TECHNICAL GUIDELINES ON WASTES COMPRISING OR CONTAINING PCBs, PCTs AND PBBs (Y10)

Production, use and waste arisings

1. This Guideline addresses the three classes of PCBs, PCTs and PBBs. PCBs represent by far the most significant group in terms of quantities originally produced, the volumes of waste requiring disposal, and the environmental significance of past, present and future waste disposal practices. PCBs have been studied much more than PCTs and PBBs, and hence the information available relates mainly to PCBs. In may respects, the three groups of substances display similar characteristics, and can cause similar problems if not handled properly.

2. PCBs, PCTs and PBBs are manufactured substances which do not occur naturally. They all display excellent thermal stability and fire-resistance, and have thus found application in situations where fire-risk or thermal sensitivity might otherwise have been a problem. PCBs and PCTs also demonstrate good dielectric characteristics, rendering them particularly attractive for electrical equipment uses, such as transformers, capacitors and switchgear. Such uses are known as 'closed applications'. Other applications have included non-dispersive use as hydraulic and heat exchange fluids. Dispersing uses are being found in carbonless copying paper, adhesives, mixtures with pentachlorophenols for wood treatment, and in paints and varnishes. These uses are known as 'open-ended applications'.

3. PCBs were first commercially manufactured in around 1930, and production is believed to have finally ceased in the mid-1980s. In that time, well over one million tonnes were produced for all applications, worldwide, of which a significant portion is still in use. As awareness of the environmental problems associated with PCBs grew, so its use was progressively restricted. 'Open-ended' applications, referred to in paragraph 2, were stopped in many countries during the early 1970s, and many electrical equipment manufacturers began to use other dielectric fluids where the requirements of the application permitted. Production of PCBs declined rapidly during the 1970s as uses became more and more restricted, and had virtually ceased by the early 1980s.

4. PCBs have been supplied in commercial formulations under a variety of trade names. To assist in the recognition of PCB containing products, a list of trade names is set out below.

Aceclor	France
Phenoclor	
Pyralene	
Santothern	France/UK
Therminol	France/USA
Clophen	Germany
Apirorlio	Italy
DK	
Fenchlor	
Kaneclor	Japan
Askarel	UK/USA
Aroclor	UK/USA
Ducanol	UK

```
Plastivar
Pyroclor
Asbestol        USA
Bakola 131
Chlorextol
Diaclor
Dykanol
Elemex
Hydol
Inerteen
No Flamol
Pydraul
Pyranol
Saft-Kuhl
Solvol USSR
```

PCBs can be produced having different degrees of chlorine substitution, and hence different percentages of chlorine. Commercial formulations of PCBs fluids contained different degrees of chlorination depending on their intended application since the properties of the mixture, and hence its application varied with the degree of chlorination. For example, Aroclor 1242 containing 42% chlorine was used particularly as the dielectric in power supply control circuits, whereas Aroclor 1260 containing 60% chlorine and, because of its long term stability can be found in power transformers. Some formulations may contain solvents such as trichlorobenzene and tetrachlorobenzene, particularly in transformers, since their presence increase the fluidity of the coolant without detracting from its dielectric strength.

5. Polychlorinated terphenyls (PCTs) consist of three linked phenyl groups with varying levels of chlorine substitution. Properties of PCTs are very similar to those of PCBs, and hence the uses also show marked similarities. PCTs are generally solid at room temperature and may be encountered as resins, waxes or crystalline solids. Quantities used are very much lower than for PCBs, but include applications, the major ones being investment (lost wax) casting, locating waxes employed in precision engineering and in sensitive pipe benching applications (nuclear pipework) as well as plasticizers, resins, adhesives, paper coatings, inks, waxes, fire-retardants, brake linings, abrasives and in electrical equipment as cable coatings, insulation and dielectrics and as a heat transfer medium.

