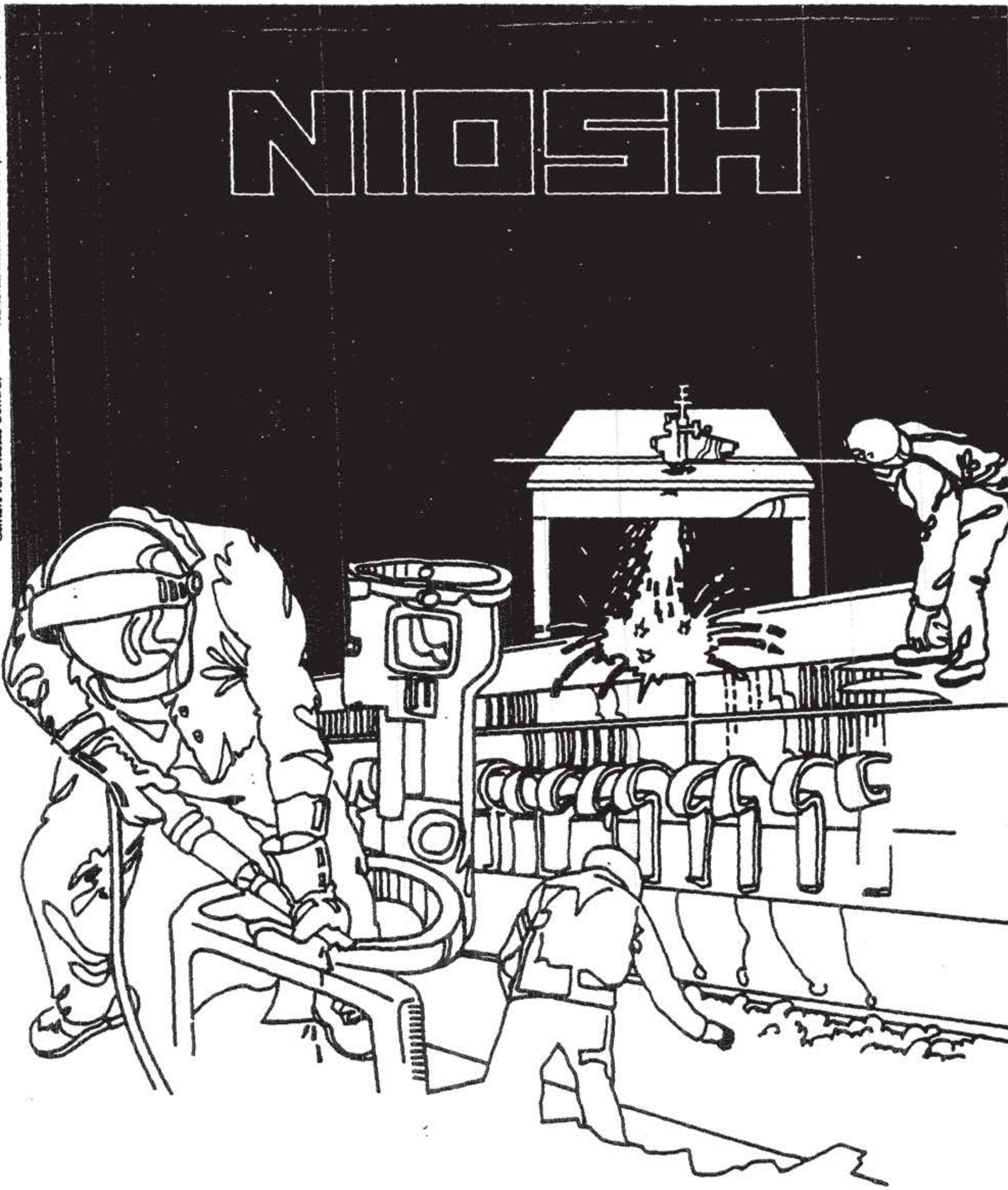
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 82-319-1569
INTERNATIONAL ASSOCIATION
OF FIREFIGHTERS, NEW JERSEY

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 82-319-1569
Revised July 1985
INTERNATIONAL ASSOCIATION
OF FIREFIGHTERS, NEW JERSEY

NIOSH INVESTIGATORS:
Joseph Schirmer, M.S.
Timothy Liveright, MD
New Jersey Dept. of Health

I. SUMMARY

On June 25, 1982, The International Association of Firefighters (IAFF) requested that the National Institute for Occupational Safety and Health (NIOSH) evaluate the health hazards to emergency personnel potentially exposed to polychlorinated biphenyls (PCBs) and their combustion products while responding to a fire in a subway train operated by the Port Authority Trans-Hudson Corporation (PATH). NIOSH assigned the evaluation to the New Jersey State Department of Health, Occupational Health Program (OHP), under a Cooperative Agreement.

Because the request came three weeks after the fire and since PCBs are non-volatile liquids, most of the airborne PCBs liberated by the fire would have condensed out of the air back to liquid or solid form by this time. It was decided that the HHE should concentrate on the measurement of serum PCB levels to determine whether these levels were associated with exposure during the PATH fire itself and/or with overall service fighting fires. A review of environmental data collected by a consultant contracted by PATH suggested that air PCB levels were as high as 4,200 micrograms per cubic meter in Tunnel L. Moreover, polychlorinated dibenzofuran (PCDF) and polychlorinated dibenzodioxin (PCDD) levels were measured at low levels, but the most toxic isomers (2,3,7,8 PCDF or 2,3,7,8 PCDD) were not found.

There were 64 evaluation participants including 36 fire fighters with direct fire exposure, 13 firefighters with peripheral exposure and 7 emergency medical technicians with peripheral exposure. Serum PCB levels ranged from non-detectable to 35 parts per billion on the 64 participants.

No association was found between PCB levels and time spent fighting this particular fire when the analysis controlled for length of service as firefighters and took into account the percentage of time wearing respirators during the fire. When applying several different statistical procedures, weak correlations were found both between firefighter age and serum PCB levels and between number of years fighting fires (length of service) and serum PCB levels. However, after comparing the firefighter group to a "non-exposed" worker group and with the general population, with the exception of one or two individuals, no obvious health hazard specifically related to PCBs could be isolated.

It was determined that the blood PCB levels of fire fighters increased slightly with age as well as with their length of service. It was impossible in this small, cross-sectional study to distinguish precisely the effects of age from the effects of length of service. Recommendations on control methods including cleaning of contaminated equipment and clothing, and the installation of independent ventilation systems in subway tunnels are presented in the final section of this report.

Keywords: SIC 9224, polychlorinated biphenyls (PCBs), polychlorinated dibenzofurans (PCDFs), Polychlorinated dibenzodioxins (PCDDs), Fire Fighters

II. INTRODUCTION

On June 25, 1982 the International Association of Firefighters (IAFF) requested that the National Institute for Occupational Safety and Health (NIOSH) evaluate the health hazards to emergency personnel potentially exposed to polychlorinated biphenyls (PCBs) and their combustion products while responding to a fire. The fire, which took place on the night of June 2, 1982, and continued into the morning of June 3, was located in a seven car subway train parked in an underground tunnel near the Exchange Place passenger station in Jersey City, New Jersey.

This subway system is operated by the Port Authority Trans-Hudson Corporation (PATH), a subsidiary of the Port Authority of New York and New Jersey and provides service to New York and New Jersey using tunnels under the Hudson River. Based on the Port Authority's examination of cars not damaged during the fire, it was estimated that the electrical components in each subway car contained a maximum of 1 kilogram (2.2 pounds) of PCBs.

PCBs at room temperature are non-volatile liquids. They are used as insulators because they are resistant to heat and electricity. However, when PCB's are heated to their boiling point or burned, the potential for exposure to airborne PCBs or their more toxic combustion products is created.

