	Road tractor cab	0.03	480	816.0	36.76
Apr 21	FW.969	Local cab	0.03	517	878.9	34.13
Apr 21	FW.962	Local cab	0.05	521	885.7	56.45
Apr 21	FW.966	Garage, south end	0.05	388	679.0	73.64
Apr 21	FW.960	Garage, north bay	0.02	382	645.6	30.98
Apr 21	FW.961	Road tractor cab	0.04	460	782.0	51.15
Apr 21	FW.977	Road tractor cab	0.03	480	816.0	36.76
Apr 21	FW.958	Dock, foreman's desk	0.02	433	749.1	26.70
Apr 21	FW.957	Dock, city bill desk	0.04	432	730.1	54.79
Apr 22	FW.955	Dock, foreman's desk	0.04	405	688.5	58.10
Apr 22	FW.965	Dock, city bill desk	0.03	406	690.2	43.47
Apr 22	FW.971	Local cab	0.09	480	816.0	110.29
Apr 22	FW.973	Local cab	0.02	486	826.2	24.21

Table 3. Submicrometer Dust Results
P*I*E Nationwide, Inc., Jacksonville, FL
April 1988

Date	Sample Number	Job/Area	Weight (mg)	Time (min)	Volume (L)	Submicrom Dust Conc (ug/m3)
Apr 21	17522	Dock; billing desk	0.02	406	812	24.6
Apr 21	17531	Dock; Foreman's desk	<0.01	434	868	<11.5
Apr 22	17539	Dock; Foreman's desk	0.03	404	808	37.1
Apr 21	17540	Garage, north bay	0.04	376	752	53.2
Apr 21	17524	Garage, north bay	0.02	381	762	26.2
Apr 21	17537	Garage, south end	0.01	386	772	13.0
Apr 21	17536	Local Cab	0.02	522	1044	19.2
Apr 22	17528	Local Cab	0.03	486	972	30.9
Apr 22	17534	Local Cab	0.07	540	1080	64.8
Apr 21	17338	Road Tractor Cab	0.05	1389	2778	18.0
Apr 21	17529	Road Tractor Cab	0.04	1200	2400	16.7