# A Study of the Present Status of Management of PCBs, and Development of a Preliminary Inventory for PCB contaminated Transformers in Sri Lanka



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# Declaration

This dissertation has not been previously presented in whole or part to any university or institute for a higher degree.

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I certify that the above statement made by the candidate is true and that this thesis is suitable for submission to the university for the purpose of evaluation.



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# Acronyms and Abbreviations

| | |
|---|---|
| CP | Central Province |
| CEB | Ceylon Electricity Board |
| EP | Eastern Province |
| EU | European Union |
| GC | Gas chromatography |
| Gen | Generation |
| HS | Harmonized System |
| IARC | International Agency for Research on Cancer |
| ITI | Industrial Technology Institute |
| LECO | Lanka Electricity Company |
| LTL | Lanka Transformers Limited |
| NCP | North Central Province |
| NIOSH | National Institute for Occupational Safety and Health |
| NIP | National Implementation Plan |
| NWP | Northwestern Province |
| OECD | Organization for Economic Corporation and Development |
| PCB | Polychlorinated biphenyls |
| PCDD | Polychlorinated Dibenzo Dioxin |
| PCDF | Polychlorinated Dibenzo Furan |
| Sab P | Sabaragamuwa Province |
| SP | Southern Province |
| TEF | Toxic Equivalent Factor |
| UNEP | United Nations Environment Program |
| UP | Uva Province |
| US EPA | Environmental Protection Agency of United States |
| WHO | World Health Organization |
| WP | Western Province |

# Abstract

Polychlorinated biphenyls (PCBs) have wide applications and one of its main uses is as the dielectric fluid in electric equipment. During 1970s PCBs were identified as a substance dangerous to health and environment and was banned in most countries since 1980s. Assuming that 60% of its uses are as dielectric fluid in electrical equipment, this survey was concentrated on transformers.

In Sri Lanka, CEB, LECO, LTL are the main service sector stakeholder agencies that own and manage transformers and capacitors that could be contaminated with PCBs. Other than these institutions there are transformers owned by private sector users. Small scale recyclers also handle transformers for smelting of copper and recycling of waste oil.

The objective of this study is to estimate the extent to which there are PCB contaminated equipments in the country; to identify issues faced by stakeholders and to provide recommendations for the management of PCB contaminated equipment.

Questionnaires, surveys and field visits were undertaken for the collection of information. In the survey, information about transformers manufactured on or before 1986 were collected.

There are 14,354 transformers owned by CEB and 2700 owned by LECO. In the survey, 354 in-use transformers and 296 decommissioned transformers were investigated. 118 In-use transformers were tested with the Dexsil Field Test Kit and 52 decommissioned transformers were tested. Dexsil Field Test Kit was used to eliminate PCB negative transformers.

In Sri Lanka, there are a few pure PCB transformers, but a considerable potion of contaminated mineral oil transformers exist in the country. According to the findings of the study, with 95% confidence level, it can be stated that 73% to 56% of in-use transformers in the population are contaminated with PCBs, while at the same confidence level, 78% to 52% of decommissioned transformers are contaminated.

There are several HS codes under which PCB oils, contaminated material and waste oils could be imported to Sri Lanka. There is no legal requirement for a 'PCB free certificate'.

Possibility of informal recyclers being contaminated with PCBs is quite high because there are no controls over disposal of PCB contaminated transformers. Recyclers are completely unaware about the hazards of PCBs. Storage of contaminated transformers/material is not environmentally acceptable and there is a high possibility for environmental contamination.

Main recommendations of the study;

1. Establishment of a complete Inventory and a Database on contaminated transformers.
2. Identify all Pure PCB transformers and have a phasing out plan.
3. Establish procedure for Operation and maintenance of contaminated transformers to prevent further cross contamination.
4. Prevent new entry of contaminated capacitors, transformers and oils to Sri Lanka
5. Proper disposal of decommissioned transformers.
6. Establishment of proper storage; identification and remediation of contaminated sites.
7. Establishment of necessary regulations for the implementation of the above.

# Chapter 1

## Introduction

### 1.1 Background

The term Polychlorinated biphenyls or PCBs refers to a class of synthetic organic chemicals that are to a large degree, chemically inert. PCBs have been widely used as additives to oils in electrical equipment, hydraulic machinery, and other applications where chemical stability was required for safety, operation, or durability. Although the chemical stability of PCBs has been beneficial from the standpoint of commercial use, it has created an environmental problem mainly because of the extreme persistence of the chemical in the environment.

PCBs are a subset of synthetic organic chemicals known as chlorinated hydrocarbons. The chemical formula for PCBs is $C_{12}H_{(10-n)}Cl_n$, where n is the number of chlorine atoms within the range of 1-10.



PCBs include all compounds with a biphenyl structure of two benzene rings linked together, that have been chlorinated to varying degrees. Theoretically there are a total of 209 possible PCB congeners, but only 130 of these are likely to occur in commercial products. (Secretariat of the Basel Convention, 2003) Empirical formula of PCB is given in figure 1.1

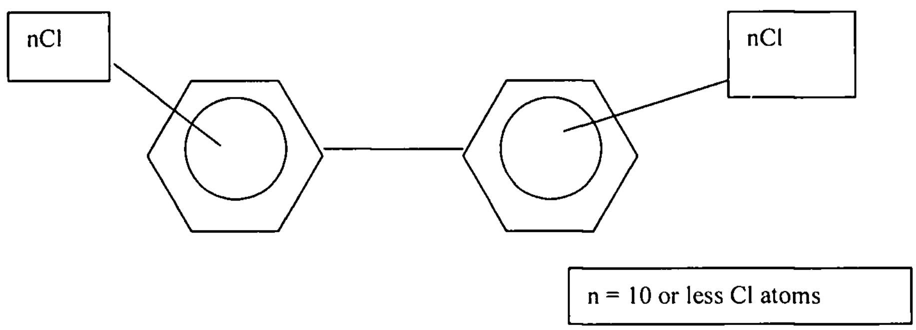


Figure 1.1 Structure of PCB

PCBs have been used extensively since 1920s for a variety of industrial uses. The value of PCBs derives from their chemical inertness, resistance to heat, non-flammability, low vapor pressure and high dielectric constant.

As electricity came into widespread use during the first half of 20th century, equipment suppliers became major users of PCBs.

As shown by the Secretariat of the Basel Convention (2003), Table 1.1 indicates the use of PCBs in different applications.

Table 1.1 Distribution of PCBs Source: Secretariat of the Basel Convention, (2003)

| | |
|---|---|
| Dielectric fluids in transformers and capacitors | 60% |
| Industrial and hydraulic fluids, gas turbines | 15% |
| Adhesive textiles, printing works and pesticides | 25% |
| Additives in preparation of insecticides, bactericides etc. | ND |

PCBs have been used in two different applications; closed and open systems. Their major applications were as coolants in transformers. Capacitors are another type of common equipment that can contain PCBs as the dielectric fluid. The size of capacitors can vary. According to Secretariat of the Basel Convention (2003), all capacitors manufactured between 1930 and 1977 contain PCBs as the dielectric fluid.



## 1.2 Toxicology of PCBs

PCB has a very high flash point and no fire point, and therefore, is stable in changing temperatures. They only burn when in contact with an open flame.

When PCBs do burn, they can form Dioxins and Furans. These two gasses are highly toxic and their deleterious effects on health have been well demonstrated. Apart from the danger of PCBs producing Dioxins and Furans, they themselves are dangerous substances because of their high stability and their oleophilic nature. They can be easily absorbed by fatty tissues of humans and animals. PCBs can bioaccumulate in bodies, especially in fat and liver.

US EPA, (1999) states that although PCBs are readily absorbed into the body, there metabolism and excretion is slow. After first distributing preferentially to the liver and muscle tissue, PCBs are subsequently redistributed to the adipose tissue, skin, and other fat-containing organs.

The rate of individual congener metabolism depends on the number and position of chlorine atoms. In rats, the half-lives of PCB congeners range from 1 to 460 days, depending on the degree of chlorination. In general, less-chlorinated isomers are more readily metabolized than are more highly chlorinated congeners.

According to WHO (1993) excretion of PCBs is very slow, so bioaccumulation occurs even at low exposure levels. The International Agency for Research on Cancer (IARC), which is a part of the World Health Organization (WHO), measures the carcinogenic risks of various chemicals and places them in two groups; those that are carcinogenic to humans are placed in Group 1 and those which are probably carcinogenic to humans are placed in Group 2. Group 2 is subdivided in to groups A and B;

For Group A; evidences of carcinogenicity are fairly well established.

For Group B; evidences of carcinogenicity are less well established.



PCBs are categorized by the IARC as a Group 2B chemical.

## 1.3 Present global status of PCB use and stockpiles

PCBs were started to be manufactured on an industrial scale in 1920 and were used extensively between 1929 and 1980. PCBs were gradually phased out for application in electrical equipment from the early 1980s, specially in developed countries.

United States prohibited manufacture and marketing of PCBs from 1976, while the European Union mandated that all PCBs should be destructed by 2010.

A very large number of electrical equipment exists today globally, which still contain PCBs. There are several ways in which these transformers or oils therein can reach Sri Lanka. Furthermore, there are a large number of equipment in Sri Lanka contaminated with PCBs, and the challenges are first to identify such equipment, and then to select the most appropriate steps to eliminate the PCBs that they contain.

## 1.4 Main Stakeholders in the management of PCB contaminated equipment in Sri Lanka

6520 GWh of Electricity has been generated in Sri Lanka in 2001 for supplying the national grid. 47.7% of this was generated from hydro while 52.3% was from thermal sources. The growth in demand is expected to increase annually by 8%. Three major categories of transformers are used to supply electricity - Generation transformers, Transmission transformers and Distribution transformers.

There are many institutions dealing with management of PCBs, contaminated equipment and sites. Roles and Responsibilities of these institutions differ vastly. Following institutions have been identified as main stakeholder institutions in Sri Lanka;

> Ministry of Environment and Natural Resources, Ministry of Power and Energy, Ceylon Electricity Board, Lanka Electricity Company, Lanka Transformers Limited, Central Environmental Authority, Sri Lanka Customs, Industries, Plantations, Informal Recyclers of waste oil and disposed transformers.



The Ceylon Electricity Board (CEB), Lanka Electricity Corporation (LECO) and Lanka Transformers Limited (LTL) can be considered as the three main agencies that deal directly with transformers and capacitors, which may be contaminated with PCBs. These institutions import and handle a very large portion of transformers used by the state sector, by the private sector and by the power utilities in the country.

Two kinds of transformers are used by the CEB; Step up transformers (Generating Transformers) where voltage is increased in order to reduce the energy loss during transmission and Step down transformers (Power Transformers) where voltage is reduced to assure safety of user and equipment. Generating transformers of 12.5

kV/220kV and 12.5 kV /132kV and distribution transformers of 33kV/415V and 11kV/415kV are presently used.

CEB purchases high voltage transformers from several foreign vendors. Before the establishment of LTL, the CEB used to import Transformers from various countries from over 140 different manufacturers.

Maintenance of medium voltage transformers is done at the Maintenance Branch of the CEB at Piliyandala. Some repairs are done at Lanka Transformers Ltd, while in case of major repairs, the manufacturer's assistance is sought. All burnt distribution transformers of CEB are taken to the LTL Yard in Homagama, for repairs, servicing or inspection before disposal.

PCBs have been used in transformers and other electrical equipments in Sri Lanka, but the extent of the use have not been assessed before. The Ceylon Electricity Board (CEB), the Lanka Electricity Company (LECO) and the Lanka Transformers Limited (LTL) are the main institutions handling transformers, but there is a dearth of information about the use of PCBs in transformers.



Several industries also own the transformers that they are using.

Another group that was taken in to account is the informal recyclers of transformers/ oil. These small scale recyclers are scattered throughout the country. Another group of recyclers are engaged in recycling of scraps from transformers, specially the metal and porous parts.

### 1.5 Objectives of research

Objectives of this study are to determine the status of PCB contamination in transformers, both In-use and decommissioned. A preliminary inventory was prepared using the data of the survey. Study assessed the status of storage and handling methods in the country. Study aimed to identify the amount of stockpiles available and their storage. An understanding of the condition and operation of PCB-containing equipment, and reasons for cross contamination was identified.

Recommendations are made for the proper use and management of PCB contaminated equipment and material in the country, and for the prevention of further contamination.

## 1.6. Scope of the study

Based on the assumption that 60% of the PCBs are in closed systems, open applications such as paints and waxes which can contain PCBs were not considered in this study. Out of closed systems, only transformers were investigated due to practical reasons.

In order to achieve the objectives of the study, types of PCB containing transformers within the country, likely quantities of contaminated oils, owners, operational practices, health and safety management and end-of-life management were investigated. Furthermore, possibilities for future import to the country were assessed.

The literature survey looked at appropriate PCB management systems available, and at health, environmental impacts, legislation and issues on final disposal. This study took into account only the transformers that are presently in use and decommissioned. Possibilities of future entry to the country were identified using customs statistics.



Present status of obsolete stocks were considered in this study, and data available on PCB levels in humans, food items and in environment are discussed.

## 1.7 Lay out of the report

Chapter 1 of the report provides an introduction to PCBs and its toxicology, issues on PCBs and global trends in its management. It also gives the stakeholders involved in the management of PCBs in Sri Lanka. Objective and scope of the study are indicated.

Chapter 2 provides the literature review on PCBs including an overview of health and environmental impacts of PCBs, standards and regulations with respect to PCBs in other countries, and issues on management of PCBs.

Chapter 3 lists out the methodology of the study.

Chapter 4 gives the results and observations. Results are discussed in detail in Chapter 5.

Chapter 6 gives the conclusions of the study while Chapter 7 presents the Recommendations.

The list of references cited in the report is given at the end of the report.

# Chapter 2

## Literature Review

### 2.1 Introduction to PCBs

#### 2.1.1 What are PCBs?

According to the U.S. EPA (1999), PCBs are mixtures of synthetic organic chemicals with the same basic chemical structure and similar physical properties. PCBs can be oily liquids or waxy solids. Abeysundara, et.al (2001), say that PCBs are synthetic liquid chemical compounds consisting of chlorine, carbon, and hydrogen. As shown in the WHO (1993), PCBs have the CAS Registry Number 1336-36-3.

According to Miller (1986) the Molecular weight of PCBs can range from 291.98 – 360.86. Boiling point can be 340-375$^0$C. Flash point is 195$^0$C, and the density is 1.4-1.5 at 30$^0$C.



According to Barbalace (1995), as the amount of chlorine in the PCB mixture increases the flash point rises. As shown by Holobeck (2000), theoretically there are 209 possible polychlorinated biphenyl isomers, although only 130 of these are likely to occur in commercial products. Polychlorinated Biphenyls (PCBs) as colorless crystals in the pure form. Commercial products are mixtures and hence are liquids because the melting point is depressed when polychlorinated biphenyls are mixed. There are no known natural sources of PCBs. Although banned in the United States from further production in 1979, PCBs are distributed widely in the environment because of their persistence and widespread use. PCB mixtures found in the environment are different from the commercially produced PCB mixtures (known as Aroclors in the United States) because of differences in chemical properties, persistence, and bioaccumulation among the different congeners.

According to Neumeir (1978), Polychlorinated biphenyls are practically insoluble in water and soluble in oils and organic solvents. Technical-grade polychlorinated biphenyls have varying proportions of the different isomers with small amount of polychlorinated dibenzofurans and polychlorinated naphthalenes as contaminants.

According to Barbalace, (1995) PCBs have been given 4 digit code designations. Since PCBs technically have 12 carbons (6 in each phenyl ring), the first 2 numbers of the code are typically 12, indicating the number of carbons in the structure. The second 2 digits in the code indicate the average percentage weight of the chlorine in the molecule.

They are thermally stable, resistant to oxidation, acids, bases and other chemical agents and have excellent dielectric properties, and this property of the chemical made it a persistent chemical. According to Obstrosky-Wegman and Gonsebatt, (1996), PCBs have long been recognised as posing a threat to the environment because of their toxicity, persistence and tendency to bioaccumulate (ie to build up in the bodies of animals, particularly at the top of the food chain). Although they have been used in the past to a significant extent, the overwhelming consensus now is that the risks posed by PCBs greatly outweigh any benefits of using them.



Toxicity of PCBs is dependent not only upon the number of chlorine present, but also on their position. For instance, the congeners with chlorine in both Para positions 4 and 4' and at least two at Meta positions (3, 3, 3',5') are considered to be 'dioxin like' and are particularly toxic.

This group of non*ortho* (PCBs 77, 81, 126, 169) and mono-*ortho* (PCBs 105, 114, 118, 123, 156, 157, 167, 189) PCBs are assumed to have essentially the same toxicity profile as the dioxins and furans, since they all bind to the Ah receptor.

