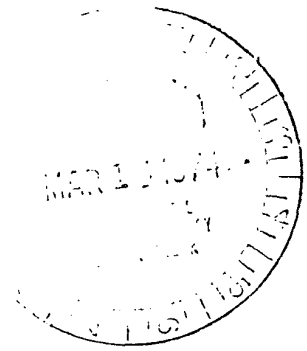
83-33



PRESENTATION

To The

INTERDEPARTMENTAL TASK FORCE ON PCBs

WASHINGTON, D. C.

May 15, 1972

by

MONSANTO COMPANY



WATER_PCB-SD0000001987

Introduction

By

W. B. Papageorge

Considerable interest has been and continues to be expressed by many involved in studies of PCBs and the environment concerning their degradability. Monsanto has received many inquiries relating to results of our studies. We now have accumulated some meaningful data which we believe would be appropriate to present in a status report to the Interdepartmental PCB Task Force. We sincerely appreciate this opportunity to share this information with you this afternoon.

Slide #1 - We plan to discuss current results of laboratory biodegration studies of PCBs and the levels of PCB residues observed in the tissues of laboratory animals which were used in our toxicity studies. We will review briefly actions Monsanto has taken to reduce PCB usage and environmental losses. We will also discuss the application of our laboratory findings to the development of a modified more readily degradable PCB mixture for use by the capacitor industry as a dielectric fluid. As many of you are aware, we have designated this material as Aroclor 1016.

Slide #2 - Our presentation will begin with Dr. Tucker discussing primary bacterial degradation and PCB residues in fish, fowl and mammal tissues. Dr. Munch will review evidence that demonstrates disappearance of PCBs from the environment and Dr. Paton will discuss Monsanto's PCB sales and use actions and the impact these actions will have on the environment.

Because of the limited time available, may I suggest that questions be held until all the speakers have completed their reports. Following the presentations there will be opportunity for further discussion of information which may be of particular interest to you.

Dr. Tucker, Research Group Leader, will now present a status report of his laboratory results.

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OBJECTIVES

- PROGRESS REPORT ON LABORATORY BIODEGRADATION OF PCB'S
- RESIDUE ACCUMULATION STUDIES IN FISH, BIRDS AND MAMMALS
- TO SHOW REDUCTION IN LESS BIODEGRADABLE PCB'S AS A RESULT OF MONSANTO ACTIONS ON SALES AND PRODUCTS

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AGENDA

- INTRODUCTION — W. B. PAPAGEORGE
- PCB STUDIES — E. S. TUCKER
  - PRIMARY BACTERIAL DEGRADATION
  - RESIDUES IN FISH, FOWL AND MAMMALS
- EVIDENCE FOR LOSS OF PCB FROM THE ENVIRONMENT — R. H. MUNCH
- MONSANTO PCB ACTIONS — C. PATON
- DISCUSSION

WATER_PCB-SD0000001990

ASSESSME. OF THE BIOLOGICAL PERSIS. ICE OF POLYCHLORINATED BIPHENYLS

By

Dr. E. S. Tucker

The research I will review today will focus upon one aspect of Monsanto's efforts to understand the environmental impact and behavior of our polychlorinated biphenyl or PCB products.

This research was initiated early in 1969 after development of the necessary PCB analytical methodology and subsequent confirmation of Dr. Soren Jensen's identification of PCB residues in fish and birds in Sweden.

At this point in time, PCB residue data from Monsanto and external environmental monitoring programs indicated that at the previous rate of use and release of these products that some PCB homologs were beginning to reach detectable levels in fish, birds and mammals. Conversely, these data indicated to us that with the exception of localized, controllable contamination, PCB homologs with less than five chlorine atoms per molecule had not accumulated to detectable levels; even though it was known that significantly greater amounts of the PCB homologs with less than 5 chlorine atoms per molecule had been manufactured and used over the years.

