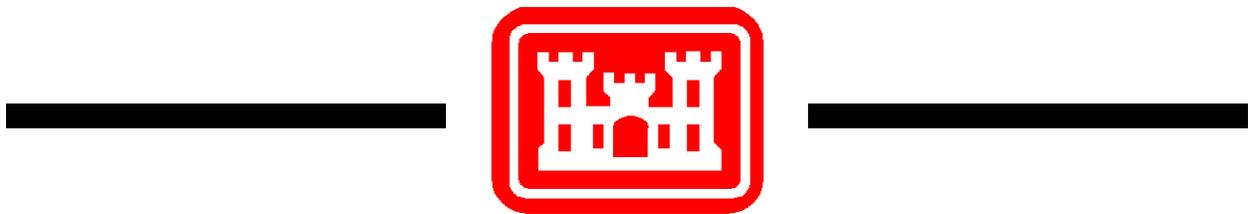


PUBLIC WORKS TECHNICAL BULLETIN 200-1-126
31 DECEMBER 2012

PCBs IN CAULK AND PAINT



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Public Works Technical Bulletin

31 December 2012

No. 200-1-126

Facilities Engineering
Environmental

PCBs IN CAULK AND PAINT

1. Purpose

a. This Public Works Technical Bulletin (PWTB) describes the historic use of PCBs in non-electric applications, including caulk and paint in construction products. This information is provided as reference for DPW managers, should PCBs be found on their installations. There is currently no federal regulation governing removal of construction materials containing PCBs.

b. All PWTBs are available electronically at the National Institute of Building Sciences' Whole Building Design Guide webpage, which is accessible through this link:

http://www.wbdg.org/ccb/browse_cat.php?o=31&c=215

2. Applicability

This PWTB is informational in nature, and therefore applies to all US Army facilities engineering activities.

3. References

a. Army Regulation (AR) 200-1, "Environmental Protection and Enhancement," revised 13 December 2007.

b. 40 CFR (Code of Federal Regulation) §761.62, "Disposal of PCB Bulk Product Waste."

4. Discussion

a. Section 9-2(c) of AR 200-1 describes the Army's policy for dealing with PCBs: manage in place where possible; prevent human exposure; and comply with relevant environmental regulations.

b. 40 CFR 761.62 lists requirements for the disposal of "PCB bulk product waste."¹ This phrase means a waste product derived from manufactured products containing non-liquid PCBs at a concentration of over 50 ppm. This fits the description of PCBs in construction-finish products, the subject of this PWTB. Note that it is the *disposal* of this material that EPA regulates. Material in place is not regulated.

c. The first part of Appendix A contains a detailed description of the industrial history, chemistry, and uses of PCBs during the twentieth century. While most regulatory activity starting in the 1970s centered on the liquid PCB oils used in electric components, very little attention was paid to other historic uses, including construction finish materials like caulks and paints. In the early 2000s, however, ad hoc samples revealed occasionally high concentrations of PCBs in these products. PCBs were found in paints at Army industrial sites.

d. The second part of Appendix A describes field-level sampling technologies that could be used to identify PCBs in building products.

e. Appendix B gives a list of references.

f. Appendix C contains a list of common abbreviations.

g. Appendix D contains a material safety data sheet (MSDS)² on PCBs from the Monsanto Corporation which was the largest U.S. manufacturer of PCBs.

5. Summary

PCBs were widely used in the twentieth century in a variety of products. Some uses in construction products were not recognized by the environmental community until recently. In most cases, the presence of PCBs in construction products in existing

¹ 40CFR761.3 also gives the specific definition of PCB waste.

² Now globally known as a Safety Data Sheet (SDS).

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buildings should not pose a health or environmental threat. Thus, there is currently no federal requirement for sampling. However, in cases where there is either a high chance of child contact (e.g., schools) or construction projects that would likely cause these materials to be disturbed, it would be a reasonable precaution to sample suspect materials for PCB content.

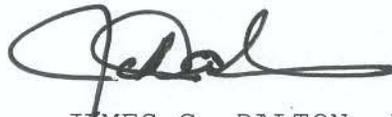
6. Points of Contact

a. Headquarters, US Army Corps of Engineers (HQUSACE) is the proponent for this document. The point of contact (POC) at HQUSACE is Mr. Malcolm E. McLeod, CEMP-CEP, 202-761-5696, or e-mail: Malcolm.E.Mcleod@usace.army.mil.

b. Questions and/or comments regarding this subject should be directed to the technical POC:

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APPENDIX A

INDUSTRIAL HISTORY OF PCBs, THEIR USE IN CAULK AND PAINT, AND CURRENT DETECTION TECHNOLOGIES

Chemistry of PCBs

Polychlorinated Biphenyls (PCBs) are a class of molecules consisting of two joined benzene rings (biphenyl) with a varying number and location of chlorine atoms attached. Each variation is called a congener. There are 209 possible PCB congeners, but only about half are found in commercial mixtures. Figure A-1 and Figure A-2 show the naming convention for PCB molecules, which is based on the number and position of chlorine atoms on the biphenyl rings.

The Monsanto Company, a North American chemical manufacturer, marketed PCB-containing oils under the brand name "Aroclor," followed by a four-digit number. For most of the Aroclors, the first two digits generally referred to the number of carbon atoms in the biphenyl skeleton (usually 12), and the second two digits indicated the percentage of chlorine by mass in the mixture. Thus, Aroclor 1260 has 12 carbon atoms and contains 60% chlorine by mass. Each Aroclor is a mixture of congeners, selected to give the desired properties. The higher fraction of chlorine in the mixture, the more viscous the oil, and the more thermally stable the Aroclor. Aroclor 1254 and 1260 appear to have been used most frequently for many varied purposes.

While Monsanto used the name Aroclor, subsequent equipment manufacturers marketed the PCB oils in their own products under many different trade names. USEPA has an extensive list at <http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/aroclor.htm>. The most common North American trade names include: Asbestol, Askarel, Inerteen, and Pyranol.

Figure A-3 shows a gas chromatogram of common Aroclors. The number on each peak indicates the number of chlorine atoms per biphenyl molecule. This graph simply shows that the congeners with more chlorine elute from the Aroclor mixture at higher temperatures (i.e., they are more thermally stable).

In animal studies, PCBs have been shown to cause cancer and have adverse impacts on the immune, reproductive, nervous, and endocrine systems. The US Environmental Protection Agency

(USEPA) determined in 1996 that PCBs are a probable human carcinogen.³

However, existing human epidemiological studies are not conclusive, due to their small sample size. Also, industrial exposure in the chemical plants may have a very different effect than long-term environmental exposure (e.g., food-chain bioaccumulation).

