U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 76-52-386

WESTINGHOUSE ELECTRIC CORPORATION
BLOOMINGTON, INDIANA

APRIL 1977

I. TOXICITY DETERMINATION

Environmental and medical investigations were conducted at Westinghouse Electric Corporation, Bloomington, Indiana on June 1-3, 1976, and September 9, 1976. The purpose of these investigations was to evaluate exposures of Electrical Technicians and Materials Technicians to polychlorinated biphenyls contained in substances tested in the research laboratories.

On the basis of environmental and medical data collected during these surveys, it has been determined that exposure to polychlorinated biphenyls has resulted in increased absorption of these compounds by several workers in the areas tested. However, no significant biomedical findings were present that would indicate the presence of a toxic situation at the time of this survey.

Since polychlorinated biphenyls tend to be retained in the tissues of exposed persons for long periods of time and since the long-term effects of polychlorinated biphenyls are not known, it is recommended that the employer reduce concentrations of polychlorinated biphenyls as low as practicable through the use of engineering controls and that any employee who is exposed to these compounds on a routine basis be provided with appropriate protective equipment.

It is further recommended that a comprehensive program of environmental and medical surveillance be instituted in order to continually monitor employee exposures to polychlorinated biphenyls.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are 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 National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office at the Cincinnati address. Copies have been sent to:

a) Westinghouse Electric Corp., Bloomington, Indiana
b) Authorized Representative of Employees
c) U.S. Department of Labor - Region V
d) NIOSH - Region V

For the purpose of informing the approximately 15 affected employees, the Determination Report shall be posted for a period of 30 calendar days in a prominent place(s) near where exposed persons work.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of employees regarding exposure of employees to Monsanto 1238® and 1016®, Sunoco XD-489-17® and Westinghouse P.D.S. 54201KJ®. The request alleged that Electrical Technicians and Materials Technicians were exposed to these four chemicals and expressed concern that one such employee has "unexplainable liver damage" and had worked with two of these chemicals for 12 years.

IV. HEALTH HAZARD EVALUATION

A. Process Description - Conditions of use

Westinghouse Electric Corporation in Bloomington, Indiana, manufactures electrical distribution apparatus equipment, for example, capacitors, circuit breakers, fuses, etc. The total plant has been in existence since 1957 and employs 720 persons; one of the specific areas covered by the request began operation when the original facility was built, the other was added in 1968. Both areas, the Engineering Lab and the Materials Lab are non-production areas. The four chemicals specified in the request are dielectric fluids which are among the substances tested in the laboratories.

Exposure to the polychlorinated biphenyls contained in two of the four specified chemicals in the request could result during the handling of these fluids directly or of prototype apparatus containing these fluids. Two persons normally work in the Materials Lab testing dielectric fluids and 6-8 persons work in the Engineering Lab.

B. Evaluation Design

The employees in the materials laboratory and engineering laboratory at Westinghouse, Bloomington, Indiana, have potential exposure to polychlorinated biphenyls. The areas in question are relatively small and approximately 10-12 workers are located there on a routine basis. The NIOSH medical investigator attempted to interview and examine all of these workers, conducting medical interviews and physical examinations on the first visit and collecting blood for PCB analysis and liver profile (serum glutamic oxalic transaminase (SGOT), serum pyruvic glutamic transaminase (SGPT), alkaline phosphatase, and total bilirubin) on the second visit. Because of vacations and refusal to cooperate on the part of some employees, a total of eight workers were evaluated. Medical records of approximately 40 additional employees who had worked in these areas in the past were also reviewed.

The initial screening survey was conducted on June 1-3, 1976, in order to determine the range and severity of health effects experienced by employees in the Materials and Engineering Laboratories and to observe the conditions of usage of the four chemicals specified in the request. Environmental air samples were also obtained in the two laboratories to determine the concentrations of polychlorinated biphenyls (PCBs) in the work atmosphere. The medical portion of the investigation included detailed medical questionnaires, a review of the plant's medical records, and a short physical examination of the workers currently working in the laboratory areas.

During this initial survey, materials that were being tested were contained in closed ovens. It was believed that environmental concentrations of air contaminants would therefore represent a minimum level. In order to get a representation of the air concentrations of PCBs that would be achieved when the ovens were open and liquids or prototype apparatus was being handled out in the open work area, it was decided that a second environmental survey should be performed. This would be combined with the gathering of additional medical data.

