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 between 0.01 ppb* are observed in air and sea water and less than 1 ppb in freshwater. 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 in the basic starting materials or arise as by-products 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 PCB are also provided for research projects related to transformers and capacitors and also for analytical and toxicological studies. The likelihood of previous 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.

(iii) Transformer fluids

PCBs have been used in transformers since the 1940s. These particular PCBs are the highly-chlorinated, very persistant 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 windings, 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 1990s, 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 is one 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, when 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 this 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.

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 revised 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

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 Électriques (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 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 principle, 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 included in the review suggested for 5 years hence.

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