According to the Van der Berg etal (2000), Ah receptors (Aryl hydrocarbon receptors) are prone to binding with halogenated aromatic hydrocarbons, including dioxins and polychlorinated biphenyls (PCBs), which can cause changes in gene expression, affecting cell growth, form and function. This is the reason these chemicals can be carcinogenic or teratogenic.

According to Van der Berg etal, (1988), of 209 congeners of PCBs, 12 are considered more toxic because they have toxic features similar to those of 2,3,7,8

TCDD. Under WHO, these 12 Dioxin like has been given values of toxicity with respect to 2,3.7,8 TCDD - Toxic Equivalent Factor (TEF). TEFs of Dioxin-like PCBs are as follows; Here 2,3,7,8 TCDD is considered as the reference compound and hence have a TEF value of 1. (Table 2.1)

Table 2.1 TEFs for human risk assessment based on the conclusions of the World Health Organization (Source: Van den Berg et al., 2000).

| **Congener** | **TEF value** | **Congener** | **TEF value** |
|---|---|---|---|
| ***Dibenzo-p-dioxins*** | | ***Non-ortho PCBs*** | |
| 2,3,7,8-TCDD | 1 | PCB 77 | 0.0001 |
| 1,2,3,7,8-PnCDD | 1 | PCB 81 | 0.0001 |
| 1,2,3,4,7,8-HxCDD | 0.1 | PCB 126 | 0.1 |
| 1,2,3,6,7,8-HxCDD | 0.1 | PCB 169 | 0.01 |
| 1,2,3,7,8,9-HxCDD | 0.1 | | |
| 1,2,3,4,6,7,8-HpCDD | 0.01 | ***Mono-ortho PCBs*** | |
| OCDD | 0.0001 | PCB 105 | 0.0001 |
| | | PCB 114 | 0.0005 |
| ***Dibenzofurans*** | | PCB 118 | 0.0001 |
| 2,3,7,8-TCDF | 0.1 | PCB 123 | 0.0001 |
| 1,2,3,7,8-PnCDF | 0.05 | PCB 156 | 0.0005 |
| 2,3,4,7,8-PnCDF | 0.5 | PCB 157 | 0.0005 |
| 1,2,3,4,7,8-HxCDF | 0.1 | PCB 167 | 0.00001 |
| 1,2,3,6,7,8-HxCDF | 0.1 | PCB 189 | 0.0001 |



According to WHO (1993), other PCBs (non-dioxin-like PCBs) do not exert their toxicological effects via binding to the Ah receptor but nonetheless are associated with a wide spectrum of toxic responses in toxicological studies, including developmental effects, immuno- and neurotoxicity, endocrine disrupting effects and tumour promotion.

### 2.1.2 Uses of PCBs

According to Abeysundara etal., (2001), fire-resistant and insulating properties of PCBs make them ideally suited for use as cooling and insulating fluids in industrial transformers and capacitors; in hydraulic and heat transfer systems; and in products such as plasticizers, rubbers, inks, and waxes.

ATSDR (2000), states that due to their chemical stability, high boiling point and electrical insulating properties (high electrical resistivity), PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; as plasticizers in paints, plastics and rubber products; in pigments, dyes and carbonless copy paper and many other applications. According to Claudio (2002), some other commercial applications of PCBs were for dye carriers in carbonless copy paper, adhesives. They were also used in electronic devices such as fluorescent lights, refrigerators and television sets.

They were popular because they were inexpensive, and last a very long time without degrading. They were marketed under several trade names, including Aroclor, Askarel, Pyroclor, Sanotherm, Kennechlor, Hyvol, Chlorextol, and Pyranol.

As insulating fluids in electrical equipment, Aroclors were seldom used in pure form, but were frequently mixed with fluids such as trichlorobenzene or tetrachlorobenzene. These Aroclor-fluid mixtures are generically called Askarels.

According to the Canadian Council of Resources and Environment Ministers (1981), PCBs may be present in electrical transformers designated to use PCBs as dielectric fluids at levels of 40-70% (that is at concentrations of 400,000 – 700,000 ppm). According to US EPA (1999) the life expectancy of electrical transformers that contain PCBs is 30 years or more.



Since 1974, all uses of polychlorinated biphenyls in the United States have been confined to closed systems such as electrical capacitors and transformers, vacuum pumps, and gas - transmission turbines.

Currently, says the ATSDR (1993) polychlorinated biphenyls are used by individual petitioners granted exemptions for use as a mounting medium in microscopy, as an immersion oil in low fluorescence microscopy, as an optical liquid, and for research and development.

### 2. 1. 3 Production of PCBs

According to Claudio (2002), General Electric Company (GE), formed when Thomas Edison consolidated his patents for incandescent bulbs in 1892, was one of the most important industries to establish manufacturing operations on the Hudson River. The company grew as the demand increased for electrical capacitors and transformers, which help transmit electricity to homes over long distances.

At the time, electric companies used coolants made of organic oils in electrical capacitors, but these were not efficient in dispersing heat, and the capacitors tended to explode. This problem was solved with the development of polychlorinated biphenyls (PCBs) in the 1920s.

PCBs were produced in the United States between 1929 and 1977. Between 1929 and 1989, total world production of PCBs (excluding the Soviet Union) was 1.5 million tons. An average of about 26,000 tons was produced per year.

Even after US banned manufacture, sale and distribution of PCBs except in 'totally closed' systems, in 1976, world production continued at 16,000 tons per year from 1980-1984 and at 10,000 tons per year from 1984-1989. (Secretariat of the Basel Convention, 2003)



US EPA (2000) says that Annual U.S. production of PCBs peaked in 1970 when 85 million pounds were produced. Monsanto, the sole U.S. manufacturer at the time production was banned, had been producing Aroclors 1016, 1221, 1242, and 1254 at a facility in Sauget, Illinois. PCBs are no longer produced or used in new products in the United States.

Commercial mixtures of PCBs were manufactured in the U.S. by the Monsanto Chemical Company and sold under the trade name of Aroclor. Aroclors 1260, 1254, and 1242 were most frequently used in electrical equipment. These Aroclor designations refer to the PCB mixture. Aroclor 1260 is 60% chlorine by weight, 1254 is 54% chlorine by weight and so on.

According to the ATSDR (1993), even though PCBs are no longer manufactured in the U.S., small amounts of PCBs continue to be formed in production processes when chlorine, carbon and elevated temperatures or catalysts are present together.

List of common Trade Names of PCB mixtures are given in Annex 5

## 2.2 Effects of PCBs on Environment and Health

### 2.2.1 Effects of PCBs on the environment

Obstrosky-Wegman and Gonsebatt, (1996), states that PCBs have long been recognised as posing a threat to the environment because of their toxicity, persistence and tendency to bioaccumulate (ie to build up in the bodies of animals, particularly at the top of the food chain).

Environment Canada (1981) states that small amounts of PCB contaminants are found in the environment all over the world. Traces of PCBs are found in our food as well as in our bodies. The body fat of animals and fish for example, can contain PCBs and once people ingest the meat or fish, the PCBs can stay in a person's system for a long period of time.

According to the (IUCN, 2004), the IUCN Red List now includes 12,259 species threatened with extinction (falling into the Critically Endangered, Endangered or Vulnerable categories). A total of 762 plant and animal species are now recorded as Extinct with a further 58 known only in cultivation or captivity.



Joining the List as Endangered is the Mediterranean subpopulation of the short-beaked common dolphin *(Delphinus delphis)*. Its population has declined more than 50% in the Mediterranean region over the last 30-40 years due to reduced dolphin prey in the Mediterranean because of overfishing and habitat degradation. High levels of Polychlorinated Biphenyls (PCBs) found in these dolphins compared to dolphins in other areas also cause concern.

On a research done by Kurunthachalam etal., (2001) mono-ortho substituted polychlorinated biphenyls were measured in tissues of humans, fishes, chicken, lamb, goat, predatory birds, and Genges river Dolphins in India. They have detected PCBs in fat tissues of these animals, but in lower concentrations than PCDD and PCDF.

According to the US EPA (1999), exposure to PCBs is predominantly through the diet, and especially from fish and seafood products. Red meat, poultry, eggs, and dairy products also may be important dietary sources of PCBs. Individuals in the general population who may be exposed to higher than average levels of PCBs include recreational and subsistence fishers who routinely consume large amounts of locally caught fish, subsistence hunters who routinely consume the meat and organ tissues of marine mammals, and persons who live near hazardous waste sites contaminated with PCBs.

According to the US EPA (1999) concentrations of PCBs in aquatic organisms may be 2,000 to more than a million times higher than the concentrations found in the surrounding waters, with species at the top of the food chain having the highest concentrations. Bioaccumulation factors vary among the congeners and generally increase with chlorine content from the trichlorobiphenyls up through the hexachlorobiphenyls.

### 2.2.2 Health Impacts of PCBs

PCBs are labelled as a probable human carcinogen by the U.S. Environmental Protection Agency (US EPA) and have also been shown to affect learning in both animals and humans. They are absorbed through the skin and can also be part of a meal if a person eats fish that have been swimming in contaminated water.



According to Obstrosky-Wegman and Gonsebatt, (1996), it is nearly impossible to totally avoid contact with polychlorinated biphenyls (PCBs) and dioxins, ubiquitous pollutants that are produced by the electrical, plastics, pesticide, paper, and other industries. These fat-soluble toxicants accumulate in the food chain, especially in meat, fish, and dairy products. Mothers pass PCBs and dioxins to their children through the umbilical cord and breast milk.

US EPA (1999) says that PCBs accumulate in breast milk, and breast-fed infants might be at additional risk because human milk contains a steroid that inhibits PCB metabolism and excretion however, the risks posed by PCBs in breast milk are outweighed by the benefits of breastfeeding in all but the most unusual circumstances.

According to Secretariat of the Basel Convention (2003) possible routes of human exposure to PCBs are inhalation, indigestion and dermal contact.

Black, (2000) says that although out of use for nearly 30 years, PCBs are still found in soils and the sediments of rivers such as the Hudson in New York and the Fox in Wisconsin. These chemicals are also found in the atmosphere, drifting thousands of miles from warm climates and precipitating out into the Arctic region.

According to Ostrosky-Wegman and Gonsebatt, (1996), health effects from environmental toxicants may be a more serious problem in developing countries compared with developed countries because the problem is potentiated by other factors such as;

- lack of failure to enforce regulations
- under nourishment of lower economic classes which comprise fo the most exposed populations
- Occupational exposure in developing countries are higher than in developed countries mainly due to lack of knowledge and safety procedures.

According to Claudio, 2002, PCBs bioaccumulate in human tissues and the level increase as one ages. Virtually all persons in U.S have some PCBs in their bodies; the average 70kg male has a total body burden of 20-50mg PCB with approximately 1ppm in fat.



According to Chen etal (1985), the levels of PCBs in the rice oil samples collected from the factory and school cafeterias and the families of the poisoned patients, from an incident that occurred in Taiwan, are in the range of 53 to 99 ppm for PCBs,. The blood samples of 165 patients collected 9 to 18 months after the onset of poisoning contained 10 to 720 ppb of PCBs, with a mean value of 38 ppb.

Various tissues from a patient who died 2 years after poisoning were analyzed for PCBs. The intestinal fat contained the highest level of PCBs.

Background levels of PCBs in human sera are typically <20 ppb and residues measured in human milk have values ranging from 40 to 100 ppb. Reported levels in adipose tissue range from 1 to 2 ppm.

### 2.2.2.1 Health effects due to Acute exposure to PCBs

Secretariat of the Basel Convention, (2003) indicates that acute exposure to high levels of PCB have been associated with skin rashes, itching, burning, eye irritation, skin and fingernail pigment changes, disturbances of liver functions, changes in immune system, irritation of the respiratory tract, headaches, dizziness, depression, memory loss, nervousness, fatigue and impotence.

### 2.2.2.2 Health effects due to Chronic Exposure to PCBs

Figure 2.1 summarize the health effects due to chronic exposure to PCBs.

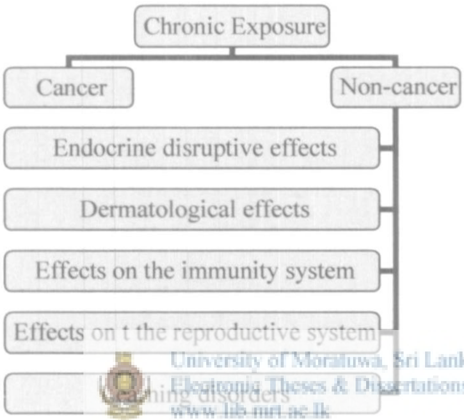



Figure 2.1 Health effects due to chronic exposure to PCBs

UNEP, (2002) reports that chronic low level exposure can lead to liver damage, reproductive and developmental anomalies, and possibly cancer. Much of data on effects of PCB exposure on humans comes from incidents of PCB contamination from long term exposure to PCBs of capacitor manufacturing workers.

Foetuses and neonates are potentially more sensitive to PCBs than are adults because the hepatic microsomal enzyme systems that facilitate the metabolism and excretion of PCBs are not fully functional. In addition, infants and young children consume a greater amount of food per kilogram of body weight and therefore have a proportionately greater exposure to PCBs than do adults eating food with the same level of contamination (ATSDR 2000).

Some of the documented effects from chronic exposure to PCBs are given below;

*a. Carcinogenic effects of PCBs*

According to Faroon etal, (2001), US EPA has classified PCBs as Group B2; Probable human carcinogens. The U.S. EPA estimates that if a person were to ingest waste containing PCBs at 0.005 micrograms per liter over an entire lifetime, that the person would theoretically have only a 1 in 1million chance of developing cancer.

Since studies in animals provide conclusive evidence that PCBs cause cancer. Studies in humans raise further concerns regarding the potential carcinogenicity of PCBs, the International Agency for Research on Cancer (IARC) has classified PCBs as Group 2A; Probable human Carcinogen. (WHO, 1993)

However, according to Faroon etal, (2001) the State of California has determined that PCBs are carcinogens. They estimate that the potential excess cancer risk for a person exposed over a lifetime to 1 micrograms per cubic meter of PCBs to be no greater than 2,200 in 1million.

According to the US Department of Health and Human Services, (1993), several mixtures of polychlorinated biphenyls, including Aroclor 1260 (11096-82-5), Aroclor 1254 (11097-69-1), and Kanechlor 500 (37317-41-2), are *reasonably anticipated to be human carcinogens* based on sufficient evidence of carcinogenicity in experimental animals (IARC 1978,1982,1987, Norback and Weltman 1985).

According to NIOSH (1997) a slight increase in the incidence of cancer, particularly melanoma of the skin, has been reported in a small group of men exposed occupationally to Aroclor 1254. A study of 1,310 workers with at least 6 months of exposure to polychlorinated biphenyls in a capacitor manufacturing plant showed an excess of all cancers among male workers. The excess was mainly due to cancers of the digestive system and of the lymphatic and hematopoietic tissues (IARC 2003).

*b. Non cancer effects of PCBs*

According to the UNEP (1999), exposure to PCBs may cause skin, eye, nose, throat and respiratory tract irritation. Chronically overexposed workers may suffer from chloracne and mild liver injury. Infrequently reported symptoms include anorexia, gastrointestinal disorders, and peripheral neuropathies. In animal studies, oral exposure to PCBs was reported to cause possible liver, kidney and central nervous system effects.

Black, (2000) reports that U.S. EPA has evaluated all of the available data in determining the potential noncarcinogenic toxicity of environmental contaminants, including PCBs. Extensive study has been conducted in animals, including non-human primates using environmentally relevant doses. EPA has found clear evidence that PCBs have significant toxic effects in animals, including effects on the immune system, the reproductive system, the nervous system and the endocrine system. The body's regulation of all of these systems is complex and interrelated. As a result, it is not surprising that PCBs can exert a multitude of serious adverse health effects.

*b.1 Endocrine disruptive effects of PCBs*

WHO (1993) says that, PCBs have been demonstrated to exert effects on thyroid hormone levels in animals and humans. Thyroid hormone levels are critical for normal growth and development, and alterations in thyroid hormone levels may have significant implications.



It has been shown that PCBs decrease thyroid hormone levels in rodents, and that these decreases have resulted in developmental deficits in the animals, including deficits in hearing. PCB exposures have also been associated with changes in thyroid hormone levels in infants. Additional research will be required to determine the significance of these effects in the human population.

According to the ATSDR (2003), because thyroid hormones are essential for normal behavioral, intellectual, and neurologic development, it is possible that the deficits in learning, and memory.

*b.2 Dermatologic Effects of PCBs*

According to ATSDR (2003) chloracne is the only overt effect of PCB exposure in humans. In a person with PCB-induced chloracne, the acneform lesions arise as a result of inflammatory responses to irritants in the sebaceous glands.

