X. APPENDIX II

ANALYTICAL METHOD FOR POLYCHLORINATED BIPHENYLS

Principle of the Method

A known volume of air is drawn through a tube containing Florisil to adsorb the PCBs present in the air sample. The collected PCBs are desorbed with hexane, and the resulting solutions are analyzed using gas-liquid chromatography with electron capture detection. The concentration of PCBs relative to a standard PCB preparation is read from a standard curve. If the air sample is found to differ significantly in composition from available PCB standards, then use the alternate procedure of perchlorination described in paragraph (b)7 of Procedure.

Range and Sensitivity of the Standard Analysis

NIOSH has found with Aroclor 1016, that the minimum detectable amount of PCB is 32 pg/4 μl. With a total desorption volume were 5 ml, this would represent a total sample of 40 ng of Aroclor 1016. Thus the method is capable of detecting a concentration of 40 ng in a 1 cu m air sample, or a concentration of about 1 μg/cu m in an air sample of 50 liters. The upper range of the analytical method is apparently limitless depending only upon the degree of dilution needed to maintain the concentration of the sample within the linear range of the electron capture detector (32 pg to 3 ng/injection). In practice, concentrations in workplace air have been found to be as high as 1.5 mg/cu m.

Interferences

(a) Strict measures to avoid contamination are required when using the electron capture detector. Foremost, the syringe must be thoroughly cleaned after each injection. Hexane to be used in the analytical procedure should be periodically analyzed by GLC for purity. It should show no chromatographic peaks later than 45 seconds, if less than 5 μl have been injected.

(b) Any compound which has nearly the same retention time on the GLC column as one of the PCBs is an interferent. This type of interference can often be overcome by changing the GLC operating conditions or by selecting another column. Retention time data on a single column, or even on a number of columns, cannot be considered as proof of chemical identity. It is important, therefore, that a sample of the bulk mixture of PCBs be analyzed at the same time as the contents of the sample tubes so that chemical identification of possible interferences can be made.

(c) The interferences which have been reported in the literature in the GLC analysis of PCBs are not expected to be important for this method. Chlorinated pesticides, such as DDT, DDE, etc, have been reported as interferences due to coextraction with PCBs during workup of samples such as water, tissue, soil, or biologic fluids. In the case of personal air sampling in an industrial environment, these interferences would not be present in amounts that would significantly interfere unless they were manufactured in the same area. Thus, unless these chlorinated pesticides are specifically known as potential interferents, extra cleanup or separation steps for these materials are not necessary.

(d) Sulfur-containing compounds in petroleum products have been reported as interferences.

(e) If present in the PCB mixture, biphenyl will be an interference when samples are analyzed by perchlorination; however, PCBs for the purpose of this recommended standard include biphenyl.

(f) Brominated impurities in antimony pentachloride have also been found to lead to interferences in perchlorination procedures. Results from NIOSH laboratories indicate, however, that these brominated impurities may be removed by vacuum distillation of the antimony pentachloride.

Precision and Accuracy

The performance characteristics of the method as found by NIOSH are presented below.

(a) The volume of air sampled can be measured to ±1% if a pump with a calibrated volume indicator is used. Volumes calculated from initial flow rate settings may be less accurate (±5%) because of changes in flow rate during sampling.

(b) At airborne PCB concentrations of up to 10 mg/cu m, the front section of the Florisil tube has a 100% collection efficiency for 50-liter air samples.

(c) Recovery of known amounts of PCBs adsorbed on Florisil is quantitative (100%).

(d) Sealed tubes or desorbed sample solutions can be stored for 2 months without PCB loss.

(e) The precision of the analysis is dependent upon the precision and sensitivity of the technique used to quantitate the GLC peaks of the

samples and standards. The precision of the standard analytical procedure has a relative standard deviation of 4.4%.

(f) The average conversion of PCBs to decachlorobiphenyl is about 100% with a relative standard deviation of about 2%.

(g) Recovery of decachlorobiphenyl subjected to the decachlorination procedure is >99% with a relative standard deviation of 1.8%.

(h) The accuracy of these procedures is not known; accuracy depends on the ability to separate and identify each compound in the PCB mixture and to compare each with a known standard. Many of the isomers in commercial PCB mixtures have not been separated or identified, and standards for many of the isomers are not available.

Advantages of the Sampling and Analytical Methods

(a) The sampling device is small, portable, and involves no liquids.

(b) The capacity of the solid sorbent sampling device for PCBs is large and recovery of PCBs from the sorbent is quantitative.

(c) The contents of the sample collection tubes are analyzed by means of a rapid instrumental method.