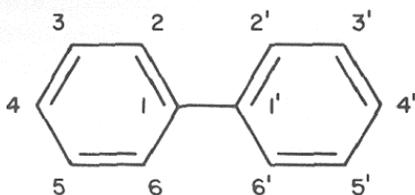
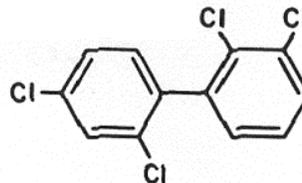


Figure A-1. PCB numbering of chlorine atom position in the biphenyl ring system (Huntzinger 1974).



2,2',3,4'-tetrachlorobiphenyl

Figure A-2. Example PCB molecule with name (Huntzinger 1974).

History of PCB Manufacturing

PCBs were first synthesized in 1881. They were subsequently first commercially manufactured in 1927 by the Anniston Ordnance Company in Anniston, Alabama. This company changed its name to Swann Chemical in 1930. From the earliest days, this company foresaw and marketed PCBs for a wide variety of applications (Penning 1930).

In 1935, Monsanto Industrial Chemical Company of St. Louis, Missouri, purchased Swann Chemical. Monsanto continued to manufacture PCBs in Anniston and in Sauget, Illinois, through the 1970s.

Great quantities of PCBs were produced in the United States from 1929-1979, after which time U.S. production was banned due to long-documented and numerous toxicological effects from contact with PCBs.

Monsanto produced about 640,000 tons of PCBs between 1935 and 1970, about one-half of the total worldwide production (Breivik 2002). Figure A-4 shows domestic sales of PCBs from Monsanto,

³ <http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/effects.htm>

separated by Aroclor number. Note the dramatic decrease after 1970—only about 15,000 tons were sold in the U.S. in 1974 (Durfee 1976). Figure A-5 shows worldwide PCB production by decade; this data matches well with Figure A-4.

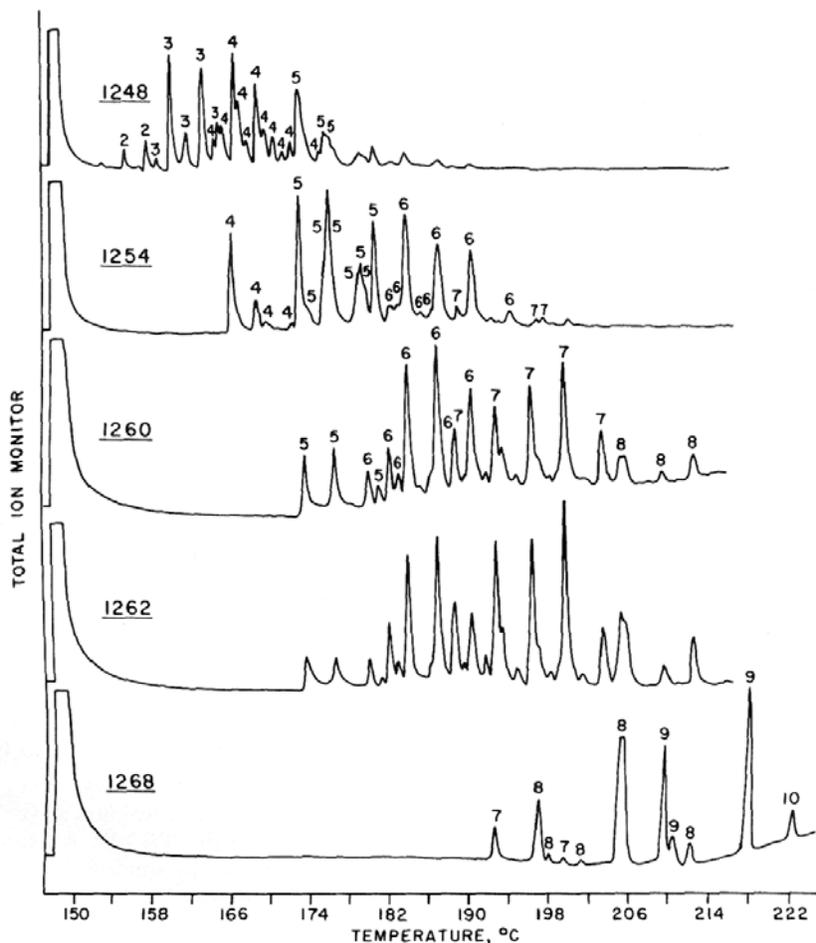


Figure A-3. Chromatogram of common Aroclors (Huntzinger 1974).

Figure A-6 shows Monsanto's domestic sales of PCBs during the last years of production for uses *other* than electrical devices (Broadhurst 1972). This period represents the highest use of PCBs as a plasticizer in paints, caulks, or other products.

The largest industrial use of PCBs was as a liquid in transformers, capacitors, heat exchangers, and hydraulic equipment. Use of PCBs in electrical equipment was very common because of their excellent dielectric properties and also due to their very low flammability. A PCB oil can absorb rapid changes in electric fields without increasing temperature, (i.e., with very little loss of electric energy). Also, PCBs have a low

flash point and no fire point, meaning that they are stable in changing temperatures.

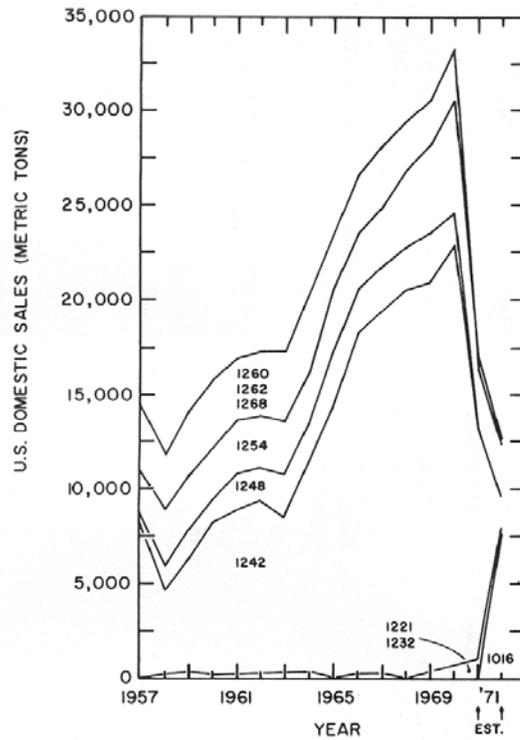


Figure A-4. Monsanto's PCB domestic sales (Huntzinger 1974).