On September 9, 1976, an industrial hygienist and a physician again visited the Westinghouse facility. Blood samples were obtained by the physician to be analyzed for PCBs. Breathing zone and general area samples were also obtained for PCB analysis.

C. Evaluation Methods

1. Environmental

Sipin pumps were used to draw air at a flow rate of 50 cc per minute through glass tubes containing Florosil®, a magnesium silicate. Both breathing zone and general area samples were obtained in this manner. Because environmental PCB concentrations were expected to be low and because Florosil had been determined by laboratory testing to be capable of absorbing large amounts of PCBs without significant breakthrough, the samples were taken over the entire workday. Samples were analyzed in the NIOSH laboratories in Cincinnati on a gas chromatograph equipped with an electron-capture detector. Results were reported as total PCB per sample, that is, there was no distinction as to specific individual PCBs.

2. Medical

Analysis of the liver profiles was done by Medical Diagnostic Services, Inc., using standard measurement techniques. Analysis of human blood specimens for PCB content represented a difficult and time-consuming undertaking. These measurements were made by the Clinical and Biochemical Support Section, BSB, NIOSH. Analysis of the serum samples for polychlorinated biphenyls represented an extremely difficult analytical procedure. Comparisons of standard PCB's and those which have been absorbed into the body and partially metabolized is a major problem. Because of its complexity an appendix (Appendix A) is included at the end of this report to further define and clarify what was done. Final results were reported in mg/DL or parts per billion of PCBs related to the standard Monsanto 1016®.

D. Evaluation Criteria

1. Environmental Standards

The chlorination of biphenyl produces a number of chlorinated biphenyls which differ in percent chlorination as well as isomer form. The byphenyl nucleus has 10 possible positions for chlorine substitution and commercial products are commonly defined on the basis of their chlorine content. In any specific compound, however, there is usually a complex mixture of chlorinated biphenyls, and the compounds name usually refers to the single species present in greatest proportion.

Current standards for occupational exposure to polychlorinated biphenyls exist for only two of these chlorinated biphenyls, one containing 42% chlorine, and one containing 54% chlorine. Both the Federal standard promulgated by the U.S. Department of Labor (29 CFR 1910.1000, Table G-1) and the standard recommended by the American Conference of Governmental Industrial Hygienists set an exposure limit of 1 mg/m^3 for the chlorinated biphenyl containing 42% chlorine and 0.5 mg/m^3 for that composed of 54% chlorine.

2. Toxicologic Effects

Polychlorinated Biphenyls - The term PCB describes a group of synthetic multichlorinated organic compounds that are very resistent to degradation. They tend to accumulate in animal tissues rich in lipids. Highly chlorinated PCBs remain in tissues in an unmetabolized state. PCB exposure may occur through inhalation, skin absorption, or oral ingestion. Effects from acute ingestion include nausea, vomiting, diarrhea, constipation, cramping, weight loss, ataxia, dehydration, central nervous system depression, skin eruptions, lassitide, anorexia, restlessness, headache and jaundice with occasional severe liver involvement.[9,11] The effects of chronic exposure are varied. Severe chloracne, skin pigmentation, eye discharge and swelling, as well as hair follicle changes have been reported. Descriptions of gastrointestinal disburbances including liver malfunction, abdominal cramping and diarrhea have been reported. Facial edema, impotence, hematuria, and inability to concentrate urine have also been noted.[9,11]

Blood and tissue PCB levels, as well as physical examination and other biomedical function abnormalities thought to be related to PBCs have been inconsistent. It has been reported that changes in liver functions tests (SGOT, SGPT) have been elevated in 30% of those exposed to toxic levels of PCBs.[7] Inability to concentrate urine, electro encephalographic disturbances and electromylographic disorders have also been attributed to toxic exposure to PCBs.[6] Current review of the literature indicates that excessive PCB exposure will cause skin lesions (chloracne) and if exposure continues the possibility of toxic liver and renal damage can be anticipated in some cases.

PCB levels can be determined by evaluating PCB content in blood, fat, or high lipid content organs, ie. liver. However, no consistent measurements have been reported in occupationally exposed subjects that have been evaluated and have had detectable PCB levels present. There is no present correlation between body burden of PCBs and blood or tissue measurements.