(d) Interferences are minimal, and most of those which do occur can be eliminated by altering chromatographic conditions.

(e) The perchlorination procedure provides qualitative confirmation and quantitative measure of PCBs, since it is based on measurement of the single GLC-EC detection response of decachlorobiphenyl.

Disadvantages of the Sampling and Analytical Methods

(a) The precision of the sampling method is limited by the reproducibility of the pressure drop across the tubes. Pressure drop changes will result in variability in the flow rate and cause the sampling volume to be imprecisely known because the pump is usually calibrated for only one tube.

(b) A substantial difference between the composition of PCBs in the air sample and that of the commercial PCB mixture being used as a standard will result in a large error in accuracy when the standard analytical procedure is used, since estimation of the PCB content of the sample is based on comparison with such a PCB mixture.

Apparatus

(a) Gas liquid chromatograph equipped with an electron capture detector capable of maintaining a detector temperature of 350 C.

(b) Glass column (6 feet x 2 mm I.D.) packed with 1.5% OV-17/1.95% QF-1 on 80/100 mesh Supelcoport.

(c) Vials (20-ml), with aluminum-lined caps.

(d) Microliter syringe (10-μl).

(e) Volumetric flasks (10-ml for standards) with glass stoppers.

(f) Method for determining peak areas.

(g) Culture tubes, 13 x 100 mm, with unlined screw top caps.

(h) Oven, capable of maintaining 160 C ± 5 C.

(i) Sand bath.

(j) Vortex mixer.

Reagents

(a) Hexane, pesticide-grade quality.

(b) Nitrogen carrier gas, prepurified.

(c) PCB mixture under study.

(d) Antimony pentachloride, distilled under vacuum.

(e) Decachlorobiphenyl.

(f) Sodium sulfate, anhydrous.

(g) Hydrochloric acid, 20% aqueous.

Calibration and Standards

(a) Standardization Procedure

Use the particular PCB mixture as the standard that was being used in the work area in which air samples were taken. Prepare standards in hexane at concentrations ranging from 8 to 500 ng/ml. Calibration curves should be established daily since the electron capture detector response may vary from day to day. Plot the standard curve in terms of concentration (ng/ml) versus area. Since the injection volumes of the standard and the sample are identical, the concentration of the sample can be read directly from the standard curve.

(b) Alternate Standardization Procedure (Perchlorination)

The product of the perchlorination of the PCB mixture with antimony pentachloride is decachlorobiphenyl. Standards of decachlorobiphenyl are prepared in hexane at concentrations ranging from 70 to 440 ng/μl. Calibration curves are established daily since the electron capture detector response may vary from day to day. The standard curve is plotted in terms of concentration (ng/ml) versus peak area. Since the injection

volume of the standard and the sample are identical, the concentration of the sample can be read directly from this curve.

Procedure

(a) Cleaning of Equipment

All glassware used for the laboratory analysis should be washed with a detergent, throughly rinsed with tap water, distilled water, pesticide-grade acetone, and finally pesticide-grade hexane and then dried.

(b) Analysis of Samples

(1) Preparation of Samples

Score each tube with a file and place the glass wool and front section in a clean, dry vial. Place the separating urethane foam plug, the back section of the sorbent, and the retaining urethane foam plug in a second clean, dry vial. The front and back sections are analyzed separately.

(2) Desorption of Samples

Prior to analysis, pipet 5.0 ml of hexane into each vial. Florisil particles should not be allowed to cling to the glass above the solvent. A minimum desorption time of 10 minutes is required before analysis.

(3) Gas-liquid chromatographic conditions for PCB determination by this procedure are:

(A) Nitrogen carrier gas flow rate, 60 ml/minute.

(B) Injector temperature, 300 C.

(C) Interface and detector temperatures, both 325 C.

(D) Column temperature, 180 C.

(4) Sample Injection

The solvent-flush technique is recommended for injection of materials into the GLC apparatus. With this method, the following procedure would be used to inject 4 μl of sample. Three microliters of hexane would be drawn into the syringe, followed by 1 μl of air, followed by 4 μl of sample solution. After the needle is removed from the sample solution, 1 additional μl of air is drawn into the syringe to minimize evaporation at the tip of the needle. The plunger now rests at the 9-μl mark. Inject at least 7 μl of the syringe contents into the gas chromatogram. Not less than 1 μl of flush-solvent should be used. Larger volumes of flush may give a solvent peak which interferes with sample component peaks. The syringe must be cleaned with hexane after each injection.

