REPORT OF THE SUB-GROUP ON PCBS

To the Chairman,
Working Group on Disposal of Toxic and Hazardous Wastes

INTRODUCTION

1. We were established by the above Working Group in June 1973 in order to:

(i) consider whether PCBs should be subject to an authorisation procedure under the proposed legislation (at present lapsed) for the protection of the environment

(ii) identify particular problems arising in the disposal of PCBs

(iii) recommend appropriate methods of disposal of waste PCBs

(iv) submit a Report to the above Working Group incorporating an assessment of points (i)-(iii) above, describing how and where wastes arise, how they have been disposed of and what their impact has been on the physical and biological environment.

2. The complement of the Sub-group has been as follows:

Chairman: Mr I Prestt, Central Unit on Environmental Pollution, Department of the Environment; at present Deputy Director, Nature Conservancy Council

Secretary: Mr J P Giltrow, Central Unit on Environmental Pollution, Department of the Environment

Mr H A Vodden	Monsanto Chemicals Ltd
Dr D Davies	Marketing Director, Redland/Purle Ltd
Mr H Pullen	also of Redland/Purle, attended on one occasion
Mr R L Stanley	Director, BEAMA Transmission and Distribution Association
Mr Christopher	attended in Mr Stanley's place on one occasion
Mr A W Davies	Chief Pollution Officer, Glamorgan River Authority
Mr O Davies	also of the Glamorgan River Authority filled this position on Mr A W Davies's appointment to a regional water authority

MONS 044380

Mr N Stansfield	Department of Trade and Industry
Mr J Bentley	Directorate General, Water Engineering, Department of the Environment
Mr A W Kenny Mr R Osmond	of the above Directorate each attended one meeting.

The report of the above sub-group now follows.

THE NEED FOR SPECIAL ATTENTION

3. The term polychlorinated biphenyls (PCBs) refers to the range of substances in which more than one chlorine atom is substituted into the biphenyl molecule. As manufactured, PCBs are invariably mixtures of compounds chlorinated to varying degrees; they may also contain ter- and higher phenyls and furans. The number of chlorine atoms per molecule is adjusted to the proposed use, dielectric fluids for transformers being more highly chlorinated than those used in small capacitors.

4. It has already been recognised both nationally and internationally in OECD that the use and subsequent dispersal of PCBs warrant special attention. The reasons for this relate to their particular characteristics. PCBs do not occur naturally but are wholly synthetic substances which are generally very stable (stability increasing with degree of chlorination) and which persist in the environment for very long periods. Their high fat-solubility and the fact that some are metabolised and excreted only very slowly leads to their concentration and accumulation in the fatty tissues of living organisms. This persistence and accumulation, coupled with uncertainties about long-term effects of low concentrations, is the basis of the need for special consideration in disposal of wastes.

5. Prior to recent restrictions (paras 13 and 14), PCBs were used extensively as dielectric fluids for transformers and capacitors, as hydraulic fluids, heat transfer agents, lubricants and vacuum pump oils, and as plasticisers in adhesives, sealants, paints, plastics and carbonless copying paper. In consequence they have become widely (but not uniformly) distributed in the environment. Generally the higher levels are found in industrial areas, but elsewhere levels are usually very low. Typically, concentrations of less than 0.01 ppb* are observed in air and sea water and less than 1 ppb in fresh water; soil and submarine sediments usually contain less than 10 ppb, but up to several hundred thousand ppb near some industrial outfalls.

6. Aquatic organisms take in PCBs from water and the mean concentration in North Atlantic plankton is about 200 ppb, or more than 20,000 times the level in the

---

* 1 ppb is one part per billion (1 billion = 1 thousand million)

North Atlantic itself. In the larger invertebrates levels of up to 100 ppb in lobster and 500 ppb in mussels have been found. In fish, higher levels eg 10-2,000 ppb in herring and 100-1,000 in others, have been reported. Predatory birds living in polluted areas and feeding on aquatic organisms at the end of food chains can accumulate very high concentrations of PCBs. Thus the fish-feeding white-tailed eagle in the Baltic has been found with up to about 200,000 ppb in the whole body, and even higher levels in the liver. Similarly a heron in the UK has been reported with 900,000 ppb of PCBs in the liver.

7. Man of course eats food derived from animals but in the great majority of foods, PCBs are generally well below 50 ppb in the UK. The American Food and Drug Administration have set interim levels for safety ranging from 200 ppb for special infant and junior foods to 5,000 ppb for poultry and the edible portions of fish and shellfish.

8. In considering the toxicity of PCBs, it is necessary to distinguish between acute, chronic and long-term toxicity. Acute toxicity refers to a condition coming rapidly to a crisis, usually as a result of a single ingestion of a massive quantity of the toxin, whereas chronic toxicity refers to a condition which is established or recurrent.

9. The routes of entry of PCBs to man are via respiration, absorption through the skin and food. The first two may be relevant to acute toxic effects, the latter to chronic effects. The acute oral toxicity of PCBs to mammals and birds is low, with lethal levels being similar to those of DDT. For instance, in the case of rabbits, the oral LD_{50} (dose to kill 50% of the subjects) is in the range 4,000-20,000 ppm* whole body weight and the skin MLD (minimum lethal dose) is in the range 1,000-8,000 ppm whole body weight.

