MANUFACTURE, USE, INVENTORY AND DISPOSAL OF POLYCHLORINATED BIPHENYLS (PCBs) IN POLAND

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Introduction

Polychlorinated biphenyls (PCBs) are a class of inert industrial chemicals with physical appearance ranging from transparent and mobile liquids to viscous or hard yellowish and brown coloured resins with excellent dielectric properties, which are inflammable and compatible with many organic substances. Polychlorinated biphenyls were introduced as substitute to earlier known polychlorinated naphthalenes (PCNs). Chloronaphthalenes, biphenyls and terphenyls (PCTs) found numerous and largely similar industrial applications. Around 50% of the amount of technical mixtures of PCBs produced world-wide were utilised as capacitor and transformer insulating oils (1, 2).

The Directive 96/59/EC on disposal of PCBs and PCTs (3) obligate the member states of the European Union to manage environmentally safe elimination of PCB/PCT by the end of 2010. The EU associated countries in Central and Eastern Europe have to implement in their national legal orders the bulk of EU environmental legislation and including specific requirements on hazardous waste management as regard to PCBs and PCTs.

Key words: polychlorinated biphenyls, PCBs, polychlorinated naphthalenes, PCNs, polychlorinated terphenyls, PCTs, inventory.

Materials

The data in this study have been gathered from scientific literature search, collection of the background documents from the manufacturing companies, interviews and direct contacts with persons engaged in the industry as well as research and governmental organisations.

Results and Discussion

The exact date of introduction of technical formulations of PCNs, PCBs and PCTs, and specific materials or products containing these compounds introduced for the first time into Poland is unknown. Technical PCN formulations were produced around 1910 and are an example of the earliest known class of popular synthetic dielectric insulating materials and resins, which were widely used in the past in industry. These compounds were also manufactured in neighbouring countries like Germany and were commercially available under the trade names Nibren Wax, Perna Wax and Basileum. Some of the materials, products and electric equipment made in Germany were available in Poland at least during the Second World War and thereafter. 2-Chloronaphthalene was synthesised in the past in Poland and used as a solvent. An unauthorised source has indicated that in the past some higher chlorinated naphthalene mixtures were also produced in southern Poland but there is no official data to support such statement. Poland has produced two technical PCB mixtures namely Tarnol and Chlorofen, and there is no data indicating that PCTs were synthesised.

Polish PCB formulations

Tarnol or Chlorowany bifenyl

Tarnol, which is also called Chlorowany bifenyl, is a low chlorinated technical PCB formulation manufactured between the years 1971 and 1976 by the companyZaklady Azotowe in Moscice near the city of Tarnów in south-eastern Poland. The mixture is, in its physical appearance and properties, similar to well known foreign technical PCB mixtures such as Aroclor 1248, Clophen A 40, Phenoclor DP-4, Fenchlor 42 or Kanechlor 400. Tarnol was a product of the "anti import" policy, which was on the agenda of the government in the 1970s. The total quantity of manufactured Tarnol was 679 tonnes. Tarnol is a colour-less clear liquid of density 1.45-1.47 g/ml at 20°C. Chlorobiphenyl isomer and congener composition ofTarnol is unknown. According to the manufacturer of Tarnol this mixture is composed mainly of trichlorobiphenyls with di-, tetra- and pentachlorobiphenyls as minor constituents. Nevertheless, the composition of Tarnol was not confirmed by capillary gas chromatography and mass spectrometry (HRGC- MS) for analysis. No official data on the use of Tarnol were released – It appears that Tarnol was used exclusively as a dielectric fluid for the transformers, but use as a dielectric in capacitors could be also possible.

Chlorofen

Chlorofen is a highly chlorinated (63.6% Cl) PCBs formulation (2, 4, 5) manufactured in the town of Z□bkowice Sl□skie in southern Poland. The mixture is a light to dark-brown sticky and viscous resin mainly composed of PCB congeners with 5 to 9 chlorine atoms that comprised 99.55% of total PCBs. The average number of Cl per biphenyl molecule in Chlorofen is 7.3 and the average molecular weight is 405.4. Chlorofen contains at least 59 PCB congeners with the major components such as PCBs nos. 153 ofhexa-, 176, 180 and 187 of hepta-, 194, 195, 198, 201/196 of octa- and 206 of nonachlorobiphenyls (4). Chlorofen was used as a lubricant in mining equipment.

