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I. SUMMARY

On December 3, 1986, the Arkansas Department of Health requested the National Institute for Occupational Safety and Health (NIOSH) to evaluate worker exposures to polychlorinated biphenyls (PCB) at the ENSCO hazardous waste incinerator in El Dorado, Arkansas. NIOSH personnel conducted an initial walk-through inspection on January 27, 1987, reviewed company environmental sampling and blood PCB data, and then conducted an in-depth environmental and medical survey on March 23-26, 1987.

Quantifiable amounts of PCB were found in all 41 air samples collected by NIOSH investigators. Air concentrations ranged from 0.85 to 40 micrograms per cubic meter (ug/m^3), with highest levels in the kiln dock area. All but one air concentration exceeded the NIOSH recommended exposure limit of 1 ug/m^3. (The Occupational Safety and Health Administration [OSHA] permissible exposure limits are 1,000 ug/m^3 for 42% chlorinated PCB and 500 ug/m^3 for 54% chlorinated PCB.) Quantifiable amounts of PCB were also found on all 56 surface wipe samples. For low-contact surfaces (floors), 25 (89%) of 28 samples had PCB levels exceeding 100 ug/m^2, a guideline based on the background level in non-industrial buildings. For high-contact surfaces, such as desk and table tops and control panels, 12 (60%) of 20 samples showed surface concentrations greater than 100 ug/m^2. Polychlorinated dibenzofurans (PCDF) and polychlorinated dibenzo-p-dioxins (PCDD) were found in all five surface wipe samples, at levels of 4-40 nanograms of total 2,3,7,8-tetrachlorodibenzo-p- dioxin (TCDD) equivalents per square meter, all in excess of 1 ng/m^2, a guideline intended to maintain the risk of exposure-related cancer less than one in a million for a working lifetime (30 years). (2,3,7,8-TCDD, the most toxic isomer, was not found.)

Serum PCB levels ranged from 2 to 385 parts per billion (ppb), with a median of 18 ppb. (Persons without occupational exposure to PCB generally have a serum PCB level less than 20 ppb.) Forty-one (51%) were less than 20 ppb, 10 (12%) were in the 20-50 ppb range, 14 (17%) were in the 51-100 ppb range, 10 (12%) were in the 101-200 ppb range, 1 was in the 201-300 ppb range, and 5 (6%) were greater than 300 ppb. Employees in the Production Department (which includes the kiln dock) had the highest serum PCB levels (median: 98 ppb); warehouse and maintenance workers also had elevated PCB levels (medians: 52 and 46 ppb, respectively). Serum PCB level was not correlated with time at the plant or time in the current job. Nine workers had skin findings suggestive of chloracne. Their median serum PCB level (48 ppb) was numerically higher than that of the participants without such findings (18 ppb), but the difference was not statistically significant ($p = 0.75$, Wilcoxon rank sum test). Three of the four with no preceding history of common acne had serum PCB levels less than 20 ppb; all four had minimal skin findings.

Although none of the PCB levels measured exceeded current OSHA standards, from NIOSH's perspective the environmental and medical data documented excessive exposure to PCB, and the environmental data documented the presence of PCDF and PCDD. The lack of a consistent association between skin findings suggestive of chloracne and serum PCB level suggests either that the skin findings were not due to chloracne or that, to the extent they were, the cause was something other than PCB, perhaps PCDD or PCDF. Recommendations for reducing exposures, addressing engineering and administrative controls, work practices, personal protective equipment, and exposure monitoring, are contained in section VIII of this report.

KEYWORDS: SIC 4953 (Refuse Systems), polychlorinated biphenyls, dioxins, dibenzofurans, hazardous waste, incinerator

II. INTRODUCTION

On December 3, 1986, the Arkansas Department of Health (ADH) requested assistance from the National Institute for Occupational Safety and Health (NIOSH) in evaluating worker exposures to polychlorinated biphenyls (PCB) at the ENSCO hazardous waste incinerator in El Dorado, Arkansas. This request was part of the ADH's multifaceted investigation of potential community exposure to PCB. The ENSCO facility was the putative source of this PCB, and there was a newspaper report of an ENSCO worker with a very high blood PCB level.

NIOSH and ADH personnel conducted a walk-through inspection of the ENSCO facility January 27, 1987, and NIOSH personnel reviewed the company's environmental sampling and blood PCB data. Based on the findings during this visit, NIOSH personnel conducted an environmental and medical survey March 23-26, 1987. On February 20, April 16, August 3, and September 21, 1987, we sent letters to the ADH, the company, and the union (Oil Chemical and Atomic Workers Local 5-434) reporting the progress of our evaluation. We notified participants of their blood test results on July 20, 1987.

III. BACKGROUND

A. Workforce

The ENSCO Hazardous Waste Incinerator began burning PCB in March 1981. At the time of our survey there were approximately 275 ENSCO employees in El Dorado, including 14 at the geographically separate North warehouse and about 50 outside truck drivers. The others work at the incinerator site, although not all have jobs in processes that involve direct exposure to PCB. In addition, employees of other corporately related but separate companies work on the site, though not necessarily with PCB. Virtually all ENSCO production and maintenance workers are men. Administrative, clerical, and laboratory personnel include both men and women.

B. Process Description

This facility is a commercial incinerator for the combustion of hazardous waste, including large volumes of PCB. Incoming shipments are received by truck or rail, tested for composition by an on-site laboratory, and stored in warehouses prior to incineration.

The "old PCB warehouse" is used for storage of liquid PCB, primarily in 55-gallon drums. The drums are opened, and the liquids are pumped into a holding tank. Any residual solid material or sludge is packaged into 10-gallon plastic drums for subsequent shredding and incineration.
The "North warehouse" is located several miles away from the main site. The North warehouse site actually consists of four interconnected warehouses, identified as warehouses A, B, C, and D.

Capacitors and PCB-contaminated solids are stored here prior to incineration at the main site. The North warehouse is being phased out gradually. The warehouse contents are being transferred to the main site, where they will be incinerated or stored in the "new PCB warehouse".

The new PCB warehouse, which opened less than a year before our survey, is designed for on-site storage of PCB-contaminated solids and capacitors prior to incineration.

The incineration process begins at the "kiln dock", where capacitors and other solids are unloaded from trucks onto the dock and are fed by lift truck into a shredder, from which the materials enter a high-temperature rotary kiln. A ram-feed system is also used in this area to inject plastic drums of flammable liquid organic wastes into the incinerator. At the exit side of the rotary kiln, residual solids (metal and ash) drop out of the system into 55-gallon drums for collection; this step is called the "ash drag".