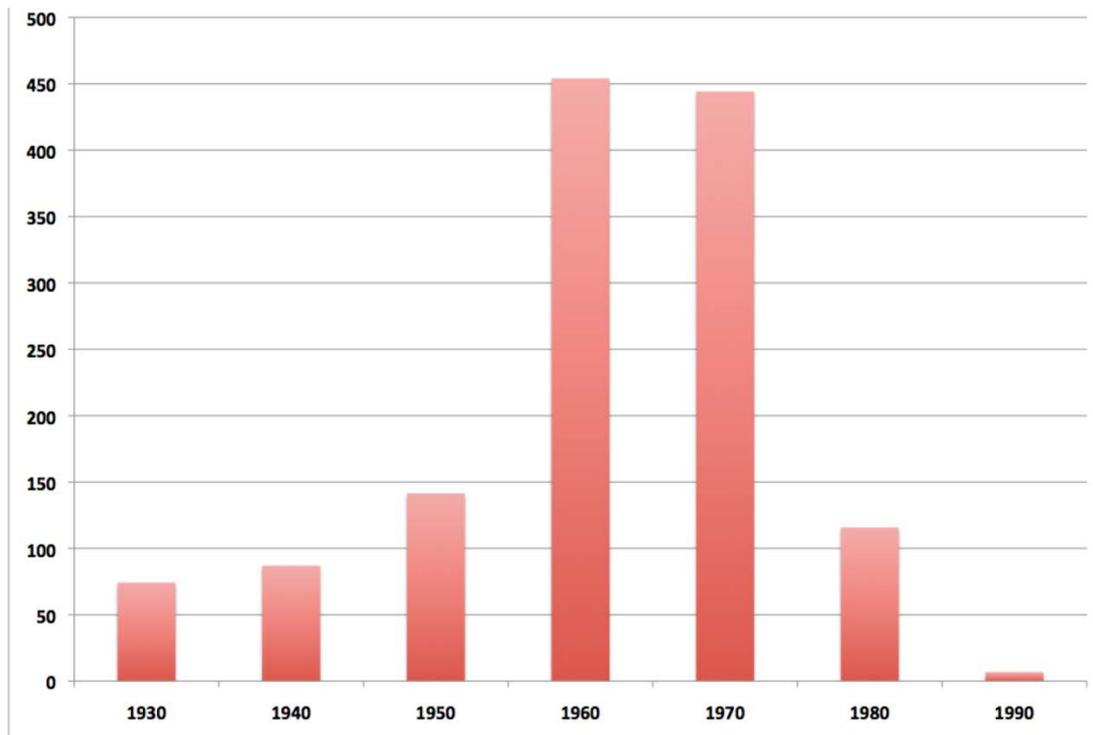


Figure A-5. Worldwide PCB production thousands of metric tons (Breivik 2002).

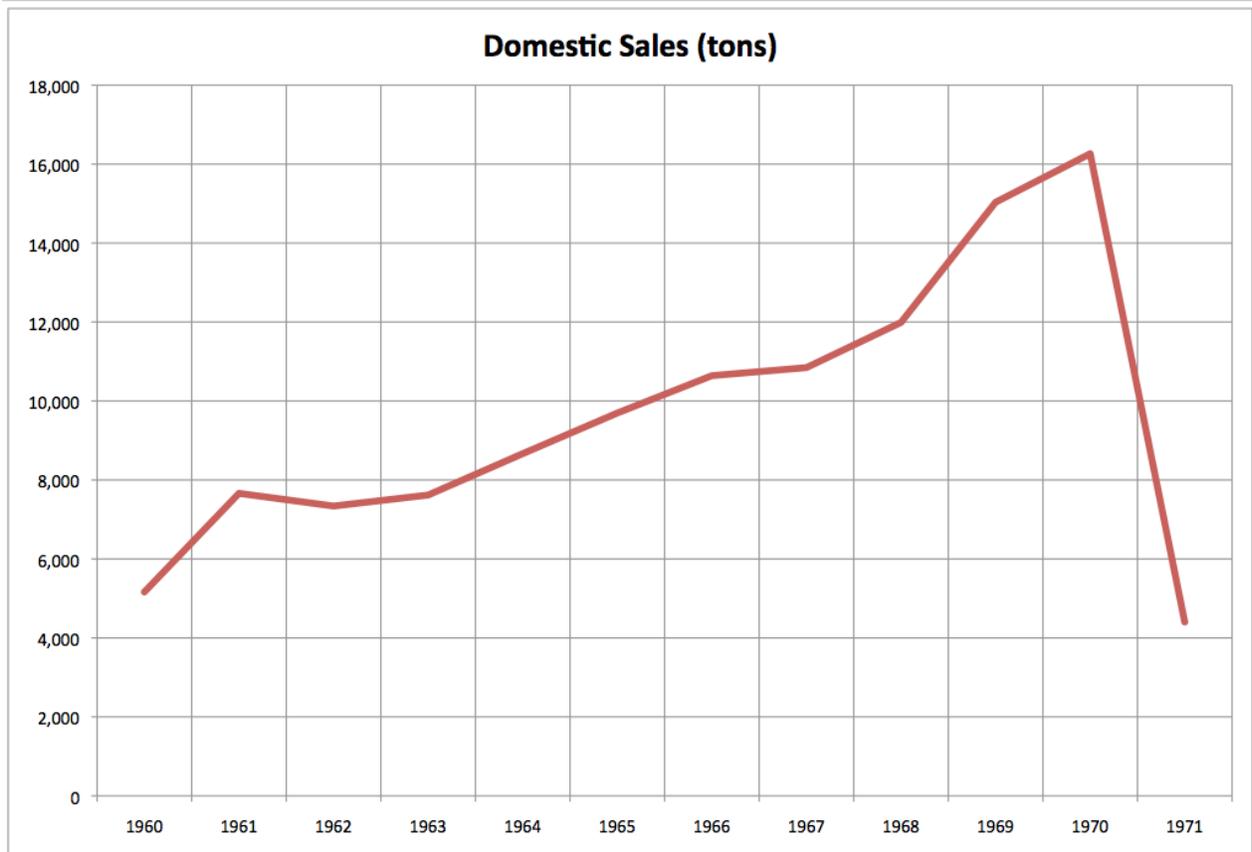


Figure A-6. Domestic sales of PCBs for heat transfer, lubricants, and plasticizers (Broadhurst 1972).

Regulation and Ban of PCBs

In 1979, the USEPA issued final regulations banning the manufacture of PCBs. In addition, USEPA rules gradually ended many industrial uses of PCBs from 1979 to 1984, but allowed their continued use in existing, enclosed electrical equipment under controlled conditions.