The IAFF made the request to NIOSH primarily on behalf of the members of two of its local union affiliates who fought the fire. (Members of Locals 1064 and 1066 of the Fire Fighters Association of New Jersey). In addition, the IAFF requested that the Health Hazard Evaluation include emergency medical technicians (EMTs) employed by the Jersey City Medical Center. These people, although not members of an IAFF bargaining unit, may also have been exposed to PCBs since they worked at Exchange Place station during the fire, treating and evacuating firefighters suffering from smoke inhalation. During the time between when the fire occurred June 2nd and when the IAFF made its request to NIOSH on June 25th, the Port Authority of New York and New Jersey conducted environmental monitoring to characterize the extent of PCB contamination caused by the fire. When the Port Authority notified the Jersey City Fire Department on June 25th that PCBs had been involved in the fire, this information prompted the Fire Department and the Firefighters' Union (IAFF) to request the NIOSH Health Hazard Evaluation (HHE).

Thus, at the time of the request, three weeks had elapsed since the time of the fire. Since PCBs are non-volatile liquids, most of the airborne PCBs liberated by the fire would have condensed out of the air back to liquid or solid form by this time, NIOSH decided therefore that the HHE methodology should utilize biological monitoring methods to assess the potential PCB exposures rather than environmental monitoring. In addition, the Port Authority had hired a consulting firm (A.D. Little) to perform a more detailed environmental assessment and to assist the Port Authority medical department in a clinical epidemiological study to assess PCB exposure among PATH employees. In order to most effectively use NIOSH's available resources, the major tools employed in this investigation were:

1. Blood testing to determine PCB body burden. 2. Interviews with the firefighters. 3. Statistical analyses of the data from #'s 1 and 2. The purpose of the investigation was to evaluate the potential health hazards to firefighters and emergency medical technicians who responded to this particular fire emergency.

III. BACKGROUND

The Jersey City Fire Department responds to all fires within Jersey City. The Port Authority of New York and New Jersey (PATH) operates a subway system which links New York City to New Jersey via tunnels passing under the Hudson River. Four PATH subway stations are located in Jersey City. The headquarters for the PATH subway operations are also located in Jersey City.

The fire which took place in June 1982 was not the first fire in this subway system. Newspaper reports cite PATH officials who stated that the frequency of fires in the system increased from one fire every 3.4 days in 1980 to one fire every 2.6 days in 1981 and one fire every 2.2 days during the first six months of 1982. While not all of these reported fires were serious, these reports did suggest some growing problems within the PATH subway fire prevention and response system. Following a fire in March 1982, fire officials in New York and New Jersey had made a series of recommendations including: the development of an improved communications system, the installation of permanent water supply standpipes to fight tunnel fires, the construction of improved emergency exits and the development of a ventilation system to remove subway tunnels. In response to these suggestions PATH has begun to implement a large capital improvement program. Included in this plan are the installation of standpipes to provide water for firefighting in the tunnels, new emergency exits and ventilation systems. As of the date of this report the installation of a permanent water supply system was nearly completed. Most significantly, PATH has begun a systematic program to remove all PCBs from their electrical system. The fire at the Exchange Place Station took place in the fourth car (car # 643) of a seven car train. This train was not in operation but was stored in a dead end tunnel (terminal L) while awaiting service for the morning rush hours. This tunnel is located approximately 200 feet west of the Exchange Place Station. Three other cars were showed minimal damage but there was no evidence of any effect on electrical equipment.

The fire, which is believed to have been caused by an electrical short circuit, caused severe damage to car 643 and destroyed some electrical capacitors located beneath the car. These capacitors contained PCBs. Thus during the fire, PCBs and their toxic combustion byproducts (including dibenzofurans and dioxins) may have been released into the environment.

Compounding this problem, firefighters had difficulty locating the source of the fire because of dense smoke which filled the subway tunnels and obscured their vision. Although the fire was reported by PATH at 11:30 PM on June 2, 1982, firefighters were unable to reach the burning train until 1:23 AM on June 3, 1982. The blaze was not extinguished until 5:46 AM.

Forty-five firefighters and seven emergency medical technicians were exposed to smoke for approximately five hours. Thirteen firefighters were treated for smoke inhalation at the Jersey City Medical Center and then released. All of the above individuals participated in the evaluation except for one of the firefighters exposed to smoke for five hours. After firefighters learned that PCBs had been involved, forty-three firefighters had their personal protective equipment stored until environmental tests were conducted to evaluate the potential contamination of this equipment.

IV. METHODS OF EVALUATION

A. Medical

Two principle questions were posed in this HHE. Did the PATH fire, in and of itself, lead to increased PCB absorption as measured in the serum of the firefighters who volunteered for the Evaluation? Second, have firefighters developed increased body burdens of PCB's as a result of their overall service fighting fires?

At the same time that the blood samples were taken, each firefighter was interviewed, eliciting information about age, length of service as firefighter, role in the PATH fire (i.e. extent of contact with the blaze in Tunnel "L"), and use of respiratory protection during the fire. The purpose of the questionnaire was to provide data concerning employment history, medical history and exposure to subway fire in tunnel L, June 2 and 3, 1982.

Participant blood samples were analyzed (at the parts per billion leve) for all of the more common PCB mixtures. Through the New Jersey Department of Health Laboratory, serum samples were extracted three times with methanol hexane solution. The extract was concentrated and PCB fractionated from the chlorinated hydrocarbons on a silica column. The amounts of PCB were quantitated on a gas chromatograph using electron capture detectors. The PCBs were quantified as 1254, since this was the dominant isomer detected.

B. Analytic

Question #1 - did the PATH fire, in and of itself, lead to PCB absorption as measured in the serum of the firefighters who volunteered for the Evaluation (all but one of those exposed were evaluated) - was initially approached by comparing the PCB levels of those firefighters who had been in Tunnel "L" for varying amounts of time during actual blaze with those firefighters who had not been in Tunnel "L" during the blaze. Second, those firefighters who had been in the tunnel during the fire were divided further into two subgroups based on the length of time they wore respiratory protection. Subgroup one included those wearing respiratory protection for fewer than thirty five minutes; subgroup two, greater than thirty five minutes.)

In making the above comparisons it was necessary to account (control) for the apparent effects the ages of the firefighters had on their serum PCB levels. This was done because it was found in the course of the overall analysis that PCB levels seemed to be higher in older firefighters.

An analysis of variance was applied to test for statistically significant differences between the groups; i.e. testing to see if differences in PCB levels were merely chance happenings or due to actual exposure differences.

Next, in order to control for age, an analysis of co-variance was applied. In this kind of analysis factors such as age that may also contribute to differences in PCB levels are taken in account. The co-variates in the analysis were, as mentioned previously, age and respirator usage.

Question #2 - does past service as a firefighter have any affect on (i.e. correlate with) PCB level - was approached somewhat differently. First, a statistical procedure was used looking at all levels of correlation among PCB level, age, and length of service as a firefighter.

Second, a related but more complicated procedure - stepwise multiple regression - was employed to determine if either age, service, or respirator usage seemed to be associated with higher PCB levels. Third, use was made of information about serum PCBs obtained from another Health Hazard Evaluation. These serum PCB levels were analyzed in the same laboratory as the samples for this evaluation. This permitted a comparison between the PATH firefighters and this other group of workers who had no or limited known PCB exposure. The mean PCB levels of the two groups were compared; first, not controlling for age and second, applying an analysis of covariance, controlling for age because, as mentioned above, PCB levels showed a weak correlation with age.