Downstream from the rotary kiln are thermal oxidation units (TOU), which are designed to maintain the temperature required for complete combustion of PCB. Liquid PCB is pumped from storage tanks and injected directly into the TOU in a closed system. The effluent stream then goes through a scrubber, where the hydrochloric acid formed by PCB combustion is removed. Finally, the combustion products (carbon dioxide and water) are discharged to the atmosphere through a tall stack.

C. PCB Exposure Monitoring

The ENSCO plant safety manager at the El Dorado site conducts monthly air sampling in PCB-handling areas of the facility. The air sampling includes both personal exposure and area samples. From time to time, the corporate industrial hygienist also conducts surveys at the site. His monitoring has included area air samples, personal worker exposure monitoring, and surface wipe samples.

A review of air monitoring data from May 1985 through December 1986 shows that, in terms of air PCB concentrations, the facility may be classified into 3 contamination levels:

<u>Lower Exposure Areas</u>
RCRA Warehouse
Laboratory
New PCB Warehouse

<u>Intermediate Exposure Areas</u>
(Old) PCB Warehouse
North Warehouse

<u>Higher Exposure Area</u>
Kiln Dock

According to ENSCO's data, in 6 air samples from the RCRA warehouse (storage of waste materials other than PCB) PCB was either undetectable or detectable but not quantifiable. The one exception was a sample with 7 micrograms of PCB per cubic meter of air (ug/m^3). The levels in 17 samples from the laboratory were also below the limit of quantification, except for 3 samples with concentrations ranging from 9 to 23 ug/m^3. Only two air samples had been collected in the new PCB warehouse; both had PCB concentrations of 4 ug/m^3.

Air PCB levels in the (old) PCB warehouse ranged from none detected to 115 ug/m^3, with 25 (89%) of 28 sample results less than 20 ug/m^3. Air PCB levels in the North Warehouse ranged from none detected to 92 ug/m^3, with 21 (88%) of 24 samples showing 50 ug/m^3 or less.

Air PCB concentrations in the kiln dock area ranged from 3 to 408 ug/m^3, with 14 (41%) of 34 samples in less than 50 ug/m^3, 10 (29%) in the 50-100 ug/m^3 range, 7 (21%) in the 100-200 ug/m^3 range, and 3 (9%) greater than 200 ug/m^3.

ENSCO's wipe sampling has documented surface contamination in the warehouses and at the kiln dock. Past surveys also found significant surface contamination in the lunchroom, break rooms, and shower room.

IV. METHODS

A. Environmental

1.Polychlorinated biphenyls

Airborne PCBs were collected by drawing air through a glass tube containing 150 milligrams (mg) of florisil adsorbent (100 mg front section and 50 mg backup section) at a flow rate of either 0.8 or 1.0 liters per minute (lpm) using calibrated, battery-operated sampling pumps. Some samples were collected at locations considered representative of a particular process (area samples). Most samples were worn by workers to measure their individual exposure levels during the work day (personal samples). The samples were capped and sent to the laboratory for analysis.

At the laboratory, each florisil tube was separated into front and backup sections. Each section was desorbed in 1 milliliter (ml) of hexane with sonication for one-half hour to release the PCBs from the florisil for analysis.

A wet-wipe protocol was used to assess the surface concentrations of PCB. The surface wipe samples were collected using 3" x 3" Soxhlet-extracted cotton gauze pads. The sampling procedure consisted of marking off a surface into 0.25 m^2 areas using a metal tape measure. Each 0.25 m^2 area was wiped with a 3" x 3" gauze pad, which had been wetted with 8 ml of pesticide-grade hexane. The wet-wipe sample pad was held with a gloved hand; a fresh, non-linear polyethylene, unplasticized glove was used for each sample. The surface was wiped in two directions, the second direction at a 90 angle to the first. Each gauze pad was used to wipe only one 0.25 m^2 area. The gauze pad sample was then placed in a glass sample container equipped with a Teflon-lined lid and submitted to the laboratory for analysis.

The gauze samples were prepared for analysis by extraction; they were shaken for 30 minutes in 40 ml of hexane. The hexane was transferred to a concentrator tube, and the gauze was rinsed twice with 10 ml of hexane. The concentrated hexane eluent was cleaned on a florisil column, and the sample was brought to a final volume of 3 ml. Three drops of sulfuric acid were added to some of the samples prior to the florisil clean-up.

For both the air and surface samples, the gas chromatographic analysis was performed on a Hewlett-Packard Model 5730A gas chromatograph equipped with an electron capture detector and accessories for capillary column capabilities. A 30 m x 0.31 mm fused silica WCOT capillary column coated internally with DB-5 was used with temperature programming from 210° C (held for two minutes) to 310° C at a rate of 8° C/minute. Five percent methane in argon was used as the carrier gas. The capillary injector was operated in the splitless mode.

The presence of an Aroclor was determined by comparison with standard samples of Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260 obtained from the U. S. Environmental Protection Agency (EPA). Quantitation was performed by summing the peak heights of the five major peaks of the standards and comparing those sums to the sums of the same peaks in the sample.
Air and surface PCB concentrations were calculated by dividing the quantity of individual Aroclor measured in the sample by the sampled volume of air (m^3) or surface area (m^2), respectively. For air samples, the instrumental limit of detection (lowest amount that could be detected in a sample) was 0.02 ug/sample, and the calculated limit of quantitation (the lowest amount that could be accurately measured in a sample) was 0.16 ug/sample. For surface samples, the limits of detection and quantitation varied by Aroclor type.

2.Polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF)

To attain an acceptable detection limit, each PCDD/PCDF surface wipe sample consisted of a composite of four 0.25 m^2 wipe samples, for a total area of 1.0 m^2. The wipe samples were extracted with toluene for 16 hours using a Soxhlet apparatus to dissolve the PCDD and PCDF from the samples. The resulting toluene solution was concentrated to near dryness on a rotary evaporator. An extensive purification process was then used to prepare the samples for analysis. The samples were analyzed by gas chromatography and mass spectrometry. Selected C^{13} and Cl^{37} labeled PCDD and PCDF isomers were included as internal standards and recovery (surrogate) standards.

Analyses were performed to measure total tetra-, penta-, hexa-, hepta-, and octachlorinated dibenzofurans; total tetra-, penta-, hexa-, hepta-, and octachlorinated dibenzodioxins; and specific PCDD and PCDF isomers containing chlorine substitution in the 2, 3, 7, and 8 positions. Limits of detection and quantitation varied by isomer and isomer group. For 2,3,7,8-TCDD, the limit of detection varied from sample to sample, with a range of 0.03 to 0.09 nanogram (ng)/sample.

B. Medical

The medical survey included, for each participant, (a) an interview regarding work history at ENSCO and previous work potentially involving PCB exposure, (b) an examination of the skin of the head and neck for signs of chloracne, and (c) measurement of serum PCB concentration. Additional information on work history was obtained from personnel records when necessary.