The chin, periorbital, and malar areas are most often involved. However, the absence of chloracne does not rule out exposure. Chloracne typically develops weeks or months after exposure. The lesions are often refractory to treatment and can last for years to decades.

Chen etal (1985) says that in addition to chloracne, persons in the Yusho population had conjunctivae, gingivae, and nails. These pigmentation disturbances have also been noted in some PCB-exposed workers.

***b.3 Effects of PCBs on Immune system***

According to Ostrosky-Wegman and Gonsebatt, (1996) explored the longer-term immunological consequences of PCB and dioxin exposure in older children. They report that prenatal exposure to PCBs and dioxins affects the occurrence of infectious diseases and allergic disorders in preschool-age children.

ATSDR (2003) declares that the immune effects of PCB exposure have been studied in Rhesus monkeys and other animals. Immune systems of Rhesus monkeys and humans are very similar. Studies in monkeys and other animals have revealed a number of serious effects on the immune system following exposures to PCBs, including a significant decrease in size of the thymus gland, which is critical to the immune system.



Fritzgerald and Deres (1999) have found that the higher the child's body concentration of PCBs and dioxins at age 42 months, the higher the likelihood of having developed recurrent ear infections. In order to do this research, they recruited pregnant women who lived in Rotterdam and the surrounding area between 1990 and 1992, and were exposed to PCBs. The women did not know whether they were exposed to high or low amounts of PCBs and dioxins.

***b.5 Effects of PCBs on the Reproductive System***

US Department of Health and Human Services (1993) states that mothers exposed to PCBs through fish consumption have given birth to infants with adverse development effects including motor deficits, impaired visual systems and deficits in short term memory. Decreased birth weights and lower gestational age at birth are reported among women occupationally exposed to high levels of PCBs as compared to ones exposed to lower levels of PCBs.

According to Rozati etal (2002), PCBs and phthalate esters are linked to infertility in men. They report that a series of sperm parameters were significantly lower in a group of infertile men than in a control group, and that the infertile men also had higher levels of contaminants.

PCB levels in semen were highest in urban fish eaters, followed by: rural fish eaters, urban vegetarians, rural vegetarians.

According to U.S EPA (1999), potentially serious effects on the reproductive system were seen in monkeys and a number of other animal species following exposures to PCB mixtures. Most significantly, PCB exposures were found to reduce the birth weight, conception rates and live birth rates of monkeys and other species and PCB exposure reduced sperm counts in rats. Effects in monkeys were long-lasting and were observed long after the dosing with PCBs occurred. Rhesus monkeys are generally regarded as the best laboratory species for predicting adverse reproductive effects in humans.

ATSDR (2003) in rhesus monkeys, exposure to PCBs is associated with alterations in the menstrual cycle, decreases in fertility, increases in spontaneous abortion, and a reduced number of conceptions.

*b.6 Learning disorders caused by PCBs*

Renner, (2004) says that children exposed to relatively high levels of polychlorinated biphenyls (PCBs) can have deficits in general intellectual ability, poor short-term memory, and short attention span. Some researchers propose that this may be caused by the ability of PCBs to interfere with thyroid hormone action. Thyroid hormone plays an important role in directing brain development.

Children exposed to PCBs through fish eaten by mothers, still had deficits in weight gain, depressed responsiveness, and reduced performance on the visual recognition-memory test by the age of 4 years. At 11 years of age, the children of highly exposed mothers were three times more likely than controls to have low full-scale verbal IQ scores, were twice as likely to lag behind at least 2 years in reading comprehension, and were more likely to have difficulty paying attention (ATSDR and EPA 1998).

According to a survey done by Schantz etal (2001), it is shown that impairment of memory and learning disorders occurred in older adults exposed to PCBs via consumption of fish of Great Lakes of USA.

***b.7 Gastrointestinal disorders caused by PCBs***

US EPA (1999) reports appetite loss in transformer and electrical equipment manufacturing workers exposed to various PCB-containing mixtures (ATSDR and EPA 1998). Other nonspecific gastrointestinal symptoms experienced by workers exposed to PCBs include nausea, epigastric distress and pain, and intolerance to fatty foods (ATSDR 2000a).

According to WHO (1976) the liver is the primary site of PCB metabolism.

ATSDR (2003) states that histological liver damage is a consistent and prominent finding among PCB-exposed animals; however, no evidence of hepatic dysfunction or overt hepatotoxicity has been seen in PCB-exposed workers (ATSDR 2000a). In the Yu-Cheng population, the incidence of chronic liver disease and cirrhosis was significantly higher than the incidence of these conditions in the general population of Taiwan.



### 2.2.3 Prevention of damage due to PCB exposure

ASTDR (2003) indicates that there is no specific treatment for chronic exposure to PCBs. Because no known methods exist for reducing the reserves of PCBs in adipose tissues, attempts to purge the body of PCBs could not be made.

However according to Black, (2000) it has been found that taking supplements of antioxidants to make high exposure groups working at cleaning PCB contaminated sites, less susceptible to PCB-mediated toxicity. This is because vitamin E is known to counter the effects of free radicals, the fact that it can block damage helps firm up the idea that the damage is caused by PCB induction of free radicals.

Exposure to other hepatotoxins, including medications with known hepatotoxicity, such as ethanol, and chlorinated solvents should be avoided.

## 2. 3 Sources of PCBs and Recorded contaminated sites in other countries

### 2. 3.1 Point sources and non point sources

According to US EPA, (1999) there are no known natural sources of PCBs. Therefore, all sources of PCBs are related to commercial manufacture, use, storage, and disposal of man made equipment and material.

Currently, the major source of PCBs is environmental reservoirs from past releases. PCBs have been detected in soil, surface water, air, sediment, plants, and animal tissue in all regions of the earth. PCBs are highly persistent in the environment with reported half-lives in soil and sediment ranging from months to years. Because PCBs have very low solubility in water and low volatility, most PCBs are contained in sediments that serve as environmental reservoirs from which PCBs may continue to be released over a long period of time. PCBs may be mobilized from sediments if disturbed (e.g., flooding, dredging).

Secretariat of the Basel Convention (2003), states that volatilization from land and surface water is also an important source for the global distribution of PCBs.



The global cycling of PCBs results from their evaporation from soils and surface waters to the atmosphere and their redeposition back to land and surface water. Adsorption to sediments and revolatilization are the primary loss mechanisms from surface water. PCBs are highly lipophilic (fat soluble) and are rapidly accumulated by aquatic organisms and bioaccumulated through the aquatic food chain.

US EPA (1999), states that persons living near incinerators, other PCB-disposal facilities, or any of the 432 current or former hazardous waste sites on the EPA at which PCBs have been found are also at increased risk for exposure to PCBs.

IARC (2003) states that present sources of PCBs are landfills containing PCB waste materials and products, destruction of manufactured articles containing PCBs in municipal and industrial waste disposal burners, and gradual wear and weathering of PCB containing products.

According to the Friends of the Earth (2003) that more than 300 tons of PCBs are waiting to be disposed in marine ships. PCBs are regularly encountered during recycling of merchant ships. Up to 800 kilograms of PCBs in the paint of merchant ships have been recycled in India in recent years and also PCBs in electric cables and other materials.

**2. 3.2 Accidents in global scenario**

Chen etal., (1985) describes one of the major incidents that drew attention of the world. It was a mass outbreak of poisoning which occurred in central Taiwan in 1979 due to the ingestion of rice-bran oil contaminated with polychlorinated biphenyls (PCBs), dibenzofurans (PCDFs) and quaterphenyls (PCQs). High concentrations of PCBs and polychlorinated dibenzodurans were present in the rice oil. PCDF were formed by heating the PCB in rice oil to 200 $^{0}$C at reduced pressure.

The incident was called PCB poisoning or Yu-Cheng in Taiwan. The major PCB and PCDF congeners in the toxic oil and in the blood and tissues of the poisoned patients were found to be considerably high. 39 babies born from PCB poisoned mothers had hyperpigmentation and 24 of these died either from liver dysfunction, liver cancer or infection.



According to Secretariat of the Basel Convention, (2003), a fire broke out in the first level basement mechanical room of an 18-story office building in Binghamton, New York in 1981 . The fire resulted in a cracked bushing on an adjacent Askeral-filled transformer providing service to the building. Approximately 180 gallons of insulating fluid spilled from the transformer. Ventilation intake ducts located adjacent to the transformer spread the oily smoke and soot throughout the building. 10 million dollars have been spent for cleaning up, but until 1984 the building remained closed.

According to Miller (1986) an outbreak of PCB food poisoning occurred in Japan in 1968. This disease was called Yosho which means 'the oil disease'. Yosho arose from ingestion of rice oil contaminated with PCB heat transfer oil. The average Yusho case had ingested about 2 g of PCBs and the dose response relationship was evident. The more PCB oil consumed, sever the clinical illness By 1978 a total of 22 deaths occurred among 120 of the Yosho victims. 41% of the deaths were due to cancer.

According to Secretariat of the Basel Convention (2003) another accident occurred in Reims, in 1985, where a 250kva transformers insulated with PCBs exploded in the basement of a six floor flat. Fire spread thick black smoke up necessitating the evacuation of the building.

According to WHO (1993), numerous non specific symptoms which persisted in both accidents and some of these were chloracne, immune system dysfunction, reproductive impairment, headaches and dizziness.

According to Canadian Council of Resources Environmental Ministers (1987), much public attention was focussed on the transportation of PCBs following an accidental spill of transformer oil containing PCBs in 1985. That spill contaminated a stretch of the Trans-Canada Highway outside Kenora, Ontario, and brought into question current procedures for transporting hazardous wastes.

US EPA, (1999) states that during the 1940s and 1950s, the inside of concrete silos on many farms in the Midwest were coated with sealants containing PCBs. Over time, these sealants peeled off and became mixed with silage used to feed beef and dairy cattle. Farmers and their families who lived on these farms and who regularly ate farm-raised beef and dairy products were exposed to PCBs. Although most of these silos have been dismantled and removed, the remaining silos represent a potential source of exposure to PCBs.



## 2.4 Management of PCBs

### 2.4.1 Present global status

According to UNEP (1999), a PCB management strategy should achieve following objectives are shown in Table 2.2

Table 2.2 PCB management Strategy ( Source: UNEP, 1999)

| Objectives | Activities to be undertaken |
|---|---|
| 1. PCB phase out | Eliminate all discharges to the environment |
| 2. Management through life cycle | Safe use, maintenance, retrofilling, storage, domestic and Transboundary movement, treatment and elimination. |

Management of PCBs and contaminated equipment needs a number of capacities, and different countries have management capacities for PCB at different levels.

A comparison of PCB Management in North America are indicated in Table 2.3

Table 2.3 Capacities available in North American Countries ( Source: US EPA (1997)

| Management measure | US | Canada | Mexico |
|---|---|---|---|
| Primary law | Toxic substances Control Act (TSCA), Resource Conservation & Recovery Act (RCRA), Comprehensive Environmental Response Compensation & Liability Act (CERCLA) | Waste Import, Storage, Treatment & Disposal regulations | Hazardous waste regulation of the General Ecology Law |
| Equipment use restrictions | Yes | Yes | Yes |
| Incineration capacity | Yes | Yes | Yes |
| Landfill capacity | Yes | Yes | No |
| Decontamination capacity | Yes | Yes | Yes |
| Labelling requirement | Yes | Yes | No |
| Emergency planning | Yes | Yes | Yes |
| Inventory | No | Available | In preparation |
| Public education programs | Yes | Yes | Yes |

### 2.4.2 Prevention of PCB discharges to the environment and decontamination of contaminated sites

According to Environmental Canada (1997), proper identification and handling of PCB-contaminated equipment and wastes is critical to the prevention of releases to the air. Therefore, it is necessary that all equipment or waste containing PCBs be properly labelled, alerting people to the requirement for special handling procedures.

Problems are also likely to arise in identifying capacitors containing PCBs. Capacitors are often difficult to locate. They are usually plain boxes which can be remote from switchrooms or found on individual items of plant. They are very widely distributed throughout the UK. Potentially they could be found in many factories, offices, schools, hospitals etc.

According to Canadian Council of Resources Environmental Ministers (1987), considerable amounts of PCBs were released into the environment through disposal in open landfills, incomplete (low-temperature) burning of municipal wastes containing discarded PCB products, illegal dumping, leakage into sewers and streams, and accidental spills.



According to literature, several options are available for the prevention of environmental contamination with PCBs. They are retrofilling, use of alternatives, proper storage, prevention and control of movements, decontamination of contaminated sites and environmentally sound final elimination. Safe handling of equipment and waste will also prevent contamination of the environment.

#### 2.4.2.1 Retrofilling

Canadian Council of Resources Environmental Ministers (1987) has identified that in some cases it may be practicable to deal with the PCB charge contained in the equipment rather than destroy the equipment. The dielectric liquid in transformers may be retrofilled (that is, the PCBs may be replaced with an alternative liquid) or PCB contaminants may be chemically destroyed through dechlorination which allows the reuse of the treated oils. Repeated treatment, particularly with retrofilling, may be needed to meet the legislative 50 ppm by weight limit and this is acceptable under the terms of the EC Directive.

### 2.4.2.2 Use of alternatives for PCBs

In selecting an alternative for PCBs, the Dielectric Strength is the most important electrical property. Transformer-insulating oil must have a dielectric breakdown voltage of 50kV. (Abeysundara etal., 2001)

According to US EPA(1997), possible substitutes for PCBs are given in table 2.4 for PCBs

Table 2.4 Alternatives for PCBs (Source: US EPA : 1997)

| Application | Substitute |
|---|---|
| Dielectric fluid | Mineral oil |
| Hydraulic fluid | Phosphate esters, water/glycol solutions, water/oil emulsions |
| Heat transfer fluid | Modified esters, synthetic hydrocarbons, polyaromatic compounds, partially hydrogeneated and mixed teraphenyls |

According to Abeysundara etal, (2001), mineral oil, synthetic esters and silicon oil are traditionally used as transformer oils. Mineral transformer oil (hydrocarbons) has Paraffinic, Aromatic or Naphthenic structure, and they are obtained by fractional distillation of crude petroleum. Substitution of chlorine atoms for hydrogen atoms in hydrocarbon molecules makes synthetic oils.



According to Forrester and Milby (1983), Silicon has a very high flash point (low flammability) and it is generally used in places where safety is highly desired. It is the most expensive oil of all types.

Apart from traditional oils, sunflower oil, which is 100% environmental friendly, is used as a transformer oil in some countries. Unfortunately the price of sunflower oil is very high when compared to mineral oil. Some countries are exploring the use of soybean based oil in electric transformers Research on the use of coconut oil as transformers fluid, has been carried out. Coconut oil, which is biodegradable and environmental friendly, and are cheap and available in Sri Lanka as an alternative transformer oil.

According to Forrester and Milby (1983), there are several non-PCB insulating fluids commercially available which have already been accepted on their engineering qualities. Mineral oil probably has the longest track record of any of the non-PCB insulating fluids. It has demonstrated satisfactory electrical insulating qualities and has not been associated with any harmful effects other than as a flammable liquid.

According to (UNEP 2003) Perchloroethylene or tetrachloroethylene is being suggested as a very good PCB substitute insulating fluid because of its electrical qualities and more important, its non-flammability. However, perchloroethylene, like PCBs, is another chlorinated hydrocarbon which may bioaccumulate in the environment and is regarded as a toxic substance and suspected carcinogen.

Paraffin-based, high molecular weight hydrocarbon oil are also considered as substitutes for PCBs. It has good electrical properties, but it is a flammable liquid and, like mineral oil, may have some future problems due to trace amounts of polynuclear aromatic hydrocarbons.

**2.4.2.3 Establishment of proper storage**



According to UNEP (1999), interim storage is considered to be an important step in the process of environmentally sound management. All storage installations must be well away from food processing and preparation facilities.

Secretariat of the Basel Convention (2003) states that PCB cannot be stored together with inflammable wastes, and hence it is not possible to have multi purpose storage areas.

According to US EPA (1997), PCB regulations of the US include requirements for proper storage of PCBs. Proper storage requires that given guidelines should be followed in establishing the facility. Such facilities should use of proper containers, proper making, inspection procedures and adequate record keeping.

**2.4.2.4 Prevention and control of movement of PCBs**

According to McDonough (1991), Brittain's high court has blocked a British company from dismantelling a fleet of US Navy ships, since it is identified that these contain PCB waste.

According to Secretariat of the Basel Convention (2003), any Transboundary movement of PCB containing waste must respect obligations set out in the Basel and Rotterdam Conventions. It is recommended that transformers are drained before transporting.