(5) Preliminary Analysis

Using the solvent-flush method of subsection b(4), inject 1 μl of sample and 1 μl of flush-solvent at the conditions specified under subsection b(3). If the sample is too concentrated, further dilutions will be necessary to bring the concentration of the sample solution into the linear range of the electron capture detector. Once the concentration of the sample is appropriately adjusted, its chromatogram should be compared to that of a standard to determine if the air sample is qualitatively different in composition from the standard. If there is little difference between the two chromatograms, then proceed with the standard analysis using the PCB mixture for standardization, subsection b(6). On the other hand, should there be a significant difference between the two chromatograms (such that comparison with the PCB mixture could result in

gross error), then use the alternate procedure for standardization, subsection b(7).

(6) Standard Analysis

Select at least five prominent peaks in the sample chromatogram and compare their heights or areas with those of the standard. Calculate the concentration of PCBs by comparing the heights or areas of the selected peaks in the sample chromatogram of those in the standard chromatograms of known amounts of material.

(7) Alternate Standardization Procedure

A 200-µl aliquot of the sample is placed in a 13-mm x 100-mm culture tube and the hexane is slowly evaporated with dry nitrogen until 10 µl or less remain. Do not allow hexane to climb the tube during evaporation and do not allow the sample to evaporate to dryness. Immediately add 0.2-0.5 ml of distilled antimony pentachloride with a disposable pipet as rapidly as possible (antimony pentachloride decomposes rapidly in air) and cap the tube. The sample should remain light yellow after this addition, but if the sample turns dark brown or black, it must be discarded and another aliquot of that sample must be used. All samples are placed together in a sand bath. There should be no liner in the cap of the tube, since most liners are attacked by antimony pentachloride. A sample of decachlorobiphenyl is treated in a manner similar to the samples. The sand bath containing all of the treated samples is placed in a preheated oven at 160 C for at least 3 hours. Samples may also be treated overnight. After perchlorination, the sand bath is removed from the oven and the samples are removed from the sand and allowed to cool to room temperature. To each sample is added dropwise 0.5 ml of 20% hydrochloric acid. This mixture is

then extracted four times with 1-2 ml of hexane each time. Each extract is passed through a funnel containing approximately 0.5 g of anhydrous sodium sulfate (retained by a glass wool plug) into a 10-ml volumetric flask. The volume of the sample is brought to 10 ml by rinsing the pipet, sodium sulfate, and funnel tip with hexane. The funnel should not rest on thezlip of the flask during filtration. The glass wool plug and sodium sulfate in the funnel are replaced after each sample. An aliquot of the sample solution is injected under the GLC conditions described above. The solvents flush technique is recommended using 2 μl of solvent back flush and 6 μl of standard or sample solution. The syringe must be cleaned with hexane after each injection. The height or area of the decachlorobiphenyl peak is compared to that of the decachlorobiphenyl standard and the weight of decachlorobiphenyl present is calculated.

(8) Gas-liquid chromatographic conditions for decachlorobiphenyl determination:

(A) Nitrogen carrier gas flow rate, 90 ml/minute.

(B) Injector temperature, 300 C.

(C) Interface and detector temperature, 325 C.

(D) Column temperature, 220 C.

(c) Determination of Desorption Efficiency

NIOSH has found average desorption efficiency is >99.3%, thus, results of sample analyses need not be corrected for desorption efficiency.

Calculations

(a) Standard Analytical Procedure

The following are the steps in the calculation of concentrations of

PCBs in air when determined with a PCB mixture as the standard.

(1) Add the heights or areas of several selected prominent peaks (at least five) in the chromatogram, compare with the total heights or areas of those same peaks in the standard, and read the concentration of the sample solution (ng/ml) from the standard curve.

(2) Multiply the concentration, in ng/ml, of the sample solution by the total volume, in ml, of the sample solution and calculate the weight of PCBs in the sample. Make corrections for the blanks if necessary.

(3) Add the weights found on the front and the back sections of the tube to find the total weight of PCBs in the air sample.

(4) Divide the total weight of the PCBs in the air sample by the volume, in liters, of air sampled and report the PCB concentration in ng/liter or its equivalent in μg/cu m.

(b) Alternate Standardization Procedure

The following are the steps in the calculation of concentrations of PCBs in air using the perchlorination method.

(1) The height or area of the decachlorobiphenyl peak in the chromatogram of the sample aliquot is compared to the height or area of the decachlorobiphenyl peak in the chromatograms of the standard. The concentration of decachlorobiphenyl in the sample aliquot is read from the standard curve.

(2) The concentration of decachlorobiphenyl in this aliquot (ng/ml) is multiplied by the total volume (ml) of the sample solution to give the total weight of PCBs in the sample as decachlorobiphenyl.

