

APPENDIX C

The Need For Continued Use of PCBs As Electrical Insulating Liquids

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TABLE 2

Composition of Different Liquid Chlorinated Biphenyls

<u>Components</u> <u>- given as % -</u>	<u>Monsanto Aroclors</u>							
	<u>1221</u>	<u>1232</u>	<u>MCS 1043</u>	<u>1242</u>	<u>MCS 1016</u>	<u>1248</u>	<u>1254</u>	<u>1260</u>
Chlorine	21	32	32	42	42	48	54	60
Biphenyl	14.8		.04	.02	.02			
Mono-chlorobiphenyl	56.5		22.2	.72	.93			
Di-chlorobiphenyl	26.9	~ 55	74.4	15.6	19.4			
Tri-chlorobiphenyl	1.42		3.3	54.5	64.5			
Tetra-chlorobiphenyl	.06			22.5	15.0	~ 55		
Penta-chlorobiphenyl				6.7*	.16*		60	
Hexa-chlorobiphenyl								70

*Includes higher than penta-chlorinated isomers.

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III. THE NEED FOR PCBs IN CAPACITORS

PCBs are used in more than 90 percent of the electric utility (large power) type and smaller industrial type capacitors made today. They are needed for safety, reliability and long life, and to achieve sizes compatible with equipment and installation requirements.

The principal types of PCB-impregnated capacitors and their applications are high voltage power capacitors used primarily for power factor correction in the distribution of electric power; low voltage power capacitors installed in industrial plants at the load (typically large motors); ballast capacitors to improve the efficiency of lighting systems; and small industrial capacitors for power factor improvement in such equipment as air conditioning units, pumps, fans, etc. Almost 80 million such capacitors are manufactured annually, most of them for first-time use.

Capacitors used in lighting and air conditioning applications contain 0.005 to 0.09 gallons of PCB per unit. The largest power capacitors contain about 6.7 gallons of askarel. The most popular size contains about 3.1 gallons. The National Electrical Code requires that any installation of capacitors in which any single unit contains more than 3 gallons of combustible liquid shall be in a vault like that required for transformers. During 1968, the last complete "normal" year for the electrical industry, the total amount of PCBs used in capacitors was approximately 14.4 thousand tons.

Possible alternatives to PCB-impregnated capacitors are capacitors impregnated with mineral oil, or certain other liquids.

A. MINERAL OIL

1. Size

The single most important property of a liquid to be used in a capacitor is its dielectric constant (the ratio of its ability to store electrostatic energy relative to air). The dielectric constant of the capacitor-grade PCB (Aroclor 1242) is 5.85 while that of mineral oil is 2.25. (See Table 3) Reverting to an oil-paper dielectric system would increase the average capacitor volume(size) by approximately 600 percent the weight by 500 percent, and the cost by approximately 400 percent. At the present levels of demand for capacitor KVAR, there would be a shortage of electrical grade paper and a shortage of capacitor factory facilities further tending to increase the cost to the utility, and ultimately to the consumer.

2. Reliability and Life

PCBs are thermally and oxidatively more stable than mineral oils, and discharges, which can occur in capacitors, are less likely to generate gases from askarels than from mineral oils. The chemical stability of PCBs in the presence of capacitor tissue and plastic films and the favorable stress distributions between solid and liquid have made it possible to design low-cost capacitors with a life expectancy of more than 10 years life in lighting applications and more than 20 years in electric utility applications. In each application the first-year failure rates are less than 0.2 percent. This level of life and reliability had not been achieved prior to the introduction of PCBs.

3. Safety

The relative non-flammability of PCBs significantly reduces the fire hazard that might otherwise accompany those failures that result in rupture of the case.

B. OTHER LIQUIDS

1. Castor Oil. The dielectric constant of castor oil is 4.5, and this material is useful as an impregnant in D.C. energy storage capacitors. However, A.C. capacitors filled with this liquid have relatively short lives and are not very stable under A.C. discharges and in the presence of water derivable from the cellulosic paper.

2. Dibutyl sebacate. This ester is especially useful in high frequency parallel plate capacitors because of its low, flat loss characteristics over a broad frequency range. In this type of construction the liquid is the sole dielectric material. When used in conjunction with paper, this ester is also unstable.

3. Silicone Fluids. These materials have a dielectric constant of 2.7 and would generally be subject to the same disadvantages as mineral oil.

In the interest of achieving a higher degree of environmental compatibility the capacitor industry switched during 1971 from Aroclor 1242 to Aroclor MCS 1016, from which the higher-chlorinated persistent fractions have been substantially removed.

IV. ENVIRONMENTAL PROTECTION

The advantages to the public in terms of safe, reliable, and efficient electrical equipment made possible by the use of PCBs have been documented in the body of, and especially Appendix B to, this report. It is also clear that there are no present or prospective substitutes for these materials, and that the functions they perform are essential. Thus the continuing need for PCBs in closed electrical system applications is conclusive. The electrical industry well understands, however, that continued use of these materials requires unusual protective measures. These measures were the subject of recommendations made by a previous NIPCC Sub-Council report (The Use and Disposal of Electrical Insulating Liquids, June 1971) and are judged to be well on their way toward implementation: witness the introduction of the new capacitor dielectric, the provision of facilities for the incineration of liquid and solid wastes, and the instructions to operating personnel and users regarding the need for care in waste disposal, an activity now being further formalized and strengthened by ANSI's committee C107. The annual residual leakage to the environment from the continued use in transformers and capacitors has been estimated between one part in a thousand and one in ten thousand of the existing environmental PCB burden.

1. The above paper was prepared by the Electric and Nuclear Sub-Council, National Industrial Pollution Control Council: Chairman, D. C. Burnham, Westinghouse Electric Corporation; Vice Chairman, Fred J. Borch, Chairman and Chief Executive Officer, General Electric Company; Members: A. P. Fontaine, President and Chairman, The Bendix Corporation; Raymond H. Giesecke,