10. The chronic toxicity of PCBs to man and other mammals is moderate. In the "Yusho" incident in Japan, involving consumption of PCB-contaminated rice-oil, the average dose associated with significant clinical symptoms in man was about 30 mg/day, but positive effects were recorded for those consuming 3 mg/day over several months. Research is in progress to investigate possible low-level long-term effects.

11. Certain aquatic organisms are very unusual in that they may be killed by very low concentrations of PCBs in their environment, ie in the water: in particular, certain species of shrimps have been killed at levels of 1 ppb or less. This is a consequence of the uptake, concentration and accumulation of PCBs exhibited by these organisms.

* 1 ppm is one part per million.

12. Differences in the toxicity of commercial PCBs can arise from the importance of certain of the impurities, notably polychlorodibenzofurans. These substances may either originate from impure starting materials or arise as by-products of the manufacturing process. It is therefore difficult to set permissible levels for PCBs in the various components of the environment, especially in view of the limited data available for humans. However, the levels proposed for food in the USA have already been mentioned (para 7); in addition the US Environmental Protection Agency has recommended that discharges to water should be controlled so that levels of PCBs in the recipient waters do not exceed 0.01 ppb.

EXISTING CONTROLS

(a) Use

13. The UK is party to a voluntary international agreement of the OECD which in essence proposed that PCBs should be used only in closed systems in a limited number of cases where the risk of contamination of the environment is outweighed either by the fact that no adequate substitutes exist for particular applications or by the considerable advantages associated with their use in special areas, eg the safety aspects of their non-flammability.

14. In fact, the sole manufacturer of PCBs in the UK, Monsanto Chemicals Ltd, has since 1971 imposed its own restrictions, supplying PCBs to the electrical industry only, for use solely as dielectric fluids in transformers and capacitors. At present no adequate substitutes for these uses exist. UK practice therefore falls within the terms of the OECD agreement. Very small quantities of PCBs are also provided for research projects related to transformers and capacitors and also for analytical and toxicological studies. The likelihood of supplies reaching industry for other uses from unused pre-1971 stocks is thought to be minimal and in any case must be diminishing.

15. There is no information on possible imports of PCBs, either for material as produced or for products containing PCBs. However, in view of the fact that most manufacturing countries are members of OECD, it may be supposed that imports would only be supplied for uses coming within the terms of the OECD agreement.

(b) Disposal

16. The Oslo and London Dumping Conventions to which the UK is a signatory, prohibit dumping of PCBs at sea unless present in only trace quantities, and the Dumping at Sea Bill will enable enforcement of procedures developed for these conventions. In addition, the Deposit of Poisonous Wastes Act 1972 penalises the depositing on land of poisonous waste which gives rise to an environmental hazard.

PCB WASTES

17. In the UK, PCBs requiring disposal arise in several distinct areas: these are;

(i) manufacturing wastes;

(ii) imported wastes;

(iii) fluids from scrapped transformers;

(iv) dielectrical material from scrapped large capacitors;

(v) dielectrical material from scrapped small capacitors;

(vi) various materials from uses prior to the 1971 restrictions.

Manufacturing wastes

18. Manufacturing wastes, comprising both fluids and fluid-contaminated solid materials, amount to about 400 tonnes of PCBs/annum at present. As a result of the voluntary restrictions on sales and the development of alternative systems which do not employ PCBs, particularly for small capacitors, this quantity is not likely to increase. Liquid wastes, accounting for about one third of the total waste in this category, are at present disposed of by high-temperature incineration (see para 37). Solid wastes comprise still-bottom residues, contaminated rags, paper, sawdust, Fuller's Earth, etc and faulty capacitors arising at the manufacturing plant. Disposal of these solid wastes poses a technical problem which is dealt with in detail in paras 38-41.

Imported wastes

19. Because sufficient high-temperature incineration facilities are not available in continental Europe, about 250 tonnes of liquid PCBs are imported into UK each year for disposal by incineration. Whilst import involves transportation of large quantities of PCBs, and thus some risk of accidental spillage, it is preferable that adequate methods, ie high-temperature incineration, should be used, rather than inadequate, eg indiscriminate dumping. In the absence of adequate facilities in continental Europe , this trade should not be discouraged.

Transformers

20. PCBs have been used in transformers since the 1940s. These particular PCBs are the highly-chlorinated, very persistent types. Since 1971, all transformers have carried a label warning users of the need for adequate disposal methods, and some have done so since 1940. There is a need for a unified, standard label to be

agreed, and it is preferable that this should be done internationally. This is being considered by the EEC and other interested parties. Some manufacturers of transformers have written to all purchasers of transformers, even back to those buying in the 1940s, informing them of the need for adequate disposal arrangements. Others might be encouraged to do likewise.