(3) The weights of PCBs, as decachlorobiphenyl, found on the front and back sections of the tube are summed, corrections for blanks are made, and the total weight of PCB, as decachlorobiphenyl, in the air sample is calculated.

(4) The total weight of PCB is divided by the volume of air sampled and the air concentration is reported in ng/liter or its equivalent in μg/cu m.

XI. APPENDIX III

MATERIAL SAFETY DATA SHEET

General instructions for preparing a Material Safety Data Sheet (MSDS) are presented in this chapter. The examples used in the text are for illustrative purposes and are not intended to apply to any specific compound or product. Applicable information about a specific product or material shall be supplied in the appropriate block of the MSDS.

The product designation is inserted in the block in the upper left corner of the first page to facilitate filing and retrieval. Print in upper case letters as large as possible. It should be printed to read upright with the sheet turned sideways. The product designation is that name or code designation which appears on the label, or by which the product is sold or known by employees. The relative numerical hazard ratings and key statements are those determined by the guidelines in Chapter V, Part B, of the NIOSH publication, An Identification System for Occupationally Hazardous Materials. The company identification may be printed in the upper right corner if desired.

(a) Section I. Product Identification

The manufacturer's name, address, and regular and emergency telephone numbers (including area code) are inserted in the appropriate blocks of Section I. The company listed should be a source of detailed backup information on the hazards of the material(s) covered by the MSDS. The listing of suppliers or wholesale distributors is discouraged. The trade name should be the product designation or common name associated with the material. The synonyms are those commonly used for the product, especially

formal chemical nomenclature. Every known chemical designation or competitor's trade name need not be listed.

(b) Section II. Hazardous Ingredients

The "materials" listed in Section II shall be those substances which are part of the hazardous product covered by the MSDS and individually meet any of the criteria defining a hazardous material. Thus, one component of a multicomponent product might be listed because of its toxicity, another component because of its flammability, while a third component could be included both for its toxicity and its reactivity. Note that a MSDS for a single component product must have the name of the material repeated in this section to avoid giving the impression that there are no hazardous ingredients.

Chemical substances should be listed according to their complete name derived from a recognized system of nomenclature. Where possible, avoid using common names and general class names such as "aromatic amine," "safety solvent," or "aliphatic hydrocarbon" when the specific name is known.

The "%" may be the approximate percentage by weight or volume (indicate basis) which each hazardous ingredient of the mixture bears to the whole mixture. This may be indicated as a range or maximum amount, ie, "10-40% vol" or "10% max wt" to avoid disclosure of trade secrets.

Toxic hazard data shall be stated in terms of concentration, mode of exposure or test, and animal used, eg, "100 ppm LC50-rat," "25 mg/kg LD50-skin-rabbit," "75 ppm LC man," or "permissible exposure from 29 CFR 1910.1000," or, if not available, from other sources of publications such as the American Conference of Governmental Industrial Hygienists or the

American National Standards Institute Inc. Flashpoint, shock sensitivity or similar descriptive data may be used to indicate flammability, reactivity, or similar hazardous properties of the material.

(c) Section III. Physical Data

The data in Section III should be for the total mixture and should include the boiling point and melting point in degrees Fahrenheit (Celsius in parentheses); vapor pressure, in conventional millimeters of mercury (mm Hg); vapor density of gas or vapor (air = 1); solubility in water, in parts/hundred parts of water by weight; specific gravity (water = 1); percent volatiles (indicate if by weight or volume) at 70 degrees Fahrenheit (21.1 degrees Celsius); evaporation rate for liquids or sublimable solids, relative to butyl acetate; and appearance and odor. These data are useful for the control of toxic substances. Boiling point, vapor density, percent volatiles, vapor pressure, and evaporation are useful for designing proper ventilation equipment. This information is also useful for design and deployment of adequate fire and spill containment equipment. The appearance and odor may facilitate identification of substances stored in improperly marked containers, or when spilled.

(d) Section IV. Fire and Explosion Data

Section IV should contain complete fire and explosion data for the product, including flashpoint and autoignition temperature in degrees Fahrenheit (Celsius in parentheses); flammable limits, in percent by volume in air; suitable extinguishing media or materials; special firefighting procedures; and unusual fire and explosion hazard information. If the product presents no fire hazard, insert "NO FIRE HAZARD" on the line

labeled "Extinguishing Media."

(e) Section V. Health Hazard Information

The "Health Hazard Data" should be a combined estimate of the hazard of the total product. This can be expressed as a TWA concentration, as a permissible exposure, or by some other indication of an acceptable limit. Other data are acceptable, such as lowest LD50, if multiple components are involved.