#### 2.4.2.5 Decontamination of contaminated equipment and sites

According to Environment Canada, (1991) mobile technologies to treat PCB contaminated mineral oil chemically are well proven and commercially available. Best method for treatment of waste transformers is decontamination by solvent flushing followed by metal recovery and smelting.

As shown in the Defra (1999) in some cases it may be practicable to deal with the PCB charge contained in the equipment rather than destroy the equipment. The dielectric liquid in transformers may be retrofilled (that is, the PCBs may be replaced with an alternative liquid) or PCB contaminants may be chemically destroyed through dechlorination which allows the reuse of the treated oils. However, care must be taken to ensure that the residual PCB concentrations leaching from plant internals do not become elevated to unacceptable levels. Repeated treatment, may be needed to meet the legislative 50 ppm by weight limit and this is acceptable under the terms of the EC Directive.



Mineral oils contaminated with PCBs in concentrations of up to a few thousand parts per million can also be decontaminated thorough chemical treatment processes. The most common of these is chemical dechlorination. By destroying PCBs that contaminate otherwise valuable oils, chemical dechlorination also allows these oils to be reused.

According to Kim (1988) since the degradation of hydrocarbons is initiated by the action of oxygenases in the presence of molecular oxygen, only anaerobic reactions could be used to degrade toxic hydrocarbons like PCBs into a substance metabolizable by aerobes. PCBs are considered as xenobiotics – toxic chemicals that are recalcitrant against microbial metabolism. Since PCBs are not directly metabolized by aerobes, some anaerobes could be used to dechlorinate them to forms that could be metabolized by aerobes. Denitrification could be used as the method of anaerobic degradation for PCBs.

#### 2.4.2.6 Environmentally sound elimination

According to Defra (1999), in UK there are comprehensive controls on the disposal of PCBs. Phasing out and destruction of polychlorinated biphenyl (PCBs) and dangerous PCB substitutes, should be done according to Council Directive 96/59/EC.

According to US EPA (1997), it is necessary to dispose of items containing PCBs at concentrations of 50 ppm or greater. Disposal of items containing less than 50 ppm is not regulated.

Defra, (1999) identifies that it is necessary to ensure exclusion of direct discharges of PCBs into ground waters and rivers or drains and sewers during the period of elimination. The assistance of trade associations, equipment manufacturing companies and licensed disposal companies should be obtained to enable owners to identify items originally charged with PCBs.

According to the Environment of Canada, (1987), in Canada, the provinces of Alberta, Ontario and Quebec are currently constructing or studying the possibility of constructing fixed PCB destruction facilities. In addition, all provinces are currently using or actively considering the use of mobile treatment/destruction units. These mobile units have an advantage of being more readily acceptable to the general public than the larger fixed units since they are not based permanently at one particular location.

Canadian Council of Resources Environmental Ministers (1987) states that technologies to destroy PCBs effectively and safely, are available and in use in many countries. The most effective destruction technology currently being employed is thermal treatment. Two examples of this method are the burning of high-concentration PCB liquid wastes in liquid injection incinerators, and PCB-containing solids and sludges in rotary kiln incinerators.

Low-concentration PCB liquids (less than 500 parts per million) can be destroyed in high-efficiency boilers that have residence times and temperature characteristics similar to those specified for liquid injection incinerators for hazardous waste.

According Environment Canada (1991), to high temperature incineration is the approved method of disposal for shredded capacitors.

According to Defra (1999), characteristics of cement kilns should fit them for PCB destruction but that trials must first resolve questions about exhaust gases from kilns and their impact on the environment.

According to the Secretariat of the Basel Convention (2003) a few Asian countries have the capacity to incinerate PCB wastes. An incineration plant at equipped with a rotary kiln, a secondary combustion chamber and a flue gas- cleaning system is an environmentally sound option. According to UNEP (2002) such waste disposal facility should operate at a high temperature to maintain a volatile destruction and claim the removal of at least 99.999% of PCBs. Drums containing PCBs waste will be incinerated in this way.

The ash after incineration should be deposited in a landfill which is lined with impermeable layers. When the landfill is full it will be covered with a low density polyethylene liner to protect it from rain water and to minimize seepage.



#### 2.4.2.7 Safe handling of equipment and waste



According to the Environmental Canada (1987), it is necessary that all equipment or waste containing PCBs be properly labelled, alerting people to the requirement for special handling procedures. While procedures may vary depending on the industry or specific operation, as a general rule, any time there is a risk of contact with PCBs, appropriate protective equipment should be worn to limit contact with the skin and eyes and to protect against inhalation of PCB fumes.

According to Secretariat of the Basel Convention (2003) safety equipment may include plastic or rubber gloves, boots, overalls, aprons, face shields or self-contained breathing apparatus. For workers cleaning up a major spill containing high concentrations of PCBs, a full suit of non-porous material should be worn. Clothing that has become contaminated should be disposed of along with other PCB wastes.

## 2.5 Standards and Regulations on PCBs

In order to prevent and mitigate PCB contaminations which will have adverse health and environmental impacts, most of the developed countries have been establishing guidelines and regulations.

However, according to Ostrosky-Wegman and Gonsebatt, (1996) health effects from environmental toxicants may be a more serious problem in developing countries compared with developed countries because the problem is aggravated by factors such as lack of regulations as well as failure to enforce available regulations.

According to Canadian Council of Resources and Environment Ministers (1987), by 1972 researchers and scientists had established that there are sufficient evidences to clearly indicate that eh release of PCBs to the environment posed a potential hazard to humans and the environment. Therefore, by 1973, the OECD (Organization for Economic Corporation and Development) decided that all member countries should limit the use of PCBs to enclosed uses so as to prevent releases to the environment.

According to the US EPA (1997), U.S. EPA regulates polychlorinated biphenyls under the Clean Water Act (CWA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), Resource Conservation and Recovery Act (RCRA), Superfund Amendments and Reauthorization Act (SARA),and Toxic Substances Control Act (TSCA).

### 2.5.1 Regulations pertaining to water

According to Japan Environmental Management Association for Industry (1998), the environmental quality standard for human health specifies that the PCB concentration in public waters should be not detectable.

According to Wijesooriya (1997) under the National Environmental Act, standards have been proposed for inland water bodies. Proposed maximum acceptable levels of organic micro-pollutants in 'Inland surface waters where fisheries and aquatic life are to be protected' gives a limit of 1 nanograms per litre of PCB (total) as the maximum acceptable level.

According to Wijesooriya(1997), the 'Proposed quality standards for different use classes of coastal water in Sri Lanka' proposes PCB levels for different uses. These concentrations are given in Table 2.5 below.

Table 2.5 Proposed standards of PCBs for different user classes of water in Sri Lanka
Sources: Proposed quality standards on PCB for different use classes of coastal water in Sri Lanka; Wijesooriya (1997)

| Parameter | Unit | Value for different use classes | | | |
|---|---|---|---|---|---|
| | | Nature conservation | Fishery of shell fish | Fishery of fin fish | Non consumption use |
| PCB (total) | μg/l | Natural condition | Less than 0.03 | Less than 0.03 | Less than 0.06 |

### 2.5.2 Regulations pertaining to Food

According to the US EPA (1997) , the Food and Drug Administration (FDA) of US regulates polychlorinated biphenyls under the Food, Drug, and Cosmetic Act (FD&CA), establishing tolerances for polychlorinated biphenyls in several foods and in feeds for food-producing animals.



According to the US EPA (1999) FDA mandates tolerances ranging from 0.2 to 3.0 ppm PCBs for all foods, with a tolerance level of 2 ppm for fish.

FDA established action levels of 3 ppm (fat basis) in red meat and 10 ppm in paper and plastic food-packaging material.

According to the Environmental Canada (1991), Canada's guideline for PCBs in fish is 2 parts per million (ppm). This guideline was set taking into consideration other dietary exposure and consumption over a lifetime. The guideline is consistent with that of the U.S. Food and Drug Administration (FDA) and the World Health Organization (WHO).

According to US EPA (2004), Fish Advisories are issued by the United States to inform the public that high concentrations of chemical contaminants, such as PCBs have been found in local fish. Table 2.6 lists number of advisories issued by different States. These Advisories recommend either limiting or avoiding consumption of certain fish from specific water bodies. By 1998, 679 fish consumption advisories have been issued by 37 States. Out of these 10 states have issued more than 70% of the Advisories;

Table 2.6 Number of advisories issued against PCBs in different states of US

Source: U.S. EPA (2004)

| State | No. of Advisories |
|---|---|
| Indiana | 125 |
| Michigan | 104 |
| Minnesota | 83 |
| Wisconsin | 54 |
| New York | 47 |
| Ohio | 37 |
| Georgia | 25 |
| Pennsylvania | 22 |
| Nebraska | 22 |
| Massachusetts | 20 |
| | 539 |



According to US EPA (1999), the number of Advisories issued for PCBs are second only to that for mercury Advisories. The number of states that have issued advisories have increased from 1993 to 1998. The number of advisories issued has also increased. (Table 2.7)

Table 2.7 Statistics on Advisories against PCBs ( Source: U.S. EPA Fact Sheet, 1999)

| Year | Number of Advisories issued on PCBs | Number of States issued Advisories |
|---|---|---|
| 1993 | 319 | 31 |
| 1998 | 679 | 37 |

### 2.5.3 Standards for Air emissions

According to the US EPA (1997), under the Clean Air Act (CAA), EPA assessed air pollution sources of polychlorinated biphenyls and is considering the need for regulation of emissions from incinerators, the only source for which controls may be essential.

### 2.5.4 Occupational exposure Standards

According to Defra (1999), the handling and disposal of PCBs present a potential risk for occupational exposure. In the United Kingdom a Guidance Note has been drafted to help those coming into contact with PCBs to identify and handle them safely. In January 1997, a Maximum Exposure Limit (MEL) of 0.1 mg/m$^3$ (8 hour time weighted average reference period) came into force.

Inhalation exposures should be reduced so far as is reasonably practicable below this MEL and employers are advised that there is a particular risk of absorption through the skin.

US EPA, (1999) The National Institute for Occupational Safety and Health (NIOSH) recommends a 10-hour TWA of 1 μg/m$^3$ based on the minimum reliable detectable concentration and the potential carcinogenicity of PCBs. NIOSH also recommends that all workplace exposures be reduced to the lowest feasible level.



Inhalation exposures should be reduced so far as is reasonably practicable below this MEL and employers are advised that there is a particular risk of absorption through the skin.

### 2.5.5 Regulations on storage, handling, waste management and disposal

USA has clearly specified standards for PCB contamination for wastes as given in Table 2.8.

Table 2.8 Standards for PCBs in waste management in US Source: US EPA,(1997)

| Media | Standard |
|---|---|
| Hazardous waste | 0.05 mg/L PCBs in solid waste. If the concentration exceed this, the waste is considered hazardous waste |

US Department of Health and Human Services (1993) states that the US regulations of 1976 prohibiting the manufacturing, processing and sale of PCB contaminated material was amended in 1996. The new amendment had provisions to cover safe storage and disposal. EPA has established a polychlorinated biphenyl Spill Cleanup Policy under TSCA. ATSDR (2000) states that according to the US EPA, accidental releases of PCBs into the environment of one pound or more are required to be reported to the EPA.

In the case of Sri Lanka, waste substances and articles containing or contaminated with PCB and/or PCTs and/or PBB are included as a waste stream (Waste Stream 23), in Schedule I of the regulation No. 1 of 1990, of the National Environmental Act, as amended by Gazette Extraordinary No. 595/16 of 1990. Under this regulation, no person shall collect, transport, store, recover, recycle or dispose waste containing or contaminated with PCBs or establish any site or facility for their disposal, except under a license issued by the CEA.

According to ARB/SSD/SEC (1997) an EC Directive on the disposal of PCBs and PCTs with requirements for the preparation of inventories, labelling, and treatment has been adopted in 1996. This Council Directive 96/59/EC on the disposal of Polchlorintaed Biphenyls and Polychlorinated Terphenyls.

According to Japan Environmental Management Association for Industry (1998) in Japan, there are 3 laws relevant for the management of PCBs. The Law regarding Safety Assessment and Production of Chemicals of 1974; Waste Management Law of 1976; and the Law regarding Promotion of Proper Treatment of PCB Wastes of 2001.



Chun (1998) states that Korea has 3 major laws which have provisions for the control of PCBs. The Toxic Chemicals Control Law; Waste Management Law and the Electronic Business Act are these laws. However, transformers installed before 1979 allowed to be used until they are decommissioned.

According to the Canadian council of Resources Environmental Ministers (1987), strict federal and provincial regulations have been established in Canada regarding the handling, transportation, storage and disposal of PCBs. Further, regulations under the Transportation of Dangerous Goods Act now require shippers to prepare precise documentation for the interprovincial or international movement of PCBs.

## 2.6. International conventions

According to UNEP (1998) there are a large number of international conventions which has provisions for the control of pollution by PCBs. Some are;

1. North Sea Conference to phase out and destroy the remaining PCBs in use by 31st December, 1999. Parties – Belgium, Denmark, France, Germany, Netherlands, Norway, Sweden and UK
2. The Basel Convention on the Control of Transboundary movements of hazardous wastes and their disposal, (1989); This is the global instrument concerning hazardous waste, including PCBs.
3. Washington Declaration (1995) 100 national governments are parties. An agreement to phase out POPs including PCBs.
4. Directive EC96/59 of the European Communities on the elimination of PCBs and PCTs and the phase out by year 2010.
5. The 1998 Protocol on POPs to the Convention on Long range Transboundary Air Pollution for the UNECE (United Nations Economic Committee for Europe); 42 countries in the Northern hemisphere and EU countries can become party to the POPs Protocol. The basic obligation under the Protocol is to carry out wide ranging action from bans of production/use, phaseout and emission control.



According to GTZ (1999) , another major convention, the 1998 Rotterdam Convention on the Prior Informed Consent (PIC) procedure for Certain Hazardous Chemicals and Pesticides in International Trade came about in reaction to the broadening of international trade in toxic chemicals and its consequent problems, specially in developing nations. Its prime objective is to protect countries which do not have adequate means of import monitoring, management and infrastructure. This PIC procedure covers 22 pesticides and 5 industrial chemicals. The Rotterdam Convention provides a first line of defence giving importing countries the tools and information they need to identify the potential hazards and to exclude chemicals they cannot manage safely.

According to Batuwitage (1999), under the Basel Convention on the Control of Transboundary Movements of Hazardous waste and their disposal, parties are obliged to find environmentally sound solutions for PCB wastes. Under this Convention, guidelines for the management of PCB, PCT and PBB containing wastes, which falls under the waste stream Y10 were adopted in 1995.

According to UNEP (2003) the Stockholm Convention on Persistent Organic Pollutants is another international convention that control PCBs.

According to the Defra (1999) the PCBs which remain in existing equipment pose a continuing environmental threat particularly to marine life as it is anticipated that PCBs will continue to migrate towards the sea. The UK and other North Sea countries agreed at the Third International Conference on the North Sea in 1990 to phase out and destroy remaining identifiable PCBs by the end of 1999.

# Chapter 3

## Methodology

The methodology was developed to determine the degree of contamination of the transformers in Sri Lanka. It is also necessary to find out the possibilities of PCB containing equipment/oil ending up in the environment. The study methodology adopted is given below.

### 3.1. Study methodology

#### 3.1.1 Collection of data

5 main sources were considered in order to get information regarding the situation of the country on PCBs and contaminated equipment. Those are;

a. Power service sector

b. Private sector users

c. Customs statistics



d. Recyclers

e. Decommissioned transformers.

The Flow chart in Figure 3.1 explains the data collection schematically.

A number of methods were used to collect necessary data and information. Use of questionnaires was the main method used for transformers. In order to collect information from the Power Service Sector and from the Private Sector, a questionnaire was designed. (Questionnaire provided for information collection is given in Annex 1)

The population of transformers investigated was limited to transformers manufactured in or before 1986 because;

- Electrical industries in most industrialized countries stopped manufacturing and selling PCB transformers around 1985.

➢ To limit the scope of the survey

Information about the transformers is collected from the name plate data.

All the information about transformers which contain trade names given in Annex 5 was obtained separately, since they are pure PCB containing transformers.

Information from Northern Province was not obtained due to practical difficulties and information from the Eastern provinces was obtained where ever possible.

**a. Information from Power Service sector**

Since the Generation and Transmission equipments are owned and held by the CEB manned Power Stations and Substations respectively, information about these two categories was obtained from the CEB. In the case of Distribution transformers, information was obtained both from CEB and LECO.

Sampling was distributed to different provinces as much as possible. The largest number was investigated from the Western Province since the number of transformers in this province was the highest. Table 3.1 shows the in-use transformers investigated in different provinces, while Table 3.2 shows the breakdown of in-use transformer types investigated in each province.