This federal regulatory action⁴ spawned a host of initiatives to identify, repair, track, and decommission electrical equipment; such action included cleanup of soil contaminated by leaking transformers. The federal regulations also anticipated management of non-liquid, non-electrical PCBs; however, there has not been a comprehensive effort to identify, treat, or remove these other types of PCBs.

⁴ Federal regulations regarding PCBs are contained in 40 CFR 761. Requirements for disposal of materials with a concentration of over 50 ppm can be found at 40 CFR 761.62.

After the 1979 ban, the tracking and management of PCB-containing electrical components was well understood and regulated. However, there were many other uses of PCBs that were not as well documented, and in fact, were relatively unknown to the environmental community.

In recent years, USEPA has learned that caulk containing PCBs was used in many buildings—including schools—in the 1950s through the 1970s. The PCBs gave the caulk flexibility over a wide temperature range. Any connection between the concentrations of PCBs in caulk and PCBs in the air or dust is not well understood. In September 2009, USEPA provided new guidance to communities and announced additional research to address PCBs that may be found in the caulk in many older buildings, including schools. The USEPA continues to study the issues of PCBs in caulk; see their website for the latest information.⁵

Please note that PCB building products might also contain other hazardous materials. For example, PCB-containing paint might also have heavy metals like lead (Pb) or chromium (Cr). Caulk or mastic products might also contain asbestos. These co-contaminants would each have their own requirements for safety, removal criteria, and disposal.

Evidence of PCBs Remains

As noted above, many buildings across the country which were constructed or renovated from 1950–1978 may have high levels of PCBs in the caulk around windows and door frames, between masonry columns, and in other masonry building materials. In general, schools and buildings built after 1978 do not contain PCBs in caulk. Exposure to these PCBs may occur via their release from the caulk into the air, dust, surrounding surfaces and soil, and through direct contact.

Additionally, polysulfide sealants were used from the 1950s to the 1970s as waterproof coatings and as a component in gasket and joint filler material (e.g., between a sidewalk and a building; Bente 1992). PCBs were added in concentrations up to 300,000 ppm to improve flexibility of the sealants. This putty bonded well to a variety of building materials and was nonhardening (Broadhurst 1972).

⁵ EPA website on PCBs in caulk:
<http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/caulk/index.htm> or start at
<http://www.epa.gov/pcb>.

PCBs also were used in commercial wood floor finishes in residences in the 1950s and 1960s; this use is an overlooked but potentially important source of PCB exposure in the general population. Disturbing this finish, especially through sanding, could impart a significant dose to residents or workers (Rudel 2008).

The US Army and PCBs

In 2001, technicians at Army industrial sites discovered PCBs in paint that coated many structures and process equipment. PCBs had been added to industrial paints to increase heat tolerance and plasticity. The concentration of PCBs in these paints ranged up to tens of thousands of parts per million (Figure A-7). This discovery has limited some Army installations' plans for the decontaminating process of equipment and buildings.

Of additional interest to Army installation personnel, the USEPA published information in 2009 on PCBs that have been discovered in caulk products, creating special concern for school buildings or other areas where children might play (USEPA 2009).

Tracking PCBs in Buildings

Monsanto product literature (Monsanto 1960) lists numerous benefits, along with commercial and industrial applications of their Aroclor products. Aroclor uses included insulating fluid, heat transfer, sealants, expansion media, elastomers, adhesives, paints, lacquers, varnished, pigments, and waxes.

In fact, PCBs were marketed to improve plasticity, heat resistance, and insulating properties for a huge range of products. Thus, many years later, it is nearly impossible to find exact quantities of products sold that contained PCBs. However, one reference yields a breakdown of PCB sales by general end-use, based on data from Monsanto (Huntzinger 1974). Figure A-8 shows domestic PCB sales by intended application, from 1956-1971.

Throughout the mid-twentieth century, there were a series of "formularies" published that listed the chemical ingredients for a wide variety of generic and specific commercial products (Ash 1978; Bennett 1948, 1967, 1970). A survey of these sources revealed numerous products and product categories that contained PCBs (Table A-1 lists the results of this non-exhaustive survey). This table only includes products not related to electrical devices. These results correspond with the sales numbers shown in Figure A-8 (i.e., the maximum annual production

corresponds with the highest number of products around 1970). Note that Aroclor 5460 is a polychlorinated A-8riphenyls (not a PCB, but Monsanto included this in their nomenclature).

Table A-2 gives an ingredient list for semigloss white paint, recommended by Monsanto and using Aroclor 1248 (Payne 1954). The 1967 edition of the Chemical Formulary (Bennett) lists three versions of paint for swimming pools, calling for 5%, 7%, and 8% Aroclor by weight.

Researchers from the Harvard School of Public Health worked with a local bricklayers union to revisit and sample the caulking at buildings around Boston where those workers had installed caulking in the 1970s (Herrick 2007). Sampling results showed detectable PCBs in 13 of the 24 buildings. The concentration of the PCBs found in caulk ranged from 0.56 to 36,200 ppm by mass. This highest figure happened to be from a university building. Almost all of the PCBs found were characterized as Aroclor 1254. The wide range in PCB concentration from similar, contemporary products might be explained by differing commercial formulations.

Finally, recent research has shown that PCBs can still be found in commercial paints (Hu 2010), although at much lower concentrations. PCB-11 that was found in these studies is not one of the congeners used in the old Aroclors. Rather, it appears to be a byproduct in the manufacturing process of certain organic pigments. These pigments are used in a variety of commercial products, and possibly because of this, PCB-11 has been found in the air of urban areas. Any chronic health impacts are unknown at this time.



Figure A-7. Paint sample composite (ERDC-CERL).

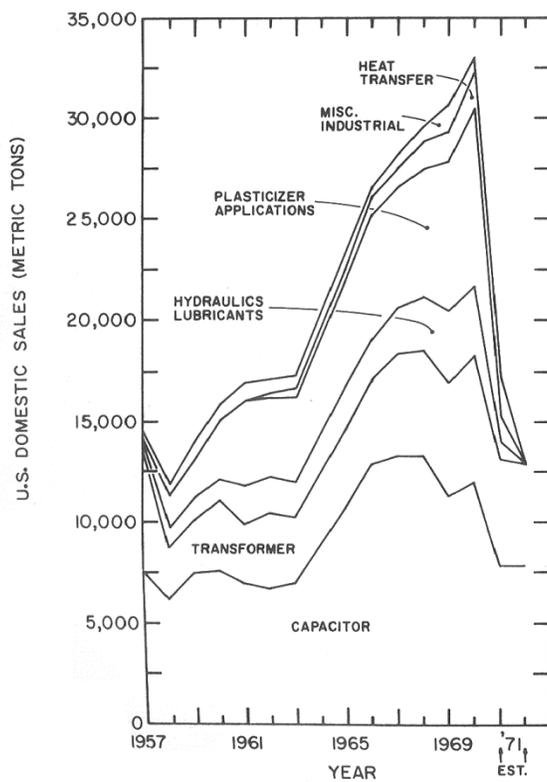


Figure A-8. Domestic PCB sales by use (Huntzinger 1974, courtesy of Monsanto Company).