Trade names for commercial formulations include:

```
Aroclor       USA
Leromoll      Germany
Clophen       Germany
Cloresil      Italy
Kanechlor     Japan
Phenoclor     France
Electrophenyl T-60 France
```

6. Polybrominated biphenyls (PBBs), have identical molecular structures to PCBs, but involve substitution of the molecule by bromine rather than chlorine. Technical and commercial formulations are typically white/grey/beige powders with high densities. Uses

are largely related to the fire retardant properties provided to products into which they are incorporated and in particular plastics and mouldings, coatings and lacquers, and in polyurethane foams. Trade names for commercial formulations include:

Firemaster	USA
Bromkal	Germany
Adine	France
HFO 101	UK
Flammex	UK

7. The pattern and nature of PCB waste arisings, and indeed ultimately the selection of a waste management option, requires special considerations which do not apply generally to other substances. First, since PCBs is no longer produced, and has not been for many years, the question of the adoption of clean technologies to avoid or minimize production wastes does not arise! Secondly, sales of PCBs into dispersive uses were successfully phased out from the middle 1970s, so the amounts still in circulation in such uses has been dramatically reduced. Traces can still however be found, in some products, such as waste paper, old in-service marine paints, etc. and in terms of environmental impact potential, these cannot be neglected. Thirdly, as a result of decisions and initiatives taken within bodies such as the North Sea Conference, and the European Community, there is a presumption against attempts to recycle or recover PCBs for reuse as such. This does not, however, preclude their use as a feedstock for the production of non-PCB products.

In line with the declared intention of the above-referred bodies to remove PCBs and articles and products containing them from use within an accelerated timescale, it is considered that all products containing PCBs should not be allowed to be marketed or sold. Rather, they should be disposed of using approved destruction methods. However, taking into account the quantity of PCBs involved and the limited capacity available for its destruction worldwide, it may be appropriate that equipment containing PCBs, so long as it continues to function satisfactorily, is labelled and is subjected to regular inspections to confirm that it is in good condition and is not leaking, should be allowed to continue to be used until the end of its useful life. Then, at that time the equipment must be disposed of as a PCBs waste.

8. At the present time PCB waste arisings fall into the main categories of:

- Capacitors, transformers or other items of electrical equipment containing commercial formulations consisting principally of PCB materials;

- Transformers which, originally having contained PCBs, but subsequently have been drained and refilled with a non PCBs dielectric fluid which contains residual PCBs concentrations;

- Commercially formulated PCBs liquids drained from electrical equipment, or PCBs/solvent mixtures from the flushing and rinsing of such equipment;

- All other liquid wastes, including solvents and waste oils which may be described as secondary fuels;

- Any soil or other loose materials including absorbents.

9. In considering the question of PCB wastes, particular note must be made of the problems of waste oil contaminated with PCBs. Concerns over the use of PCBs have caused some users of PCB containing transformers to remove the PCBs liquid and replace it with another liquid. This practice, known as 'retrofilling' can itself result in problems, in that the internal design of the equipment can make it difficult to remove all the PCB, even when a flushing stage or stages using suitable solvent, is employed. Refilling the transformer with another fluid can result in that fluid becoming contaminated with PCBs to an extent that it would need to be regarded as a PCBs fluid for disposal purposes. Where the retrofilling fluid used was a mineral oil, it might be considered for use as a fuel.However, if used as such in a boiler furnace the presence of PCBs should be carefully evaluated to ensure that the combustion process does not produce dibenzodioxins and dibenzofurans which would be released to the environment in the combustion products. Also, where PCBs are being burned in high concentrations, the creation of HCl would create problems of acid corrosion for the materials of furnace construction.

Environmental and Health Effects

10. PCBs are lipophilic, so tend to accumulate in fatty tissues. They are thus found more frequently in animals than plants, and more in certain species of animal than others. PCBs accumulate in aqueous sediments, and may therefore be consumed in significant quantities by 'bottom feeding' marine species, and by insect larvae. Predatory birds such as ospreys and pelicans, which consume large quantities of potentially affected species may themselves become significantly affected. PCBs display anti-oestrogen properties, and can thus inhibit calcium deposition during egg shell development, leading to insufficiently robust shells, and premature loss. PCBs may also display anti-androgen properties leading to adverse effects on male reproductive capabilities of bird and animal species.

11. In more specifically human terms, the toxic effects elicited by PCBs have included body weight loss, impaired immune function, teratogenicity and reproductive problems, dermal effects, a role in modulating carcinogensis and carcinogenicity, and effects on the liver. These responses are comparable to those of other halogenated aromatics such as the polychlorinated dibenzodioxins and dibenzofurans, and are believed to arise from a common ability - derived from molecular structural similarities - to act in a similar way within the body. Only a few of the PCB congenors exhibit the closest structural similarities, and these have been shown to be the most toxic.

12. Non-carcinogenic effects of PCBs include chloracne, a reversible dermatological problem, and effects on the central nervous system, causing headaches, dizziness, depression, nervousness and fatigue. Also included, and deriving from chronic exposure, are changes to the liver and related enzyme activities.