Now, before discussing our biological studies, I would like to review for you the gross homolog composition of our Aroclor products and then in a very brief fashion, try and illustrate to you the complexity of these materials and hence the complexity of the problem.

In the first slide (#1), is shown the most recent data on the weight % composition of four of our Aroclor products as a function of each detectable PCB homolog. The first column on the left lists the homolog in question and the subsequent columns under each product show the weight % distribution of each PCB homolog in each product.

As most of you probably know, with the exception of Aroclor 1016, the last two digits of each product number refer to the degree of chlorination. For example, Aroclor 1221 contains 21% chlorine by weight, and so on.

Aroclor 1016 is a special case in that while it contains about 41% chlorine by weight, its penta, hexa, and heptachloro biphenyl content has been significantly reduced with respect to Aroclor 1242, a product produced by direct chlorination, containing 42% by weight chlorine. Please note that the penta, hexa, and heptachloro biphenyl homologs in Aroclor 1016 have been reduced by factors of about 8, 10, and 10, respectively, with reference to Aroclor 1242.

As you can also see, the chief constituents of Aroclor 1221 are the mono- and dichloro biphenyls, while Aroclor 1016 and Aroclor 1242 contain predominantly di-, tri-, and tetrachloro biphenyls, and Aroclor 1254, tetra, penta, and hexachloro biphenyls.

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As I indicated earlier, this table represents our most recent efforts at determining the homolog distribution of our PCB products and as such a number of you may have seen estimations of the homolog content of these products which are significantly different. The analytical methodology used is currently in a very dynamic state and our understanding of the contents of these products increases as the methodology is improved. At this point in time, we regard these numbers as the most accurate ones currently available.

In the next slide (#2) are shown examples of low resolution - packed column electron capture chromatograms of Aroclor 1221, Aroclor 1242, Aroclor 1254, and Aroclor 1260. This is what these products look like to a residue analyst using the most commonly employed detection system.

From these chromatograms, it can be readily seen that we are dealing with multi-component products, which of course, increases the complexity of assessing every aspect of this problem - relative to a well defined single component system such as DDT.

I should mention at this point, that the PCB residues generally found in wildlife are most similar to Aroclor 1254 and Aroclor 1260 chromatograms.

The next slide (#3) demonstrates that in reality, these materials are even more complex than is generally realized. In the upper right portion of this slide is again shown a low resolution electron capture gas chromatogram of Aroclor 1242 under the optimum conditions normally employed by residue analysts. Under these conditions, Aroclor 1242 would appear to be a 15 component system.

In the lower portion of this slide is a flame ionization gas chromatogram of the same material using a high resolution S.C.O.T. column. If one carefully inspects this chromatogram, our simple 15 component product has now been resolved into 55 different components.

These facts simply indicate that all PCB products cannot be lumped together in terms of either their environmental impact or persistence.

The type of biological studies which we have carried out to date are shown in the next slide (#5). For discussion purposes, they can be conveniently divided into two categories: "Primary Bacterial Degradation Studies", an area in which research on PCBs is just beginning, and "Residue Accumulation Studies". Most of our bacterial degradation work has been centered around the fairly well known semi-continuous activated sludge degradation test.

Our residue accumulation studies have been fairly extensive and have involved the exposure of better than 2100 fish, chickens, rats and dogs to the various Aroclor products; resulting in the collection of over 1200 samples of which approximately 500 pooled samples were eventually analyzed for PCB residues.

The prime objective of these studies is given on Slide #6.

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Slide #7. The semi-continuous activated sludge test procedure we used to evaluate the primary bacterial degradation rates of the Aroclor products is the test method recommended by the Soap and Detergents Association for the evaluation of the biodegradability of linear alkyl benzene sulfonate type surfactants [JAOCS 42, 986 (1965) & 46, 432 (1969)].

> Primary Biodegradation - Minimum alternation of the chemical structure of the material in question to an extent that characteristic properties of the original material are no longer evident.