All employees currently in the following departments were invited to participate: Production (operations), Maintenance, PCB material handling, North warehouse, Laboratory, and Process engineers. Also, all employees who had worked in MWP-75 (mobile incinerator) were invited to participate. In addition, a sample of employees in other departments, systematically selected by the NIOSH medical officer and modified according to availability of employees, was included in the study. Finally, a few non-selected employees participated at their request.
Venous blood was obtained using a multiple-draw Vacutainer system. The blood was allowed tto clot, and serum was separated, frozen, and sent to the Center for Environmental Health (CEH), Centers for Disease Control, Atlanta, Georgia, for analysis. To prevent contamination of the blood sample with PCB from the skin, the first tube of blood was discarded, and the second was used for PCB analysis. Six participants had a third tube of blood drawn as a quality control measure; it was submitted to the laboratory identified as if it were from another participant. Nine other participants had a third tube drawn, handled, and processed in the same manner as the others, then given to ENSCO's laboratory for analysis. (The ENSCO serum samples were identified only by a arbitrary number assigned by NIOSH personnel.)

The analytical method used by the CEH laboratory involves gas chromatography with electron capture detection, using the Webb-McCall factors to quantify PCB.[1] The results were reported as specific Aroclors which were determined by matching the GC pattern of a participant's serum with serum from animals fed known Aroclors. For purposes of (a) notifying participants of their own results, and (b) analyzing the study results, we added the individual Aroclor concentrations and obtained a single serum PCB level for each participant. ENSCO's laboratory uses a quantification method based on mass spectroscopy; results are reported as a single serum PCB concentration.

V. <u>EVALUATION CRITERIA</u>

A. Health Effects

1.Polychlorinated biphenyls

PCBs are chlorinated aromatic hydrocarbons that were manufactured in the United States from 1929 to 1977 and primarily marketed under the trade name Aroclor.[2] They found wide use because they are heat stable; resistant to chemical oxidation, acids, bases and other chemical agents; stable to oxidation and hydrolysis in industrial use; and have low solubility in water, low flammability, and favorable dielectric properties. Additionally, they have low vapor pressure at ambient temperatures and viscosity-temperature relationships that were suitable for a wide variety of industrial applications. PCBs have been used commercially in insulating fluids for electrical equipment, hydraulic fluids, heat transfer fluids, lubricants, plasticizers, and components of surface coatings and inks.[3]

The different PCB mixtures marketed under different trade names are often characterized by a four-digit number. The first two digits denote the type of compound ("12" indicating biphenyl), and the latter two digits giving the weight percentage of chlorine, with the exception of Aroclor 1016. In other commercial preparations the number code may indicate the approximate mean number of chlorine atoms per PCB molecule (Phenoclor, Clophen, Kanechlor) or the weight percentage of chlorine (Fenclor).

Dietary PCB ingestion, the major source of population exposure, occurs especially through eating fish, but PCB residues are also found in milk, eggs, cheese, and meat. PCB residues are detectable in various tissues of persons without known occupational exposure to PCB. In past years, reported mean whole blood PCB levels ranged from 1.1 to 8.3 parts per billion (ppb), and mean serum PCB levels from 2.1 to 24.2 ppb, for persons without known occupational exposure.[4] Mean serum PCB levels among workers in one capacitor manufacturing plant studied by NIOSH ranged from 111 to 546 ppb, or approximately 5 to 22 times the background level in the community. Mean serum PCB levels among workers in transformer maintenance and repair typically range from 12 to 51 ppb, considerably lower than among workers at capacitor manufacturing plants.[5]

PCB toxicity is complicated by the presence of highly toxic impurities, especially the polychlorinated dibenzofurans,[6] which vary in amount depending on the manufacturer[7] and percent chlorination,[8] and which are found in increased concentration after incomplete pyrolysis of the PCB.[9,10] Furthermore, different animal species, including humans, vary in their pattern of biologic response to PCB exposure.[11]

Two human epidemics of chloracne, "Yusho" and "Yu-cheng," from ingestion of cooking oil accidentally contaminated by a PCB heat-exchange fluid used in the oil's pasteurization, have been described in detail.[12,13] Although PCB was initially regarded as the etiologic agent in the Yusho study, analyses of the offending cooking oil demonstrated high levels of PCDF and polychlorinated quarterphenyls, as well as other unidentified chlorinated hydrocarbons, in addition to PCB.[14]

The results of individual studies of PCB-exposed workers are remarkably consistent. Among the cross-sectional studies of the occupationally exposed, a lack of clinically apparent illness in situations with high PCB exposure seems to be the rule. Chloracne was observed in recent studies of workers in Italy,[15] but not among workers in Australia,[16] Finland,[16] or the United States.[5,18-20] Weak positive correlations between PCB exposure or serum PCB level, and serum aspartate aminotransferase (SGOT) level,[15,17-19] serum gamma-glutamyltranspeptidase (GGTP) level,[5,15,19,20,] and plasma triglycerides[5,21,22] have been reported. Correlations between plasma triglycerides[23] and GGTP[24] have also been found among community residents with low-level PCB exposures. Causality has not been imputed to PCBs in these cross-sectional studies.

The International Agency for Research on Cancer (IARC) has concluded that the evidence for PCB carcinogenicity in animals and humans is limited. "Certain polychlorinated biphenyls are carcinogenic to mice and rats after their oral administration, producing benign and malignant liver neoplasms. Oral administration of polychlorinated biphenyls increased the incidence of liver neoplasms in rats previously exposed to N-nitrosodiethylamine".[25]

In a mortality study among workers at two capacitor manufacturing plants in the United States,[26] a greater than expected number of observed deaths from cancer of the liver and cancer of the rectum were noted. Neither increase was statistically significant for both study sites combined. In a recent update of this study,[27] however, with follow-up through 1982, the excess in liver/biliary tract cancer was statistically significant (5 observed vs. 1.9 expected). The excess in cancer of the rectum was still elevated but not statistically significantly so. In this mortality study, the personal time-weighted average exposures in 1976 ranged from 24 to 393 ug/m^3 at one plant, and from 170 to 1260 ug/m^3 at the other. During the time period (1940-1976) when most of the workers were exposed, the levels were probably substantitally higher. At one of the plants, the geometric mean serum PCB levels in 1976 were 1470 ppb for 42% chlorinated biphenyls and 84 ppb for 54% chlorinated biphenyls.