Under "Routes of Exposure," comments in each category should reflect the potential hazard from absorption by the route in question. Comments should indicate the severity of the effect and the basis for the statement, if possible. The basis might be animal studies, analogy with similar products, or human experiences. Comments such as "yes" or "possible" are not helpful. Typical comments might be:

> Skin Contact--single short contact, no adverse effects likely; prolonged or repeated contact, irritation, and cracking. Readily absorbed through the skin with severe systemic effects.
>
> Eye Contact--some pain and mild transient irritation; no corneal scarring.

"Emergency and First Aid Procedures" should be written in lay language and should primarily represent first-aid treatment that could be provided by paramedical personnel or individuals trained in first aid.

Information in the "Notes to Physician" section should include any special medical information which would be of assistance to an attending physician including required or recommended preplacement and periodic medical examinations, diagnostic procedures, and medical management of overexposed workers.

(f) Section VI. Reactivity Data

The comments in Section VI relate to safe storage and handling of hazardous, unstable substances. It is particularly important to highlight instability or incompatibility to common substances or circumstances such as water, direct sunlight, steel or copper piping, acids, alkalies, etc. "Hazardous Decomposition Products" shall include those products released under fire conditions. It must also include dangerous products produced by aging, such as peroxides in the case of some ethers. Where applicable, shelf life should also be indicated.

(g) Section VII. Spill or Leak Procedures

Detailed procedures for cleanup and disposal should be listed with emphasis on precautions to be taken to protect workers assigned to cleanup detail. Specific neutralizing chemicals or procedures should be described in detail. Disposal methods should be explicit including proper labeling of containers holding residues and ultimate disposal methods such as "sanitary landfill," or "incineration." Warnings such as "comply with local, state, and federal antipollution ordinances" are proper but not sufficient. Specific procedures should be identified.

(h) Section VIII. Special Protection Information

Section VIII requires specific information. Statements such as "Yes," "No," or "If Necessary" are not informative. Ventilation requirements should be specific as to type and preferred methods. Specify respirators as to type and NIOSH or US Bureau of Mines approval class, ie, "Supplied air," "Organic vapor canister," "Suitable for dusts not more toxic than lead," etc. Protective equipment must be specified as to type and materials of construction.

(i) Section IX. Special Precautions

"Precautionary Statements" shall consist of the label statements selected for use on the container or placard. Additional information on any aspect of safety or health not covered in other sections should be inserted in Section IX. The lower block can contain references to published guides or in-house procedures for handling and storage. Department of Transportation markings and classifications and other freight, handling, or storage requirements and environmental controls can be noted.

(j) Signature and Filing

Finally, the name and address of the responsible person who completed the MSDS and the date of completion are entered. This will facilitate correction of errors and identify a source of additional information.

The MSDS shall be filed in a location readily accessible to workers potentially exposed to the hazardous material. The MSDS can be used as a training aid and basis for discussion during safety meetings and training of new employees. It should assist management by directing attention to the need for specific control engineering, work practices, and protective measures to ensure safe handling and use of the material. It will aid the safety and health staff in planning a safe and healthful work environment and in suggesting appropriate emergency procedures and sources of help in the event of harmful exposure of employees.

MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION	
MANUFACTURER'S NAME	REGULAR TELEPHONE NO. EMERGENCY TELEPHONE NO.
ADDRESS	
TRADE NAME	
SYNONYMS	

II HAZARDOUS INGREDIENTS		
MATERIAL OR COMPONENT	%	HAZARD DATA

III PHYSICAL DATA			
BOILING POINT, 760 MM HG		MELTING POINT	
SPECIFIC GRAVITY (H_2O=1)		VAPOR PRESSURE	
VAPOR DENSITY (AIR=1)		SOLUBILITY IN H_2O, % BY WT	
% VOLATILES BY VOL		EVAPORATION RATE (BUTYL ACETATE=1)	
APPEARANCE AND ODOR			

IV FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)		AUTOIGNITION TEMPERATURE	
FLAMMABLE LIMITS IN AIR, % BY VOL.	LOWER		UPPER
EXTINGUISHING MEDIA			
SPECIAL FIRE FIGHTING PROCEDURES			
UNUSUAL FIRE AND EXPLOSION HAZARD			