This procedure employs sludge from a sewage treatment plant as the source of microorganisms to which a specific amount of the material being evaluated and a synthetic sewage mixture are fed on a periodic basis in a specially designed aeration chamber. The next slide (#8) graphically illustrates what the aeration chamber looks like. It is simply a large glass cylinder with provisions for aeration, auxiliary stirring, a siphon for periodic removal of the supernatant and a septum for introduction of the test material.

The mixed liquor (sludge + water) obtained from the sewage treatment plant is initially adjusted with tap water to a suspended solids concentration of about 2500 mg/l, and 1500 ml of this mixture is then charged to the aeration chamber.

The mechanical cycle employed is shown in the next slide (#9). Each cycle is initiated by the addition of the synthetic sewage and 1 mg of the PCB product being tested.

Since the PCBs are quite water insoluble, they are fed to the unit via injection of 200 µls of a concentrated ethanol solution. In this manner, homogenous dispersion of the PCBs on the bacterial sludge is obtained.

After about one hour of aeration an aliquot of the mixed liquor is withdrawn from the chamber and analyzed for PCBs via UV spectrophotometry and/or electron capture gas chromatography. Aeration is continued for about 48 hours and a second sample is withdrawn for analysis. At this point, the aeration is stopped and the sludge allowed to settle, the sludge volume and pH are then checked to insure that the unit is operating satisfactorily. Two-thirds of the supernatant is withdrawn and replaced with tap water; aeration is then resumed. The cycle is re-initiated by the addition of the synthetic sewage and Aroclor in question. This cycle is continuously repeated until a steady state and consistent degradation rates are obtained.

The per cent degradation rate is calculated as shown in the equation on the slide from the amounts found in the samples analyzed during each cycle.

Degradation testing of the Aroclor products shown in the next slide (#10) have been carried out over an eight month period in our laboratories. In this slide, we have shown graphically the results observed to date. Here we have plotted the mean per cent degradation

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rates for biphenyl, Aroclor 1221, HCS 1043, a research material containing 30% by weight chlorine, Aroclor 1016 (41% chlorine), Aroclor 1242, and Aroclor 1254 versus the weight per cent chlorine present in each. The actual mean per cent degradation rates and 95% confidence limits for each material are shown in the lower left portion of the slide. These data were all obtained by UV spectrophotometry which in essence follows the decrease in the aromatic ring content and is indicative of bacterial ring cleavage. The important point to note here is that as the degree of chlorination decreases the degradation rate increases.

In order to give you a feeling for the degradation rates observed with other materials, Aroclor 1221 degrades at about the same rate as a non-linear ABS surfactant.

We have also used this technique to study p,p'-DDT and have at this point in time noted no significant primary degradation.

The next slide (#11) shows the changes in homolog distribution observed for Aroclor 1242 via electron capture gas chromatographic analyses. The upper chromatogram shows the character of the residue one hour after addition. The numbers above each peak indicate the dominant homolog or homologs present in each. The lower chromatogram is of the residue after 72 hours of exposure to the bacterial sludge. It can be readily seen by comparing the two chromatograms that all the dichloro biphenyls, most of the trichloro biphenyls, and a significant portion of the tetrachloro biphenyls are degraded in 48 hours under these test conditions.

The conclusions which we draw from this preliminary data are shown in the next slide (#12).

Next, I will discuss our "Aroclor Residue Studies" (Slide #13).

Our white leghorn chicken studies (Slide #14) have consisted of a 90 day oral exposure of Aroclor 1242, Aroclor 1254, and Aroclor 1260 at 1, 10, and 100 ppm feed levels and a repeat 90 day study of Aroclor 1242 at the 2, 4, and 8 ppm feed levels. 336 Chickens were employed from which a total of 521 tissue, chick, and egg samples were collected. Of these 112 pooled samples were analyzed for PCB residues.