In a mortality study among workers at a capacitor manufacturing plant in Italy,[28] males had a statistically significant increase in the number of deaths from all neoplasms. When these were analyzed separately by organ system, deaths from neoplasms of the digestive organs and peritoneum (3 observed vs. 0.88 expected) and from lymphatic and hematopoietic tissues (2 observed vs. 0.46 expected) were elevated. This study was recently expanded to include vital status follow-up through 1982 for all workers with one week or more of employment.[29] In the updated results, there was a statistically significant excess in cancer among both females (12 observed vs. 5.3 expected) and males (14 observed vs. 7.6 expected). In both groups there were statistically non-significant excesses of lymphatic/hematopoietic cancer and a significant excess of digestive cancer among males (6 observed vs. 2.2 expected).

2.Polychlorinated dibenzo-p-dioxins (PCDD, dioxins) and polychlorinated dibenzofurans (PCDF, furans)

PCDDs and PCDFs are two series of tricyclic aromatic compounds. The number of chlorine atoms can vary between 1 and 8 (mono- through octachloro homologs), resulting in 75 PCDD and 135 PCDF positional isomers.

The toxic effects of these compounds are associated with the number and specific placement of the chlorine atoms in the molecule. The tetra-, penta- and hexachlorinated isomer groups exhibit greater toxicity than the other chlorinated forms.[31-33] PCDDs and PCDFs with chlorine at positions 2,3,7, and 8 are particularly toxic.[34-36] PCDDs and PCDFs are highly toxic in experimental animals when administered acutely, subchronically, or chronically.[36-44] Toxic effects include severe weight loss, liver necrosis and hypertrophy, skin lesions, immunosuppression, reproductive toxicity, teratogenesis, and death. Of the 75 PCDD and 135 PCDF isomers, only 2,3,7,8-TCDD and a mixture of hexachlorinated dibenzo-p-dioxins with four of the six chlorines in positions 2,3,7, and 8 have been tested for carcinogenicity. Two independent studies of 2,3,7,8-TCDD showed significant increases in the incidence of liver and/or lung tumors in exposed rodents.[43,44] A mixture of two 2,3,7,8-substituted hexachlorinated dibenzodioxins was found to produce an increased incidence of liver tumors or neoplastic nodules in exposed rats and mice.[45]

Exposure to PCDD can cause chloracne and liver toxicity in humans.[41,46] There is suggestive evidence of an increased incidence of cancer in people exposed to PCB containing substantial amounts of PCDF[47,48] and in people exposed to phenoxy herbicides contaminated with PCDD, including TCDD.[49,50] Definite causal relationships between exposures and carcinogenic effects in humans remain unclear, however, due to the inadequately defined study populations and the influences of mixed exposures.

B. Environmental Evaluation Criteria

1.General

As a guide to the evaluation of the hazards posed by work place exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other work place exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the work place are: 1) NIOSH criteria documents and recommended exposure limits (RELs), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) threshold limit values (TLVs), and 3) the federal Occupational Safety and Health Administration's (OSHA) permissible exposure limits (PELs). Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA PELs. The NIOSH RELs and ACGIH TLVs are usually based on more recent information than are the OSHA standards. The OSHA PELs may also be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

2.PCB

a.Air

In February 1986, NIOSH reiterated its previous recommendation that exposure to PCB in the workplace not exceed 1 ug/m^3 (based upon the recommended sampling and analytical method in use at the time), determined as a TWA for up to a 10-hour workday, 40-hour workweek.[51] This recommended exposure limit was based on the findings of adverse reproductive effects in experimental animals, on the conclusion that PCBs are carcinogens in rats and mice and, therefore, potential human carcinogens in the workplace, and on the conclusion that human and animal studies have not demonstrated a level of exposure to PCBs that will not subject the worker to possible liver injury[(52)].

In 1971, based on the 1968 ACGIH TLVs, OSHA promulgated its permissible exposure limits of 1 mg/m^3 for airborne chlorodiphenyl products (PCB) containing 42% chlorine and 0.5 mg/m^3 for chlorodiphenyl products containing 54% chlorine, determined as 8-hr TWA concentrations (29 CFR 1910.1000). The TLVs, which have remained unchanged at 1.0 and 0.5 mg/m^3 through 1987, are based on the prevention of (non-carcinogenic) systemic toxicity.[53] The OSHA PEL and the ACGIH TLV values include a "skin" notation, which refers to the potential contribution to overall exposure by the cutaneous route, including the mucous membranes and eyes, by either airborne or direct skin contact with PCB.

b. Surfaces

NIOSH recommends that occupational exposures to carcinogens be reduced to the lowest feasible level. Results of several investigations of PCB surface contamination in office buildings indicate that there is a "background" level of surface contamination in the range of 50 to 100 micrograms per square meter (ug/m^2).[54-57] Therefore, for surfaces in the occupational environment that may be routinely contacted by the unprotected skin, NIOSH investigators have recommended that PCB contamination not exceed 100 ug/m^2 (the lowest feasible level considering background contamination).

The risk posed by this level of contamination was assessed by the Environmental Protection Agency (EPA) in its PCB spill cleanup policy.[58] In the "Development" section of the policy (Risks Posed by Leaks and Spills of PCBs), the EPA states that the estimated level of oncogenic risk associated with dermal exposures to 50 ug/m^2 of PCBs on hard, indoor, high-contact surfaces is between 1 x 10^{-5} and 1 x 10^{-6} (between 1 in 100,000 and 1 in 1,000,000 excess deaths, usually stated in terms of workers with a 30-year work history). Although the EPA document did not provide a risk estimate for the cleanup criterion it established for high-contact indoor surfaces (1000 ug/m^2), it did state, "EPA also believes that the surface standards of 10,000 ug/m^2 for indoor low-contact surfaces (and vaults) and high-contact surfaces in a restricted access industrial facility would not present significant risks to workers or the the general population." However, since there is a considerable degree of uncertainty associated with such a risk assessment calculation, EPA also stated that, "...the results of these [EPA] studies indicate that high-contact surfaces such as manually operated machinery may require surface standards more stringent than the 1000 to 10,000 ug/m^2 standards."

3. PCDD and PCDF

NIOSH recommends that 2,3,7,8-TCDD be regarded as a potential occupational carcinogen, that occupational exposure to 2,3,7,8-TCDD be controlled to the lowest feasible level, and that decontamination measures be used for 2,3,7,8-TCDD-contaminated work environments. This recommendation is based on a number of reliable studies demonstrating carcinogenicity in rats and mice.[41]

In July 1985, an advisory panel was convened to develop air and surface cleanup guidelines for PCB, PCDD, and PCDF for the New Mexico State Highway Department Building in Sante Fe. Both NIOSH and EPA were represented on this panel, which considered the potential risk of developing cancer as a result of exposure to PCDF and PCDD. The panel's exposure guidelines for PCDF and PCDD were intended to maintain this risk below one in one million for a person spending his/her working lifetime (30 years) in the building.