21. The major UK transformer manufacturers are GEC, with factories at Stafford, Broadstairs and Walton-on-Thames; Brush (Hawker-Siddeley) at Loughborough; Ferranti at Hollinwood, Manchester; and Parsons of Peebles in Scotland. There are also a number of smaller manufacturers including Bonar Long in Scotland, Fullers at Walthamstow, AGEC in Northern Ireland and Yorkshire Transformers.

22. Collectively, these manufacturers use about 300 tonnes of PCBs annum, but the usage is decreasing due to the development of large dry-type transformers and alternative high-duty dielectric fluids such as those based on silicones. However, the higher costs of dry transformers (up to 60% more than the equivalent fluid-filled unit) and the substantially higher cost of silicone units (up to 5 times more expensive than the conventional type) is at present retarding a general change over to their use.

23. PCB-filled transformers are used principally where there would be serious consequences if a flammable dielectric were to ignite, eg in ships, basements of buildings and, in continental Europe, in mines. However, the dense fumes which are evolved when they become overheated make them unacceptable for some similar applications, eg in the London Transport Underground system, where there is an internal restriction against their use. They are not used in coal mines in the UK for technical reasons.

24. Transformer users are advised by the manufacturers to sample the dielectric fluid at regular intervals and to have the sample analysed by Monsanto. The fluid may pick up water during service and this may cause dielectric failure, necessitating replacement of the fluid. Dalton and Co of Belper offer a reclamation service for PCBs; they have the facilities to recover about 200 tonnes/annum, but at present are recovering only about 40 tonnes/annum. This material costs about half as much as new material. Unreclaimable fluids arising from this source are disposed of by high-temperature incineration.

25. The life of large transformers is about 30 years and a few units, containing a total of about 10 tons of liquid PCBs are scrapped each year at present. These liquids are disposed of by high-temperature incineration. About 300 units are

currently manufactured each year in UK, of which about 200 are for the home market. By 1985, about 100 units/annum, containing a total of about 130 tons PCBs, may require scrapping; by the year 2000, the level may reach 200 units/annum, equivalent to 250 tons PCBs.

Large capacitors

26. Power factor correction capacitors are used to smooth out fluctuations in current in electrical power circuits and many large factories are equipped with banks of such capacitors. The principal manufacturers in the UK appear to be BICC, Dubilier and Johnson and Phillips, but a small number of other companies are said to make these types of capacitor on a one-off basis. It is probable that a total of a few thousand of these units are made each week. On average over the last 5 or 6 years, about 600 tonnes of PCBs have been used annually in this application.

27. In the UK, each capacitor contains between about 0.75 and 30 kg of PCBs, the average quantity being about 3kg. Most of this is absorbed on the windings, but a little is present as the free liquid. These capacitors first went into service in the late 1950s, but because of their long life (about 25 years), very few have yet been taken out of service. However, by the 1980s, a number sufficient to give rise to about 130 tons of PCBs will require disposal and by the year 2000 this may rise to about 400 tons PCBs. Thus these will be more important, in terms of quantity of PCB waste, than transformers. It is desirable and practicable that these units should also be labelled on an internationally agreed basis as to the need for adequate disposal and this is being discussed.

Small capacitors

28. These are generally mounted singly inside equipment such as flourescent light fittings, in the starting systems of fractional horse-power electric motors used in washing machines, air conditioning units and refrigerators and in a range of industrial electrical equipment. Each capacitor contains of the order of 50 g of PCBs, the majority of which is absorbed on the paper insulating separator.

29. The principal manufacturers of small capacitors are Plessey, Pye TMC, RIC, STC and Dubilier. The larger users have storage tank facilities for PCBs supplied by tanker, whilst the smaller use drums. About 12 million capacitors are now being produced annually for use in flourescent light fittings and a total about 60-100 million have been installed: for electric motors, the figures are put at 4 million and 20-30 million respectively. The total quantity of PCBs used in small capacitors has averaged about 600 tonnes/annum over the last few years, but this is likely to diminish (para 32).

30. The rate of scrapping of these items varies widely: moreover, in the case of washing machines etc the capacitor and motor is often recovered and reused when the parent equipment is discarded. Hence it is difficult to estimate a mean life for small capacitors but it is probably between 5 and 10 years.

31. At present the quantity of PCBs in capacitors being scrapped is probably about 250 tonnes/annum; this may rise to a peak of about 600 tonnes/annum around 1980 and then fall to about 100 tonnes/annum by 1990, due to the introduction of other forms of dielectric (see para 32).

32. There has been some movement towards the use of alternative materials in capacitors for flourescent light fittings and this trend has accelerated very recently. A dry-type capacitor, based on metallised polypropylene, has been introduced and is currently used in about 5% of new fittings, even though it is at present about 10% more expensive than the PCB-filled type. One company now uses only the new dry-type capacitor for 220 volt fittings and will be doing the same for 440 volt fittings shortly. It has been predicted that the use of PCB-filled capacitors in this application may be discontinued entirely within the next 3-5 years. There is also some evidence that the use of capacitor-start motors in domestic appliances is diminishing, due to changes in design, automatic washing machines now employing direct-current motors and refrigerators using package cooling units.