Table 3.1 Transformers investigated in different provinces

| Owner category | CP | EP | NCP | NP | NWP | SabP | SP | UP | WP | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| CEB | 57 | 10 | 15 | 2 | 23 | 15 | 41 | 30 | 110 | 303 |
| LECO | nt | nt | nt | nt | nt | nt | nr | nt | 21 | 21 |
| User | Nr | 4 | nr | nr | 7 | nr | 3 | nr | 16 | 30 |
| **Total** | 57 | 14 | 15 | 2 | 30 | 15 | 44 | 30 | 147 | 354 |

Note: nr – no response nt – no transformers

Table 3.2 Transformers investigated in different provinces

| Type | CP | EP | NCP | NP | NWP | SabP | SP | UP | WP | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Distribution | 14 | 6 | 13 | Nr | 28 | 9 | 35 | 29 | 109 | 243 |
| Generation | 38 | 2 | nr | Nr | nr | 4 | nr | nr | 17 | 61 |
| Transmission | 5 | 6 | 2 | 2 | 2 | 2 | 9 | 1 | 21 | 50 |
| **Total** | 57 | 14 | 15 | 2 | 30 | 15 | 44 | 30 | 147 | 354 |

Note: nr – no response

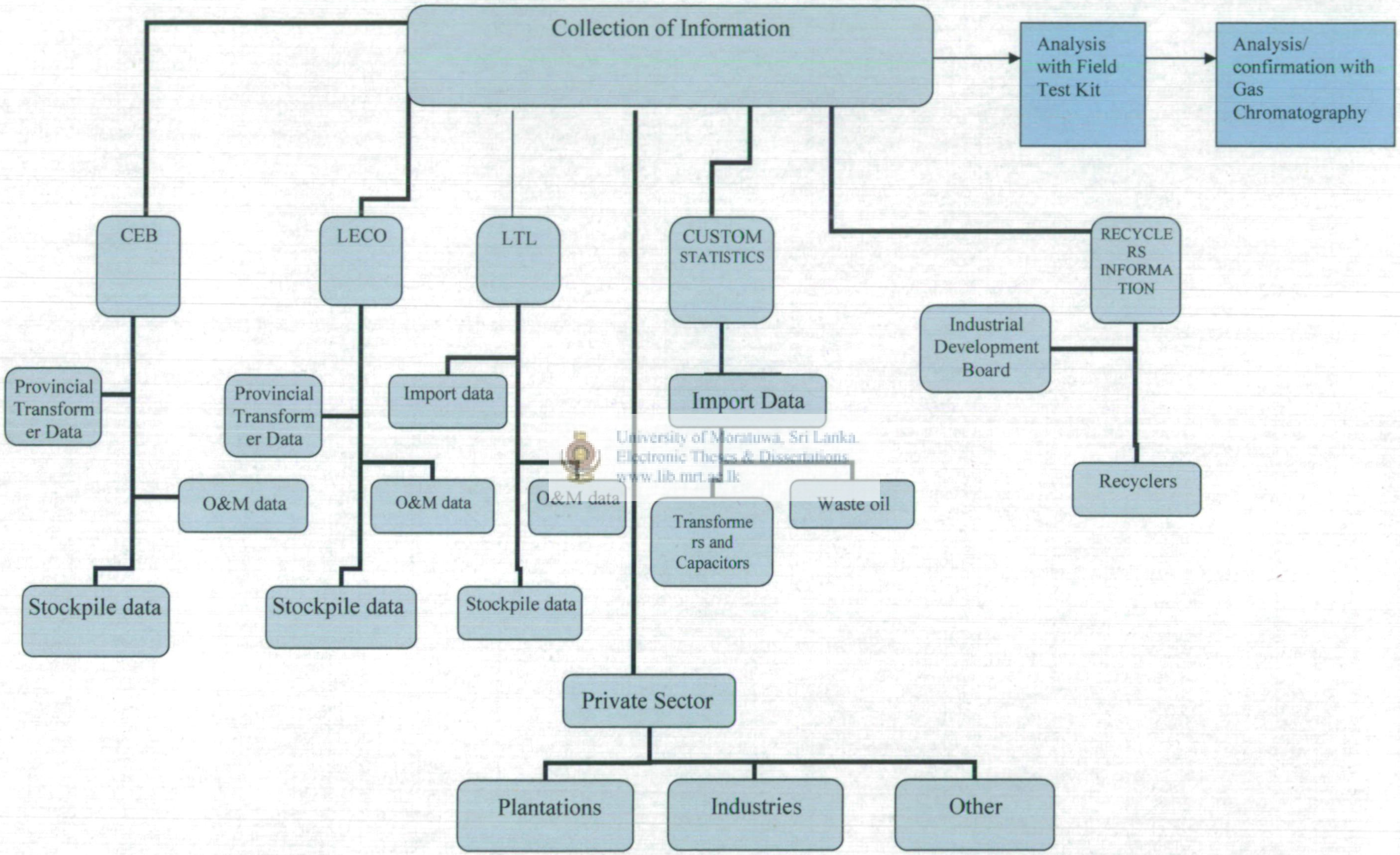




Figure 3.1 Methodology of Survey

**b. Information from Users of the private sector –**

Since a small percentage of Distribution transformers are owned and held by industries and plantations and only a very few are owned by community groups, information from the private sector was collected from 2 categories, the industrialists and from the plantations.

Information was collected from atleast 10 transformers owned by the Industries, from each Province. Since a large number of industries are located in the Western Province, information of about 30 transformers was obtained from this Province. In doing so, 12 questionnaires were allocated for Colombo, 12 for Gampaha and 6 for Kaluthara.

**c. Customs Statistics –**

Customs Statistics was used to determine the trend of PCB containing oils/equipments being imported to Sri Lanka.

An attempt was made to ascertain the amount of transformer oil, and waste oil contaminated with PCBs that are imported to Sri Lanka. Sri Lanka Customs Tariff Guides and Statistics collected by the Department of Customs were used. However Customs information is available only from year 1989.

**d. Recyclers information –**

Recycler's information was collected by visiting them. Site inspections were also conducted to storage sites in order to obtain information. Because PCB containing oils are still in use in transformers in detectable amounts, there is a probability of these entering in to recycling operations. Used PCB oils or contaminated transformer mineral oils can be mixed with waste mineral oil, resulting in contamination with low concentrations of PCBs. Information on the informal recycling was obtained from the Industrial Development Board of Ceylon. Several recycling institutions were visited during the survey.

**c. Decommissioned transformers –**

In order to determine the fate of decommissioned transformers and its contaminated materials and to determine the method of storage of decommissioned transformers, the survey was extended to cover the decommissioned transformers.

Information on Decommissioned transformers was collected by distributing questionnaires among LTL & LECO storage yards.

Table 3.3 shows the number of decommissioned transformers of different categories investigated.

Table 3.3 Number of decommissioned transformers investigated

| LECO | LTL | User | Grand Total |
|---|---|---|---|
| 36 | 255 | 5 | 296 |

## 3.2 Method of sample analysis

In order to find out the percentage of transformers positive for PCBs in the sample of 650, following tests were carried out for randomly selected transformers;

a. Using the field test kit – This was used to eliminate transformers negative for PCBs. Information regarding the use of field test kit are given in Annex 6

b. Gas Chromatography (GC) – Some of the positive transformers were analysed with GC in order to confirm the percentage of reliability of the Field Test Kit. Information regarding the method is given in Annex 7.

Analysis with the Field Test Kit was done with the use of Dexsil Clor-N-Oil 50 test kits. Using this test kits it is possible to eliminate negative transformers. Information about Dexsil Clor-N-Oil 50 are given in Annex 6.

Out of the 650 transformers from which information was collected, only 170 were selected to be analyzed with the Field Test Kit, due to the high cost of a Test Kit (US $10 per sample) According to the literature survey, it is possible for the Field Test Kit to give false positive results, but it will not show false negative results.

Therefore, the purpose of using the Field Test Kit is to eliminate all transformers which do not have PCBs.

Breakdown of the numbers of transformers tested are given in tables 3.4, 3.5 and 3.6.

Table 3.4 In use Transformers analyzed with Field Test Kits

| Tested | Total |
|---|---|
| Not tested | 236 |
| Tested | 118 |
| **Total** | 354 |

Table 3.5 Ownership of transformers analysed with Field Test Kits

| Owner category | Tested |
|---|---|
| CEB | 107 |
| LECO | 8 |
| User | 3 |
| **Total** | 118 |



Table 3.6 Decommissioned transformers analysed with Field test Kits

| Tested | Total |
|---|---|
| Not tested | 244 |
| Tested | 52 |
| **Total** | 296 |

## 3.3 Method of information analysis

i. In order to identify the distribution of PCB contaminated transformers, analysis was carried out according to the;

Power capacity — Type
Country of manufacture — Location
Age

ii. Rate of contamination of transformers in Sri Lanka was determined.

iii. Possibilities of PCB containing equipment/oil ending up in the environment were identified.

iv. Fate of decommissioned transformers and its contaminated materials were identified.

v. Methods of storage of decommissioned transformers were identified.

### 3.4 Method of statistical analysis

The amount of oil that requires to be managed in an environmentally sound manner, was estimated by extrapolating the results obtained from the sample of 650 transformers for all the transformers in the country manufactured on or before 1986. In order to extrapolate the sample results to the population, Z test was used to determine the confidence limits. When the number of samples was less than 30, a finite population correction factor was applied.



### 3.5 Recommendations

Based on the information collected, management objectives and activities to be undertaken for the effective management of PCB contaminated transformers in Sri Lanka, were identified. Recommendations are provided for future management of PCBs/PCB containing equipment to prevent this toxic substance entering the environment and human bodies.

# Chapter 4

## Results, Observations and Discussion

### 4.1. Information regarding In-use transformers

Inventory of transformers in-use is given in Annex 2

#### 4.1.1 Overall results of the investigation

Overall results of the investigation are given in table 4.1

Table 4.1 Transformers investigated and the results

| No. Investigated | No. Tested | No. positive | % positive | Population (estimate) |
|---|---|---|---|---|
| 354 | 118 | 76 | 64.4 | 1759 |

At 95% confidence level,



$p \pm Z_0 \sqrt{p\,(1-p)/n}$

$Z_0$ at 95% confidence level $= 1.96$

For all in-use transformers in the country; .

$= 0.644 \pm 1.96 \sqrt{(0.644 \times 0.356) / 118}$

$= 0.644 \pm 0.0863$

Therefore, with 95% confidence level, it can be stated that 73% to 56% of the transformers in the population of transformers manufactured in or before 1986 are PCB contaminated.

#### 4.1.2 Type wise calculation of contaminated transformers

There are 3 major categories of transformers;

- Generation Transformers
- Transmission Transformers
- Distribution Transformers

Table 4.2 indicates ownership of Power service sector transformers in Sri Lanka, their types and numbers and Table 4.3 shows the summary of results.

Table 4.2 Ownership of transformers, types and Numbers in Sri Lanka

| | Ownership and Number | |
|---|---|---|
| **Type of Transformer** | **CEB** | **LECO** |
| Distribution | 14,185 | 2,700 |
| Generation Aux | 12 | Nt |
| Gen Interbus | 2 | Nt |
| Generation | 58 | Nt |
| Transmission | 97 | Nt |
| Total | 14,354 | 2,700 |

Note: nt – No transformers

Table 4.3 Summary of results according to the type of transformers

| Type | No. Positive | No. Tested | % Positive | Population (estimate) |
|---|---|---|---|---|
| Distribution | 59 | 82 | 71 | 1656 |
| Generation | 13 | 24 | 54 | 56 |
| Transmission | 4 | 12 | 33 | 47 |
| Total | 76 | 118 | | 1759 |



At 95% confidence level,

$p \pm Z_0 \sqrt{p\,(1-p)/n}$

$Z_0$ at 95% confidence level = 1.96

**For Distribution transformers;**

$= 0.71 \pm 1.96 \sqrt{(0.71 \times 0.29)/82}$

$= 0.71 \pm 0.0982$

Therefore, with 95% confidence level, it can be stated that 81% to 61% of the Distribution transformers in the population are PCB contaminated.

*Calculating the amount of contaminated oil in distribution transformers;*

Number of Distribution transformers in the population = 1656

% positive according to test kits (at most) = 0.8082

% confirmed by the GC = 0.80

Therefore number of positive transformers (at most scenario) = 1656 x 0.81 x 0.8

= 1073

In 58 Distribution transformers there are 25,350 kg of dielectric.

Therefore, at most the amount of oil in 1073 units = 468,975 kg

= 469 MT

Therefore, the number of positive tf (at least scenario) = 1656x.61x.80

= 808

Similarly, (in at least scenario) amount of oil in 808 units = 353 MT

**For Generation transformers;**

At 95% confidence level,

$p \pm Z_0 \sqrt{p(1-p)/n} \cdot \sqrt{(N-n)/(N-1)}$



$Z_0$ at 95% confidence level = 1.96

In order to find the number of positive transformers in the population of Generation Transformers;

$= 0.54 \pm 1.96 \sqrt{(0.54 - (1-0.54)} \times \sqrt{(56-24)/56-1)}$

$= 0.54 \pm 0.15$

Therefore, with 95% confidence level, it can be stated that 69% to 39% of the transformers in the population of Generation transformers manufactured in or before 1986, are PCB contaminated.

*Calculating the amount of contaminated oil in Generation transformers;*

Number of Generation transformers in the population = 56 units

% positive according to test kits (at most) = 0.69

% confirmed by the GC = 0.80

Therefore number of positive transformers (at most scenario) = 56 x 0.69 x 0.8

= 31 units

In 14 Generation transformers there are 45,015 kg of dielectric fluid

Therefore, (in at most scenario) the amount of oil in 31 units = 99 MT

Similarly, (in at least scenario) amount of oil in 17 units = 55 MT

**For Transmission Transformers**

In order to find the number of positive transformers in the population of Transmission category;

$= 0.33 \pm 1.96 \sqrt{} (0.33 - (1\text{-}0.33) \times \sqrt{} (47\text{-}12)/ (47\text{-}1)$

$= 0.33 \pm 0.23$

Therefore, with 95% confidence level, it can be stated that 100% to 56% of the transformers in the population of Transmission transformers manufactured in or before 1986, are PCB contaminated.



***In calculating the amount of contaminated oil in Transmission transformers;***

Number of Transmission transformers in the population = 47 units

% positive according to test kits (at most) = 0.1

% confirmed by the GC = 0.80

Therefore number of positive transformers (at most scenario) = 47 x 0.1 x 0.8

= 38 units

In 4 Transmission transformers there are 21,100 kg of dielectric fluid

Therefore, (in at most scenario) the amount of oil in 38 units = 200 MT

Similarly, (in at least scenario) amount of oil in 21 units = 111 MT

***Accordingly, the estimated total amount of dielectric fluid that is positive for PCBs;***

At most scenario = 768 MT

At least scenario = 519 MT

Table 4.4 and Figure 4.1 show the distribution of contamination in the population of transformers according to the type;

Table 4.4 Distribution of contamination in the population (at 95% confidence level)

| **Type** | **Estimated Population** | **No. of contaminated TF (at most)** | **No. of contaminated TF (at least)** |
|---|---|---|---|
| Distribution | 1656 | 1073 | 808 |
| Generation | 56 | 31 | 17 |
| Transmission | 47 | 38 | 21 |
| Total | 1759 | 1142 | 846 |



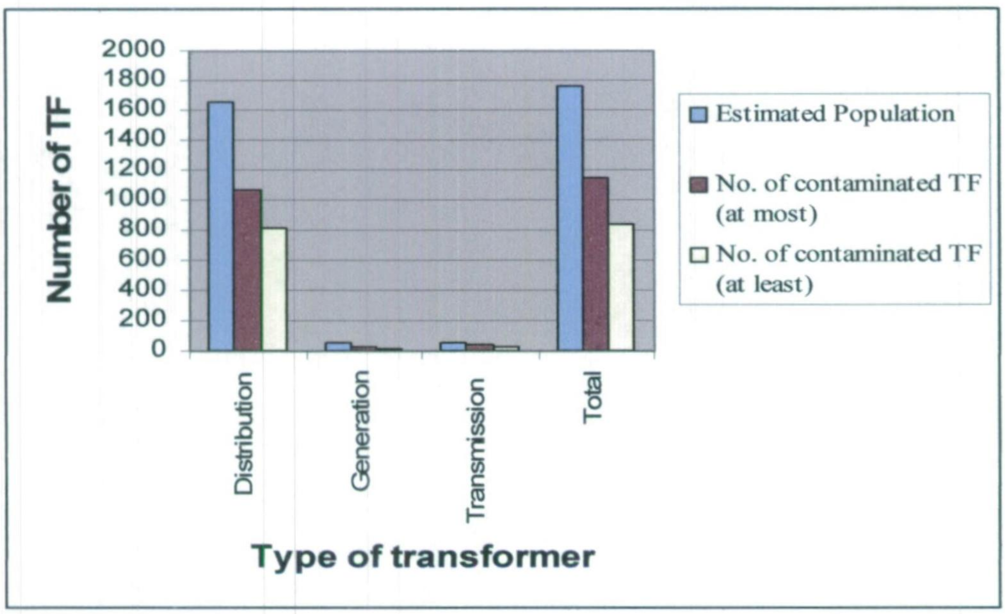


Figure 4. 1 Distribution of contaminated transformers according to the type

### 4.1.3 Province wise calculation

The number of transformers differs from province to province. The largest numbers of transformers are seen in the Western Province. Table 4.5 shows the allotment of CEB and LECO owned Distribution transformers in different provinces.