V. EVALUATION CRITERIA

Polychlorinated biphenyl (PCB) is not a single discrete substance; rather it is a name applied to a group of 209 chlorobiphenyl isomers. Only about half of the 209 theoretically possible PCB isomers have been commercially manufactured. Commercial PCBs are usually mixtures of the various isomers. Although many individual PCBs are solids at room temperature, most mixtures are liquids of varying viscosities. PCB mixtures are resistant to degradation by heat or chemical attack from oxidation processes or from acids or bases. Because of their chemical stability and long life in applications involving electrical fields and high temperatures, PCBs have enjoyed wide use since 1929 in capacitors and transformers. By 1976 more than 95% of all U.S. power capacitors contained PCBs. PCBs have been utilized also as plasticizers, hydraulic fluids and heat transfer fluids. Commercial mixtures of PCBs can be manufactured to meet various operational specifications such as dielectric constant, flash point, fire point, density, percent chlorine and color(1).

Because of their relative stability, PCBs are ubiquitous in the human environment. Because PCBs are fat-soluble and resistant to oxidation, they tend to bio-accumulate in ecological systems, with increasing concentrations appearing in fat-storing carnivorous animals such as striped bass and humans. The accumulation of PCB in fat tissue tends to be greater for the more highly chlorinated biphenyls. Over 90 percent of the general population has detectable levels of PCBs in their fat tissue. Typical levels found are 0-2 parts per million (ppm)(2).

In 1976 Congress passed the Toxic Substances Control Act which instructed the Environmental Protection Agency (EPA) to ban PCB manufacture in the United States as of 1978.

The 1976 ban on PCB manufacture has apparently been effective at reducing environmental exposure to the U.S. population. The EPA reported a decline between 1977 and 1981 in the percentage of the United States population with PCB levels above 2 ppm in fat tissue.

Health Effects

PCBs can enter the body through inhalation, skin absorption or ingestion. Although short term occupational exposure to PCBs has not been shown to cause immediate health effects, long term exposures can be irritating to the skin and mucous membranes and may cause liver damage and chloracne. There is data which shows a relationship between increasing blood levels of PCBs and liver enzyme abnormalities(3).

NIOSH recognizes all PCBs as potential carcinogens and recommends that occupational exposures be limited to 1 microgram per cubic meter, the lowest concentration in air which could be reliably measured by currently available sampling and analytical methods (at the time of recommendation). This recommendation is based on numerous animal studies which have shown PCBs to be carcinogenic and mutagenic. PCBs are therefore considered to be potentially carcinogenic and mutagenic in humans.

Concentrations of PCBs in the blood of people occupationally exposed to PCBS have been in the range of 20 to 3300 parts per billion (ppb)(4,5). While the data is not conclusive, in general, it has been stated by one official of NIOSH that "a reasonable acceptable upper limit value for serum PCBs would appear to be around 30 ppb."(6)

Studies of workers have found that blood levels of PCBs increased with both severity of exposure(4) and duration of exposure(7). In studies of the general population with no known exposure to PCBs, blood levels of PCBs have been measured at an average of 6-7 ppb(8). Additionally, the blood PCB concentration in the general population has been found to vary in proportion to the age of the population; i.e. people accumulate PCBs as they age.

In contrast, PCB blood levels of individuals who are occupationally exposed tend to be much higher, with levels up to several hundred ppb. While the reports are inconclusive, in general, adverse effects have not been observed at blood levels less than 30 ppb. See Figure 1 which compares serum PCB levels in the general population, PATH firefighters, railroad workers and capacitor manufacturers. As detailed in the NIOSH Criteria Document on PCBs, "In the United States, PCBs are present in ambient air, water, and in many foods . A common dietary intake of 10-20 micrograms/day has been estimated for teenage males in the US. PCBs frequently have been found in various tissues and body fluids of the US population, e.g., at ppm concentrations in adipose tissue, ppb concentrations in blood, and in milk at ppm or ppb concentrations in the milk fat or whole milk, respectively."

When PCBs are burned other hazardous compounds can be produced. The precise identity of these combustion products will vary depending on environmental conditions such as temperature and pressure, as well as the presence of other reactive chemicals like acids, bases or oxygen. At temperatures over 800 degrees centigrade the main decomposition products of PCBs are carbon monoxide, carbon dioxide, hydrogen chloride and chlorine gases. At lower temperatures (between 500 to 800 degrees C.) polychlorinated dibenzofurans (PCDFs) have been produced(9). Polychlorinated dibenzodioxins (PCDDs) may also be formed in certain circumstances(10).

Both PCDDs and PCDFs have many different isomers (or arrangements of atoms). The most toxic of these are believed to be 2,3,7,8 tetra-CDD and 2,3,7,8-tetra-CDF. On a weight basis, 2,3,7,8-tetra-CDD is one of the most toxic synthetic compounds ever studied. While 2,3,7,8-tetra- CDF is also toxic, it is 30 times less toxic (on a weight basis) than the corresponding dioxin isomer (2,3,7,8-tetra-CDD).

2,3,7,8-tetra-CDD has also been identified as a carcinogen based on testing of laboratory mice.

Previous studies have indicated that furans are more likely to be produced than dioxins by burning PCBs(11,12).

The original concern with the human health effects of PCBs was caused largely by two factors: findings of increased PCBs in various environmental samples including human fat tissue, blood and breast milk and the severe health effects observed in patients who accidentally ate cooking oil contaminated with PCBs. Subsequently this cooking oil was found to contain elevated levels of PCDFs caused by heat applied to the oil during manufacturing(13). These patients have been followed and their clinical signs remain persistent while their blood PCBs have decreased to "levels that barely exceed those of the general population."(14). This suggests that some factor other than PCBs is responsible for the observed health effects. The available evidence suggests that PCDFs are the possible agent responsible for these health effects(15)

VI. RESULTS

A. DESCRIPTIVE STATISTICS

1. Table 1 shows the overall makeup of those participating in the fire. The ages of the range from 20 to 64 (the average age being 43); the overall length of service ranged from 1 to 35 years (the average length of service being 15.89 years). PCB levels are shown to range from 2.5 ppb's to 35 ppb (the average level, 8.59 ppb). Three individuals, two of whom had greater than thirty years of service, were found to have PCB levels over 20 ppb.

The three additional factors of interest - time spent in Tunnel "L" during the actual blaze, percentage of time wearing a respirator and total time not wearing a respirator - are summarized. Overall, participants spent an average of 36.64 minutes in the tunnel during the blaze (ranging from 0 to 180 minutes).

Referring to Table 1B, those directly in contact with the tunnel blaze spent an average of 65.14 minutes fighting the fire (ranging from 5 to 180 minutes). For those in direct contact with the fire, it can be seen that respirators were worn an average of 39.5 percent of the time (ranging from 25% to 75% of the time). It was also determined by calculation that those who were in the tunnel during the actual blaze did not wear their respirators, on the average, 38 minutes (ranging from 3.75 to 135 minutes). Table 1A describes those with no direct contact with the fire.

2. Figure 2 plots the relationship between age and PCB level showing a weak correlation ($r = 0.4$; $p < 0.001$)(16) between age and serum PCB level. Figure 3 plots the relationship between overall firefighter service and PCB level illustrating again a weak correlation ($r = 0.371$; $p < 0.01$) between service and serum PCB level. Figure 4 then plots the relationship between age and service -a good illustration of why, in subsequent analysis, it did not matter whether age or service was used as the independent variable when comparing different exposure groups since they are so strongly correlated; the correlation coefficient is quite high at $r = 0.9$; $p < 0.001$.

Approximately 16% of the total variation among participants in PCB levels may be related to age or length of service.