The air and surface guidelines recommended by the advisory panel were 1 picogram per cubic meter (pg/m^3) and 1 nanogram per square meter (ng/m^2), respectively, expressed as 2,3,7,8-TCDD equivalents.[59] 2,3,7,8-TCDD equivalents are defined as the concentration of 2,3,7,8-TCDD which, by itself, would exhibit the same biological potency as the mixture of structurally-related compounds, PCDDs and PCDFs, actually present in a sample. The structually-related PCDDs and PCDFs that are considered in the calculation of 2,3,7,8-TCDD equivalents include the tetra- through octachloro homologs and 2,3,7,8-substituted isomers.

This procedure, initially developed by the New York State Department of Health, estimates the amount of 2,3,7,8-TCDD that would have to be present to exhibit a similar toxicity as the measured amounts of all of the other PCDDs and PCDFs. The procedure assumes certain weighting factors (ratios of toxicities) between 2,3,7,8-TCDD and the other PCDDs and PCDFs.[60] The weighting factors (called toxicity equivalency factors by EPA) used in this report (ENSCO) are those currently proposed by EPA [Interim Procedures for Estimating Risks

Associated with Exposures to Mixtures of Dibenzo-p-Dioxins and Dibenzofurans (CDDs and CDFs), Risk Assessment Forum, EPA 625/3-87/012, 1987].

PCDFs	Factor	PCDDs	Factor
2,3,7,8-TCDFs	0.1	2,3,7,8-TCDD	1.0
other TCDFs	0.001	other TCDDs	0.01
2,3,7,8-PeCDFs	0.1	2,3,7,8-PeCDDs	0.5
other PeCDFs	0.001	other PeCDDs	0.005
2,3,7,8-HxCDFs	0.01	2,3,7,8-HxCDDs	0.04
other HxCDFs	0.0001	other HxCDDs	0.0004
2,3,7,8-HpCDFs	0.001	2,3,7,8-HpCDDs	0.001
other HpCDDs	0.00001	other HpCDDs	0.00001
OCDFs	0.0	OCDDs	0.0

The concentrations of the PCDD and PCDF compounds are converted to TCDD equivalents by multiplying measured values by the appropriate factor. The TCDD equivalents are then summed and compared to the guideline value.

VI. RESULTS AND DISCUSSION

A. Environmental

Airborne PCBs were found in quantifiable amounts in all samples (Table 1). None of the measured air levels exceeded OSHA's permissible exposure limits or ACGIH's threshold limit values. However, 40 (98%) of 41 sample results exceeded NIOSH's recommended exposure limit of 1 ug/m^3. The highest levels, 16-40 ug/m^3, were found on the kiln dock. All the warehouses and the TOU area also had air concentrations of PCB in excess of 1 ug/m^3.

PCBs were found in quantifiable amounts in all surface wipe samples (Table 2). For low-contact surfaces, such as floors, 25 (89%) of 28 samples taken at the facility contained PCB in excess of 100 ug/m^2. Of the 20 samples from measured areas of high-contact surfaces, such as desk and table tops and control panels, 12 (60%) had levels in excess of 100 ug/m^2.

Five wipe samples were taken for PCDD and PCDF surface contamination. The floors of areas suspected of heaviest contamination, such as loading dock floors and transfer areas, were sampled in order to obtain the greatest likelihood of detecting quantifiable amounts (a worst case scenario). 2,3,7,8-TCDD (the most toxic and most widely studied isomer) was not detected in any of the samples. However, PCDF and other PCDD isomers were detected in quantifiable amounts in all five samples. Levels, converted to 2,3,7,8-TCDD equivalents, ranged from 4 to 40 ng/m^2, all in excess of the 1 ng/m^2 guideline.
In every sample the majority of the calculated TCDD equivalents was due to the presence of PCDF, specifically 2,3,7,8-TCDF and 2,3,7,8-penta-CDFs. The highest TCDD equivalents surface concentrations were in the kiln area. Their presence in floor surface samples (low-contact surfaces) raises the question of whether they are also present on high-contact surfaces such as manned machinery, control panels, and work benches.

Although most of the floor surface PCB concentrations exceeded the guideline of 100 ug/m^2, and all of the floor surface concentrations of 2,3,7,8-TCDD equivalents exceeded the 1 ng/m^2 guideline, the health risk is uncertain because the potential for direct skin contact is reduced by the use of boots, gloves, and other protective clothing.

During the two field visits to this facility, NIOSH industrial hygienists observed several conditions that could result in unnecessary PCB exposure. Several respirators were seen lying on contaminated surfaces in PCB areas of the facility. Although certain areas are designated as restricted areas due to presence of PCB (for authorized personnel only, using appropriate respirators and other personal protective equipment), workers were observed at times in these areas without respirators and without use of contamination control and decontamination procedures when entering and leaving. This was particularly the case in the kiln area where construction work was in progress. In general, both at the kiln area and all warehousing areas, restriction of entry, use of appropriate equipment, and decontamination prior to exit seemed to be informal and dependent upon vigilant enforcement by the area supervisor. There were few physical barriers to entry and exit. Warning signs were not very prominent. Clearly separated "clean" change rooms (for street clothes), washing and showering rooms, and "dirty" change rooms (for work clothes and equipment) were lacking.

B. Medical

Eighty-one ENSCO employees completed the interview and skin examination and provided a blood sample. (Four others completed the interview and skin examination but provided no blood sample; none had findings suggestive of chloracne, and they will not be included in any of the subsequent analyses or discussion.) The 81 participants included 72 men and 9 women. They ranged in age from 20 to 66 years, with a median of 34 years. They had worked at ENSCO's El Dorado facility from 4 months to 11 years, with a median of 4.6 years, and had been in their current job from less than 1 month to 10 years, with a median of 2.2 years. Their current departments are listed in Table 3. Participation rates by departments could not be accurately determined since there were some discrepancies between official staffing lists and current jobs reported by participants. Approximately half of the employees in production, maintenance, and PCB material handling participated, as did all but one of the former mobile incinerator employees. On the other hand, none of the North warehouse material handlers, and only one chemist, participated. None of the participates reported being transferred from a job for medical reasons, including an elevated blood PCB level. Two persons reported potential PCB exposure at a job held prior to working at ENSCO.

Nine (11%) of the 81 participants had skin findings (none severe) suggestive of chloracne: comedones (blackheads) or other acneiform lesions affecting the malar (cheekbone) areas, temples, ears, or periauricular (near the ear) areas.[61] Four of them (5% of the 81) had no preceding history of common acne; the other five did have such a history.