Table A-1. Commercial products containing Aroclors.

Product Name	Aroclor number(s)	Year cited
Moisture-proof coating	5460	1948
Strippable spray coatings	1260, 5460	1967
Swimming pool paint	1254	1967
Wood filler	5460	1967
Wood improver	4465	1967
Polyurethane coatings	1254	1967
Ethyl cellulose lacquers	1254, 5460	1967
Cellulose acetate - butyrate lacquers (paper lacquers)	1260, 1262	1967

Product Name	Aroclor number(s)	Year cited
Flow-back lacquers	5460	1967
Strippable lacquer	1254	1967
Adhesive resin	1254, 1260	1970
Glass, aluminum, steel, construction adhesives	1248	1970
Emulsion-type terrazzo paint	5460	1970
Abrasion-resistant floor finish	1254	1970
Maintenance paint topcoats	1260 resin, 1254 resin, 5460 plasticizer	1970
Metal primers	1260 plasticizer, 1254 plasticizer, 5460 resin	1970
Thixotropic zinc chromate primer	1254, 5460	1978
Zinc-rich primer	1254, 5460	1978
Red lead / red iron oxide general-purpose flash-dry primer	5460	1978
Concrete floor enamels	(chlorinated bi- and triphenyls)	1978
Green epoxy-polyamide flexible fire-retardant coating	1248	1978

Table A-2. Monsanto paint recipe (Payne 1954).

Product Name	Aroclor Number
Moistureproof coating	5460
Strippable spray coatings	1260, 5460
Swimming pool paint	1254
Wood filler	5460
Wood improver	4465
Polyurethane coatings	1254
Ethyl cellulose lacquers	1254, 5460

Field Detection Technologies for PCBs

Field-test technologies are the best alternative for providing the user with a quick response either for scoping a problem and determining an appropriate response or for screening a large area. Potential uses include spill response, screening of recycling scrap or building materials, compliance, long-term monitoring, and prescreening of contaminated areas to determine future actions. The field technologies for analysis of PCBs that are described below use different methods such as immunoassay principles, electrochemical analysis, and colorimetric reactions. Some of these technologies have been evaluated by the USEPA under the Environmental Technology Verification (ETV) program, and their comments have been included in this document.

L2000 PCB/Chloride Analyzer

The L2000 PCB/Chloride Analyzer, a technology developed by Dexsil Corporation,⁶ provides quantitative results from samples, based on the principle of total organic chlorine detection and electrochemical analysis using an ion-specific electrode (Figure A-9). This technology can be used to evaluate samples from four different matrices such as transformer oil, soil, water, and wipe samples. To facilitate the use of this instrument in the field, the system is powered by a rechargeable 8-volt battery. This technology has a usable concentration range of 2 to 2000 ppm in oils and solids; 20 ppb to 2000 ppm in water; and 2 to 2000 $\mu\text{g}/100\text{cm}^2$ for wipe samples.



Figure A-9. L2000 PCB/Chloride Analyzer (www.dexsil.com).

Dexsil provides a kit to facilitate wipe sample collection in the field. Surfaces should be wiped using hexane-soaked gauze, and then extracted with an organic solvent to proceed to the chlorine quantification. After the sample extraction, the procedure for chlorine quantification consists of removing the inorganic chloride present and covalently bound chlorine atoms off the PCB molecule with sodium strips. After adjusting the pH, eliminating excess sodium, and filtering the new buffered solution, a chloride ion-specific electrode is put in this aqueous solution to measure the milli-volt potential of the

⁶ <http://www.dexsil.com>

chloride solution. This potential is then converted to a PCB concentration in terms of parts per million.

Use of this technology is recommended by the USEPA for situations where the Aroclor of concern is known, and where halogenated organics are not present. Additionally it is recommended to correct the quantitative results reported by determining a correction factor that can be obtained by sending 10%-20% of the samples for laboratory analysis.

RaPID Assay PCB Test Kit

The RaPID Assay PCB Test Kit from Modern Water⁷ (Figure A-10), follows immunoassay principles for the detection of PCBs on samples such as the enzyme-linked immunosorbent assay (ELISA). Because of its high sample throughput, low detection limits, and selectivity, ELISA is the immunoassay technique most often used for environmental field testing. This technology has a detection range of 0.5 to 10 ppm.



Figure A-10. RaPID Assay PCB Test Kit from Strategic Diagnosis, Inc.

To perform this test, the sample is added along with an enzyme conjugate and mixed with paramagnetic particles coated with PCB-specific antibodies. Both the sample and the enzyme conjugate compete for the antibody binding sites on the paramagnetic particles. After incubation, a magnetic field is applied to hold the paramagnetic particles in the tube while the unbound reagents are decanted. Addition of an enzyme substrate (hydrogen peroxide) and a chromogen (3,3',5,5'-tetramethylbenzidine) will create a colored reaction. The color development will be inversely proportional to the concentration of PCB in the sample (e.g., the darker the color, the less analyte PCB is present in the sample).

The RaPID Assay PCB Test Kit also provides a separate gauze wipe kit called The RaPID Prep PCB Sample Extraction Kit. With this kit, the user is able to prepare wipe samples to be evaluated. The procedure consists of wiping a 100-cm² area with a hexane-saturated wipe, then mixing the content with a bottle of RaPID Prep PCB Extraction Solution. After diluting the sample in a

⁷ <http://www.modernwater.co.uk/monitoring/environment/>

vial of RaPID Prep PCB Extract Diluent, the sample is ready to use in the test kit.

Using the same extraction kit as for wipe samples, concrete samples can also be evaluated. The collection procedure consists of drilling holes in the structure and collecting the residual powder or dust. At least 10 g of powder are required for extraction and analysis. After collection, the concrete powder can be analyzed as a soil sample by adding approximately 0.5 g of salt to the soil collector. After this, the PCB RaPID Assay can be used by following the same procedure as outlined above.

The USEPA described the performance of this kit as "biased" depending on the Aroclor type, but described it as "precise" for a given set of environmental conditions.

Hach Company - PCB Immunoassay Kit

The Hach Company⁸ PCB Immunoassay Kit is a semi-quantitative screening method that indicates whether the PCB concentration is above or below the specified threshold values (1 ppm and/or 10 ppm). Field analysis method instructions cover soil only. However, existing reagents can be modified to address surface wipe or water applications.