B. QUESTION #1 ANALYSIS

To determine if potential exposure to PCBs during the PATH fire was associated with an increase in serum PCB level, comparisons were made between groups of participants according to the length of time spent in Tunnel "L".

A comparison was made of two groups - all those who had been in Tunnel "L" for varying lengths of time (from 1 to 135 minutes) during the actual blaze compared with those who had not been in Tunnel "L" during the blaze. It was found (where $p=0.93$)(17) that the PCB levels of the two groups were not statistically different.

An extension of this approach included two slightly different groupings of particpants. The re-grouping was done to optimize the disparity in time spent in the tunnel. One group had spent 25 or more minutes in the tunnel and the second included those who spent fewer than 25 minutes in the tunnel. It was determined again that no significant difference existed between the PCB levels for the two groups (p=0.415).

In making each of these two comparisons, age was taken into account by performing an analysis of co-variance on the different groups. Little or no effect of age on the difference in means between the two pairs of groups was found, with "p" values of 0.317 and 0.095 respectively.

Finally an analysis of variance was performed on the data from only those participants directly in contact with the fire. This group was divided into two sub-groups - the first made up of those who spent fewer than 35 minutes fighting the fire without a respirator, the second greater than 35 minutes. Once again, the PCB levels of these two sub-groups did not differ significantly from one another, before and after controlling for age. "P" values of 0.28 and 0.218 (after controlling for age) were found.

C. QUESTION #2 ANALYSIS

The second question - does past work service have any association with PCB level - was approached, as mentioned above, in three different ways. The first two methods of analysis focused solely on the PATH evaluation participants; the third method was a comparison of the PATH evaluation participants and another group of workers who had little or no known exposure to PCB's.

First looked at were correlations between the variables of interest: age, work service, and serum PCB levels. The correlation between age and service was high (r = 0.9), the correlation between age and serum PCB level was weak (r = 0.4) and the correlation between service and PCB level was also weak (r = 0.37)(18). Refer again to Figures 2 through 4.

A refinement of the multiple correlation procedure - stepwise multiple regression - was employed next in an attempt to delineate better the relationship between the independent variables (age, service, time in Tunnel "L", and pecentage of time not wearing a respirator) and the serum PCB level - the dependent variable. As it turned out, this procedure did not add to the results found in the multiple correlation procedure.

Finally, a comparison was made between the evaluation participants and another group of working people who had little or no known exposure to PCB's. A two-step analytical process was employed; first a "raw" comparison was made between these two groups. The average PCB levels of the two groups differ by 2.12 ppb with participants having the higher level. It was found however, that when a statistical test called analysis of variance was used, this difference is shown to be statistically insignificant (p = 0.26). When the expected influence of age was eliminated (by using an analysis of co-variance) the mean PCB levels of the two groups differed by 1.39 ppb which was found again to be statistically insignificant; p = 0.176.

VII. DISCUSSION

This was a cross-sectional investigation of the effect on PATH firefighters and emergency medical technicians of the exposure to PCBs. A cross-sectional investigation is restricted to the process of looking at a problem or set of questions at a single moment. The main reason for approaching the PATH fire PCB exposure problem in this way is because of non-existent information about previous PCB levels in this worker group; i.e. pre-fire and pre-employment serum PCB levels were not known and could not be taken into account. It is therefore impossible to draw any true cause and effect conclusions from such an investigation. However, by comparing different subsets of the entire PATH firefighter and emergency medical technician group, with otherwise similar backgrounds, it was possible to explore possible associations between fighting in the PATH fire and serum PCB levels and between length of work service and serum PCB levels.

By dividing the PATH evaluation participants into groups defined by differing lengths of time of exposure to the fire in Tunnel "L" and statistically controlling for age, it was determined that the PATH fire was not associated with higher PCB levels in the groups with greater exposure. At least three factors may bear on this finding. First, and perhaps most important, were the conditions of the investigation, most notably the lack of pre-PATH fire information about PCB levels existent in the workforce evaluated and the existence of background level in the general population.

Second, the participants may have been exposed to relatively low levels of PCBs. NIOSH field staff as part of investigative work not strictly part of this HHE, conducted limited sampling to determine the extent of PCB contamination of firefighters' protective clothing(19). Two samples were analyzed. A firefighter's coat which was believed to be representative of most other coats in the fire did not show any detectable levels of PCBs. Two additional samples from what was believed to be the most contaminated coat contained detectable but low levels of PCBs, 1.3 and 1.0 micrograms per sample.

Air measurements made three weeks after the fire were also found to be low. A.D. Little found PCB concentrations of 0.03 to 2.3 micrograms per cubic meter of air in Tunnel "L," the actual scene of the fire. However, based on air and surface measurements and mathematical modelling, A.D. Little estimated PCB concentrations during the fire in Tunnel "L" to be 4,200 micrograms per cubic meter.

A third reason for not seeing an association between fighting in the fire and PCB levels may have been due to (variable) respirator usage. Respirators may have offered the degree of protection necessary to prevent PCB absorption and thus prevented detectable increases in serum PCB levels.

A weak association was seen between participant age and serum PCB level. There was also a weak association between service and serum PCB level. The dilemma presented here was one of determining whether service alone may have contributed to increased serum PCB levels. Because it was also found that there was a very strong correlation between age and service, it was necessary to determine how much each of the two factors (age or service) contributed to the age-related increase in detectable serum PCB levels.

To help sort this question out, a second approach was taken. The participants' PCB levels were compared to that of another group of workers with similar backgrounds but who had not been exposed to PCBs. NIOSH had conducted n investigation of this second group of workers some of whom were exposed to PCBs used in heat transfer units in a chemical manufacturing process. Among the comparison workforce, thirty-four workers had had little or no known exposure to PCBs because of their work locations and/or because of their date of hire.

Table 2 shows the overall makeup of this second worker group. Their ages range from 25 to 65 (the average age being 39). PCB levels are shown to range from 2.5 ppb's to 16.8 ppb's (the average level, 6.23 ppb's).

When the participants were compared to these "non-exposed" workers in the control group, it was noted that the participants had, on the average, slightly higher serum PCB levels. To be sure that age (and some unrelated factor) was not responsible for the difference in average PCB levels, the groups were re-analyzed. Although the average PCB levels were lower for the "non-exposed" group, when controlling for age the difference in serum PCB levels was found not to be statistically significant. This suggests, but does not establish, that service as a firefighter is not associated with increased serum PCB levels. In fact, if one compares the average levels of serum PCBs to the general population (see Figure 1), there appears to be very little difference. Additionally, Figure 5 shows in the general population the relationship between age and PCB levels. PCB levels increase with age in a way very similar to that in the PATH firefighter group as the figure illustrates.

While this evaluation has detected no relationship between service and PCB levels, firefighters are nonetheless potentially exposed to PCBs from a variety of sources. In addition to their industrial uses in electrical transformers and hydraulic fluids, they have been used in many household products such as plasticizers in paints, inks and paper. PCBs have also been used in ballasts for fluorescent electric lights. When these ballasts burn out, levels from 12 to 166 micrograms per cubic meter of air have been measured(20). In a typical house fire, firefighters could be exposed to multiple sources of PCBs. Fortunately, because of the 1976 legislative ban and subsequent EPA regulations, these environmental sources are decreasing.

Several investigations of other occupational groups have found that blood levels of PCBs such as those found in the firefighter group are not associated with significant health effects. Perhaps the most comprehensive study focused on 289 capacitor manufacturing workers exposed to PCBs for a minimum of ten years(5). Air levels in this group's work environment ranged as high as 11 milligrams per cubic meter, over one thousand times higher than the level estimated in the PATH fire. The only abnormalities correlated with PCB levels found in this group were the presence of chloracne in 5% and high levels of a particular liver enzyme (SGOT). It is important to reemphasize that the blood levels were, on the average, five to ten times as high as in the firefighter group; ranging from 20 to 270 parts per billion.