In the next slide (#15) are shown the results of the 90 day oral exposure of white leghorn chickens to Aroclor 1242. On the left side, we have shown the oral exposure levels which were 1, 10, and 100 ppm, the theoretical residue in ppm, which would have been found in the lipid if the chickens had retained all of the Aroclor 1242 which they orally injested. As you can see, these levels are ~125, 1250, and 12,500 ppm. Next is shown the actual average level in ppm found in the lipid of the muscle, fat, and liver samples and then the levels found after 30 days on a PCB free diet. The important points to note are that ~90% of all the Aroclor 1242 consumed is directly excreted and/or metabolized and that after 30 days on a PCB free diet 35%, 44%, and 57% of the PCBs retained after 90 days of continuous exposure at the 1, 10, and 100 ppm levels was excreted and/or metabolized.

WATER_PCB-SD0000001994

the right hand side of this slide is shown the homolog distribution of the product fed and that of the residues isolated from the tissues after 90 days of exposure and 30 days on a PCB free diet. The numbers across the top simply refer to the number of chlorine atoms per biphenyl molecule. As you can see, Aroclor 1242 contains dominant amounts of the di- through pentachlorobiphenyls and a minor amount of hexachlorobiphenyl. After 90 days of exposure the dichlorobiphenyl was no longer observable and the dominant components were the tri- through pentachloro biphenyl homologs. After 30 days on a PCB free recovery diet, the hexachloro biphenyl is now a dominant component because of continued excretion and/or metabolism of the lower chlorinated homologs.

In the next slide (#16) are shown the results for the 90 day oral exposure of Aroclor 1254 in white leghorn chickens at the 1, 10, and 100 ppm exposure levels. The theoretical residues are the same as before and we have again shown the actual levels found in the tissues after 90 days of continuous exposure and 30 days on a PCB free diet. In this instance, ∿70-72% of the Aroclor 1254 ingested was directly excreted and/or metabolized and after 30 days on a PCB free diet, ∿45% of the residues retained were excreted and/or metabolized.

The homolog distribution of the product and residues is shown on the right of the slide, the product Aroclor 1254 contains minor amounts of the tri- and heptachloro homologs and dominant amounts of the tetra-, penta-, and hexachloro biphenyls. The residue after 90 days of exposure did not contain detectable amounts of the trichloro biphenyls and the tetrachloro biphenyls were no longer a dominant component. The dominant homologs were penta- and hexachloro biphenyls. After 30 days on a PCB free diet, the tetrachloro biphenyls were now not detectable, the pentachloro biphenyls were a minor component, and the hexachloro biphenyls the dominant component.

In the next slide (#17) are the results for Aroclor 1260. Again, the oral exposure level and theoretical residue levels are the same and the PCB residues found in the tissues after 90 days of continuous exposure and 30 days on a PCB free recovery diet are shown. After 90 days of exposure, 57-52% of all Aroclor 1260 consumed was directly excreted and/or metabolized and after 30 days on a PCB free diet ∿40% of the residues retained were excreted and/or metabolized.

As shown on the right, Aroclor 1260 contains dominant amounts of penta-, hexa-, and heptachloro biphenyls and a minor amount of octachloro biphenyl. The residues after 90 days of exposure and 30 days on a PCB free recovery diet contain minor amounts of the penta- and octachloro homologs. In both cases, the dominant homologs were the hexa- and heptachloro biphenyls.

Our albino rat work (Slide #18) has consisted of 30 day oral, 2 year chronic oral and a 3 generation rat reproduction exposure study with Aroclor 1242, Aroclor 1254, and Aroclor 1260 and a 90 day subacute

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Our beagle dog studies (Slide #23) have consisted of a two year chronic exposure of Aroclor 1242, Aroclor 1254, and Aroclor 1260 and a 90 day subacute study of Aroclor 1221. In these studies, 108 beagle dogs were used, resulting in the collection of 263 samples, and the analyses of 146 for PCB residues.