Similar to other immunoassay kits, the process consists of mixing the sample with the enzyme conjugate and adding the mixture to an antibody-coated tube. After incubation, the sample is washed, and the color development reagents are added. The PCB concentration will be inversely proportional to the color development.

The system has been described by the USAEPA as light, easily transportable, and rugged – all of which makes it suitable for field sampling. Additionally, the unit's performance was characterized as unbiased and precise. The use of this technology is recommended for cleanup applications where



Figure A-11. PCB in Soil Pocket Colorimeter Test kit (www.hach.com).

⁸ <http://www.hach.com/>

it could be utilized as a quick test to determine status of cleanup activities.

Hach Company also manufactures the PCB in Soil Pocket Colorimeter Test kit (Figure A-11), which follows the same procedures as above but provides quantitative readings with a portable instrument, with ranges of 0 to 1, 5, 10, or 50 ppm.

Clor-N-Soil Test Kit

Clor-N-Soil Test Kit is designed to detect extracted PCB compounds from soil samples also using the principles of total organic chlorine detection and colorimetric methods. This is a portable test kit, sold in a small cardboard box (Figure A-12). The process to detect PCBs includes a sample extraction using butyl diglyme with mercuric nitrate and diphenyl carbazone solution as indicators. This solution will generate a colorimetric reaction where the color development is inversely proportional to the chlorine content. This gives a simple, colorimetric screening for soil matrices at 50 ppm.



Figure A-12. Clor-N-Soil products (www.dexsil.com).

Clor-N-Soil test kit is a low cost-per-sample alternative for PCB screening that requires little or no technical expertise to use it. Even though this method has a high sample throughput, one of its major limitations is the tendency for false positives in the presence of halogenated organic compounds, and false negatives in the presence of mercury. Therefore, the USEPA recommends the use of this technology where the Aroclor of concern is known, and where halogenated organics or mercury are not present.

Conclusions

There is a large body of evidence suggesting that PCBs were widely used as an ingredient in many different commercial formulations of paints and caulking materials. That evidence includes

- sampling at Army industrial sites,
- sales records from the manufacturer,

- contemporary ingredient lists, and
- individual current sampling events.

The Boston sampling campaign mentioned previously illustrates that it is hard to predict if PCBs are present in a particular instance. Paint, caulk, and sealant materials should be suspected of containing PCBs if they are in a building that was originally constructed or refurbished during the time of highest commercial use of PCBs, roughly 1955-1975. Earlier or later instances are not impossible, however.

Locations where PCBs in paint seem most likely to occur include swimming pools, boiler rooms, piping on industrial equipment or on walls of industrial buildings, or anywhere the paint might be subjected to thermal stress or vibration.

There is currently no regulatory requirement to find or remove these "non-liquid PCBs." The USEPA's posture seems to be evolving in light of recent discoveries of PCB caulk at schools, however. The latest regulations can be found at <http://www.epa.gov/epawaste/hazard/tsd/pcbs/pubs/laws.htm>.

If an installation has buildings suspected of containing PCBs, further investigation or sampling effort should focus on schools, housing, or other facilities where children might reasonably be suspected of coming in contact with painted surfaces.

APPENDIX B

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APPENDIX C

ABBREVIATIONS

Abbreviation	Spelled Out
AR	Army Regulation
CECW	Directorate of Civil Works, U. S. Army Corps of Engineers
CEMP	Directorate of Military Programs, U. S. Army Corps of Engineers
CERL	Construction Engineering Research Laboratory
CFR	Code of the Federal Regulations
Cr	chromium
DPW	Directorate of Public Works
DoD	Department of Defense
ELISA	enzyme-linked immunosorbent assay
ERDC	Engineer Research and Development Center
ETV	Environmental Technology Verification (program)
HQUSACE	Headquarters, U.S. Army Corps of Engineers
MSDS	material safety data sheet (see SDS)
Pb	lead
PCBs	polychlorinated biphenyls
POC	point of contact
PWTB	Public Works Technical Bulletin
SDS	safety data sheet
USACE	US Army Corps of Engineers
USEPA	US Environmental Protection Agency

APPENDIX D

MONSANTO PCB MATERIAL SAFETY DATA

MONSANTO PRODUCT NAME
**Polychlorinated
Biphenyls (PCBs)**

MONSANTO COMPANY
800 N. LINDBERGH BLVD.
ST. LOUIS, MO 63167

Emergency Phone No.
(Call Collect)
314-694-1000

Date: 10/88

PRODUCT IDENTIFICATION

Synonyms: PCBs
Chlorodiphenyl (___% Cl)
Chlorinated biphenyl
Polychlorinated biphenyl
Chlorinated biphenyls
(approx. ___% Cl)

**Trade Names/
Common Names:** Aroclor^{®1} Series 1016, 1221, 1232, 1242, 1248, 1254, 1260
Therminol^{®1} FR Series

PYRANOL^{®2} and INERTEEN^{®3} are trademarks for commonly used dielectric fluids that may have contained varying amounts of PCBs as well as other components including chlorinated benzenes.

ASKAREL - Generic name for a broad class of fire-resistant synthetic chlorinated hydrocarbons and mixtures used as dielectric fluids that commonly contained about 30-70% PCBs. Some ASKAREL fluids contained 99% or greater PCBs and some contained no PCBs.

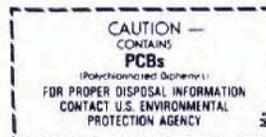
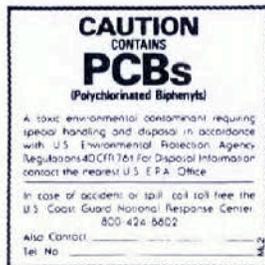
This list of trade names is representative of several commonly used Monsanto products (or products formulated with Monsanto products). Other trademarked PCB products were marketed by Monsanto and other manufacturers. PCBs were also manufactured and sold by several European and Japanese companies. Contact the manufacturer of the trademarked product, if not in this listing, to determine if the formulation contained PCBs.

^{®1} Registered trademark of Monsanto Company
^{®2} Registered trademark of General Electric Company
^{®3} Registered trademark of Westinghouse Electric Corporation

CAS No. 's: 001336363, 053469219, 021672296, 01109769, 011096825 and others

WARNING STATEMENTS

Federal regulations under the Toxic Substances Control Act require PCBs, PCB items, storage areas, transformer vaults, and transport vehicles to be marked. (check regulations, 40 CFR 761, for details)



MATERIAL SAFETY DATA
Polychlorinated Biphenyls (PCBs)



MATERIAL SAFETY DATA

PRECAUTIONARY MEASURES

Care should be taken to prevent entry into the environment through spills, leakage, use, vaporization, or disposal of liquid or containers. Avoid prolonged breathing of vapors or mists. Avoid contact with eyes or prolonged contact with skin. If skin contact occurs, remove by washing with soap and water. Following eye contact, flush with water. In case of spillage onto clothing, the clothing should be removed as soon as practical, skin washed, and clothing laundered. Comply with all federal, state, and local regulations.