According to the CEH laboratory, all 81 participants had Arochlor 1260 in their serum, and 53 (65%) had Arochlor 1242. Differences between the results for the six pairs of duplicate specimens were small and within the expected range of analytical variation (Table 4). Differences between the results from the CEH and ENSCO laboratories for the nine pairs of duplicate samples were substantial in six cases; the PCB level reported by the ENSCO laboratory was larger in all six cases (Table 5). In two of the three cases where differences were not large, the PCB concentrations were less than 20 ppb.

Among the 81 study participants, serum PCB level ranged from 2 to 385 ppb, with a median of 18 and mean of 62 ppb. (According to the CEH laboratory, persons without occupational exposure to PCB generlly have a serum PCB level less than 20 ppb.) Forty-one (51%) were less than 20 ppb, 10 (12%) were in the 20-50 range, 14 (17%) were in the 51-100 range, 10 (12%) were in the 101-200 range, 1 was in the 201-300 range, and 5 (6%) were greater than 300 ppb (Table 6). Serum PCB was weakly, but significantly, inversely correlated with age [Spearman's rank correlation coefficient (r) = -0.31, p = 0.0056), but was not correlated with duration of employment at ENSCO (r = 0.099, p = 0.38) or time in the current job (r = 0.068, p = 0.55).

Production (Operations) workers had the highest PCB levels (Table 7); all but two of their PCB levels exceeded 20 ppb, and four exceeded 300 ppb. Warehouse and maintenance workers had comparable, somewhat lower median PCB levels. Maintenance workers had 4 PCB levels that were higher than the highest level among warehouse workers, including the only level above 200 in a non-production worker. This latter worker was a maintenance mechanic for 2 years and had previously been in the labor pool for a few months. Among the three workers not in the warehouse, production, or maintenance areas, all but four serum PCB levels were less than 20 ppb. Two, 20 and 21 ppb, were in a brine operator (who had previously worked as a laborer) and a laborer, respectively. Another, 42 ppb, was in a RCRA material handler who had previously worked as laborer and a PCB material handler. The level of 106 ppb was in an inside driver who had previously worked as a laborer.

The nine workers with skin findings suggestive of chloracne had a numerically higher median serum PCB level (48 ppb) than the 72 without such skin findings (18 ppb), but the difference was not statistically significant ($p = 0.75$, Wilcoxon rank sum test). Of the five with the skin findings who had a history of common acne, one had a PCB level less than 20 ppb and three had levels greater than 100 ppb. The four workers who had the chloracne skin findings and no history of common acne had PCB levels of 3, 8, 10 and 50 ppb. In all four cases the findings were limited to a few comedones in the malar area.

VII. CONCLUSIONS

The environmental and medical data documented excessive exposure to PCB, and the environmental data documented the presence of PCDF and PCDD, though not 2,3,7,8-TCDD. The lack of a consistent association between skin findings suggestive of chloracne and serum PCB level suggests that either the skin findings were not due to chloracne or that, to the extent they were, the cause was something other than PCB, perhaps PCDD or PCDF.

The differences between the CEH laboratory's and the ENSCO laboratory's serum PCB results are not readily explained.[62] Although the laboratories used different methods, this would not seem to explain the magnitude of the differences. If a high PCB level triggers action to evaluate and reduce an employee's exposure, however, the PCB levels reported by ENSCO's laboratory should result in such action to at least the extent that would occur based on the results we reported.

VIII. RECOMMENDATIONS

ENSCO appeared to have initiated measures to reduce employee exposure to PCB and has said that other efforts to evaluate and reduce exposure to PCB, PCDD, and PCDF are planned or in progress.

1. Since most of the environmental sample results exceeded the evaluation criteria used in this report, entry into the plant should be restricted to authorized workers in order to insure that appropriate personal protective equipment, contamination control, and decontamination procedures are used.

2. Better contamination control and decontamination facilities should be provided. Two separate storage areas, one for storage of street clothing (worn to and from work), and another for work clothing and equipment, should be established either at each PCB-handling area or at the plant entrance. The two areas should be separated by a shower room (or wash room) to prevent spread of contamination; shoes should be prohibited in the wash room. Having changing/showering facilities only at PCB-handling areas will be effective only as long as the rest of the plant (through which workers must pass to get to the PCB-handling areas) is not contaminated with PCB.

   Dirty work clothing should not be taken off the company premises. Therefore, ENSCO should provide (a) regular laundering of work clothing, and (b) disposable chemical protective clothing when required.

3. Access to PCB-handling areas should be restricted. Particularly in the kiln area, formidable physical barriers should be used to establish distinct entry control points. Prominent labels and warning signs should be posted to delineate restricted areas and to specify procedures and precautions necessary for entry and exit. Enforcement by supervisory personnel and ENSCO safety staff, even for temporary entry, such as by construction and maintenance workers, should be stringent.

4. To minimize contamination of the non-PCB-handling areas, protective clothing, equipment, and tools used in PCB-handling areas should not be taken out of these areas without first being decontaminated. Disposable clothing and other items should be placed in properly labeled, approved containers and disposed of appropriately.

5. ENSCO should continue to monitor work areas for PCB in air and on surfaces.

6. Based on the blood PCB monitoring data and air and surface wipe sampling data, at least some maintenance activities should be considered as relatively high-exposure work. ENSCO should conduct personal air sampling for maintenance workers while they are working in PCB exposure areas. Contamination control procedures upon entry, and decontamination procedures upon exit, from PCB areas should apply to maintenance workers. ENSCO safety staff should evaluate how further PCB contamination of the Maintenance Shop can best be controlled.

7. ENSCO should also include all modular PCB incinerators and associated workers in the personal and area air monitoring program.

8. The required personal protective equipment (especially in the kiln area) contributes to the heat stress of working in hot weather, so appropriate measures to prevent heat-related adverse health effects should be undertaken. These include gradual acclimatization of workers, frequent breaks in cool rooms, and consumption of fluids. Chemical-resistant outer coveralls, such as Saranex-coated Tyvek or Viton-coated neoprene, are necessary when there is exposure to PCB-containing liquid but not when exposure is only to particulates. In the latter case, outer coveralls made of a non-woven fabric such as Tyvek are adequate[51] and result in less heat stress.

9. Respirator storage and sanitation practices should be improved. Regular inspection of respirators for cleanliness, maintenance, proper storage, use, and fit should be conducted by supervisors and safety officials of ENSCO.

10. For each worker whose blood PCB level (during ENSCO's periodic monitoring program) is elevated, an individual exposure assessment should be conducted, and appropriate modifications should be made to reduce exposure. The exposure assessment should concentrate on evaluating all factors which could be leading to excessive PCB absorption, such as inadequate respiratory protection, skin contact, work practices, personal hygiene, equipment and skin decontamination, and process control measures.