Much of the basis for these occupational standards mentioned above derives from animal experiments by Drinker[1] and by Treon et al.[2] Drinker had exposed rats to a chlorinated biphenyl of approximately 65% chlorine for 16 hours/day, at a concentration of approximately 0.57 mg/cu m. Slight liver damage was noted after six weeks, which was reported to progress over the next two months. Treon et al[2] exposed guinea pigs, mice, rabbits, rats, and cats either to Arochlor 1242® (42% chlorine) or to Arochlor 1254® (54% chlorine) for seven hours/day, 5 days/week for several weeks. Exposure to 1242 at 8.6 ug/liter for 24 days resulted in "poor growth" in guinea pigs and no effects noted in other animals. No significant effects were noted in experimental animals exposed to 6.83 ug/liter for a total of 82 days or 1.9 ug/liter over a seven month period either. Exposure to Arochlor 1254® at a concentration of 5.4 ug/liter for seven hours/day, 5 days/week, for 121 days did result in hepatic cell injury in some animals, and increased liver:body weight ratio in cats. Exposure to 1.5 ug/liter over 213 days also produced histologic changes in the livers of rats.

There is little information in the literature about the toxic effects of occupational exposure to the vapors of PCBs. This is in part due to the fact that chlorinated biphenyls usually have very low vapor pressures and are not likely to produce air contamination unless significantly heated. Riley[3] did report that inhalation of chlorinated naphthalene and diphenyl in industry can cause liver damage with symptoms including lassitude, nausea, vomiting, cramps, and jaundice. However, he did not differentiate between the two chemicals and did not cite specific instances.

PCBs are found nearly everywhere in the environment because of their broad spectrum of applications and their stability of accumulation in the ecosystem, even persons not occasionally exposed to PCBs may have these compounds deposited in their bodies. Therefore, it has been difficult to define "normal" levels of chlorinated biphenyls in body tissues or fluids.

E. Evaluation Results

1. Environmental

Results of sample analysis are presented in Table I. Concentrations of PCBs ranged from 0.013 to 0.264 mg/m^3 on June 2, .008 to .210 mg/m^3 on June 3, and .055 to .190 mg/m^3 on September 9.

The highest concentrations were measured on area samples placed next to the door of the oven.

2. Medical

A total of eight workers from the laboratory research areas were evaluated by history, physical examination, blood PCB concentration, and liver profile (SGOT, SGPT, Alkaline Phosphatase, Total Bilirubin). Tables II-V show the results of the testing performed. The mean age of those investigated was 38 years with a range of 25 to 49. All were white males, half were smokers and the average length of work time in the areas involved at Westinghouse was 12.5 years, with a range of 2.5 to 18 years.

Only one of eight (12%) thought he had symptoms related to his work. There were a number of symptoms reported but no direct correlation to work environment could be made. Six of eight (75%) reported past dry or sore throat, three of eight (37%) past skin rash, three of eight (37%) stomach ulcers in the past, two of eight (25%) past eye irritation, two of eight (25%) headache - one of which was described as migraine in nature. Physical examination revealed four of eight (50%) to have mildly elevated blood pressure, two of eight (25%) pharyngeal erythema, one of eight (12%) skin rash (non-chloracne), one of eight (12%) rales (heavy smoker). No significant neurological abnormalities were discovered and no abnormal abdominal organ enlargements were appreciated.

Tables IV and V show results of blood PCBs determinations and liver functions done on the workers at Westinghouse. All liver function studies were within normal limits. Blood PCB levels revealed three of seven workers to have less than 50 PPb, one of seven to be between 50 and 100 PPb, two of seven to be between 100-200 PPb and one worker greater than 200. No cases of chloracne were found and all other parameters indicated a non-toxic situation at the time of this evaluation. The fact that four of seven workers had PCB levels greater than 50 parts of PCB per Billion parts serum (an arbitarily set value above which an increased absorption situation probably occurs)[13] is cause for continued surveillance and close worker observation.

Forty medical records of present and past employees of the areas in question were reviewed. Physical examinations conducted by the plant physician and pertinent laboratory data were evaluated from the last five years. The findings on physical examinations were not contributory. A total of 15 blood counts were done; all were normal except two that had a slight increase in total

lymphocytes. Eleven Serum Multiphasic Analysis-12 (SMA-12s) were done showing one increased alkaline phophatase, two mild increases in SGOT, one increase in total bilirubin, one increased uric acid. Two random triglyceride determinations were elevated and multiple urinalysis, electrocardiograms (EKG) and chest x-rays were all within normal limits.