33. Removal of PCB-filled capacitors from each separate item of electrical equipment prior to scrapping is not practicable. These items are at present disposed of in a variety of ways:

(i) by local authorities using land fill where there is no recovery for scrap, the item being simply buried at the base of tipping face. Here it has been observed that motors (and thus capacitors) have sometimes been removed before disposal

(ii) by local authorities at a depot (ie treatment or transfer plant) where there is recovery and disposal of the electrical equipment to a scrap merchant

(iii) by the normal scrap merchant; ferrous scrap is either baled and sent direct to a steelworks or to a fragmentation plant. In the latter case (which nowadays is more usual), the fragmented scrap is cleaned (sometimes by incineration at low temperature) and separated magnetically into ferrous and non-ferrous metals.

34. It has not been possible to obtain quantitative information about what proportion of small capacitors is disposed of by each of the above methods. However, the PCB contents of those which undergo metal processing in a steel blast furnace, where temperatures reach 1600°C, will be destroyed and detoxified. Of those undergoing non-ferrous recovery, the PCB content will almost certainly be distilled in the atmosphere although some degradation may occur. And finally, the PCB content of those undergoing landfill will only be leached out when the sealed casing of the capacitor is ruptured, and then only very slowly, since little free liquid is present. These particular PCBs are less highly chlorinated than those used in transformers and are more readily degradable.

Miscellaneous

35. Prior to the voluntary restrictions of 1971, PCBs were used in a wide variety of applications (para 5). In consequence both liquid PCBs and PCB-contaminated materials to be disposed of are still arising from these sources, and may continue to do so for some time yet. The total quantity of PCBs in this category disposed of by incineration since the inception of the Deposit of Poisonous Wastes Act 1972 is about 100 tonnes.

METHODS OF DISPOSAL

Principles

36. The objective of disposal methods must be to avoid unnecessary and uncontrolled dispersal of PCBs. The Oslo and London Dumping Conventions, to which the UK is a signatory, already prohibit dumping at sea, unless present in trace quantities; and the deliberate disposal of PCBs to the sea, to estuaries, rivers and sewers cannot be knowingly permitted. While, ideally, controlled discharges should also be free from PCBs, it is inevitable that there will be low concentrations in the discharges from plants manufacturing and handling PCBs. In such cases, levels in the discharges should be controlled so that levels in the recipient waters do not exceed 0.01 ppb, as recommended by the Environmental Protection Agency.

Incineration facilities - fluids

37. The only proven adequate process ensuring destruction and detoxification of liquid PCBs is high-temperature incineration. At present there is only one high-temperature incineration plant available for use in the UK servicing the waste-disposal industry capable of effectively disposing of liquid PCBs, that of Redland/Purle at Rainham,

Essex. By the end of the year another will be commissioned, and we understand that another 2 or 3 may become operational in the near future. These facilities burn liquid organic wastes, including PCBs, at a temperature of about 1200°C, high enough to convert PCBs to CO_2, H_2O and HCl. The first two vapours are of relatively low or negligible environmental impact; HCl is removed from the effluent by scrubbing, ensuring full compliance with the standards of the Alkali Act. The PCBs are therefore effectively destroyed and detoxified. The total available capacity in the UK for high-temperature incineration of liquid organic wastes will be 20,000 tonnes/annum by the end of 1973, of which ca. 60% could be chlorinated wastes. Hence these facilities will be adequate to provide for disposal of the quantities likely to arise at least up to the end of this century. The site cost of disposal by this method is typically at present about £10-£30/ton, the upper limit being applicable to the more highly chlorinated substances; collection and transport costs which have to be added will vary of course with distance of the source from the plant.

Incineration facilities - solids

38. One possible disposal method for solid PCB-contaminated wastes involves a preliminary stage of volatilisation of the PCB content, followed by collection of the fluid and incineration in the available fluid incineration plant. Unfortunately, technical problems have arisen with this method. Combustion of the evaporating PCBs occurs within the heating ovens, resulting not only in uncontrolled emissions but also in explosions, which are clearly dangerous to the operating staff. At present, therefore, this method is not adequate for disposal of solids contaminated with PCBs. It is also known that the rotary kilns operating in the USA have run into similar problems when attempts have been made to incinerate PCB-contaminated solids.

39. There are three types of solid wastes requiring disposal: these are

(i) "still-bottom residues" from the PCB-manufacturing process, materials ranging in constitution from tars to glasses and amounting to about 250 tonnes/annum

(ii) paper windings from small capacitors, in particular those arising in large quantities in faulty capacitors at the capacitor manufacturing or handling plant

(iii) contaminated rags, sawdust, Fuller's Earth etc, arising at manufacturing and handling plants.

40. None of these can be disposed of at present by high-temperature incineration. This is not a problem in the case of (iii), since the quantities are very small and

landfill is an adequate disposal method. For (ii), the problem is a diminishing one, since PCB-containing small capacitors are being replaced by alternative types. However, there is now a backlog, accumulated over the last 18 months, of about 100 tonnes of faulty units requiring disposal. Finally, category (i), still-bottom residues, represent a low volume, high-hazard waste requiring destructive disposal for which no adequate technology exists at present.