Table 4. 5 Provincial Breakdown of CEB owned Distribution transformers

| Geographical zone | No. of Distribution Transformers |
|---|---|
| Central Province | 1451 |
| Eastern Province | 1122 |
| North Central Province | 958 |
| North Province | 303 |
| North Western Province | 1739 |
| Sabaragamuwa Prov. | 1281 |
| Southern Province | 1526 |
| UVA Province | 1070 |
| Western Province | 7745 |
| **TOTAL** | **16,885** |



Table 4.6 gives the distribution of PCB positive In-use transformers in different provinces. In the sample it shows that over 50% of the transformers in Uva Province, Western Province, Central Province and Southern Province are contaminated. Even though both transformers tested from the Eastern Province were positive, due to the smallness of the sample, a conclusion cannot be made.

Table 4.6 Province-wise breakdown of the PCB test results

| PCB Test | CP | EP | NCP | NWP | SabP | SP | UP | WP | Total |
|---|---|---|---|---|---|---|---|---|---|
| Tested | 30 | 2 | 8 | 8 | 7 | 13 | 7 | 43 | 118 |
| positive | 20 | 2 | 3 | 1 | 4 | 13 | 7 | 26 | 76 |
| % positive | 67% | 100% | 38% | 13% | 57% | 100% | 100% | 60% | 64% |

Data given in table 4.7 were used in applying the sample results to the population of transformers manufactured on or before 1986.

Table 4.7 Summary of PCB positive transformers in provinces

| Province | Sample | No. positive | Percentage positive | Population (estimate) |
|---|---|---|---|---|
| Western Province | 43 | 26 | 60 | 795 |
| Central Province | 30 | 20 | 67 | 149 |
| Southern Province | 13 | 13 | 100 | 158 |
| Uva Province | 7 | 7 | 100 | 111 |
| **Total** | | | | 1213 |

At 95% confidence level,

$p \pm Z_0 \sqrt{} p (1-p) / n$

$Z_0$ at 95% confidence level = 1.96

***For Western Province;***

= 0.60 ± 1.96 √ (0.60 x 0.4) / 43

= 0.60 ± 0.1464

Therefore, in the Western Province, it could be stated with 95% confidence level, that 75% to 45% of the transformers in the population of transformers manufactured in or before 1986, are PCB contaminated.



***For the Central Province;***

= 0.67 ±1.96 √ (0.67 x 0.33) / 30

= 0.67 ± 0.1682

Therefore, in the Central Province, it could be stated with 95% confidence level, that 83% to 50% of the transformers in the population of transformers manufactured in or before 1986, are PCB contaminated.

***For Southern Province;***

On applying the finite population correction factor

At 95% confidence level,

$p \pm Z_0 \sqrt{} p (1-p) / n . \sqrt{} (N-n)/(N-1)$

$Z_0$ at 95% confidence level = 1.96

$= 1 \pm 1.96 \sqrt{(0.67 \times 0.33) / 45} \times \sqrt{(158-13)/(158-1)}$

$= 1 \pm 0.07$

Therefore, in the Southern Province, it could be stated with 95% confidence level, that 100% to 93% of the transformers in the population of transformers manufactured in or before 1986, are PCB contaminated.

### 4.1.4 Calculation according to ownership of transformers

Table 4.8 shows the relationship between numbers investigated and numbers tested.

Table 4.8 Transformers investigated and the results

| Ownership | No. Investigated | No. Tested | No. positive | % positive | Population (estimate) |
|---|---|---|---|---|---|
| CEB | 303 | 107 | 69 | 64.5 | 1678 |
| LECO | 21 | 8 | 7 | 87.5 | 81 |
| Total | 354 | 118 | 76 | 64.4 | 1759 |

Note: UK – unknown

At 95% confidence level,



$p \pm Z_0 \sqrt{p(1-p)/n}$

$Z_0$ at 95% confidence level $= 1.96$

***For CEB owned transformers;***

$= 0.645 \pm 1.96 \sqrt{(0.645 \times 0.355) / 107}$

$= 0.645 \pm 0.0906$

Therefore, it could be stated with 95% confidence level, that 74% to 55% of the transformers owned by the CEB (in the population of transformers manufactured in or before 1986), are PCB contaminated.

**For LECO owned transformers**

On applying the finite population correction factor,

At 95% confidence level,

$p \pm Z_0 \sqrt{p(1-p)/n} \,.\, \sqrt{(N-n)/(N-1)}$

$Z_0$ at 95% confidence level = 1.96

$= 0.875 \pm 1.96 \sqrt{0.875 (0.125) / 8} . \sqrt{(81-8) / (81-1)}$

$= 0.875 \pm 0.22$

Therefore, it could be stated with 95% confidence level, that 100% to 66% of the transformers in the population of transformers manufactured in or before 1986, owned by LECO are PCB contaminated.

### 4.1.5 Distribution of contaminated transformers according to the country of origin

When data was analysed, it was evident that the highest numbers of transformers that are positive for PCBs have been manufactured by India (93%), Korea (100%), Canada (75%) and France (74%) . This is indicated in table 4.9

Table 4.9 Contamination against the country of origin

| Country of Manufacture | Data investigated | Total Tested | positive (>50 ppm) | % |
|---|---|---|---|---|
| Austria | 4 | 2 | 0 | 0 |
| Belgium | 9 | 2 | 0 | 0 |
| Bulgaria | 3 | 3 | 2 | 66 |
| Canada | 6 | 4 | 3 | 75 |
| Czechoslovakia | 4 | 1 | 0 | 0 |
| Denmark | 3 | 0 | 0 | 0 |
| France | 85 | 27 | 20 | 74 |
| Germany | 35 | 9 | 5 | 55 |
| India | 47 | 15 | 14 | 93 |
| Italy | 8 | 6 | 4 | 66 |
| Japan | 6 | 0 | 0 | 0 |
| Korea | 18 | 4 | 4 | 100 |
| Norway | 2 | 0 | 0 | 0 |
| Pakistan | 1 | 1 | 0 | 0 |
| Portugal | 1 | 1 | 0 | 0 |
| Romania | 9 | 5 | 3 | 60 |
| S.Africa | 1 | 1 | 0 | 0 |
| Sri Lanka | 57 | 12 | 7 | 58 |
| Sweden | 1 | 0 | 0 | 0 |
| UK | 16 | 7 | 4 | 57 |
| Unknown | 27 | 9 | 5 | 55 |
| Yugoslavia | 11 | 9 | 5 | 55 |
| **Total** | **354** | **118** | **76** | **64** |

Table 4.10 gives the summary of results according to the country of manufacture

.

Table 4.10 Summary of results – country wise

| Country | Tested | Positive | % |
|---|---|---|---|
| India | 15 | 14 | |
| Korea | 4 | 4 | |
| Canada | 4 | 3 | |
| France | 27 | 20 | |
| **Total** | 50 | 41 | 82 |

In the sample, the transformers manufactured in India, Korea, Canada and France shows an overall contamination rate of 82%. In applying this for the population;

At 95% confidence level,

$p \pm Z_0 \sqrt{p(1-p)/n}$

$Z_0$ at 95% confidence level = 1.96

For transformers manufactured in India, Korea, Canada and France;

$= 0.82 \pm 1.96 \sqrt{(0.82 \times 0.18)/50}$

$= 0.82 \pm 0.1064$



Therefore, in the case of transformers manufactured in India, Korea, Canada and France it could be stated with 95% confidence level, that 93% to 71% of the transformers in the population of transformers manufactured in or before 1986, are PCB contaminated.

### 4.1.6 Distribution of contaminated transformers according to the year of manufacture

When the test results were categorized into age groups the highest positive results were obtained from the group manufactured during the period 1971-1980. (Table 4.11)

Table 4.11 Results of analysis according to the year of manufacture

| Years of manufacture | Number tested | Positive | Negative | % positive |
|---|---|---|---|---|
| 1936 – 1940 | 3 | 1 | 2 | 1% |
| 1941 - 1950 | 3 | 0 | 0 | 0% |
| 1951 – 1960 | 8 | 5 | 3 | 4% |
| 1961 – 1970 | 29 | 18 | 11 | 15% |
| 1971 – 1980 | 35 | 30 | 5 | 25% |
| 1981 – 1990 | 27 | 16 | 11 | 13% |
| Unknown | 13 | 6 | 7 | 5% |
| **Total** | 118 | 76 | 42 | 64% |

According to the table 4.11, when planning of future analysis for PCB, priority must be given to transformers manufactured during the period 1961 to 1980. Results in these two years are summarized in table 4.12.

Table 4.12 Summerized results for the period 1961-1980

| Years of manufacture | Number tested | Positive | % positive |
|---|---|---|---|
| 1961 – 1970 | 29 | 18 | |
| 1971 – 1980 | 35 | 30 | |
| Total | 64 | 48 | 75% |



At 95% confidence level,

$p \pm Z_0 \sqrt{p\,(1-p)/n}$

$Z_0$ at 95% confidence level $= 1.96$

For transformers manufactured during 1961 - 1980;

$= 0.75 \pm 1.96 \sqrt{(0.75 \times 0.25)/64}$

$= 0.75 \pm 0.1061$

Therefore, in the population, it could be stated with 95% confidence level, that 86% to 64% of the transformers manufactured during the period 1961 - 1980, are PCB contaminated.

## 4.2. Information regarding Over-age transformers

According to the UNEP (1999) the average working life of a transformer is 30 years. However, according to UNEP (1999), many countries have determined the age of phasing out at 35 years. Considering the financial and practical position of Sri Lanka as a developing country, it was decided to consider Transformers over 35 years of age as Over Aged.

During the study, it was discovered that there are 19 PCB contaminated transformers In-use that are overage. (Table 4.13) These should have been phased out, but have not been and hence are still in use.

Table 4.13 Structure of overage transformers

| Fabrication date | positive (>50ppm) |
|---|---|
| 1936 | 1 |
| 1953 | 1 |
| 1955 | 2 |
| 1960 | 2 |
| 1961 | 1 |
| 1962 | 1 |
| 1963 | 3 |
| 1965 | 3 |
| 1966 | 2 |
| 1967 | 3 |
| Total | 19 |
| Total weight of Dielectric fluid | 56,917 kg |
| Total weight of PCB contaminated material | 197,489 kg |



It is necessary to formulate a phasing out action plan for these transformers. When these transformers are phased out there will be around 197,000 kg of contaminated material, out of which around 57,000 kg will be liquids, to be dealt with in an environmentally sound manner.

## 4.3. Information regarding Decommissioned transformers

Inventory of Decommissioned transformers is given in Annex 3

### 4.3.1 Overall results for contamination in decommissioned transformers

Decommissioned transformers of CEB are being held by the LTL until they are sold for the recyclers. All the decommissioned transformers across the country are supposed to be stored at the Homagama Yard, owned and managed by the LTL. Hence an estimate of all decommissioned transformers owned by the CEB could be obtained by surveying this Yard.

In addition to these, LECO owned decommissioned transformers are stored at the Wasgamuwa. 296 decommissioned transformers have been investigated during the survey. Out of this number, 52 transformers have been analysed for PCBs. This is 17.6% of the number investigated. Results of the analysis are indicated in Table 4.14.

Table 4.14 Results of analysis of Decommissioned transformers



| PCB Test | Total | % Positive |
|---|---|---|
| negative (<50 ppm) | 18 | 35% |
| positive (>50 ppm) | 34 | 65% |
| Tested | 52 | |
| Total | 296 | |

According to the sample analysis, it is shown that 65% of the decommissioned transformers are positive for PCBs.

In applying the above for the population;

At 95% confidence level,

$p \pm Z_0 \sqrt{p(1-p)/n}$

$Z_0$ at 95% confidence level $= 1.96$

For all transformers in the country;

= 0.65 ± 1.96 √ (0.65 x 0.35) / 52

= 0.65 ± 0. 1296

Therefore, with 95% confidence level, it could be stated that 78% - 52% of the decommissioned transformers in the population of transformers manufactured on or before 1986 are PCB contaminated.

### 4.3.2 Distribution of contamination in decommissioned transformers according to ownership

When the breakdown of ownership is considered, the LTL has the highest rate of contamination. (Table 4.15)

Table 4.15 Results of analysis according to ownership

| **Owner category** | **Total** | **Tested** | **Number positive** | **%** |
|---|---|---|---|---|
| LECO | 36 | 8 | 4 | 50% |
| LTL | 255 | 44 | 30 | 68% |
| User | 5 | 0 | | |
| **Total** | 296 | 52 | **34** | **65%** |



According to the Table 4.15, in the sample analyzed, about 50% of the LECO owned decommissioned transformers are contaminated, while 68% of LTL owned transformers are contaminated.

In applying these to the population at 95% confidence level, for LTL owned decommissioned transformers

= 0.68 ± 1.96 √ (0.68 x 0.32) / 44

= 0.68 ± 0. 14

Therefore, with 95% confidence level, it could be stated that 82% - 54% of the decommissioned transformers in the population of transformers manufactured on or before 1986, owned by LTL are PCB contaminated.

Applying the findings to the LECO population using the correction factor for the finite population,

$0.5 \pm 1.96 \sqrt{(0.5 \times 0.5) / 44} \;.\; \sqrt{(81-8)/(81-1)}$

$0.5 \pm 0.14$

Therefore, with 95% confidence level, it could be stated that 64% - 36% of the decommissioned transformers in the population of transformers manufactured on or before 1986, owned by LECO are PCB contaminated.

### 4.3.3 Distribution of decommissioned transformers according to the country of origin

In the population of decommissioned transformers, the largest contamination is seen in transformers manufactured in France, India, Germany and Belgium. (Table 4.16)

Table 4.16 Contaminated Decommissioned transformers according to the country of origin

| Owner | Country | Total | Tested | Positive | % positive |
|---|---|---|---|---|---|
| LECO | Belgium | 6 | 1 | 1 | 100% |
| | France | 1 | 1 | 1 | 100% |
| | Germany | 5 | 3 | 1 | 33% |
| | India | 2 | 1 | 1 | 100% |
| | Japan | 1 | 1 | 0 | - |
| | Romania | 2 | 0 | 0 | - |
| | Sri Lanka | 13 | 0 | 0 | - |
| | UK | 4 | 1 | 0 | - |
| | Yugoslavia | 1 | 0 | 0 | - |
| | Unknown | 1 | 0 | 0 | - |
| | | | | | |
| | | 36 | 8 | 4 | 50% |
| | | **Total** | **Tested** | **Positive** | **% positive** |
| LTL | Australia | 2 | 0 | 0 | - |
| | Bulgaria | 4 | 1 | 0 | - |
| | France | 26 | 10 | 9 | 90% |
| | Germany | 5 | 1 | 1 | 100% |
| | India | 48 | 7 | 6 | 85% |
| | Japan | 4 | 1 | 0 | 0 |
| | Korea | 27 | 7 | 5 | 71% |
| | Romania | 11 | 4 | 3 | 75% |
| | Sri Lanka | 91 | 6 | 2 | 33% |
| | UK | 30 | 5 | 3 | 60% |
| | Yugoslavia | 7 | 2 | 1 | 50% |
| | | | | | |
| | Total | 255 | 44 | 30 | 68% |

## 4.4 Information regarding Pure PCB transformers

Inventory of Pure PCB transformers identified is given in Annex 4

During the survey 4 transformers containing Pure PCB oils have been identified by their trade name. In these transformers there is around 60% of PCB and around 30% solvent, to make PCB less viscous. All four transformers are Generation Auxiliary transformers.

Two transformers containing Pyranol 151 are situated in Samanala Power Station at Polpitiya. They have been manufactured by GEC in Canada in 1966 with a power capacity of 300kva. One of these is leaking.

The other two containing Pyralene E are located in New Laxapana Power Station. These two Generation Auxiliary Transformers are from Alsthom France, and have been manufactured in 1972. These have a capacity of 71 mVA.