F. Conclusions

There were no indications from the environmental measurements, histories, physical examinations, and blood evaluations performed during this hazard evaluation that any current problem with PCB toxicity exists. There is evidence from blood PCB levels that workers are absorbing PCBs when compared with the control populations from the same geographic area.[13] Mean values from Bloomington area were 18.3 ppb $\pm$ 10 (standard deviation).[13]

Although a small number of abnormal biomedical tests were present in the laboratory evaluations done routinely at the Westinghouse medical department, these are too few and too sporadically performed to be of value, and give no evidence of present PCB intoxication.

V. RECOMMENDATIONS

1. Since there is no information available regarding the long-term effects of daily exposure over a working lifetime and since PCBs may be retained in the body for years, it is still advisable to reduce air concentrations to the lowest levels practicable.

2. The results of the PCB determination indicate increased PCB asborption in several workers. Because of this NIOSH recommends pre-employment and yearly medical examinations be provided for all workers exposed to chlorinated napthalenes and diphenyls. A history of liver disease or jaundice should automatically exclude a worker from possible toxic exposure. Pregnant women should not be employed for PCB exposure work.[9] The medical examination should include a medical history, including complete occupational profile, physical examination, complete blood count, serum multiphasic analysis 12 (SMA-12), urinalysis with specific gravity, EKG, and chest x-ray (suggested for those over 35-40 years of age).

3. Workers should be very strongly encouraged to report all skin conditions to the plant physician and their family doctor.

4. Those workers who develop skin lesions should be seen daily at the plant and if the condition does not clear promptly with the best available control measures the worker should be removed from this area and evaluated for potential PCB toxicity.

5. The highest concentrations were observed near the door to the oven in the Engineering Lab. This contamination may come from the oven itself or from prototype apparatus set on the floor by the oven prior to or after testing. Local exhaust ventilation is therefore recommended at this location. A small hood over the oven door was not in operation at the time of the survey. Its effectiveness should be checked both with direct ventilation measurements and by continual monitoring of the air concentrations in this area. Negative pressure in the oven would prevent leakage to the workroom.

6. Since skin exposure is a potential problem both from the standpoint that chloracne may result and because skin absorption is a possible exposure route, protective clothing should be worn. Separate work clothes or coveralls may be worn which are removed at the end of the work day or impervious gloves and aprons may be worn over street clothes.

7. Improved housekeeping in the Engineering Lab might prevent buildups of PCBs which have been deposited on work surfaces through spills or leaks.

8. All employees should be apprised of the toxic nature of chlorinated biphenyls and instructed in safe handling procedures.

VI. REFERENCES

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TABLE I

BREATHING ZONE (B.Z.) AND AREA ENVIRONMENTAL CONCENTRATIONS OF PCBs
WESTINGHOUSE, BLOOMINGTON, INC.

SAMPLE DESCRIPTION	SAMPLE PERIOD	CONCENTRATION (mg/m^3) Corrected for Blanks
June 2, 1976:		
Engineering Lab - B.Z.	8:17 - 15:17	.026
Model Shop - B.Z.	8:32 - 15:23	.021
Materials Lab - Area, by hood	8:13 - 15:20	.043
Engineering Lab - B.Z.	8:18 - 15:15	.041
Materials Lab - B.Z.	8:05 - 15:20	.046
Model Shop - B.Z.	8:35 - 15:23	.014
Materials Lab - Area, by oven	8:12 - 15:18	.042
Engineering Lab - B.Z.	9:12 - 15:16	.022
Engineering Lab - B.Z.	9:13 - 15:25	.032
Materials Lab - B.Z.	8:05 - 15:16	.053
Engineering Lab - Area, work bench	7:58 - 15:11	.013
Engineering Lab - Area, by oven	7:58 - 15:11	.264
Engineering Lab - B.Z.	9:22 - 15:14	.073
Engineering Lab - Area, by oven[1]	8:52 - 15:11	.223
Materials Lab - Area, by oven[2]	8:54 - 15:18	.065
June 3, 1976:		
Engineering Lab - Area, by oven	7:53 - 12:03	.210
Engineering Lab	7:53 - 12:03	.140
Engineering Lab	7:54 - 12:25	.160
Model Shop	7:55 - 12:25	.050
Engineering Lab	7:55 - 12:25	.046
Materials Lab	8:00 - 12:25	.047
Materials Lab	8:00 - 12:25	.043
Materials Lab	8:02 - 12:01	.029
Engineering Lab	8:05 - 12:25	.023
Materials Lab	8:02 - 12:01	.008
Engineering Lab	7:58 - 12:03	.043
September 9, 1976:		
Engineering Lab - Short Circuit	10:00 - 2:25	.028
Engineering Lab - Area, by oven	10:04 - 2:13	.190
Engineering Lab	10:09 - 2:23	.061
Engineering Lab	10:09 - 2:15	.049
Materials Lab	10:12 - 2:19	.065
Materials Lab	10:13 - 2:19	.056
Materials Lab	10:19 - 2:19	.079
New Products	10:24 - 2:27	.055
New Products	10:35 - 2:19	.080
Engineering Lab	10:47 - 2:11	.066
Engineering Lab	10:49 - 2:13	.140