The next slide (#24) shows the results of one two year study of Aroclor 1242 at exposure levels of 1, 10, and 100 ppm. In this study, the theoretical residue levels are ~500, 5000, and 50,000 ppm respectively. We have also shown on this slide the residue levels found after two years of exposure and after 30 and 60 day periods on PCB free recovery diets. The beagle dogs directly excreted and/or metabolized 99.6% of the Aroclor 1242 consumed and after 60 days on PCB free diets, 50-60% of PCB residue retained after two years of exposure was excreted and/or metabolized.

Aroclor 1242 contains dominant amounts of the di-, tri-, tetra-, and pentachloro homologs and a minor amount of the hexa- homolog. The residue found after two years of exposure contained no detectable levels of the dichloro homologs and dominant levels of the tri-, tetra-, hepta-, and octachloro biphenyls. The pentachloro homolog, although dominant in the product fed, was not a dominant component of the residue. After 30 days on a PCB free recovery diet, the di-, tri-, and tetrachloro biphenyls were not detectable components of the residue. At this point, the dominant components were the hexa-, hepta-, and octachloro biphenyls. The trend toward excretion and/or metabolism of the lower chlorinated homologs continued to the extent that after 60 days on the recovery diet the hexachloro biphenyl was no longer a dominant component, and the hepta- and octachloro biphenyls became the dominant constituents in the residue.

In the next slide (#25) are the results for the two year exposure of beagle dogs to Aroclor 1254. The oral exposure and theoretical residue levels are the same and the PCB residue levels found in the tissues after two years of exposure and after 30 and 60 day periods on PCB free recovery diets are again shown.

In this instance, the dogs excreted and/or metabolized 98-99% of all Aroclor 1254 consumed over a two year period. After 60 days on a PCB free recovery diet, 30-40% of the residues retained were excreted and/or metabolized. The product fed, Aroclor 1254, contains minor amounts of the tri- and heptachloro biphenyls and dominant amounts of the tetra-, penta-, and hexachloro homologs. After two years of exposure, the residue retained from the product did not contain detectable levels of the tri- or tetrachloro biphenyls, the penta-, and hexachloro biphenyls remained dominant components, and the heptachloro biphenyls became dominant constituents.

After 30 days on the PCB free recovery diet, the pentachloro homologs became a minor component of the residue, the hexa- and heptachloro biphenyls remained dominant components and the octachloro homologs became a minor component. After 60 days on the PCB free recovery diet, the pentachloro biphenyls were excreted and/or metabolized to the extent that the octachloro homologs became a dominant constituent of the [illegible]

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The next slide (#26) shows the results for the two year oral exposure residue study of Aroclor 1260 in beagle dogs. The exposure and theoretical residue levels are the same as those for the Aroclor 1242 and Aroclor 1254 studies. Next is shown the residues which accumulated after two years of continuous exposure and the residues retained after 30 and 60 day recovery periods on PCB free diets. With this Aroclor 98-99% of the amount consumed over two years was directly excreted and/or metabolized. After 60 days on the recovery diet ~13% of the retained residues were excreted and/or metabolized.

The homolog distribution of Aroclor 1260 is as shown, dominant amounts of the penta-, hexa-, and heptachloro biphenyls with a minor amount of the octachloro homologs. After two years, the PCB residue contains no detectable level of the pentachloro homologs, a minor amount of the heptachloro biphenyls, and dominant amounts of the hexachloro and octachloro homologs. After 30 days on the recovery diet, the dominant homologs are now the hexa-, hepta-, and octachloro biphenyls becoming a dominant component of the residue via loss of some of the hexachloro biphenyls. After 60 days on the recovery diet, the hexachloro biphenyls are no longer dominant components of the residue and it is now mainly the hepta- and octachloro biphenyls.