V HEALTH HAZARD INFORMATION

HEALTH HAZARD DATA

ROUTES OF EXPOSURE

INHALATION

SKIN CONTACT

SKIN ABSORPTION

EYE CONTACT

INGESTION

EFFECTS OF OVEREXPOSURE

ACUTE OVEREXPOSURE

CHRONIC OVEREXPOSURE

EMERGENCY AND FIRST AID PROCEDURES

EYES

SKIN

INHALATION

INGESTION

NOTES TO PHYSICIAN

VI REACTIVITY DATA

CONDITIONS CONTRIBUTING TO INSTABILITY

INCOMPATIBILITY

HAZARDOUS DECOMPOSITION PRODUCTS

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION

VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

NEUTRALIZING CHEMICALS

WASTE DISPOSAL METHOD

VIII SPECIAL PROTECTION INFORMATION

VENTILATION REQUIREMENTS

SPECIFIC PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY (SPECIFY IN DETAIL)

EYE

GLOVES

OTHER CLOTHING AND EQUIPMENT

IX SPECIAL PRECAUTIONS

PRECAUTIONARY STATEMENTS

OTHER HANDLING AND STORAGE REQUIREMENTS

PREPARED BY

ADDRESS

DATE

TABLE XII-1

CHEMICAL AND PHYSICAL PROPERTIES OF SOME AROCLORS

Aroclor	Chlorine, % w/w	Distillation Range, C (corrected)	Density g/ml 25 C	Flash-point* F	Fire-Point* F	Appearance
1221	20.5-21.5	275-320	1.18	286-302	349	Clear, mobile oil
1232	31.4-32.5	290-325	1.26	305-310	460	"
1242	42	325-366	1.38	384-356	none**	"
1248	48	340-375	1.44	379-384	"	"
1254	54	365-390	1.54	none**	"	Light-yellow visous liquid
1260	60	385-420	1.62	"	"	Light-yellow soft, sticky resin
1262	62	390-425	1.64	"	"	Light-yellow sticky, viscous resin
1268	68	435-450	1.82	"	"	White to off-white powder

*Cleveland Open Cup
**None to boiling point

Adapted from reference 1

TABLE XII-2

QUALITATIVE AND PERCENT CHLOROBIPHENYL AND BIPHENYL COMPOSITIONS OF COMMERCIAL PCB PREPARATIONS

(Qualitatively major peaks = M, minor peaks = m, ambiguous identities = ?; quantitatively, percentages rounded)

CL-Substituted Positions	Commercial Preparation Designations (trade names omitted)																				
	1221	1221	1221	1221	1232	1016	1242	1242	1242	1248	1248	1254	1254	1254	A50	1260	1260	1260	A60	A60	DP6
0	13	16	m	16	m	0.5	m		m	m				m							
2	28	32	m	35	m	1	m	0.8	m	m				m			m				
3		3	m	3																	
4	19	19	m	20	m	2								m			m				
2,3						0.4															
2,4	4	3		2		1		<0.7	m	<0.1				m			m				
2,5		0.2		tr				m	m												
2,6		0.3		0.4		tr		m													
2,2'	9	5	m	5	m	7	m	<1.0	M	m				m			m				
2,3'		3	m	2	m	1	m	m	M	m				m			m				
2,4'	14	10	m	11	m	11	m	<5	M	m	0.5			m			m				
3,4		1		m				m													
3,5						tr															
3,3'																					
3,4'				1				m			<3										
4,4'	6	4	m	4	m	2		1	M		<3			m			m				
2,3,4																					
2,3,5																					
2,3,6																					
2,2',3					m	5	m		M?	m											
2,3,3'		0.1				tr			M?												
2,3,4'						tr															
2,4,5																					
2,4,6																					
2,2',4		0.3	m	m	m	4	m	11	M	m	8			m			m				
2,3',4				m	m	4	m	<15	M	m	<13			m			m				
2,4,4'		0.2		m	m	4	m	7	M?	m	3										
2,2',5		0.6		0.6	m	12	m	2	M	m	0.1			m			m				
2,3',5		0.2				9		m	M	m	<13										
2,4',5		0.2		m	m	10	m		m	m				m			m				
2,2',6					m	1	m		m	m				m			m				
2,3',6						0.3			M?												
2,4',6						2			M					m			m				
3,4,5																					
2',3,4		0.1				tr	m	16	M	m	21		0.3	m			m				
3,3',4									m												
3,4,4'						2			M												

TABLE XII-2 (Continued)

QUALITATIVE AND PERCENT CHLOROBIPHENYL AND BIPHENYL COMPOSITIONS OF COMMERICAL PCB PREPARATIONS

(Qualitatively major peaks = M, minor peaks = m, ambiguous identities = ?; quantitatively, percentages rounded)