1. Sample obtained at 1.5 liter/minute
2. Sample obtained at 1.0 liter/minute

TABLE II

SYMPTOMS BY HISTORY
WESTINGHOUSE, BLOOMINGTON, IND.

SEPTEMBER 1976

Eye irritation	2 of 8	25%
Dry or sore throat	6 of 8	75%
Cough	0 of 8	
Shortness of breath	0 of 8	0%
Chest pain	0 of 8	0%
Headache	2 of 8(1 migraine)	25%
Skin rash	3 of 8(2 from epoxy)	37%
Nausea	0 of 8	
Vomiting	0 of 8	
Numbness	0 of 8	
Aching	0 of 8	
Increased number of colds	0 of 8	
Weakness of extremities	0 of 8	
Fatigue	1 of 8	
Jaundice	0 of 8	
GI disturbances	3 of 8 (2 ulcers in past, one present)	37&
Respiratory disorders	0 of 8	
Weight loss	0 of 8	
Abnormal kidney function	0 of 8	
Hospitalized in last five years	2 of 8 (1 back surgery, 1 prostate surgery)	25%

TABLE III

PHYSICAL EXAMINATION RESULTS
WESTINGHOUSE, BLOOMINGTON, IND.

SEPTEMBER 1976

Skin rash	1 of 8 (non-chloracne)	12%
Nasal and throat erythema	2 of 8	25%
Lungs Abnormalities	1 of 8 (Rales)	12%
Abdomen Abnormalities (liver or spleen enlargement)	0 of 8	0%
Abnormal body stature	0 of 8	0%
Blood pressure elevation	4 of 8	50%
Neurological abnormalities	0 of 8	0%

TABLE IV

BLOOD PCB LEVELS
WESTINGHOUSE WORKERS LABORATORY AREAS

SEPTEMBER 1976

WORKER NUMBER	PCB LEVEL (Parts Per Billion)
WES 11	35.8
WES 12	42.2 ± 5
WES 13	58.2 ± 13
WES 14	42.3 ± 8
WES 15	285.7 ± 7
WES 16	No Sample
WES 17	115.6
WES 18	109.6 ± 19

Range of Westinghouse Employees	249.9
Mean of Westinghouse Employees	98.4
Standard Deviation	±88.9

No standard has been set for blood PCB levels. Evaluations of control populations as well as consultations with PCB authorities have resulted in an arbitrary level of 50 PPb above which is considered the increased PCB absorption range.

TABLE V

LIVER PROFILE RESULTS
WESTINGHOUSE LABORATORY WORKERS

SEPTEMBER 1976

WORKER #	SGOT (6-26 IU)	SGPT (3-24 IU)	ALK PHOS (25-80 IU)	TOTAL BILIRUBIN (0-1.5 mg/dl)
WES 11	15	11	56	0.5
WES 12	18	20	38	0.9
WES 13	15	15	47	0.6
WES 14	13	13	41	0.8
WES 15	18	20	36	0.9
WES 16		No Specimen		
WES 17	11	12	47	0.8
WES 18	16	13	38	0.4

All values are within normal limits.

APPENDIX A

COLLECTION AND ANALYSIS OF PCBs

(a) Sample Collection and Shipment

(1) All glassware and syringes were washed with a detergent solution, rinsed thoroughly with tap and distilled water, and then rinsed with acetone and n-hexane.