## 4.5 Customs Statistics

### 4.5.1 Information on HS Headings

Table 4.17 shows information provided in Customs Statistics reports of several years on substances which might have a probability of containing PCB contaminated oils or PCBs. PCBs were not included in to a HS Code until 2000.

In the Customs Tariff Guide of 1985, Chapter 27 includes Mineral fuels, mineral oils and products and their distillation; bituminous substances mineral waxes. There are several types of oils classified under the Tariff Headings 27.10 and 27.08. There is a possibility for PCBs to be registered under HS heading 27.08.

Customs Tariff Guide on Imports and Exports of 1996, H.S Heading 29.03 include the following H.S. Code; 2903.49.09 – Other Halogenated derivatives of cyclanic, cyclenic or cyclotepent hydrocarbons.

| Year | 1985 | 1996 | 1997 | 1998 | 1999 | 2000 | 2002 |
|---|---|---|---|---|---|---|---|
| 27.08 (Oils and other products) | | | | | | 17,950MT | 29,107 MT |
| 2710.00.08 Other medium oil preparations | | 72MT | 763,285MT | 587,800MT | 698,000MT | | |
| 2710.19.09 (Medium oils and preparations not categorized elsewhere) | | | | | | 21,987 MT | 30,185MT |
| 2710.00.19 – other | | 55,000MT | 35,276MT | | | 1897MT | 2014MT |
| 2903.49.09(Halogenated derivatives) | | - | 141kg | 104,410kg | - | 1,090kg | |
| 2903.69 Other (halogenated aromatics other than Chlorobenzens and hexachlorobenzene and DDT) | | 1743kg | - | - | 13308 kg | - | |
| 3824.90.01 Hazardous waste (created in 2000) | | 9,300 kg | 24,650 kg | 1,487 kg | | 1,800kg | HS Codes changed |
| 38.25 (created in 2000) | | | | | | | 550 kg |

Table 4.17 Imports that has a probability of being PCB containing Transformer oil (Data for years from 1996- 2000)

In addition, under Halogenated derivatives of aromatic hydrocarbons there are 3 specific HS Codes.

2903.61 – Chlorobenzene, o-dichlorobenzene and p-dichlorobenzene

2903.62 – Hexachlorobenzene and DDT

2903.69 – Other (these are halogenated derivatives of aromatic hydrocarbons other than the 2 groups above.)

The same headings are seen in the 2002 amendment. There is a possibility of PCBs to be declared under these HS Headings.

In the case of Chapter 27, which was amended in 2002 and a new HS Heading 27.10 has been created. This HS Heading has 3 distinct HS Codes.

2710.11 – Light oils and preparations, 2710.19 – Medium oils and preparations;

Waste oils are under 2 HS Codes;

2710.91 – Waste oils containing PCBs, PCTs or PBBs

2710.99 – Other waste oils



According to Import Statistics of 2002, table 4.18 summarizes the amounts of waste oil imported in 2002.

Table 4.18 Import statistics after PCB containing waste oil is categorized under a distinct heading

| HS Code | Imports in Year 2002 |
|---|---|
| 2710.99 (Waste oil that does not contain PCB, PCT or PBB) | 16,763,523kg |
| 2710.91 (Waste oil that contain PCB, PCT or PBB) | None |

It is important to note that the import of waste oil containing PCB, PCT and PBB characterized by HS code 2710.91 are under Import Control License. However there is no requirement for the importer to supply a 'PCB Free' certificate in case of other oils.

Transformer Oils are imported to Sri Lanka specially by the LTL. They import transformer oil from UK, Singapore, Malaysia and USA, and these imports are under the HS Code 2710.19.03. Annual consumption of transformer oil at LTL is approximately 1,00,000 litres. However, neither the Department of Customs nor the LTL require a PCB free certificate from the supplier/exporter to certify that the oil is free of PCBs.

Other than items under Chapter 27, it is possible for PCBs to be imported as an item under Chapter 38. Under this chapter, Scraped transformers contaminated with PCBs could come in under HS heading 38.25 which is 'Residual products of the chemical or allied industries not specified elsewhere'.

There are a large number of transformers and capacitors imported to Sri Lanka during the past years. Since there is no requirement to declare whether the equipments are used ones are new ones, old transformers manufactured before 1986 could also get in under HS heading 85.32.



HS Heading 38.25 is the Residual products of the chemical or allied industries, not elsewhere specified or included; Municipal waste; Sewage sludge, other wastes as specified in Note 6 of Chapter 38. Note 6 says that HS Heading 38.25 can include waste organic solvents and hydraulic fluids, brake fluids and anti freezing fluids.

### 4.5.2 Information on Capacitors

Other than the in-built capacitors contained in various equipment, new and used, Capacitors new and old are imported to Sri Lanka from several countries. However, according to the present HS Codes, it is not possible to discern whether the consignment is a stock of new capacitors or used ones.

During the period 2001 – 2002, a large quantity of Capacitors has been imported to Sri Lanka under following subheadings;

| | |
|---|---|
| 85.32.10 | Fixed capacitors (Power capacitors) |
| 85.32.21 | Tantum |
| 85.32.23 | Ceramic dielectric Single |

| | |
|---|---|
| 85.32.24 | Ceramic Dielectric multilayer |
| 85.32.25 | Plastic or Paper dielectric |
| 85.32.29 | Other |
| 85.32.30 | Variable or adjustable |

The countries of origin are as follows;
United States of America, United Kingdom, Italy, Germany, France, United Arab Emirates, Thailand, Singapore, Pakistan, Malysia, S. Korea, Japan, India, Hong Kong, Taiwan, China, Australia, S. Africa, Switzerland, Turkey, Spain, Sweden, Netherlands, Belgium, Denmark, Canada.

Importers include a large number of private companies and the Police Dept, Ceylon Petroleum Corporation, Ceylon Electricity Board, Sri Lanka Telecom, Sri Lanka Ports Authority and the National Engineering Research and Development Center.

Due to the compact nature of these capacitors, it was not possible to test the liquid contained therein, while in use.



## 4.6 Obsolete stocks, storage sites and containing equipment

Spills of stored oils can cause contamination of ground and surface waters, soil and air.

One of the ways of contamination of the environment with PCBs is through recyclers, scrapping yards and repair yards. The recyclers use a considerable quantity of used transformer oil in their daily operations.

Scraps of transformers are sold specially for copper at recycler's yards. These may contain PCBs impregnated in to the metal. Figure 4.5 shows scraps of transformers at a yard.

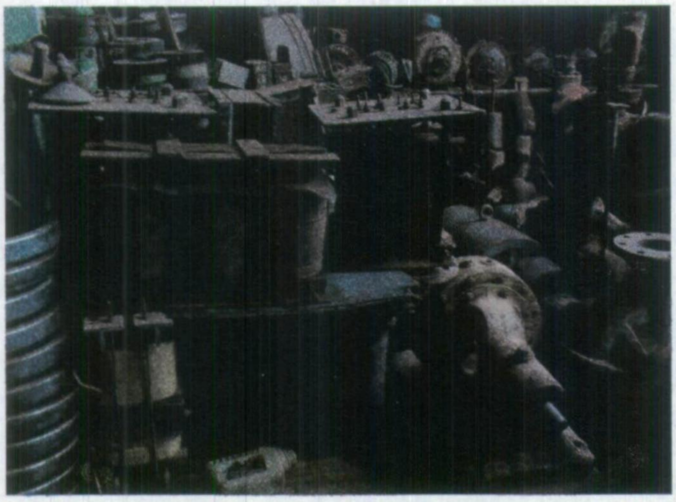

Figure 4.2 Scraps of dismantled transformers at a recycler's yard

They use saw-dust to absorb any oil that is spilled during draining of transformers, and saw-dust soaked with transformer oil is handed over to the relevant local authority for disposal. Therefore, there is a possibility of dumping and burning of saw dust used for cleaning spilled oil, which might contain PCBs.

Testing of transformers at old storage yards indicate that some of the transformers are contaminated with PCBs. Furthermore, these transformers were not stored in a proper manner, leading to leakage of transformer oil in to the ground. (Figures 4.3 and 4.4)



Figure 4.3 A decommissioned transformer

Haphazard disposal of transformers can lead to leaking of PCBs to soil and ground water.

Figure 4.4 Unsound practices of storage of decommissioned transformers

Transformer repair yards, storage yards and retrofilling sites are some of the other places that have a high probability for being contaminated with PCBs. At the moment, these places do not follow any labelling procedure nor do they use safety precautions to prevent contamination with PCBs. Samples analysed by the ITI indicated the presence of several congeners of PCBs in places where transformers were repaired and refilled.



PCB is quite stable in the environment, and therefore, as the harbour sediment is contaminated even at lower concentrations, the contaminant should be identified to prevent further contamination. It should also be remembered that there is risk of bio-concentration as well as of bio-accumulation, due to inherent properties of PCBs.

In 1988, oil was removed from 2 transformers at Kelanitissa Power Station, destined to be burned at Puttalam cement kiln. However the disposal did not proceed as planned and the contaminated oil remains stored up to now. There are approximately 1500 liters of Pyralene (which is a brand of PCB oil manufactured in France) stored at premises of Industrial Technology Institute (ITI). Approximately 3500 liters of PCB contaminated diesel oil are also stored in the same place, which are the residues of washings. The concentration of PCBs in these stockpiles is unknown.

The numbers and descriptions of barrels are as follows:

i. 12 Nos. of stainless steel drums of approx 20 gal of contaminated oil. : 80 kgs

ii. 2 Nos. drums of approx 45 gal of contaminated oil. 360 kgs

iii. 18 Nos. of 45 gal drums containing diesel contaminated with PCB (diesel was put into the transformers after they were emptied to flush out residues) 360 kgs

Storing of inflammable oils should be done well away from PCBs. Mineral oils can catch fire easily, and storing PCBs and contaminated material together can lead to fires. If PCBs catch fire, it can lead to release of PCBs, Dioxins and Furans to the environment.

## 4.7 Unintentional releases of PCBs to the environment

According to a report tilted 'Prefeasibility study on Hazardous Waste Management and Disposal for Sri Lanka', by the ERM in 1996, it has been estimated that Sri Lanka generates 6.25 tons of waste containing PCB, PCT and PBB, annually. There is a possibility that this amount be released to the environment.



As indicated above, recyclers and repair yards contaminate the environment with PCB due to lack of proper disposal mechanisms. PCB containing equipment and oil should be identified before they reach the recyclers.

## 4.8 Presence of PCB levels in human, food items and environment

Industrial Technology Institute (ITI), which is the only accredited laboratory for analysis of POPs in Sri Lanka have facilities to use GC, GCMS, HPLC for analysis of PCBs. They have the capacity to analyse 7 congeners of PCBs viz., PCB 28, 52, 110, 118, 138,153 and 180.

According to unpublished data of ITI, from analyses done in 1999, on samples of sediments taken from Colombo harbour, it is indicated that sediments are contaminated with PCBs at the concentration of 10 and 29 micrograms/kg of PCB28 and 5 microgrms/ kg of PCB101. According to Basel Convention guidelines, soil with concentrations higher than 10 ppm must be treated. Concentrations between 10-100 ppm should be disposed in an environmentally sound manner. However, concentrations under 10 ppm can be considered as non-contaminated. In another analysis, samples taken from Hambanthota Coastal zone show negative results for PCBs. , while sediment samples taken in 2000 from the Colombo harbour indicate the presence of PCBs in sediments. A sample of Shrimps was analysed in 2002 did not indicate the presence of PCB. Another analysis done in 2003 on shark liver oil, shrimps and gherkins also have shown negative results.

## 4.9 Limitations of the study

1. Small generators information was not taken because most of their transformers have been purchased after 1986.



2. The main limitation of the preliminary inventory is that the field survey was carried out only for one category of equipment, namely the transformers. However customs statistics were considered in order to identify the extent of importation of capacitors.

3. At least all transformers manufactured before 1986 should be tested and inventorized since these have the highest probability of being contaminated, and will be repaired/decommissioned due to age.

4. The stakeholder institutions were not able to track capacitors that they hold. It was not possible to trace capacitors held by the industries either, since the industries have no obligation to provide information on these.

5. At present, industries do not have any obligations to provide information related to transformers to the authorities. Authorities have no regulations for the tracking and management of industry owned transformers.

6. Capacitors as closed applications were considered only through statistical data, due to practical reasons. However, customs statistics data on import of transformers and capacitors are available only after 1998, and therefore, older data were not considered.

7. Northern Province has not been covered.

8. Use of Test Kits/GC was expensive and therefore, analysis had to be restricted.

# Chapter 5

## Conclusions

According to the survey results, the following conclusions could be made;

**1. Rate of contamination of in-use transformers**

The major conclusion that could be arrived from this research is that there are a larger number of mineral oil transformers contaminated with PCBs rather than pure PCB transformers in Sri Lanka.

On extrapolating results of the survey, for the in use transformers of the population, it could be stated with at 95% confidence level that plans should be formulated for the safe storage, labelling and disposal of 768 MT of contaminated oils at the upper level and 519MT at the lower level.

According to the survey, in case of In-use transformers, it could be stated with 95% confidence level that in the population owned by LECO 100-66% are contaminated while 74% to 55% of CEB owned transformers in the population are contaminated.



There are only 4 pure PCB transformers identified, but these are large generation transformers, and contain larger volumes of PCB oils.

**2. Rate of contamination in decommissioned transformers**

There is a high degree of contamination in decommissioned transformers held by LTL and LECO. According to the survey, in case of Decommissioned transformers, at 95% confidence level there could be 64% to 36% of contaminated transformers in the population of transformers owned by LECO. In the case of the population of transformers owned by LTL, at 95% confidence level it could be stated that 82% to 54% of transformers in the population are contaminated with PCBs.

### 3. Storage

Presently, storage of decommissioned transformers is not done in an environmentally sound manner. Due to present practices, there is a high possibility of soil and ground water contamination in the storage yards owned by the CEB, LECO and LTL.

There are stocks of pure PCBs, as well as stocks of contaminated oils stored together with flammable oils, in an environmentally unsound manner. There is no plan for their safe storage or disposal in the near future.

### 4. Importation Statistics

A considerably large amount of transformers and capacitors are being imported annually to the country. However, there is no indication whether PCB containing equipment have arrived in Sri Lanka, as there are no separate HS codes for PCB containing equipment.

It is evident from Customs statistics that there is a possibility for PCB containing oil to come to the country undetected. Presently, there is a HS Heading for waste oils, which might contain PCBs, but not for other oils. Since there are no regulations controlling entry of PCBs to the country, there is no barrier for the import of oils or equipment containing PCBs.



### 5. Recycling of decommissioned transformers

There is a demand for transformer scrap, capacitors and waste oil from the small scale local recyclers. Therefore, PCB contaminated parts and oils could get into the hands of recyclers, and through them to the environment. The recyclers are unaware about the hazards of PCBs.

# Chapter 6

## Recommendations

Study results could be used to recommend the following, for better control and management of PCBs, in Sri Lanka.

### 1. Establishment of a Full Inventory and Database on all contaminated transformers

The results of the survey could only be extrapolated to transformers that have been manufactured on or before 1986. Therefore, in order to identify the total amount of transformers/oils positive for PCBs, it is necessary to undertake a full inventory to cover all provinces of the country.

Sampling and analyse of transformers manufactured after 1986 to check for cross-contamination is important. All positive transformers should be labelled and entered in a database for effective phasing out. It is necessary to formulate a management plan for these transformers, so as to protect human health and the environment.



Highest positive results were seen in transformers manufactured in India, Korea and France, and hence, transformers manufactured in these countries should be prioritized for the implementation of management measures.

### 2. Identification of all Pure PCB transformers

It is necessary to identify all pure PCB transformers, label them and monitor them until they are phased out. Owners of these transformers should be provided with guidelines for their environmentally sound maintenance until phasing out.

Large Generation transformers contain large quantities of oil and other contaminated material. Special steps should be taken to decontaminate these, if it is not possible to phase out in near future.

### 3. Operation and maintenance for prevention of further cross contamination

Guidelines for operation and maintenance should be provided for owners of transformers to facilitate proper handling of PCB contaminated equipment. It is necessary to take steps to prevent cross contamination of transformers during filtering operations carried out regularly. CEB, LECO and LTL should undertake research and development in order to identify a mechanism for the prevention of cross contamination.

Retention tanks for leaking transformers should be established in order to prevent environmental contamination.

Recyclers and repair yards contaminate the environment with PCB due to lack of awareness on proper management measures as well as due to lack of safe disposal mechanisms.

### 4. Prevention on new entry of contaminated capacitors, transformers and oils to Sri Lanka



The capacities of relevant agencies should be strengthened to detect and identify PCB containing waste, transformers and other electrical equipment entering the country. Private sector institutions that might purchase used electrical equipment contaminated with PCBs at lower prices should be made aware on the risks.