The next slide (#27) illustrates the residue fall off as a function of Aroclor and recovery period. These data are from the two year beagle dog studies and the exposure level is 1 ppm. In this graph, I have plotted the average ppm PCB found in the lipid for Aroclor 1260, Aroclor 1254, and Aroclor 1242 after two years of continuous oral exposure and then after 1 month and 2 month recovery periods on PCB free diets. This plot simply demonstrates that the PCB residues retained from Aroclor 1242 fall off more quickly than those retained from Aroclor 1254 and Aroclor 1260.

The table in the next slide (#28) shows the relative ability of fowl, small mammals, and large mammals to retain orally ingested PCBs. These data are for Aroclor 1242 at the exposure levels and periods shown. The concentration factor is calculated by dividing the maximum PCB level found in the lipid by the exposure level. As you can see from the factors, chickens retain PCBs to a greater extent than do rats or dogs.

Our fish residue work is not very extensive at this point - primarily because we have had problems in finding consulting laboratories capable of carrying out dynamic low level fish exposure studies, and secondly, because government laboratories such as those in Duluth, Minnesota, Columbia, Missouri, and Gulf Breeze, Florida were, and are, still in better positions to carry out and evaluate these types of studies.

We have done some very preliminary 21 day dynamic exposures of catfish and bluegill fingerlings to some of our Aroclor products and it generally supports the conclusions which can be drawn from literature data.

The general conclusions which we draw from these residue studies are shown in the next three slides.

WATER_PCB-SD0000001997

Slide #29 - Build-Up - Conclusions

Slide #30 - Fall-Off - Conclusions

Slide #31 - Alteration of Homolog Distribution - Conclusions

In summary, we feel that the results of our preliminary research support, what has and is being observed via residue analysis of environmental samples; that is to say, from a residue viewpoint, that the bulk of the PCB homologs released to the environment (PCBs with less than 5 chlorines) are subject to environmental degradation of one sort or another at measurable rates and as such have not accumulated.

E. S. Tucker

WATER_PCB-SD0000001998

MONSANTO PCB ACTIONS

- PHASE-OUT OF PCB SALES WORLDWIDE IN ALL APPLICATIONS EXCEPT DIELECTRICS
- CONVERSION OF DIELECTRIC FLUIDS TO MORE BIODEGRADABLE PCB'S

WATER_PCB-SD00000001999

MONSANTO PCB SALES IN U.S.A.

(MILLION POUNDS)

	DIELECTRICS	ALL OTHERS	TOTAL
1969	37.0	30.0	67.0
1970	40.5	33.5	74.0
1972 (EST.)	32.0	--	32.0

WATER_PCB-SD000002000

EFFECT OF PHASE-OUT POLICY

PCB SALES REDUCED IN U.S.A. BY

30 TO 33 MILLION POUNDS,

OR 45%

WATER_PCB-SD0000002001

PCB PRODUCT
CHANGES IN DIELECTRICS

CAPACITORS

97% CONVERSION TO AROCLOR 1016

TRANSFORMERS

ELIMINATION OF AROCLOR 1260

WATER_PCB-SD000002002

DEGREE OF BIODEGRADATION OF PCB'S

BASED ON DATA PRESENTED

- TRANSITION IN BIODEGRADATION OCCURS AROUND PENTA-/HEXA-CHLOROBIPHENYL
- DISAPPEARANCE OF ALL HOMOLOGS BELOW HEXA-CHLOROBIPHENYL OBSERVED
- PENTA- AND HIGHER PCB DETERMINED BY SPECIFIC GLC/MS TEST METHOD

WATER_PCB-SD0000002003

PCB'S USED IN CAPACITORS

PCB	MAJOR USE PERIOD	% PCB (PENTA-CHLORO- AND HIGHER	% PCB (HEXA-CHLORO- AND HIGHER
AROCLOR 1254	1930-1952	77.0	29.0
AROCLOR 1242	1952-SEPT. 1971	9.0	1.0
AROCLOR 1016	OCT. 1971	1.1	0.1

WATER_PCB-SD0000002004

CAPACITOR FLUIDS
WHY CONVERT TO AROCLOR 1016?