11. Employees should be informed of the results of any medical testing. (A number of workers complained that they were not told their specific blood PCB levels.)

12. ENSCO's worker safety and health program should undertake steps to deal with the presence of PCDD and PCDF in the workplace. The following should be considered:

    a. Assessment of worker exposure potential to PCDD and PCDF on high-contact work surfaces, and potentially in the air.

    b. Feasibility of initial and subsequent sampling for PCDD and PCDF on work surfaces.

    c. Feasibility of decontamination and maintaining decontamination.

    d. Control methods to reduce future contamination within the facility by PCDD and PCDF.

    e. Effectiveness of personal protective equipment, including respirators and skin protection.

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1. Arkansas Department of Health
2. ENSCO
3. OCAW Local 5-434
4. OCAW International Union
5. Center for Environmental Health
6. Agency for Toxic Substances and Disease Registry
7. Arkansas Department of Labor
8. OSHA - Region VI

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

TABLE 1
PCB Air Sample Results
ENSCO, El Dorado, Arkansas
HETA 86-519 / March 24-26, 1987

Sample Description	Operation	Type of Sample (personal or area)	PCB (Aroclor 1242) Concentration (ug/m^3)
OLD PCB WAREHOUSE - March 24, 1987			
Warehouseman	receiving loading dock	P	5.1
Warehouseman	receiving shipments loading dock	P	6.1
Drum Pumper (low activity today)	pumping liquid from drums into tank	P	4.1
Barrel Crusher (low activity today)	crushing emptied drums	P	3.8
Barrel Crusher (low activity today)	crushing emptied drums	P	5.3
Sludge Handler	transferring solids from bottom of barrels into containers	P	4.9
Warehouseman	unloading shipments from trailers	P	7.0
Warehouseman	miscellaneous duties	P	3.1
OLD PCB WAREHOUSE - MARCH 25, 1987			
Drum Pumper	pumping liquid from drums into tank	P	5.8[A]
Drum Crusher	crushing emptied drums	P	15
Drum Pumping Station	table top beside pump	A	4.8
Barrel Crushing Station	top of breaker box	A	16
Loading Dock	table top beside dock	A	10

A - Aroclor 1260 also detected at 0.14 ug/m^3

TABLE 1 (continued)

Sample Description	Operation	Type of Sample (personal or area)	PCB (Aroclor 1242) Concentration (ug/m^3)
KILN DOCK - March 24, 1987			
Plant Mechanic (on Kiln Dock part of day)	Replacing bolts on main auger	P	16[B]
B Mechanic (on Kiln Dock part of day)	Working inside the shredder hopper	P	27
KILN DOCK - March 25, 1987			
Load Shredder	operate forklift	P	19
Load Shredder	operate forklift	P	19
A Operator		P	24
Ash drop operator		P	22
Kiln dock	on auger kiln timer box	A	40
Ash drag	on top of fan housing	A	24
THERMAL OXIDATION UNIT - March 25, 1987			
TOU Operator	TOU Control Room	P	9.5
Utility Man		P	5.9
Boiler Man		P	8.5
NORTH WAREHOUSE - March 26, 1987			
Warehouseman	Warehousing operation for storage of	P	10
Warehouseman	PCB-contaminated solids and	P	7.0
Warehouseman	capacitors	P	11
Warehouseman		P	17
Warehouseman		P	8.4

B - Aroclor 1260 also detected at 0.32 ug/m^3

TABLE 1 (continued)

Sample Description	Operation	Type of Sample (personal or area)	PCB (Aroclor 1242) Concentration (ug/m^3)
Warehouseman		P	7.0
Warehouse C	at aisle in center of warehouse	A	7.9
Warehouse B	at aisle in center of warehouse	A	5.8
Loading Dock		A	4.3
Warehouse A	at aisle in center of warehouse	A	9.9
Warehouse D	at aisle in center of warehouse	A	7.6
Office	in outside trailer	A	3.0
NEW PCB WAREHOUSE - March 24, 1987			
Warehouse Leadman	new warehouse for storage of capacitors	P	9.9
Materials Handler	and PCB - contaminated solids	P	12
MISCELLANEOUS AREAS - March 24-25, 1987			
A Operator (unit shut down for maintenance)	75 Unit Modular incinerator	P	1.3
Safety Department Safety Training Room	table top	A	2.1
Administrative Office top of Mail and Copy Room	mail boxes	A	0.85

TABLE 2

PCB Surface Contamination Sample Results

ENSCO
El Dorado, Arkansas
HETA 86-519

March 24-26, 1987

Area	Sample Location	PCB Surface Concentration (ug/m^2)[1] Aroclor 1260
OLD PCB Warehouse (March 24)	Floor at pumping station (L)[2]	180,000
	Floor inside berm in pumping area (L)	54,000
	Floor just outside berm in repackaging area (L)	34,000
	Surfaces of Clark forklift, including steering wheel, lever, gear shift, accelerator pad, clutch pad (H)	3,000 T*
	Aisle floor in center of warehouse (L)	80,000
	Floor in clothing change room (L)	11,000
	Interior surfaces of locker, including sides, bottom, interior of door inside locker (change room) (H)	190 T
	Bottom of street boots (change room) (H)	67 T
	Supervisor's desk top (office) (H)	180

1 - Units are in micrograms of PCBs per square meter of surface area, except where denoted by symbol T. T denotes total micrograms of PCBs on the surface sampled, and is not a square meter basis.

2 - L = low contact surface, H = high contact surface

TABLE 2 (continued)

Area	Sample Location	PCB Surface Concentration (ug/m^2) Aroclor 1242	1254	1260
New PCB Warehouse (March 24)	Floor in middle of south aisle (L)	1,200		
	Floor on south side of loading dock (L)	30,000		
	Table top in office (H)			92
	Desk top in office (H)		1,900	
	Inside and outside of office door around the door knobs (H)	96		
	Chair arms and phone handle (H)	61 T		
Maintenance Shop (March 24)	Floor in the center of the shop (L)			29,000
	Top of work bench in center of shop (H)			19,000
North Warehouses (March 26)	Warehouse C - aisle floor in center of whse (L)	6,400		2,900[A]
	Warehouse B - aisle floor in center of whse (L)			6,400[A]
	Aisle floor in in Warehouse D (L)	10,000		5,200[A]
	Aisle floor in Warehouse A (L)	8,400		8,000[A]
	Floor on loading dock (L)	18,000		6,800[A]
	Floor on "dirty side" of change room (L)			7,200
	Entire interior surface of locker for work clothing ("dirty" side of change room) (H)			63 T
	Entire interior surface of locker for street clothing ("clean" side of change room) (H)			51 T

A - Suspected mixture of Aroclor 1260, 1254, 1252, and 1248. Quantified as combination of Aroclor 1260 and 1248.