13. Carcinogenic effects represent the major toxicological effect of concern in human terms, although epidemiological studies have not been able to demonstrate any causal relationship between human PCB exposures and increased risk of carcinogenesis. Studies on rats have been able to demonstrate a carcinogenic effect, and have led to all commercial

PCB formulations being denoted as 'probable human carcinogens'. More detailed analysis of the studies has concluded that in causing rodent liver tumours, PCBs are promoters rather than initiators of carcinogenesis, and furthermore, that only a very few of the PCB congeners are responsible for carcinogenic activity.

14. It must be noted that considerable scientific work on the environmental and health effects of PCBs is in progress worldwide.

Measures for waste avoidance and minimization

15. As already explained, PCBs are no longer manufactured, and many of the commodities which contained them have long since passed through the waste management cycle. Waste avoidance and minimization are therefore somewhat different considerations with PCBs, and are largely confined to the careful control of electrical equipment still in use, and containing in total substantial tonnages of PCBs products. These are, principally electrical transformers and power factor correction capacitors - little else will qualify, and certainly nothing else on a substantial or significant scale.

16. Waste avoidance and minimization therefore, must focus on the avoidance of leakages and spillages from such equipment. The effective containment, collection and storage of any minor leakages and spillages which might occur is essential. Extreme care at the time of servicing the equipment is important. Those engaged in servicing equipment should be specially trained in clean-up procedures. When the equipment is finally taken out of service measures must be taken to handle the equipment in a safe manner and place it in secure storage prior to disposal. Care must be taken to avoid losses and especially to avoid contamination of the storage building and other materials stored there, including wastes, to avoid increasing the quantity of materials needing to be classified as PCBs and thus requiring special disposal. Any pre-treatment or storage activity related to transportation or final disposal must similarly reflect the requirement to avoid leakages and spillages and to ensure containment of all the waste up to its moment of disposal.

When PCBs, PCB-contaminated materials, and PCB-contaminated mineral oils cannot be treated or disposed of upon their decommissioning, they must be stored in a manner which:

a. Minimizes risks to the environment through transportation;

b. Avoids leakages and spillages;

c. Ensures containment of all waste up to its moment of treatment and disposal.

PCB waste in storage must be clearly labelled as such and registered with their country's competent authorities. Long term storage of PCB wastes could be practised provided that measures are taken for their proper treatment and disposal.

Recovery Technologies

17. It is no longer considered environmentally sound practice to seek to recover PCBs although this has been done in the past by the use of vacuum distillation techniques.

18. Previous paragraphs have explained how PCBs may be present in waste oils and solvents, and it is certainly possible that recovery of oil or solvent may be desirable for commercial reasons. However, in such cases, special care must be taken in the disposal of the residues from the recovery operations since these will contain PCBs at a much higher concentration than in the original, larger volume of waste.

19. Use of waste oils and solvents as a fuel can be regarded as recovery, insofar as beneficial use is made of the energy content of a waste. However, uncontrolled use as a fuel should not be interpreted as being regarded as a preferred or environmentally sound management practice. Waste oils and solvents containing significant concentrations of PCBs should *not* be used as fuels unless burned in facilities which are designed, operated and regulated to ensure adequate and safe destruction. They should be considered as PCB waste, and subjected to approved, appropriate disposal methods under domestic legislation.

20. The only recovery operation for which PCBs wastes has been used is when the waste provided a chlorine rich feed material in the production of hydrochloric acid. Combustion of PCBs in air enriched with oxygen will produce hydrochloric acid gas which can be scrubbed out of the process gas stream, subjected to concentration and clean-up stages and provide a commercial grade acid. Normally, the economics of the process are considered not to be attractive, particularly as there is scant demand for hydrochloric acid in many countries. Usually, other manufacturing activities already produce a surplus of the acid. However, the process has been used on a limited scale in cases where special conditions prevail.

Treatment and Disposal Technologies

21. Treatment and disposal methods and practices divide into those which seek to destroy the PCBs, and those which place it in a depository for long term storage in which it is hoped that it will remain contained. Disposal technologies must be capable of breaking up PCBs molecules into products exhibiting less harmful properties. Disposal of PCBs requires a significant amount of energy which usually involve the use of supplementary fuel. Landfilling should be regarded as a method for disposing of PCBs contaminated