Furthermore, as PCBs continue to be replaced and thus eliminated from the firefighter work environment, there will be decreasing potential for future exposures. However, a conclusive determination has not been made on possible long-term deleterious human health effects of exposures to either PCBs or PCB combustion products (dibenzofurans and dioxins). A.D. Little found two polychlorinated dibenzodioxin (dioxin) isomers at levels between 0.6 and 12.4 micrograms per square meter on surfaces in Tunnel "L." Polychlorinated dibenzofuran isomers were also detected at 1.3 to 1.4 micrograms per square meter on surfaces in Tunnel "L" and the surface of car #157. The human health significance of these findings is uncertain. The most toxic dioxin and furan isomers (2,3,7,8-dibenzo dioxin and furan) were fortunately not detectable.

Serum PCB levels ranged from non-detectable to 35 parts per billion on the 64 firefighters who volunteered for the evaluation. Controlling for length of service as firefighters and taking into account the percentage of time wearing respirators during the fire, no association was found between PCB levels and involvement in the PATH fire. Second, after applying several different statistical procedures, a weak correlation was found between both firefighter age and serum PCB levels and between overall service fighting fires and serum PCB levels. It was impossible to precisely distinguish the effect of age from the effect of length of service on serum PCB level. A different study design (perhaps including more firefighters followed over time) might have more precisely identified which factor, age or length of service, was more responsible for the slight increase in PCB levels observed. However, after comparing the firefighter group to another non-exposed worker group and with the general population, with the exception of one or two individuals, no obvious health hazard specifically related to PCBs could be isolated.

VIII. RECOMMENDATIONS

Based on the information presented above, NIOSH recommends the following measures:

A. Until PATH completes its program to substitute non-PCB containing material in electrical capacitors and transformers, all subway fires should be considered potential sources of PCBs. The firefighters responding to these fires should wear self-contained breathing apparatus throughout these incidents.

B. The Port Authority should continue with the capital improvements program designed to reduce subway fire hazards. Specifically a system of large fans and necessary ductwork to provide emergency ventilation of subway tunnels should be installed as soon as possible.

C. Conventional turnout clothing will not provide adequate protection from the substances found in the PCB fires, and currently there is no recommended method of decontamination. The use of disposable outer protective garments while responding to these fires would simplify the problem of how to decontaminate conventional turnout clothing. NIOSH is currently evaluating the use of freon solvents to clean PCB contaminated clothing(21).

D. As a temporary measure, equipment (not clothing) which becomes contaminated during PCB fires should be washed down at the scene with a kerosene based cleaner. Local environmental protection agencies should be notified immediately to advise them about the possibility of contamination of ground or surface water. All run off water thought to be contaminated should be contained with an earth berm and later removed in accordance applicable EPA and DOT regulations.

IX. REFERENCES

1. Lloyd JW, Roscoe M, et al.: Polychlorinated Biphenyls, Journal of Occupational Medicine 18:109-113, 1976.

2. National Institute for Occupational Safety and Health (NIOSH). Criteria for a recommended standard: occupational exposure to polychlorinated biphenyls (PCBs). Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. DHEW publication no. (NIOSH) 77-225.

3. Maroni M, Columbi A, et al.: Occupational exposure to polychlorinated biphenyls in electrical workers. II. Health Effects. British Journal of Industrial Medicine 38:55-60, 1981.

4. Chase KH, Wong O, et al.: Clinical and metabolic abnormalities associated with occupational exposure to polychlorinated biphenyls. Journal of Occupational Medicine 24:109-114, 1982;

5. Fischbein A, Wolff MS, et al.: Clinical findings among PCB-exposed capacitor manufacturing workers. Annals NY Acad. Sciences 320:703- 716, 1979

6. Personal communication from J Melius of NIOSH to Arthur D. Little, Inc.

7. Maroni M, et al. pp. 55-60; Woolf MS, Fischbein A, et al.: Body burden of polychlorinated biphenyls among persons employed in capacitor manufacturing. International Archives of Occupational and Environmental Health 49:199-208, 1982.

8. Kreiss K, Roberts C, et al.: Serial PBB levels, PCB levels, and clinical chemistries in Michigan's PBB cohort. Archives of Environmental Health 37:141-147, 1982.

9. Buser, HR and Bosshardt, HP. Formation of polychlorinated dibenzofurans (PCDFs) from the pyrollysis of PCBs. Chemosphere 1:109-119, 1978.

10. U.S. Environmental Protection Agency. 1980. Dioxins. EPA-600/2-80-197

11. National Institute for Occupational Safety and Health (NIOSH). Health Hazard Evaluation Report HETA 82-224-1336, (Miami Fire Department, Miami, Florida). DHEW, Public Health Service, Centers for Disease Control, NIOSH, Cincinnati, Ohio, 1982.

12. New York State Office of General Services, General Health and Safety Plan for Cleanup of Binghamton State Office Building, 1982.

13. Nagayama J, Kuratsune M, and Masuda Y: Determination of chlorinated dibenzofurans in Kanechlors and "Yusho oil." Bulletin of Environmental Contamination and Toxicology 15:9-13, 1976.

14. Kashimoto, T.; Miyata, H.; and Kunita, N. The presence of polychlorinated quaterphenyls in the tissues of Yusho victims. Food and Cosmetic Toxicology (In Press).

15. Rosenman, KD. Chemical Contamination Episodes. In, Environmental and Occupational Medicine, Rom WN, Editor, Little-Brown, 1983, pp. 595-597.

16. "R" is the correlation coefficient which can range from -1 to +1 and is a measure of the closeness of relationship between two variables. Positive values of "r" indicate a tendency of two variables to increase together. When "r" is negative large values of one variable are associated with small values of another. Snedecor GW and Cochran WG. 1980. Statistical Methods. Iowa State.

17. The "p" tells one what the probability is that the difference (e.g. in PCB levels) between two or more groups is just a chance happening. It is generally agreed, when statistically analyzing data from studies such as this, that "p" should be less than 0.05. This means that there is a less than five in one-hundred chance that the differences are due to chance. Snedecor GW and Cochran WG. 1980. Statistical Methods. Iowa State.

18. It is generally agreed by most statisticians and epidemiologists that "r" values between 0.3 and 0.5 signify weak correlations; values between 0.5 and 0.7, moderate correlations; anything higher, strong correlations. Snedecor GW and Cochran WG. 1980. Statistical Methods. Iowa State.

19. Kominsky JR, Letter to Jersey City Fire Department, July 20, 1982, Cincinnati, Ohio.

20. Starff DC, Quinby GE, et al.: Polychlorinateed biphenyl emission from fluorescent lamp ballasts. Bullentin Environmental Contamination and Toxicology 12:455-63, 1974.

21. Kominsky JR, McIlvaine ET, Decontamination of Firefighters' Protective Clothing with Trichlorotrifluoroethane. [Unpublished report presented at the ElectroPower Research Institute Workshop on Polychlorinated Dibenzofurans in Palo Alto, California, December 4-6, 1984].