CL-Substituted Positions	Commercial Preparation Designations (trade names omitted)																				
	1221	1221	1221	1221	1232	1016	1242	1242	1242	1248	1248	1254	1254	1254	A50	1260	1260	1260	A60	A60	DP6
2',3,5						tr															
3,3',5																					
3,4',5						tr															
2,3,4,5																					
2,3,4,6																					
2,3,5,6																					
2,2',3,4						3									1				0.7		
2,3,3',4						0.4			M		7		m								
2,3,4,4'									m		m		m								
2,2',3,5									M?												
2,3,3',5																					
2,3,4',5						0.2															
2,2',3,6						<2															
2,3,3',6								6	M?		m										
2,3,4',6															2				1		
2,2',4,5						tr			M?												
2,3',4,5																					
2,4,4',5																					
2,2',4,6														m			m				
2,3',4,6						<2			M?		m										
2,4,4',6						tr															
2',3,4,5									M?												
3,3',4,5																					
3,4,4',5																					
2,2',3,3'						1								m							
2,2',3,4'						tr															
2,2',3,5'						1	m			m		m	4	M	2	<0.4			1		
2,2',3,6'						1															
2,3,3',4'								4	m												
2,3,3',5'																					
2,2',4,4'				m		1	m			m											
2,2',4,5'						3	m	12	M?	m	16	m			1						
2,2',4,6'						0.1															
2,3',4,4'						tr	m	m		m											
2,3',4,5'																					
2,3',5,5'									M?												
2,2',5,5'		0.14				2	m	tr	M?	m		m	8	M	5		m				

	1221	1221	1221	1221	1232	1016	1242	1242	1242	1248	1248	1254	1254	1254	A50	1260	1260	1260	A60	A60	DP6
2,2',5,6'						2															
2,2',6,6'						3															
3,3',4,4'								1													
3,3',4,5'																					
3,3',5,5'																					
2',3',5',6																					
2',3,4,5'						0.5	m	9	M-	m	24			M	4	<0.4	m				
2,3',4',6														m							
2,3,4,5,6																					
2,2',3,4,5																					
2,3,3',4,5																					
2,3,4,4',5																					
2,2',3,4,6																					
2,3,3',4,6																					
2,3,4,4',6																					
2,2',3,5,6																					
2,3,3',5,6																					
2,3,4',5,6																					
2,2',3,3',4															1						
2,2',3,4,4'																<16					
2,2',3,4,5'									m		2		23.7	M	m	m	1				
2,2',3,4,6'																					
2,3,3',4,4'													m	M	4	<4					
2,3,3',4,5'																					
2,2',3,3',5																					
2,2',3,4',5																5					
2,2',3,5,5'														M	2		m		1		
2,2',3,5,6'																					
2,3,3',4',5																					
2,3,3',5,5'																					
2,2',3,3',6										m		m	m	M	3		0.3				
2,2',3,4',6												m	17								
2,2',3,5',6			m						M?			m	14	M	4	2	M		3		
2,2',3,6,6'							m			m		m	m								
2,3,3',4',6			m							m		m		M	8		m		3		
2,3,3',5',6	m																				
2,2',3',4,5										m		m		M	1	m					
2,2',4,4',5			m					m	m	m	2	m		M	2	m			tr		
2,2',4,5,5'		0.1	m							m	1	m	m	M	7		M		6		
2,2',4,5,6'																					
2,3',4,4',5			m							m	1	m	14	M	5	<16	m		2		
2,3',4,5,5'																					
2,2',3',4,6						tr															
2,2',4,4',6								8	M?												

TABLE XII-2 (Continued)

QUALITATIVE AND PERCENT CHLOROBIPHENYL AND BIPHENYL COMPOSITIONS OF COMMERCIAL PCB PREPARATIONS

(Qualitatively major peaks = M, minor peaks = m, ambiguous identities = ?; quantitatively, percentages rounded)

CL-Substituted Positions	Commercial Preparation Designations (trade names omitted)																				
	1221	1221	1221	1221	1232	1016	1242	1242	1242	1248	1248	1254	1254	1254	A50	1260	1260	1260	A60	A60	DP6
2,2',4,5',6																					
2,2',4,6,6'																					
2,3',4,4',6																					
2,3',4,5',6																					
2,3,3',4',5'																					
2,3',4,4',5'																					
2,3',4',5,5'																					
2,3',4',5',6																					
3,3',4,4',5																					
3,3',4,5,5'																					
2,2',3,4,5,6																					
2,3,3',4,5,6																					
2,3,4,4',5,6																					
2,2',3,3',4,5																					
2,2',3,4,4',5																					
2,2',3,4,5,5'																					
2,2',3,4,5,6'																					
2,3,3',4,4',5													m	0.8	<9	m		2			
2,3,3',4,5,5'																					
2,2',3,3',4,6																					
2,2',3,4,4',6																					
2,2',3,4,5',6																					
2,2',3,4,6,6'																					
2,3,3',4,4',6		m														m					
2,3,3',4,5',6																					
2,2',3,3',5,6																					
2,2',3,4',5,6																					
2,2',3,5,5',6			m												1				3		
2,2',3,5,6,6'																					
2,3,3',4',5,6																					
2,3,3',5,5',6																					
2,2',3,3',4,4'													2	m	1		M		2		
2,2',3,3',4,5'															<1				2		
2,2',3,4,4',5'			m										12	M	5		M	m	11	m	m
2,3,3',4,4',5'	m																				
2,2',3,3',4,6'			m											M	2		M		3		
2,2',3,4,4',6'																					