41. The cost of research into alternative methods of disposal for still-bottom residues is likely to be considerable, perhaps £50,000-£100,000. One possibility involves the use of waste solvents, eg toluene, to get the residues into solution (and thus combustible in the fluid-incineration plant), but this is best done at the end of the manufacturing process, not on material already set glass-like in a storage drum. Alternatively, it may be possible to reduce the melting point of the residues, but this may create process technology problems. It is not yet possible to set a time scale on the development of alternative technologies. Finally, the hearth-type kiln being developed by Rechem Ltd is being investigated for its ability to destroy the PCB content of contaminated solids.

RECOMMENDATIONS

42. In view of the evidence now available concerning the action and distribution of PCBs, we recommend that their use and disposal should be subject to special consideration.

Use

43. We regard the present voluntary controls exercised by the sole UK manufacturer as satisfactory. This voluntary system cannot control the import of either bulk PCBs or PCB-containing products, but these are most likely to come from member countries of OECD and should thus be subject to similar restrictions under the OECD agreement. However, we regard it as necessary that import of both bulk PCBs and PCB-containing products from non-OECD countries should be subject to control by licence.

44. At present, it is not profitable to recover and re-use PCBs from some applications, but the situation may change. Those recovered PCBs fall outside the scope of the present voluntary scheme. In addition, another manufacturer could at any time commence manufacture of PCBs. Whilst in both these cases, subsequent uses should be covered by the OECD agreement, they would not be covered by the present manufacturer's rather more restrictive voluntary scheme. We therefore recommend that the present arrangements should continue but be kept under review.

Disposal - liquids

45. A method of disposal of liquid PCBs that is known to be safe is high-temperature incineration and we therefore recommend obligatory disposal of liquid PCBs by this method. This recommendation thus applies to liquid manufacturing and imported wastes and liquid from transformers and large capacitors. Approved incineration plants will be specifically licensed for this purpose. We recommend that facilities should be provided for analysis of stack gases to be carried out at frequent intervals. A realistic figure for stack emissions of PCBs, based on experience gained at manufacturing plants, is a concentration of $1 mg/m^3$, with a total overall emission limit of 0.5 kg/day for each side. There are practical difficulties associated with the methods to be adopted to ensure these conditions are being met. These are at present being considered by the International Electrotechnical Commission (Technical Committee 10) on which the UK industry is represented, so we recommend that if an agreed methodology is proposed by this body, the same should be adopted in the UK for sampling and analysis of stack gases for PCBs.

46. Purchasers of transformers and large capacitors are informed of the need for adequate disposal and each piece of equipment now sold carries a label to this effect. We think that this system will prove effective when such equipment becomes obsolete. However, there is a potential problem associated with disposal of unlabelled first-generation equipment. Some retrospective labelling is being carried out; we welcome this and would wish to see this practice universally adopted by manufacturers of this kind of equipment. We feel that the probability of large transformers being obtained by uninformed scrap merchants is minimal and we regard the retrospective labelling exercise as all that can practically be achieved. However, we regard as desirable the compilation of a register of transformers containing PCBs, since this will aid in future identification.

Disposal - solids

47. The most difficult disposal problem for the solid PCB wastes arise with the still-bottom residues. These must not be disposed of by methods which are not destructive, eg landfill, but cannot yet be successfully incinerated. We therefore recommend that still-bottom residues be stored in a safe, secure and monitored place until such time as an adequate technological disposal method is developed. Storage sites and facilities should be registered and licensed for this specific purpose, and the site conditions with regard to monitoring and supervision should be specified. This recommendation may be taken as a general principle for any hazardous low volume waste for which no

adequate disposal technology exists: namely that it is preferable to store safely and securely until adequate methods of disposal are developed than to disperse the waste in an uncontrolled way.

48. The other two categories of PCB-contaminated solids requiring disposal are small capacitors and rags, paper, sawdust etc from manufacturing and handling plants. Where capacitors remain on the equipment on which they are used, we consider it acceptable that they should be disposed of by landfill, ie tipping on to dry tips. This method is also acceptable for the small quantities of contaminated rags etc which arise at manufacturing and handling plants. Where large numbers of capacitors themselves arise (as distinct from equipment using capacitors), eg as faulty units at manufacturing plants, we had hoped that their PCB content would have been destroyed during disposal by incineration at high temperature. However, a method for solids is not yet satisfactorily developed; these capacitors could therefore either be stored, as for still-bottom residues, or be disposed of by landfill. In view of the fact that the numbers of capacitors arising for disposal is likely to diminish rapidly as alternative dielectric materials come into use, we consider storage unnecessary. However, we recommend that disposal of such capacitors, including the backlog mentioned above in para 40, be a licenced procedure, to be carried out to ensure dispersal of these units to as many available and suitable tips as possible. This will avoid unnecessary concentrations arising at any particular tip. We further recommend that a record be kept of the quantities of these capacitors, and their PCB contents, going to each individual tip.