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:	Joseph Schirmer, M.S. Industrial Hygienist Occupational Health Program New Jersey State Dept. of Health
	Timothy Liveright, M.D., M.S.P.H. Senior Public Health Physician Occupatioanl Health Program New Jersey State Dept. of Health
Data Analysis	Gary Feit Analyst II Occupational Health Program New Jersey State Dept. of Health
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations, and Field Studies

IX. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available, upon request, from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161. Copies of this report have been sent to:

1. International Association of Fire Fighters (IAFF)

2. Jersey City Fire Officers Association Local 1064 IAFF

3. Uniformed Fire Fighters Associated of Jersey City Local 1066 IAFF

4. Jersey City, NJ Fire Department

5. Port Authority of New York and New Jersey/PATH

6. NIOSH Region II

7. U.S.Department of Labor, OSHA, Region II

8. Designated State Agencies

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

TABLE 1 - ALL PARTICIPANTS

Variable	Mean	Std Dev	Minimum	Maximum	N
AGE	43.31	10.94	20.00	64.00	64
SERVICE	15.89	10.17	1.00	35.00	64
TIME in TUNNEL	36.64	49.35	0.00	180.00	64
% TIME without RESPIRATOR	28.91	20.52	0.00	75.00	64
ACTUAL TIME without RESP	21.56	29.25	0.00	135.00	64
PCB	8.59	6.66	2.50*	35.00	64

* - DETECTION LIMIT FOR SERUM PCBS WAS 2.5 PPB

TABLE 1A - PARTICIPANTS WITH NO DIRECT CONTACT WITH FIRE

Variable	Mean	Std Dev	Minimum	Maximum	N
AGE	46.46	10.50	26.00	64.00	28
SERVICE	17.32	9.97	1.00	35.00	28
TIME in TUNNEL	0.00	0.00	0.00	0.00	28
% TIME without RESPIRATOR	15.18	17.13	0.00	75.00	28
ACTUAL TIME without RESP	0.00	0.00	0.00	0.00	28
PCB	8.51	4.87	2.50*	16.80	28

TABLE 1B - PARTICIPANTS WITH DIRECT CONTACT WITH FIRE

Variable	Mean	Std Dev	Minimum	Maximum	N
AGE	40.86	10.78	20.00	64.00	36
SERVICE	14.78	10.31	1.00	35.00	36
TIME in TUNNEL	65.14	49.75	5.00	180.00	36
% TIME without RESPIRATOR	39.58	16.23	25.00	75.00	36
ACTUAL TIME without RESP	38.33	29.65	3.75	135.00	36
PCB	8.65	7.85	2.50*	35.00	36

* - DETECTION LIMIT FOR SERUM PCBS WAS 2.5 PPB

TABLE II - AGE AND SERUM PCB LEVELS
IN WORKERS THOUGHT TO BE EXPOSED TO PCBS

Variable	Mean	Std Dev	Minimum	Maximum	N
AGE	39.44	11.11	25.00	65.00	34
PCB	6.23	4.10	2.50	16.80	34