- 9-FOLD REDUCTION IN PCB'S OF PENTACHLORO- AND HIGHER
- 10-FOLD REDUCTION IN PCB'S OF HEXACHLORO- AND HIGHER
- MINIMUM INDUSTRY TESTING REQUIRED

WATER_PCB-SD000002005

CAPACITOR FLUIDS
WHAT IS THE EFFECT OF AROCLOR 1016?

U.S. CAPACITOR FLUID SALES (1972):~20 M LBS.

IF AROCLOR WAS	% PENTACHLORO- AND HIGHER PCBs WOULD BE*	% HEXA CHLORO- AND HIGHER PCBs WOULD BE*
1254	15,400,000 POUNDS	5,800,000 POUNDS
1242	1,800,000	200,000
1016	220,000	20,000

*THIS DOES NOT MEAN AMOUNTS OF PCB ENTERING THE ENVIRONMENT

WATER_PCB-SD0000002006

WHAT IS CAPACITOR FAILURE RATE ?

INDUSTRY SOURCES CITE : 0.02-0.2% PER YEAR

WATER_PCB-SD0000002007

IF CAPACITOR FAILURE RATE IS 0.2% PER YEAR (WORST CASE)

PCB ESCAPE TO THE ENVIRONMENT* IS --

	AROCLOR 1242	AROCLOR 1016
ALL PCB HOMOLOGS	40,000 POUNDS	40,000 POUNDS
PENTA CHLORO- AND HIGHER	3,600	440
HEXA CHLORO- AND HIGHER	400	40

*ASSUMES U.S. FLUID SALES OF 20 M̄ LB./YEAR

WATER_PCB-SD0000002008

PCB CHANGES IN TRANSFORMER FLUID APPLICATIONS

- AROCLOR 1260 BEING PHASED-OUT NOW
- INCINERATION OF SCRAP PCB'S - 1971

NOTE: ASKAREL (PCB) TRANSFORMERS ARE HERMETICALLY SEALED UNITS

WATER_PCB-SD0000002009

IF ASKAREL (PCB) TRANSFORMERS FAIL AT 0.2%/YEAR HOW MUCH PCB IS AFFECTED* ?

ALL PCB HOMOLOGS 24,000 LBS.

(ESTIMATED PCB TRANSFORMER FLUID SALES IN U.S. 12 M LBS./YEAR)

*WITH INCINERATION FACILITIES AVAILABLE, NOT ALL THESE AMOUNTS WILL ENTER ENVIRONMENT.

WATER_PCB-SD0000002010

SUMMARY

By

W. B. Papageorge

In summary, our observations, admittedly limited, both from our laboratory data and from reports of other investigators lead us to believe with considerable confidence that PCBs do degrade in the environment. The complexity of the commercial mixtures has, however, hampered the determination of the varying rates of degradation of all the possible isomers.

Monsanto's sales actions have definitely reduced the amount of PCBs that could be introduced into the environment.

In those applications in which the use of PCBs is considered essential, namely transformers and capacitors, further actions will assure strict environmental control on PCBs.

In transformers the use of the lower chlorinated biphenyls along with proper handling during manufacture, use and repair and proper disposal of waste fluid by high temperature incineration should result in acceptable control.

For the capacitor application the development of Aroclor 1016, which satisfied all of the industry's requirements relating to dielectric characteristics and handling properties as well as having Underwriter Laboratory fire-resistance approval, permits the continued use of PCBs in this important hermetically sealed application but with a fluid that has a significantly lower content of the slower degrading isomers. The use of this material accompanied by proper handling and disposal of the scrap fluid by high temperature incineration represents in our considered opinion a significant step forward in our efforts to control the impact of PCBs on the environment.

WATER_PCB-SD0000002011