Transportation

49. The carriage on land of waste liquid PCBs should be subject to comparable conditions in terms of labelling, handling, packaging and transport as are at present voluntarily applied in UK to freshly-manufactured bulk liquid PCBs. A Code of Practice of this type is at present being drawn up by Study Committee 15, Working Group 0/2 of the Conference Internationale des Grandes Reseaux Electriques a Haute Tension (CIGRE); this would form the basis for an internationally acceptable procedure.

Analogous substances

50. Substances such as alkylated chlorobiphenyls and polychlorinated terphenyls (PCTs) are structurally similar to PCBs and have comparable properties. They have, as yet, only very restricted uses in the UK and are not manufactured here. They

do not come within the terms of the OECD agreement on PCBs and there are no controls over their import. We feel that, in particular, these substances should be subject to the same constraints in use and disposal as we recommend for PCBs, but positive proposals will depend on whether their use expands. We recommend that they be kept under review.

(Signed) I Prestt (Chairman)

D Davies	R L Stanley
M Stansfield	G Davies
H A Vodden	J Bentley

J P Giltrow (Secretary)

WORKING GROUP ON THE DISPOSAL OF TOXIC WASTES
REPORT OF THE SUB-GROUP ON PCBs

1. The need for special attention

It has already been recognised both nationally and internationally in OECD that the use and subsequent disposal of polychlorinated biphenyls (PCBs) warrant special attention. The reasons for this relate to their particular characteristics. PCBs do not occur naturally but are wholly synthetic substances which are generally very stable and which therefore persist in the environment for very long periods. Their high fat-solubility and the fact that some are metabolised and excreted only very slowly leads to their concentration and accumulation in the fatty tissues of living organisms. This persistence and accumulation, coupled with uncertainties about long-term effects of low concentrations, is the basis of the need for special consideration in disposal of wastes.

Prior to recent restrictions (Section 2), PCBs were used extensively as dielectric fluids for transformers and capacitors, as hydraulic fluids, heat transfer agents, lubricants and vacuum pump oils and as plasticisers in adhesives, sealants, paints, plastics and carbonless copying paper. In consequence they have become widely (but not uniformly) distributed in the environment. Generally the higher levels are found in industrial areas, but elsewhere levels are usually very low. Typically, concentrations of less than 0.01 ppb* are observed in air and sea water and less than 1 ppb in fresh water. Soil and submarine sediments usually contain less than 10 ppb, but up to several hundred thousand ppb near some industrial outfalls.

Aquatic organisms take in PCBs from water and the mean concentration in North Atlantic plankton is about 200 ppb, or more than 20,000 times the level in the North Atlantic itself. In the larger invertebrates levels of up to 100 ppb in lobster and 500 ppb in mussels have been found. In the fish higher levels eg 10-2000 ppb in herring and 100-1000 in others, have been reported. In extreme cases of predatory birds at the end of food chains living in polluted areas, very high concentrations can occur. Thus the fish-feeding white-tailed eagle in the Baltic has been found with up to about 200,000 ppb in the whole body, and even higher levels in the liver. Similarly a heron in the UK has been reported with 900,000 ppb of PCBs in the liver.

* 1 ppb is one part per billion (1 billion = 1 thousand million)

Man of course eats food derived from animals but in the great majority of cases PCBs are generally well below 50 ppb in the UK. The American Food and Drug Administration have set interim levels for safety ranging from 200 ppb for special infant and junior foods to 5000 ppb for poultry and the edible portions of fish and shellfish.

The routes of direct entry of PCBs to man are via inhalation and absorption through the skin. The acute oral toxicity of PCBs to mammals and birds is low, with lethal levels being similar to those of DDT. The oral LD_{50} (dose to kill 50% of the subjects) is in the range 4000 - 20,000 mg/kg body weight and the skin MLD (minimum lethal dose) for rabbits is in the range 1000-8000 mg/kg body weight. Their chronic toxicity to man and other mammals is moderate. In the "Yusho" incident in Japan, involving consumption of PCB-contaminated rice-oil, the average dose associated with significant clinical symptoms in man was about 30 mg/day, but a minimum positive effect level was lower at 3 mg/day over several months. Research is in progress to investigate possible low-level long-term effects.

PCBs can be lethal to certain aquatic organisms at very low concentrations in the water; in particular, certain species of shrimps have been killed at levels of 1 ppb or less. This is a consequence of the uptake, concentration and accumulation exhibited by these organisms.

Differences in the toxicity of commercial PCBs can arise from the presence of certain impurities, notably polychloro-dibenzo furans. These substances may originate as by-products in the basic starting materials or arise from the processing conditions.

2. Manufacture and present uses

The sole manufacturer of PCBs in the UK is Monsanto Chemicals Ltd. Since 1971 the Company has supplied PCBs to the electrical industry only, for use solely as dielectric fluids in transformers and capacitors. At present no adequate substitutes for these uses exist. Very small quantities of PCBs are also provided for research projects related to transformers and capacitors and also for analytical and toxicological studies. The likelihood of provision other users of PCBs having significant unused stocks is thought to be minimal, and this must be a diminishing possibility.