* - DETECTION LIMIT FOR SERUM PCBS WAS 2.5 PPB

FIGURE 1

PCB Level Comparison

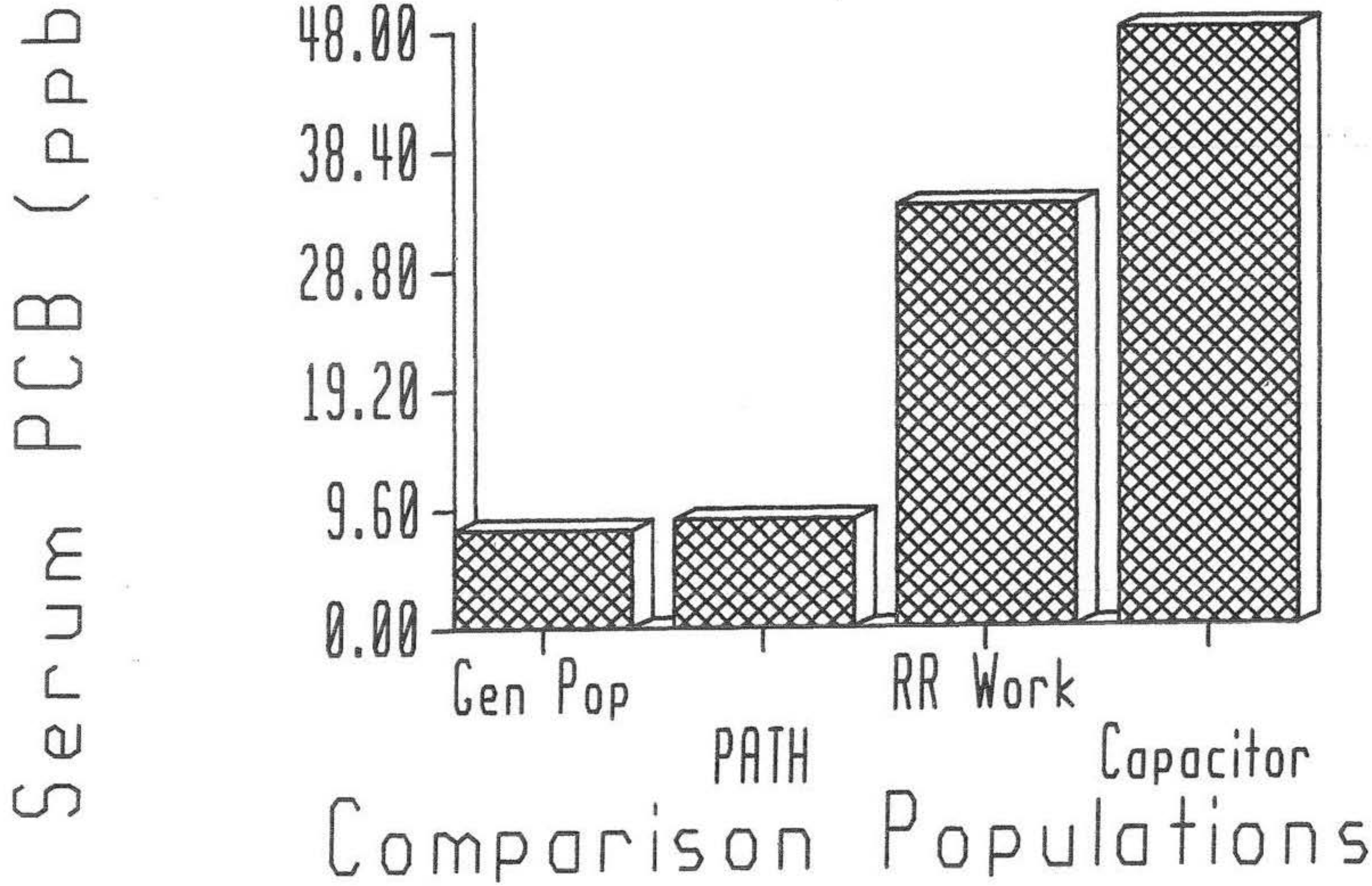


FIGURE 2

PLOT OF AGE AND FIREFIGHTER SERUM PCB LEVELS

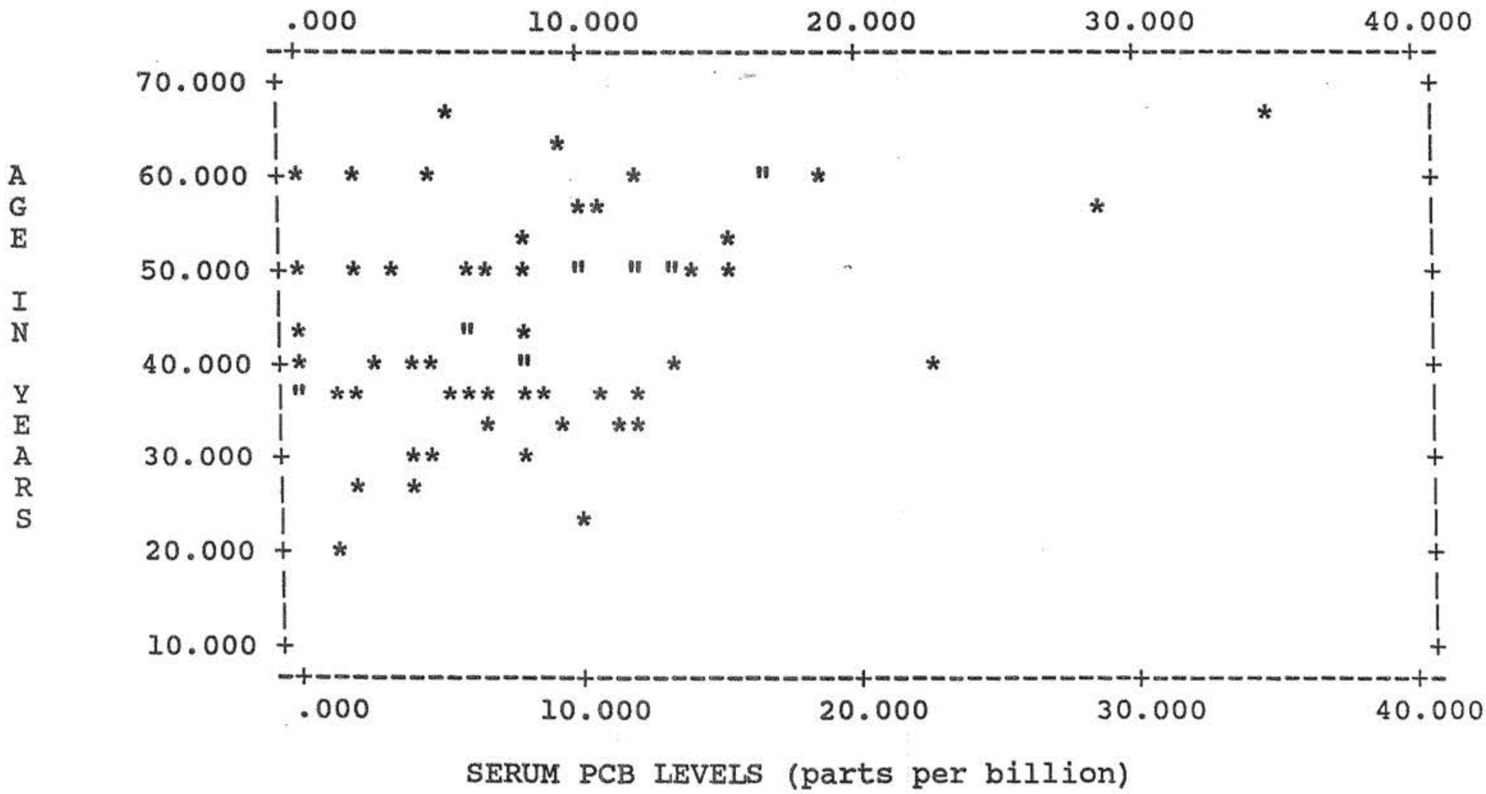


FIGURE 3

PLOT OF SERVICE AND FIREFIGHTER SERUM PCB LEVELS

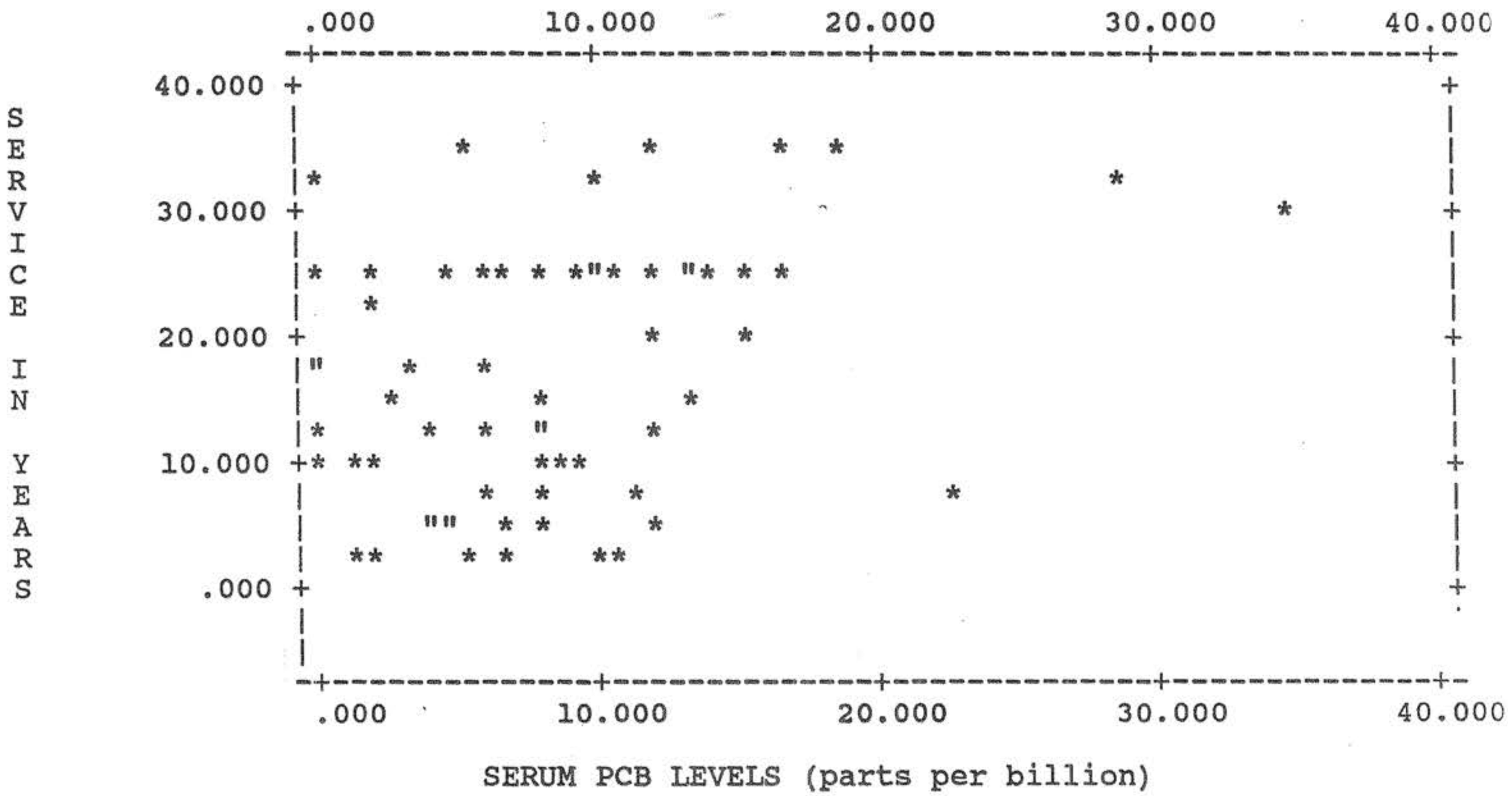


FIGURE 4

PLOT OF AGE VERSUS SERVICE AS FIREFIGHTER

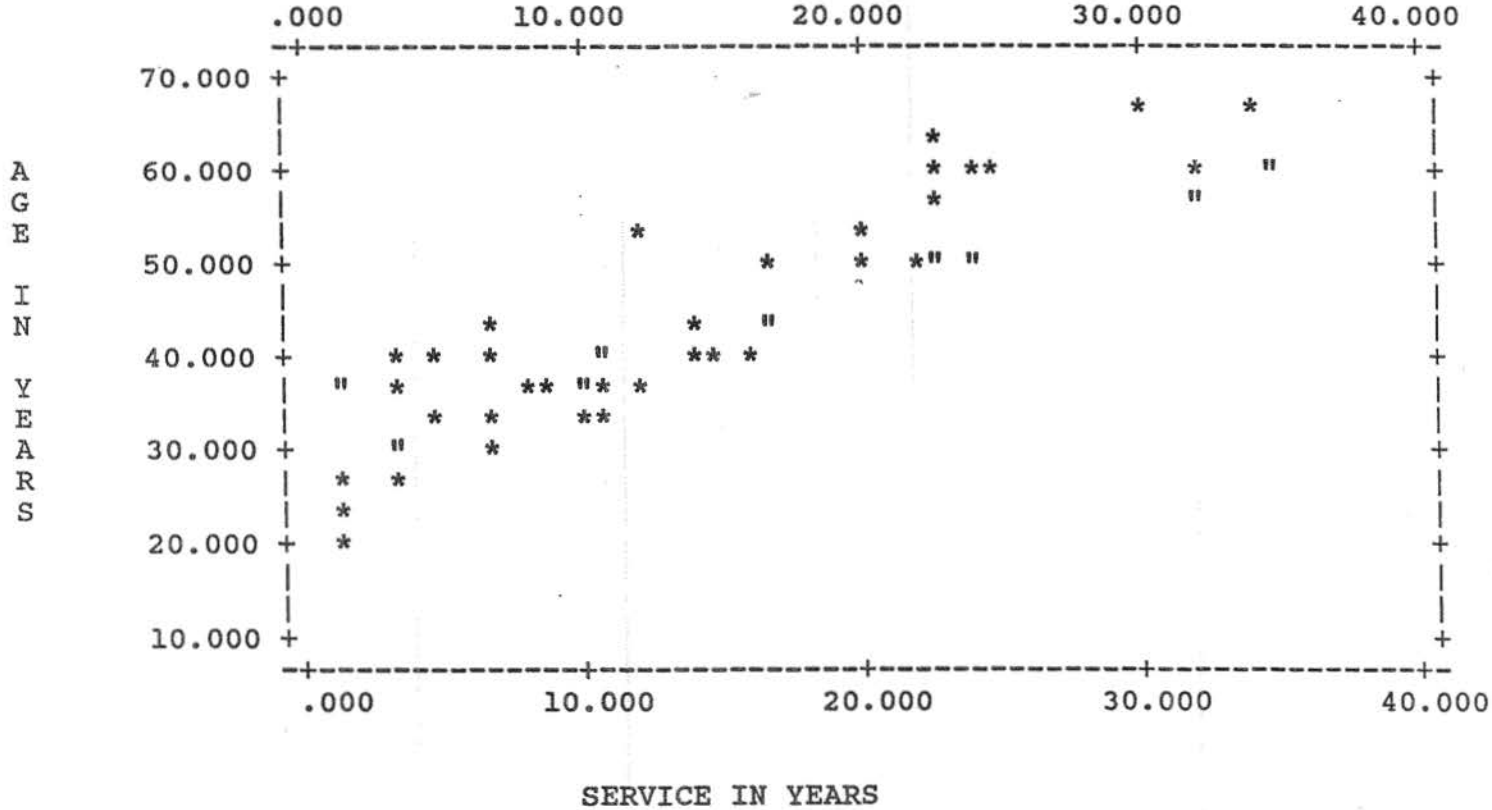