	1221	1221	1221	1221	1232	1016	1242	1242	1242	1248	1248	1254	1254	1254	A50	1260	1260	1260	A60	A60	DP6
2.2',3.3',5,5'																			3		
2.2',3.4',5.5'			m							<0.1					0.9	<16			2		
2.3.3',4',5.5'																					
2.2',3.3',5.6'			m												1				4		
2.2',3.4',5.6																<15					
2.2',4.4',5.6	m																				
2.2',4.4',5.5'												m	4	M	4	<4	M	m	13	m	m
2.3',4.4',5.5'			m										0.4	m	0.5				1		
3.3',4.4',5.5'																					
2,3',4,4',5',6																					
2.2',4',5.6.6'	m																				
2.2',4.4',6.6'																					
2.3.3',4',5',6													m								
2.2',3.3',6.6'			m												0.5	4	M	m	1	m	m
2.2',3',4.5.6'			m									m		M	2		M	m	7	m	m
2.2',3.3',4.5.6																					
2.2',3.4,4',5,6																					
2.2',3.4.5.5',6																					
2.2',3.4.5.6.6'																					
2.3.3',4.4',5.6																					
2.3.3',4.5.5',6																					
2.2',3.3',4.4',5			m											m	1	<4	M	m	4	m	m
2.2',3.3',4.5.5'															0.2	<9	m		0.9		
2.2',3.3',4.5.6'			m												0.3			m	4	m	m
2.2',3.4.4',5.5'			m												1	12	M	m	8	m	m
2.2',3.4,4',5.6'													2	m		<20	m				
2.3.3',4,4',5.5'															tr				tr		
2.2',3.3',4,4',6															0.1				0.4		
2.2',3.3',4,5',6		m											m	m							
2.2',3,3',4.6.6'															0.1				0.4		
2.2',3.4,4',5',6															0.2	<20	M		2		
2.2',3.4,4',6.6'																					
2.3.3',4,4',5',6	m	m														m					
2.2',3.3',4',5.6														m	0.3				2		
2.2',3.3',5.5',6															tr				0.5		
2.2',3.3',5.6.6'															1				1		
2.2',3.4',5.5',6			m												0.4				3		
2.2',3.4',5.6.6'																					
2.3.3',4',5.5',6																					
2.2',3.3',4.4',5.6																	m				
2.2',3.4,4',5.5',6																	m				
2.2',3.3',4.5.5',6																					
2.2',3.3',4.5.6.6'																					
2.2'3.4,4',5.6.6'																					

TABLE XII-2 (Continued)

QUALITATIVE AND PERCENT CHLOROBIPHENYL AND BIPHENYL COMPOSITIONS OF COMMERCIAL PCB PREPARATIONS

(Qualitatively major peaks = M, minor peaks = m, ambiguous identities = ?; quantitatively, percentages rounded)

CL-Substituted Positions	Commercial Preparation Designations (trade names omitted)																				
	1221	1221	1221	1221	1232	1016	1242	1242	1242	1248	1248	1254	1254	1254	A50	1260	1260	1260	A60	A60	DP6
2,3,3',4,4',5,5',6																					
2,2',3,3',4,4',5,5'															0.4	2	m		0.7		
2,2',3,3',4,4',5,6'		m															m				
2,2',3,3',4,5,5',6'															0.1	5	m		0.7		
2,2',3,3',4,4',6,6'															tr	m					
2,2',3,3',4,5',6,6'															tr		m				
2,2',3,3',5,5',6,6'															tr		M				
2,2',3,3',4,4',5,6,6'																0.4	m		tr		
2,2',3,3',4,5,5',6,6'		m															m				
2,2',3,3',4,4',5,5',6																m	m				
2,2',3,3',4,4',5,5',6,6'																	m				
Reference No.	17	★	16	★	16	★	16	★	14	16	★	16	★	14	7	★	14	8	7	16	8

★ PW Albro, written communication, November 1976

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