3. Control measures

(a) Use

The UK is party to a voluntary international agreement of the OECD. Essentially this proposed that PCBs should be used only in closed systems in a limited number of cases where the minimal risk of contamination of the

environment is outweighed either by the fact that no adequate substitutes exist for particular applications or by the considerable advantages, eg safety, associated with their use in special areas. The voluntary restrictions operated by the PCB manufacturer in the UK ensure that UK practice falls within these terms.

(b) Disposal

The objective of disposal methods must be to avoid unnecessary and uncontrolled dispersal of PCBs. The Oslo and London Dumping Conventions, to which the UK is a signatory, prohibit dumping at sea, unless present in trace quantities. The deliberate disposal of PCBs to the sea, to estuaries, rivers and sewers cannot be knowingly permitted. While ideally controlled discharges should also be free from PCBs, it is inevitable that there will be low concentrations in the discharges from plants manufacturing and handling PCBs. In such cases, levels in the discharges should be controlled so that levels in the recipient waters do not exceed 0.01 ppb, as recommended by the Environmental Protection Agency. In view of these principles, PCBs must therefore preferably be destroyed and detoxified or disposed of on land where their mobility is restricted and where control can be exercised. The only proven adequate process ensuring destruction and detoxification is high-temperature incineration.

4. Categories of PCBs requiring disposal

PCBs requiring disposal arise in several distinct areas:

(i) Manufacturing wastes

The majority of PCBs disposed of in UK arise from manufacturing wastes. These are at present disposed of by high-temperature incineration. The quantity amounts to about 400 tons/annum at present, and is not likely to increase.

(ii) Imported wastes

Because sufficient high-temperature incineration facilities are not available in continental Europe, about 250 tons of liquid PCBs are imported into UK each year for disposal by incineration. Whilst import involves transportation of large quantities of PCBs, and thus some risk of accidental spillage, it is preferable that adequate methods, i.e. high-temperature incineration, should be used, rather than inadequate, eg indiscriminate dumping. In the absence of adequate facilities in continental Europe, this trade should not be discouraged.

MONS 044396

(iii) Transformer fluids

PCBs have been used in transformers since the 1940s. These particular PCBs are the highly-chlorinated, very persistent types. Since 1971, all transformers have carried a label warning users of the need for adequate disposal methods, and some have done so since 1940. There is a need for a unified, standard label to be agreed, and it is preferable that this should be done internationally. This is being considered by the EEC and other interested parties. Some manufacturers of transformers have written to all purchasers of transformers, even back to those buying in the 1940s, informing them of the need for adequate disposal arrangements. Others might be encouraged to do likewise.

The life of transformers is about 30 years and a few units, containing about 10 tons PCBs in total, are scrapped each year at present. About 300 units are manufactured each year in UK, of which about 200 are for the home market. By 1985, about 100 units/annum, containing a total of about 130 tons PCBs, may require scrapping; by the year 2000, the level may reach 200 units/annum, equivalent to 250 tons PCBs. There is only very slow growth in the demand for PCB-filled transformers and it seems unlikely that any sudden increase in demand will arise.

(iv) Large capacitors

Power factor correction capacitors used in the UK contain between 0.5 and 20 litres of PCBs. Most of this is absorbed in the winding, but a little is present as the free liquid. Such capacitors first went into service in the late 1950s but because of their long life (about 25 years), very few have yet been taken out of service. However, by the 1980s, a number sufficient to give rise to about 130 tons of PCBs will require disposal and by the year 2000 this may rise to about 250 tons PCBs. Thus these will be equivalent, in terms of quantity of PCB waste, to transformers. It is desirable and practicable that these units should also be labelled on an internationally agreed basis as to the need for adequate disposal and this is being discussed.

(v) Small capacitors

Total production

These are generally mounted singly inside equipment such as fluorescent light fittings, washing machines, air conditioning units and a range of industrial electrical equipment. The rate of scrapping of these items probably varies quite widely, but it seems reasonable to assume an average life of about 10 years per unit. The quantity of PCBs in capacitors being presently scrapped is about 250 tons/annum; this may rise to a peak of about

400 tons/annum around 1980 and then fall to about 150 tons/annum by 1990, due to the introduction of other forms of dielectric. Thus the total quantity of PCBs being disposed of in this category is already of the same order as the other categories (i), (ii), (iii), (iv) are likely to reach by the end of the century.

Removal of these capacitors from each separate item of electrical equipment prior to scrapping is not practicable. At present, they are therefore tipped onto rubbish dumps, incorporated into scrap metal or pass through municipal incinerators. The vast majority of these capacitors contain negligible quantities of free liquid PCBs, since the dielectric is absorbed into paper windings. Even if, whe tipped onto dumps, their sealed metal casing were ruptured, the PCBs would be leached out by water only very slowly. These particular PCBs are less highly chlorinated than those used in transformers and are more readily degradable. The PCB content of those capacitors undergoing scrap metal processing in steel furnaces, where temperatures reach about 1600°C, will be destroyed. Those capacitors passing through municipal incinerators, where the temperature and the residence time are inadequate to ensure complete degradation of the PCB content, will therefore release part of their PCB content to air and part will be tipped with the ash from incinerators.