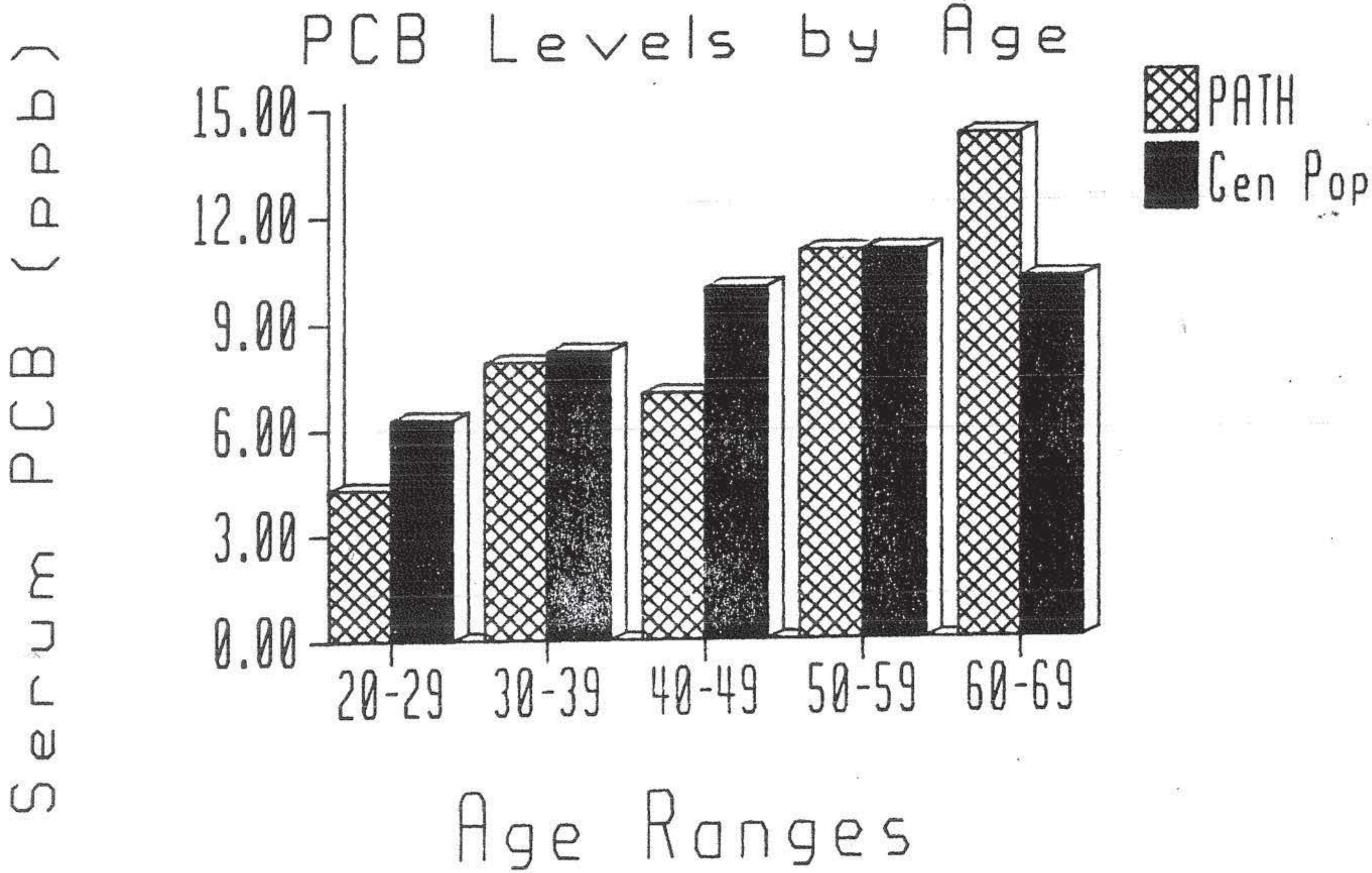


FIGURE 5


PCB Levels by Age
Serum PCB (ppb)
15.00
12.00
9.00
6.00
3.00
0.00
20-29
30-39
40-49
50-59
60-69
Age Ranges
PATH
Gen Pop

DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
ROBERT A. TAFT LABORATORIES
4676 COLUMBIA PARKWAY, CINCINNATI, OHIO 45226

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE. $300

Third Class Mail

U.S. MAIL

POSTAGE AND FEES P
U.S. DEPARTMENT OF
HHS 396