(2) Twenty ml samples of whole blood were collected by a veinapuncture using 20 cc glass syringes. Collected blood was transferred to test tubes, permitted to clot, and centrifuged. The sera were collected and transfereed to 16 x 150 mm culture tubes with Teflon-lined screw caps. Samples were packed in ice and shipped in a polyethylene container. Samples were received in Cincinnati on September 13, 1976, and refrigerated until analysis. Samples were received in good condition except for one hemolyzed, two icteric, and four chymous. This was not felt to interfere with the analytical method.

(b) Analytical Method

The analytical procedure utilized was based upon one developed by the Environmental Protection Agency at Research Triangle Park and was published in the "Manual of Analytical Methods for the Analysis of Pesticide Residues in Human and Environmental Samples," U.S. Environmental Protection Agency, Environmental Toxicology Division, Research Triangle Park, North Carolina 27711.

(1) A two ml aliquot of serum is mixed with 6 ml of a 1:1 ethyl ether-n-hexane mixture in a 16 x 125 mm culture tube with a Teflon-lined screw cap.

(2) A convenient amount of the pesticide Aldrin is added to the ethyl ether-hexane mixture as an internal standard.

(3) The serum and ethyl ether-hexane mixture are mixed for two hours by a rotating laboratory mixer.

(4) After two hours, the organic layer is transferred to another 16 x 125 mm culture tube.

(5) This extract is concentrated to approximately 0.5 ml and is placed onto a champagne-glass column containing 10 cm of Florisil and 1.3 cm of anhydrous sodium sulfate.

(6) The concentrate is eluted with n-hexane containing 4% benzene and 2% methanol and the first 10 ml of the elute collected.

(7) The 10 ml volume is reduced to 2 ml, and five microliters of the concentrate is injected into a 3920-B Perkin Elmer gas chromatograph equipped with a Ni^{63} electron capture detector.

(8) The gas chromatographic columns used were 6' x 1/4" x 4 mm I.D. glass containing (a) 1.5% OV-17, 1.9% QF-1, or (b) 4% SE-30, 6% OV-210 on 80/100 mesh Chromosorb WHP. Column (b) was used for this report. The chromatographic conditions were: injector 200°C; column 190°C; maniford 230°C; and, detector 275°C. The carrier gas, at a flow of 70 ml/minute, was Argon with 5% methane.

(c) Standards

All PCB standards, Arochlors 1016, 1221, 1242, and 1254, were obtained from EPA, Health Effects Research Laboratory, Environmental Toxicology Division, Research Triangle Park, North Carolina.

(d) Qualitative Analysis

(1) To qualitatively analyze an unknown for PCB, the retention times of various PCB isomers were compared to the retention time of Aldrin. These relative retention times were used to identify the individual isomers of a particular Arochlor.

(2) After examining the chromatograms of several respective Arochlors, bulk samples submitted (identified as 1238, WDJ, and Sun-17), and several serum samples (both exposed and controls), it appears that the most prevalent Arochlor is 1016.

(3) Most sera showed a pattern which resembled Arochlor 1016.

(4) The electron capture detector did not respond to a solution of 1238. This indicates that no electron seeking groups were present in the mixture. Thus, no PCBs are indicated in the sample.

(e) Quantitative Results

(1) To quantitate the amount of PCB present, the sum of the peak heights of individual PCB isomers in a standard Arochlor were compared with the sum of the peak heights of identified peaks in the unknowns.

(2) Values were expressed as nanograms of Arochlor 1016 per ml of serum (parts per billion, ppb). Five or more determinations were made on extractions of several samples. Some samples were extracted in duplicate to improve accuracy. When three or more determinations were made on a sample the results are reported as plus or minus the standard deviation.

(f) Discussion

This method of quantitation assumes that all PCB isomers present in the standard are present in the samples and that the electron capture detector has the same response to each isomer. These assumptions are erroneous. Not all peaks present in a standard Arochlor are present in chromatograms of unknowns. The various isomers of PCB are metabolized at different rates, and this rate varies from individual to individual. Because of this, it may appear that individuals are concentrating perhaps one or two isomers.

The Arochlors that were used for standards were mixtures. In order to determine the electron capture detector's response to each individual isomer one must have each individual isomer of the mixture in a purity that may be used for standards or have access to a mass spectrometer that will give the following information: molecular weight and percent chlorine. Neither was readily available, and assumptions had to be made to produce any useful information. In addition, many substances are extracted with PCBs and are not entirely removed during the Florisil cleanup. At times the resolution between an isomer of PCB and an interfering substance is poor, making it difficult to interpret the chromatogram.