TABLE 2 (continued)

Area	Sample Location	PCB Surface Concentration (ug/m^2) Aroclor 1242	1254	1260
North Warehouses (March 26) (continued)				
	Office floor (trailer) (L)			100
	Secretary's desk top (office trailer) (H)			11
	Lunchroom floor beside table (L)			26
	Table top in lunchroom (H)			25
	Table top in Leadman's Office (inside warehouse) (H)			250
Kiln Dock (March 25)	Dock floor 3 yards from shredder (L)		160,000	
	Floor at Ash drag tender (L)			27,000
	Floor in Change Room (L)			48,000
Dock Operators Shower Room (March 24)	"Dirty Side" floor, 2 yards inside entrance (L)			200[B]
	"Clean Side" floor 3 feet from shower room (L)			210[B]
	"Dirty Side" bench top (H)			1,400
	"Clean Side" bench top (H)			4,800
	"Dirty Side" locker outer surface near handle (H)	11		3.2
	"Clean Side" locker outer surface near handle (H)	11		
Kiln Operators Break Room (March 24)	Table top (H)			340
	Floor (L)			1,200

B - Floor still wet from mopping at time of sampling.

TABLE 2 (continued)

Area	Sample Location	PCB Surface Concentration ($\mu g/m^2$) Aroclor 1260
Other Areas (March 26, 1987)		
Main Plant Locker Room	Floor (L)	100
	Bench surface (H)	290
	Interior of locker (H)	19 T
Main Plant Lunch Room	Floor (L)	11
	Settled dust on top of vending machine (H)	16 T
	Bench surface (H)	240
Engineering Office	Floor in entrance hallway (L)	1,200
Electrician Shop (E & I)	Bench top beside motors (under Foxboro charts) (H)	280
	Floor in center of shop (L)	4,800
Lab	Floor in front of hoods (L)	210
	Benchtop in water sample area (H)	76
TOU	Floor in control room (L)	3,600
	Panel in control room (H)	1,200
Safety Dept.	Table top in training room (H)	110
	Table top in training room (H)	11

TABLE 3

Surface Concentrations of 2,3,7,8-Tetrachlorodibenzo-p-dioxin Equivalents[1]
and Corresponding Surface Concentrations of Polychlorinated Biphenyls

ENSCO
El Dorado, Arkansas
HETA 86-519

March 24-26, 1987

Location	2,3,7,8-TCDD Equivalents (ng/m^2)[2]	PCB Surface Levels (ug/m^2)[3]
Old PCB Warehouse, Floor in Pumping Area (cement floor)	40	180,000 (Aroclor 1260)
New PCB Warehouse, Floor on south end of Loading Dock (cement floor)	8	30,000 (Aroclor 1242)
Kiln Dock Floor within 3 yards of Shredder (cement floor)	25	160,000 (Aroclor 1254)
Kiln Area Floor at Ash Drag Tender (cement floor)	40	27,000 (Aroclor 1260)
North Warehouses Floor of Loading Dock (cement floor)	4	18,000 (Aroclor 1248) 6,800 (Aroclor 1260)

1 - The sum of PCDDs and PCDFs, factored for their individual toxicities relative to 2,3,7,8-TCDD. The specific 2,3,7,8-TCDD isomer was not found in any of the samples.

2 - ng/m^2 = nanograms of TCDD equivalents per square meter of surface area wipe-sampled

3 - ug/m^2 = micrograms of PCB per square meter of surface area wipe-sampled

TABLE 4

Participants in Medical Survey

ENSCO
El Dorado, Arkansas
HETA 86-519

March 24-26, 1987

Department name & (number)	Number of Participants	Number in Department*	Percent surveyed
PCB Warehouse (04)	9	11	82
Production (06)	20	39	51
Maintenance (08)	15	20	75
North warehouse (12)	1	14	7
Others	36	191	19

*Based on personnel roster provided at time of survey

TABLE 5

Duplicate Serum Samples Analyzed by
Center for Environmental Health, Centers for Disease Control, Atlanta

ENSCO
El Dorado, Arkansas
HETA 86-519

March 24-26, 1987

	Serum PCB Concentration (parts per billion) Aroclor 1242	Aroclor 1260	Total
Pair 1	9.7	9.3	19.0
	8.8	9.0	17.8
Pair 2	198	165	363
	194	160	354
Pair 3	6.2	5.3	11.5
	6.0	5.9	11.9
Pair 4	4.9	33	38
	4.8	35	40
Pair 5	16	40	56
	18	41	59
Pair 6	43	34	77
	44	35	79

TABLE 6

Duplicate Serum Samples Analyzed by ENSCO's Laboratory
and the Laboratory used by NIOSH (Center for Environmental Health,
Centers for Disease Control, Atlanta)

ENSCO
El Dorado, Arkansas
HETA 86-519

March 24-26, 1987

	Serum PCB Concentration (parts per billion)			
	ENSCO	NIOSH/CEH		
		Aroclor 1242	Aroclor 1260	Total
Pair A	157	40	66	100
Pair B	271	57	62	119
Pair C	761	114	47	161
Pair D	97	14	34	48
Pair E	63	14	57	71
Pair F	<10	4.5	7.2	11.7
Pair G	262	30	20	50
Pair H	<10	-	4.0	4.0
Pair I	517	100	69	169

TABLE 7

Serum PCB Levels by Department

ENSCO
El Dorado, Arkansas
HETA 86-519

March 24-26, 1987

Department name and (number)	Number of participants	Serum PCB Concentration (parts per billion) Range	Median	Mean
PCB warehouse (04) and North warehouse (12)	10	5-110	52	53
Production (06)	20	16-385[A]	98	146
Maintenance (08)	15	5-309[B]	46	75
Others	36	2-106[C]	6	12

A - One PCB level greater than 200 parts per billion (ppb).
B - Four PCB levels greater than 300 ppb.
C - All but 4 PCB levels less than 20 ppb.

TABLE 8

Serum PCB Levels by Chloracne Findings

ENSCO
El Dorado, Arkansas
HETA 86-519

March 24-26, 1987

Chloracne Findings[A]	Number of participants	Serum PCB Concentration (parts per billion) Range	Median	Mean
No chloracne	72	2-385	18	62
Chloracne, history of common acne	5	5-169[B]	110	99
Chloracne, no history of common acne	4	3-50[C]	9	18
Chloracne, with or without history of common acne	9	3-169	48	63

A - See text.
B - Three PCB levels greater than 100 parts per billion (ppb), 1 less than 20 ppb.
C - Three PCB levels less than 20 ppb.