EMERGENCY AND FIRST AID PROCEDURES

Ingestion: Consult a physician. Do not induce vomiting or give any oily laxatives. NOTE TO PHYSICIAN—If large amounts are ingested, gastric lavage is suggested.

Skin: If liquid or solid PCBs are splashed or spilled on skin, contaminated clothing should be removed and the skin washed thoroughly with soap and water. NOTE TO PHYSICIAN—Hot PCBs may cause thermal burns.

Eyes: Eyes should be irrigated immediately with copious quantities of running water for at least 15 minutes if liquid or solid PCBs get into them. A petrolatum-based ophthalmic ointment may be applied to the eye to relieve the irritating effects of PCBs.

Inhalation: Remove to fresh air. If skin rash or respiratory irritation persists, consult a physician. NOTE TO PHYSICIAN—If electrical equipment arcs over, PCBs or other chlorinated hydrocarbon dielectric fluids may decompose to produce HCl, hydrochloric acid, a respiratory irritant.

OCCUPATIONAL CONTROL PROCEDURES

Eye Protection: Wear chemical splash goggles and have eye baths available where there is significant potential for eye contact.

Skin Protection: Wear appropriate protective clothing and chemical resistant gloves to prevent skin contact. Consult glove manufacturer to determine appropriate type glove for given application. Wear chemical goggles, face shield, and chemical resistant clothing such as a rubber apron when splashing is likely. Wash immediately if skin is contaminated. Remove contaminated clothing promptly and launder before reuse. Clean protective equipment before reuse. Provide a safety shower at any location where skin contact can occur. Wash thoroughly after handling. **ATTENTION!** Repeated or prolonged contact may cause chloracne in some people.

Respiratory Protection: Avoid breathing vapor or mist. Use NIOSH/MSHA approved equipment when airborne exposure limits are exceeded. Full facepiece equipment is recommended and, if used, replaces need for face shield and/or chemical splash goggles. Consult respirator manufacturer to determine the type of equipment for a given application. The respirator use limitations specified by NIOSH/MSHA or the manufacturer must be observed. High airborne concentrations may require use of self-contained breathing apparatus or supplied air respirator. Respiratory protection programs must be in compliance with 29 CFR Part 1910.134.

Ventilation: Provide natural or mechanical ventilation to control exposure levels below airborne exposure limits (see below). If practical, use local mechanical exhaust ventilation at sources of air contamination such as open process equipment.

Airborne Exposure Limits: Chlorinated biphenyl (approximately 42% chlorine)
OSHA PEL: 1 mg/m³ 8-hour time-weighted average - Skin*
ACGIH TLV: 1 mg/m³ 8-hour time-weighted average - Skin*
2 mg/m³ short-term exposure limit - Skin*

*Skin notation means that skin absorption of this material may add to the overall exposure. Avoid skin contact.

(OCCUPATIONAL CONTROL PROCEDURES continued on page 3)

Polychlorinated Biphenyls (PCBs)

MATERIAL SAFETY DATA

Monsanto MATERIAL SAFETY DATA

OCCUPATIONAL CONTROL PROCEDURES (continued)

Airborne

**Exposure Limits
(Continued):**

Chlorinated biphenyl (approximately 54% chlorine)
OSHA PEL: 0.5 mg/m³ 8-hour time-weighted average - Skin*
ACGIH TLV: 0.5 mg/m³ 8-hour time-weighted average - Skin*
1 mg/m³ short-term exposure limit - Skin*

*Skin notation means that skin absorption of this material may add to the overall exposure. Avoid skin contact.

FIRE PROTECTION INFORMATION

Fire and

Explosion:

PCBs are fire-resistant compounds. They may decompose to form CO, CO₂, HCl, phenolics, aldehydes and other toxic combustion products under severe conditions such as exposure to flame or hot surfaces.

At temperatures in the range of 600-650°C in the presence of excess of oxygen PCBs may form polychlorinated dibenzofurans (PCDFs). Laboratory studies under similar conditions have demonstrated that PCBs do not produce polychlorinated dibenzo-p-dioxins (PCDDs).

PCBs in electrical equipment have been reported to produce both chlorinated dioxins (PCDDs) and furans (PCDFs) during fire situations. These combustion products may result all, or in part, from non-PCB components of the dielectric fluids or other combusted materials. Consult the equipment manufacturer for information regarding composition of the dielectric fluids in electrical apparatus.

Standard fire fighting wearing apparel and self-contained breathing apparatus should be worn when fighting fires that involve possible exposure to chemical combustion products. Fire fighting equipment should be thoroughly cleaned and decontaminated after use.

Federal regulations require all PCB transformers to be registered with fire response personnel.

If a PCB transformer is involved in a fire-related incident, the owner of the transformer may be required to report the incident. Consult and follow appropriate federal, state, and local regulations.

REACTIVITY DATA

PCBs are very stable, fire-resistant compounds.

HEALTH EFFECTS SUMMARY

Skin Contact: PCBs can be absorbed through intact skin. Local action on skin is similar to that of common organic solvents where contact leads to removal of natural fats and oils with subsequent drying and cracking of the skin. A potential exists for contracting chloracne.

Eye Contact: The liquid products and their vapors are moderately irritating to eye tissues.

Ingestion: The acute oral toxicities of the undiluted compounds are: LD₅₀ rats—8.65 gm/kg for 42% chlorinated, and 11.9 gm/kg for 54% chlorinated—"slightly toxic."

Inhalation: Animal experiments of varying duration and at different air concentrations show that for similar exposure conditions, the 54% chlorinated material produces more liver injury than the 42% chlorinated material.

(HEALTH EFFECTS SUMMARY continued on page 4)

MATERIAL SAFETY DATA
Polychlorinated Biphenyls (PCBs)

Monsanto

MATERIAL SAFETY DATA

HEALTH EFFECTS SUMMARY (continued)

Other: There are literature reports that PCBs can impair reproductive functions in monkeys. The National Cancer Institute performed a study in 1977 using Aroclor 1254 with both sexes of rats. NCI stated that the PCB, Aroclor 1254, was not carcinogenic under the conditions of their bioassay. There is sufficient evidence in the scientific literature to conclude that Aroclor 1260 can cause liver cancer when fed to rodents at high doses. Similar experiments with less chlorinated PCB products have produced negative or equivocal results.