5. Incineration facilities

At present there is only 1 high-temperature incineration plant available for use in the UK serving the waste-disposal industry capable of effectively disposing of PCBs. By the end of the year another will be commissioned, and we understand that another 2 or 3 may become available in the near future. These facilities burn liquid organic wastes, including PCBs, at a temperature of about 1200°C, high enough to convert PCBs to CO_2, H_2O and HCl. The first two vapours are of relatively low or negligible environmental impact; HCl is removed from the effluent by scrubbing, ensuring full compliance with the standards of the Alkali Act. The PCBs are therefore effectively destroyed and detoxified. The total available capacity in the UK for high-temperature incineration of liquid organic wastes will be 20,000 tons/annum by the end of 1973, of which ca. 60% could be chlorinated wastes. Hence these facilities will be adequate to provide for disposal of the quantities likely to arise at least up to the end of this century. The site cost of disposal by this method is typically at present about £10 - £30/ton, the upper limit being applicable to the more highly chlorinated substances.

MONS 044398

Only limited facilities exist for the incineration of solid PCB-contaminated wastes, eg PCBs absorbed onto the paper windings of capacitors. Incineration is labour intensive and necessitates a preliminary stage of volatilisation and collection of the PCB content; this is inevitably more costly than straightforward incineration.

6. Recommendations

In view of the evidence now available about the action and distribution of PCBs, we recommend that their use and disposal should be subject to special consideration.

(a) Use

We regard the present voluntary controls exercised by the sole UK manufacturer as satisfactory. While this voluntary system cannot control the import of either bulk PCBs or PCB-containing products, these are most likely to come from OECD countries, and should thus be subject to similar restrictions under the OECD agreement. At present, it is not profitable to recover and reuse PCBs, but the situation may change and these recovered PCBs would fall outside the scope of this voluntary scheme. In addition, another company could at any time commence manufacture of PCBs and whilst this should come within the OECD agreement, it would not be covered by the present manufacturer's rather more restrictive voluntary scheme. We therefore recommend that the present arrangements should continue but be reviewed in five years' time. The Secretary of State for the Environment will be afforded emergency powers under the Protection of the Environment Bill to control the use of any materials which represent a hazard to any part of the community. In view of the voluntary basis of present controls on PCBs, these substances should be included amongst those covered by these powers.

(b) Disposal

(i) Liquids

A method of disposal of liquid PCBs that is known to be safe is high-temperature incineration and we therefore recommend obligatory disposal of liquid PCBs by this method. Approved incineration plants will be specifically licensed for this purpose. We recommend that facilities should be provided for analysis of stack gases to be carried out at frequent intervals. A realistic figure for stack emissions of PCBs, based on experience gained at manufacturing plants, is a concentration of $1mg/m^3$, with a total overall limit of 0.5 kg/day for each site. There are practical difficulties associated with the methods to be adopted to ensure these conditions are being met. These are at present being considered by the International Electrotechnical Commission (Technical Committee 10) on which the UK industry is represented, so we recommend that

MONS 044399

if an agreed methodology is proposed by this body, the same should be adopted in the UK for sampling and analysis of stack gases for PCBs.

Purchasers of transformers and large capacitors are informed of the need for adequate disposal and each piece of equipment now sold carries a label to this effect. We think that this system will prove effective when such equipment becomes obsolete. However, there is a potential problem associated with disposal of unlabelled first-generation equipment. Some retrospective labelling is being carried out and we welcome this. We feel that the probability of large transformers being obtained by uninformed scrap merchants is minimal and we regard the retrospective labelling exercise as all that can practically be achieved.

(ii) Contaminated solids

A substantial proportion of solid wastes containing PCBs occurs in small capacitors. Other solid wastes contaminated with PCBs include rags, sawdust, Fullers Earth, paper, etc., arising from manufacturing and handling plants. Where capacitors remain in the apparatus it is considered acceptable that they can be disposed of by tipping onto dry tips. Where large numbers of capacitors or large quantities of contaminated solids require disposal, eg from manufacturing or handling plants, these should be roasted to volatilise the PCB content, which may then be incinerated at approved high-temperature facilities.

(iii) Transportation etc

The carriage on land of waste liquid PCBs should be subject to comparable conditions in terms of labelling, handling, packaging and transport as are at present voluntarily applied in UK to freshly-manufactured bulk liquid PCBs. We understand that a Code of Practice of this type is at present being drawn up by the Conférence Internationale des Grands Réseaux Electriques (CIGRE Working Group WG/02); this would form the basis for an internationally acceptable procedure.

(c) Analogous substances

Substances such as alkylated chloro-biphenyls and polychlorinated terphonyls (PCTs) are structurally similar to PCBs and have comparable properties. They have as yet, only very restricted uses in the UK and are not manufactured here. They do not come within the terms of the OECD agreement on PCBs and there are no controls over their import. We feel that, in principle, these substances should be subject to the same constraints

MONS 044400

in use and disposal as we recommend for PCBs, but positive proposals will depend on whether their use expands. We recommend that they be included in the review suggested for 5 years hence.

.....

MONS 044401