Imported PCB formulations

Some foreign PCB mixtures were also imported to Poland before 1971 because of the demand for the manufacture of capacitors and transformers. The PCB mixtures such as Sovol (former Soviet Union) and Delor (Czechoslovakia) are likely candidates but other formulations were also possible. Demand for PCB dielectric oil for the manufacture of capacitors was assessed to be approximately 100 tonnes annually in the late 1960s (7).

Use

Domestically produced and imported PCB mixtures were used mainly as dielectric fluid in capacitors, transformers and other electromagnetic equipment, lubricant in mining industry, hydraulic fluids and heat exchange fluids.

Capacitors

Capacitors of various type, size and origin are in use in Poland. In addition to those manufactured domestically, they were also imported from the former East Germany, Soviet Union, Romania, Hungary, Czechoslovakia, Italy, France, Finland and Sweden. Thecapacity of the capacitors in service approximately is between 1 and 50 litre. There has been no requirement to posses a register of capacitors or their movement at any level of organisation (company and institution or local, district and national administration).The total number of capacitors with capacity greater than 5 litres (assuming 25 L on the average) in use or stored is roughly estimated to be ~400,000, while the amount of impregnating material contained is ~10,000 tonnes. A large percentage (approx. 40 %) of capacitors in use in Poland contain impregnant material of unknown origin or composition. The estimated percentage of

capacitors with impregnating material containing PCBs is 35-50 %. Thus, the total quantity of impregnant material composed of PCBs is assessed to be ~3,500-5,000 tonnes.

Transformers

Transformers of various type, size and origin are in use in practically every industrial enterprise in Poland. In addition to transformers that were made locally they were also imported from former East Germany, West Germany, Soviet Union, Czechoslovakia and Yugoslavia. Less than 1.0 % of transformers have been assessed to contain PCB dielectric fluid. There is no information available on the number of transformers produced and designated for domestic use.. There is no data on the number of transformers refilled (exchange of PCB contaminated dielectric fluid for PCB-free oil), removed from service and their method of disposal or those units which were destroyed. The current estimate of total number of transformers in Poland is 285,000 (less than 1.0 % contain PCBs), and the corresponding amount of oil in use or stored is 300,000 tonnes.

Electromagnetic equipment other than capacitors or transformers

The total number of equipment such as breaker switches, choking coils, measuring transformers, starters, voltage regulators, other machinery which may contain PCBs in use in industry and the amount of PCB contaminated dielectric oil is highly uncertain – This is assumed to be approximately 50,000 units (~5,500 tonnes of oil; 25% units may contain PCB contaminated oil).

Total amount of dielectric oil with PCBs contained in capacitors, transformers and other electromagnetic equipment is assessed on 8,000 to 9,500 tonnes.

Inventory and disposal

There is no national register or inventory of the amounts and fluxes of technical PCB/PCT/PCN formulations produced, imported and utilised in Poland as well as of the materials, products, equipment or waste containing these chemicals. There are both examples of bad and good practice as regard to the management and disposal of PCB contaminated oil and equipment (capacitors, transformers) removed from the service or scrubbed. Large transformers, especially those owned by the state Power Gird Companies, are subjected to internal company inspection and control measures, and those in service are generally in good condition. Randomly collected soil samples at a few "transformer stations" inspected in the former Gdansk Voievodeship in northern part of Poland (8) did not contain PCB concentrations above a background level.

There is a lack of rules regarding equipment storage for outdated equipment containing PCBs or used dielectric fluid containing PCBs. Nevertheless, there are examples where outdated or scrapped capacitors are gathered and kept in dry condition in enclosed spaces or closed outdoors under umbrella roof, and used transformer oil contaminated with PCBs is also stored in closed vessels in dry condition in separate areas.

Used PCB dielectric oil has been treated at collection facilities similar to mineral oils and subsequently mixed with used-mineral oils for further regeneration. A randomly selected six samples of used mineral oil contained PCBs at concentrations between 2.9 and 53 mg/kg (median 36 mg/kg), while in six samples of used transformer oils, concentrations were between 2.3 and 31 mg/kg (median 4.3 mg/kg). There were also cases noted when outdated transformers were decommissioned under uncontrolled conditions, while transformer and capacitor oil and materials incinerated in open conditions or in unauthorised (dioxins emission etc.) hazardous waste incinerators. A legislative action on the management and safe disposal of

PCB containing materials, equipment and waste, is expected to be introduced in Poland. It is anticipated that the introduction (in force from around late 1999) of two national "norms" (10, 11) regarding safe use of electric equipment containing PCBs will assist to establish proper decontamination practice.

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