The consistent finding in animal studies is that PCBs produce liver injury following prolonged and repeated exposure by any route, if the exposure is of sufficient degree and duration. Liver injury is produced first, and by exposures that are less than those reported to cause cancer in rodents. Therefore, exposure by all routes should be kept sufficiently low to prevent liver injury.

Numerous epidemiological studies of humans, both occupationally exposed and non-worker environmentally exposed populations, have not demonstrated any causal relationship between PCB exposures and chronic human illnesses such as cancer or neurological or cardiovascular effects. PCBs can cause dermatological symptoms; however, these are reversible upon removal of exposure source.

PCBs are identified as hazardous chemicals under criteria of the OSHA Hazard Communication Standard (29 CFR Part 1910.1200). PCBs have been listed in the International Agency for Research on Cancer (IARC) Monographs (1987)-Group 2A and in the National Toxicology Program (NTP) Annual Report on Carcinogens (Fourth).

PHYSICAL DATA

PROPERTIES OF SELECTED AROCLORS ¹							
PROPERTY	1016	1221	1232	1242	1248	1254	1260
Color (APHA)	40	100	100	100	100	100	150
Physical state	mobile oil	mobile oil	mobile oil	mobile oil	mobile oil	viscous liquid	sticky resin
Stability	inert	inert	inert	inert	inert	inert	inert
Density (lb/gal 25°C)	11.40	9.85	10.55	11.50	12.04	12.82	13.50
Specific gravity x/15.5°C	1.36-1.37 x-25°	1.18-1.19 x-25°	1.27-1.28 x-25°	1.30-1.39 x-25°	1.40-1.41 x-65°	1.49-1.50 x-65°	1.55-1.56 x-90°
Distillation range (°C)	323-356	275-320	290-325	325-366	340-375	365-390	385-420
Acidity mg KOH/g, maximum	.010	.014	.014	.015	.010	.010	.014
Fire point (°C)	none to boiling point	176	238	none to boiling point			
Flash point (°C)	170	141-150	152-154	176-180	193-196	none	none
Vapor pressure (mm Hg @ 100°F)	NA	NA	0.005	0.001	0.00037	0.00006	NA
Viscosity (Saybolt Univ. Sec. @ 100°F) (centistokes)	71-81 13-16	38-41 3.6-4.6	44-51 5.5-7.7	82-92 16-19	185-240 42-52	1800-2500 390-540	— —

NA—Not Available

Polychlorinated Biphenyls (PCBs)

MATERIAL SAFETY DATA

Monsanto MATERIAL SAFETY DATA

SPILL, LEAK & DISPOSAL INFORMATION

Cleanup and disposal of liquid PCBs and other PCB items are strictly regulated by the federal government. The regulations are found at 40 CFR Part 761. Consult these regulations as well as applicable state and local regulations prior to any disposal of PCBs, PCB items, or PCB-contaminated items.

If PCBs leak or are spilled, the following steps should be taken immediately:

All non-essential personnel should leave the leak or spill area.

The area should be adequately ventilated to prevent the accumulation of vapors.

The spill/leak should be contained. Loss to sewer systems, navigable waterways and streams should be prevented. Spills/leaks should be removed promptly by means of absorptive material, such as sawdust, vermiculite, dry sand, clay, dirt or other similar materials, or trapped and removed by pumping or other suitable means (traps, drip-pans, trays, etc.).

Personnel entering the spill or leak area should be furnished with appropriate personal protective equipment and clothing as needed. See Occupational Control Procedures section of this MSDS.

Personnel trained in the emergency procedures and protected against the attendant hazards should shut off sources of PCBs, clean up spills, control and repair leaks and fight fires in PCB areas.

All wastes and residues containing PCBs (e.g., wiping cloths, absorbent material, used disposable protective gloves, clothing, etc.) should be collected, placed in proper containers, marked and disposed of in the manner prescribed by EPA regulations (40 CFR Part 761) and applicable state and local regulations.

Various federal, state and local regulations may require immediate reporting of PCB spills and may also define spill clean-up levels. Consult your attorney or appropriate regulatory officials for information relating to spill reporting and spill clean-up.

ENVIRONMENTAL INFORMATION

Care should be taken to prevent entry of PCBs into the environment through spills, leakage, use, vaporization or disposal of liquids or solids. PCBs can accumulate in the environment and can adversely affect some animals and aquatic life. In general, PCBs have low solubility in water, are strongly bound to soils and sediments, and are slowly degraded by natural processes in the environment.

ADDITIONAL COMMENTS

Polychlorinated Biphenyls

For regulatory purposes, under the Toxic Substances Control Act the term "PCBs" refers to a chemical substance limited to the biphenyl molecule that has been chlorinated to varying degrees or any combination of substances which contain such substance (40 CFR Part 761).

Chemically, commercial PCBs are defined as a series of technical mixtures, consisting of many isomers and compounds that vary from mobile oily liquids to white crystalline solids and hard non-crystalline resins. Technical products vary in composition, in the degree of chlorination and possibly according to batch.

The mixtures generally used contain an average of 3 atoms of chlorine per molecule (42% chlorine) to 5 atoms of chlorine per molecule (54% chlorine). They are used as components of dielectric fluids in transformers and capacitors. Prior to 1972, PCB applications included heat transfer media, hydraulic and other industrial fluids, plasticizers, carbonless paper, paints, inks and adhesives.

In 1972 Monsanto restricted sales of PCBs to applications involving only closed electrical systems (transformers and capacitors). In 1977 all manufacturing and sales were voluntarily terminated. In 1979 EPA restricted the manufacture, processing, use, and distribution of PCBs to specifically exempted and authorized activities.

MATERIAL SAFETY DATA

Polychlorinated Biphenyls (PCBs)

Monsanto

MATERIAL SAFETY DATA

Page 6 of 6

DATE: Issued 10/1/88 - reprinted - 10-92

SUPERSEDES: All prior to 10/1/88

FOR ADDITIONAL NON-EMERGENCY INFORMATION, CONTACT:

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Polychlorinated Biphenyls (PCBs)

MATERIAL SAFETY DATA

Note: Although the information and recommendations set forth (hereinafter "Information") are presented in good faith and believed to be correct as of the date hereof, Monsanto Company makes no representations as to the completeness or accuracy thereof. Information is supplied upon the condition that the persons receiving same will make their own determination as to its suitability for their purposes prior to use. In no event will Monsanto Company be responsible for damages of any nature whatsoever resulting from the use of or reliance upon Information. NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR OF ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO INFORMATION OR THE PRODUCT TO WHICH INFORMATION REFERS.