One of the important steps to be taken is to prevent new entry of PCB to the country. A compulsory 'PCB free certificate' should be requested for imports of oils and equipment.

A considerably large amount of transformers and capacitors are being imported annually to the country. However, there is no indication whether these are new ones or used ones, and hence separate HS Codes should be created for these items. In addition to this, separate HS Codes should be created for transformers oils, in order to determine whether PCBs are imported.

## 5. Decommissioning of transformers

All transformers should be tested latest before disposal in order to prevent PCB contaminated oils getting in to the environment through small scale recyclers. Environmentally sound final disposal options should be determined for PCB transformers and for contaminated transformers. Options available in the country for final disposal should be carefully evaluated.

## 6. Establishment of proper storage and identification of contaminated sites for remediation

Special care should be taken when storing PCBs and contaminated material. Transformers should be drained and washed. All contaminated fluid should be stored in rust free stainless steel barrels, away from flammable liquids. Unauthorized persons should not be allowed to enter the storage yards. A crisis control plan should be in place, with a competent team with clear instruction to handle any emergency.

It is necessary to establish an inventory on contaminated sites, specially old storage yards. Once the contaminated sites are identified, containment and decontamination of these sites should be carried out.



## 7. Establishment of Regulations

Appropriate regulations should be established to facilitate the implementation of above recommendations.

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# Annex 1

**QUESTIONNAIRE**

**FOR THE PRELIMINARY INVENTORY ON PCB CONTAINING TRANSFORMERS**

**Information Related to Transformers***

| | | |
|---|---|---|
| | **Location of the Transformer** | |
| 1 | Owner of the transformer | |
| 2 | Division /Branch | |
| 3 | Name of site/location | |
| 4 | Owner's Identification Number** | |
| | | |
| | **Name Plate Infromation** | |
| 5 | Type of the Transformer | |
| 6 | Serial number | |
| 7 | Name of Manufacturer | |
| 8 | Country of origin** | |
| 9 | Year of Manufacture | |
| 10 | Power (kVA) | |
| 11 | Total mass | |
| 12 | Mass of Insulating Liquid | |
| 13 | Insulating Liquid** | |
| | | |
| | **Maintenance** | |
| 14 | Present Status of the transformer | Leaking/Not leaking |
| 15 | Service Status | In use/Repaired/Decommissioned |
| | | |



Inspector : ..........................................................................................

Date of Inspection : ..........................................................................................

Name of Manager : ..........................................................................................

Contact Numbers : ..........................................................................................

**NOTES FOR FILLING OF THE QUESTIONNAIRE :**

*Transformers manufactured on and before 1986 should be sampled

4.** Identification number given to the transformer by the Owner. To be used for tracking.

8. ** If Country of Origin is avialable in the Name Plate

## Annex 2

## Inventory of Inuse Transformers studied

| | Owner category | Geographical zone | PCB Test | Tested | Type | Country of Manufacture | Fabrication date | Power Kva | Total weight (kgs) | Weight of the dielectric fluid | Status of the equipment | Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CEB | WP | Not tested | Not tested | D | France | 1967 | 500 | 2,200 | 540 | In use | 37 |
| 2 | CEB | WP | Not tested | Not tested | D | Korea | 1981 | 800 | 1,285 | 295 | In use | 23 |
| 3 | CEB | WP | Not tested | Not tested | D | France | 1967 | 500 | 2900 | 710 | In use | 37 |
| 4 | CEB | WP | Not tested | Not tested | D | India | UK | 500 | 2,200 | 540 | In use | UK |
| 5 | CEB | WP | negative (<50 ppm | Tested | D | France | 1962 | 500 | 2,200 | 540 | In use | 42 |
| 6 | CEB | WP | Not tested | Not tested | D | Germany | 1982 | 400 | 2,200 | 540 | In use | 22 |
| 7 | CEB | WP | negative (<50 ppm | Tested | D | UK | 1936 | 500 | 2,200 | 540 | In use | 68 |
| 8 | CEB | WP | negative (<50 ppm | Tested | D | UK | 1955 | 500 | 2,200 | 540 | In use | 49 |
| 9 | CEB | WP | Not tested | Not tested | D | Germany | 1984 | 800 | 1,285 | 290 | In use | 20 |
| 10 | CEB | WP | Not tested | Not tested | D | India | 1971 | 500 | 2,200 | 540 | In use | 33 |
| 11 | CEB | WP | Not tested | Not tested | D | Korea | 1984 | 630 | 2500 | 650 | In use | 20 |
| 12 | CEB | WP | positive (>50 ppm) | Tested | D | France | 1955 | 750 | 5,525 | 1,775 | In use | 49 |
| 13 | CEB | WP | Not tested | Not tested | D | Japan | 1979 | 500 | 2,200 | 540 | In use | 25 |
| 14 | CEB | WP | Not tested | Not tested | D | France | 1955 | 750 | 5,525 | 1,775 | In use | 49 |
| 15 | CEB | WP | positive (>50 ppm) | Tested | D | UK | 1955 | 750 | 5,525 | 1,775 | In use | 49 |
| 16 | CEB | WP | Not tested | Not tested | D | Germany | 1974 | 500 | 2,200 | 540 | In use | 30 |
| 17 | CEB | WP | positive (>50 ppm) | Tested | D | Italy | 1963 | 500 | 2,200 | 540 | In use | 41 |
| 18 | CEB | WP | negative (<50 ppm | Tested | D | UK | 1936 | 500 | 2,200 | 540 | In use | 68 |
| 19 | CEB | WP | Not tested | Not tested | D | India | 1968 | 500 | 2,200 | 540 | In use | 36 |
| 20 | CEB | WP | Not tested | Not tested | D | France | 1962 | 500 | 2,200 | 540 | In use | 42 |
| 21 | CEB | WP | positive (>50 ppm) | Tested | D | India | 1960 | 500 | 2900 | 710 | In use | 44 |
| 22 | CEB | WP | Not tested | Not tested | D | India | 1967 | 500 | 1566 | 435 | In use | 37 |
| 23 | CEB | WP | positive (>50 ppm) | Tested | D | India | 1979 | 400 | 1578 | 364 | In use | 25 |
| 24 | CEB | WP | Not tested | Not tested | D | India | 1969 | 150 | 1400 | 486 | In use | 35 |
| 25 | CEB | WP | Not tested | Not tested | D | India | 1979 | 400 | 1578 | 364 | In use | 25 |
| 26 | CEB | WP | positive (>50 ppm) | Tested | D | UK | 1960 | 750 | 5,525 | 1,775 | In use | 44 |
| 27 | CEB | WP | Not tested | Not tested | D | India | 1966 | 500 | 2,200 | 540 | In use | 38 |
| 28 | CEB | WP | Not tested | Not tested | D | France | 1978 | 500 | 1000 | 245 | In use | 26 |
| 29 | CEB | WP | positive (>50 ppm) | Tested | D | France | 1967 | 500 | 957 | 235 | In use | 37 |
| 30 | CEB | WP | Not tested | Not tested | D | India | 1982 | 100 | 835 | 238 | In use | 22 |
| 31 | CEB | WP | Not tested | Not tested | D | France | 1967 | 150 | 1030 | 302 | In use | 37 |
| 32 | CEB | WP | positive (>50 ppm) | Tested | D | France | 1967 | 300 | 1556 | 432 | In use | 37 |
| 33 | CEB | WP | Not tested | Not tested | D | Korea | 1979 | 100 | 950 | 311 | In use | 25 |
| 34 | CEB | WP | Not tested | Not tested | D | France | 1979 | 400 | 1578 | 364 | In use | 25 |
| 35 | CEB | WP | Not tested | Not tested | D | France | 1966 | 500 | 2200 | 540 | In use | 38 |
| 36 | CEB | WP | Not tested | Not tested | D | Korea | 1978 | 1000 | 4400 | 1200 | In use | 26 |
| 37 | CEB | WP | Not tested | Not tested | D | France | 1973 | 400 | 1499 | 330 | In use | 31 |
| 38 | CEB | WP | negative (<50 ppm | Tested | D | Yugoslavia | 1981 | 250 | 1,040 | 181 | In use | 23 |
| 39 | CEB | WP | Not tested | Not tested | D | India | 1981 | 100 | 835 | 192 | In use | 23 |
| 40 | CEB | WP | Not tested | Not tested | D | India | 1977 | 160 | 1200 | 400 | In use | 27 |
| 41 | CEB | WP | Not tested | Not tested | D | Sri Lanka | 1984 | 100 | 1010 | 275 | In use | 20 |
| 42 | CEB | WP | Not tested | Not tested | D | Sri Lanka | 1984 | 100 | 1010 | 275 | In use | 20 |
| 43 | CEB | WP | Not tested | Not tested | D | France | 1967 | 150 | 1030 | 302 | In use | 37 |
| 44 | CEB | WP | Not tested | Not tested | D | India | 1970 | 150 | 1340 | 486 | In use | 34 |
| 45 | CEB | WP | Not tested | Not tested | D | France | 1967 | 200 | 1206 | 347 | In use | 37 |
| 46 | CEB | WP | Not tested | Not tested | D | Sri Lanka | 1986 | 160 | 1165 | 357 | In use | 18 |

| | Owner category | Geographical zone | PCB Test | Tested | Type | Country of Manufacture | Fabrication date | Power Kva | Total weight (kgs) | Weight of the dielectric fluid | Status of the equipment | Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 47 | CEB | WP | positive (>50 ppm) | Tested | D | Romania | 1978 | 250 | 1240 | 357 | In use | 26 |
| 48 | CEB | WP | positive (>50 ppm) | Tested | D | Germany | 1984 | 250 | 1,530 | 400 | In use | 20 |
| 49 | CEB | WP | Not tested | Not tested | D | UK | 1986 | 150 | 1030 | 302 | In use | 18 |
| 50 | CEB | WP | Not tested | Not tested | D | Sri Lanka | 1984 | 160 | 1250 | 357 | In use | 20 |
| 51 | CEB | WP | negative (<50 ppm | Tested | D | Romania | 1982 | 160 | 750 | 173 | In use | 22 |
| 52 | CEB | WP | Not tested | Not tested | D | India | 1978 | 250 | 1450 | 357 | In use | 26 |
| 53 | CEB | WP | positive (>50 ppm) | Tested | D | Italy | 1966 | 300 | 1,515 | 374 | In use | 38 |
| 54 | CEB | WP | Not tested | Not tested | D | Sri Lanka | 1987 | 400 | 1795 | 485 | In use | 17 |
| 55 | CEB | WP | positive (>50 ppm) | Tested | D | India | 1977 | 100 | 930 | 320 | In use | 27 |
| 56 | CEB | WP | positive (>50 ppm) | Tested | D | Romania | 1981 | 400 | 1795 | 485 | In use | 23 |
| 57 | CEB | WP | Not tested | Not tested | D | Sri Lanka | 1985 | 630 | 2500 | 650 | In use | 19 |
| 58 | CEB | WP | Not tested | Not tested | D | Sri Lanka | 1985 | 630 | 2,500 | 650 | In use | 19 |
| 59 | CEB | WP | Not tested | Not tested | D | Sri Lanka | 1985 | 250 | 1540 | 330 | In use | 19 |
| 60 | CEB | WP | Not tested | Not tested | D | France | 1980 | 500 | 1550 | 330 | In use | 24 |
| 61 | CEB | WP | positive (>50 ppm) | Tested | D | India | 1977 | 400 | 2400 | 665 | In use | 27 |
| 62 | CEB | WP | Not tested | Not tested | D | Sri Lanka | 1985 | 250 | 1,840 | 460 | In use | 19 |
| 63 | CEB | WP | Not tested | Not tested | D | India | 1973 | 250 | 1,840 | 635 | In use | 31 |
| 64 | CEB | WP | Not tested | Not tested | D | France | 1979 | 250 | 1,840 | 462 | In use | 25 |
| 65 | CEB | WP | Not tested | Not tested | D | Sri Lanka | 1985 | 630 | 2500 | 650 | In use | 19 |
| 66 | CEB | SP | Not tested | Not tested | D | France | 1970 | 100 | 336 | 70 | In use | 34 |
| 67 | CEB | SP | positive (>50 ppm) | Tested | D | Romania | 1982 | 250 | 1034 | 238 | In use | 22 |
| 68 | CEB | SP | Not tested | Not tested | D | India | 1972 | 30 | 780 | 300 | In use | 32 |
| 69 | CEB | SP | positive (>50 ppm) | Tested | D | Bulgaria | 1979 | 250 | 1030 | 238 | In use | 25 |
| 70 | CEB | SP | Not tested | Not tested | D | France | 1979 | 250 | 1738 | 520 | In use | 25 |
| 71 | CEB | SP | Not tested | Not tested | D | India | 1973 | 400 | 1,650 | 762 | In use | 31 |
| 72 | CEB | SP | Not tested | Not tested | D | India | 1981 | 100 | 835 | 238 | In use | 23 |
| 73 | CEB | SP | positive (>50 ppm) | Tested | D | India | 1978 | 250 | 1090 | 250 | In use | 26 |
| 74 | CEB | SP | Not tested | Not tested | D | Korea | 1983 | 1200 | 6500 | 1810 | In use | 21 |
| 75 | CEB | SP | Not tested | Not tested | D | India | 1982 | 5000 | 11300 | 3,700 | In use | 22 |
| 76 | CEB | SP | Not tested | Not tested | D | India | 1982 | 5000 | 11300 | 3,700 | In use | 22 |
| 77 | CEB | SP | positive (>50 ppm) | Tested | D | Italy | 1965 | 200 | 4550 | 1015 | In use | 39 |
| 78 | CEB | SP | Not tested | Not tested | D | Korea | 1983 | 1000 | 4400 | 1200 | In use | 21 |
| 79 | CEB | SP | positive (>50 ppm) | Tested | D | France | 1969 | 500 | 2034 | 403 | In use | 35 |
| 80 | CEB | SP | Not tested | Not tested | D | Sri Lanka | 1986 | 100 | 1987 | 344 | In use | 18 |
| 81 | CEB | SP | Not tested | Not tested | D | Sri Lanka | 1986 | 100 | 930 | 300 | In use | 18 |
| 82 | CEB | SP | positive (>50 ppm) | Tested | D | Sri Lanka | 1978 | 160 | 1064 | 355 | In use | 26 |
| 83 | CEB | SP | Not tested | Not tested | D | India | 1971 | 250 | 1775 | 600 | In use | 33 |
| 84 | CEB | SP | Not tested | Not tested | D | France | 1967 | 200 | 1206 | 347 | In use | 37 |
| 85 | CEB | SP | Not tested | Not tested | D | Sri Lanka | 1986 | 100 | 1017 | 409 | In use | 18 |
| 86 | CEB | SP | positive (>50 ppm) | Tested | D | Sri Lanka | 1978 | 160 | 1016 | 355 | In use | 26 |
| 87 | CEB | SP | Not tested | Not tested | D | India | 1973 | 2000 | 6610 | 1700 | In use | 31 |
| 88 | CEB | SP | positive (>50 ppm) | Tested | D | India | 1973 | 2000 | 6610 | 1700 | In use | 31 |
| 89 | CEB | SP | Not tested | Not tested | D | Korea | 1983 | 160 | 1100 | 270 | In use | 21 |
| 90 | CEB | SP | Not tested | Not tested | D | Korea | 1983 | 2000 | 7250 | 1650 | In use | 21 |
| 91 | CEB | SP | positive (>50 ppm) | Tested | D | Korea | 1983 | 2000 | 7250 | 1650 | In use | 21 |
| 92 | CEB | SP | Not tested | Not tested | D | India | 1969 | 100 | 1230 | 410 | In use | 35 |
| 93 | CEB | SP | Not tested | Not tested | D | Korea | 1984 | 2000 | 6610 | 1700 | In use | 20 |
| 94 | CEB | SP | positive (>50 ppm) | Tested | D | India | 1973 | 2000 | 6500 | 1600 | In use | 31 |
| 95 | CEB | SP | Not tested | Not tested | D | Korea | 1984 | 2000 | 6500 | 1600 | In use | 20 |
| 96 | CEB | SP | Not tested | Not tested | D | Sri Lanka | 1978 | 160 | 1250 | 355 | In use | 26 |
| 97 | CEB | NWP | negative (<50 ppm | Tested | D | Bulgaria | 1979 | 150 | 1045 | 222 | In use | 25 |
| 98 | CEB | NWP | Not tested | Not tested | D | Sri Lanka | 1986 | 160 | 916 | 245 | In use | 18 |
| 99 | CEB | NWP | Not tested | Not tested | D | Romania | 1980 | 400 | 1751 | 385 | In use | 24 |
| 100 | CEB | NWP | Not tested | Not tested | D | Germany | 1981 | 100 | 700 | 180 | In use | 23 |
| 101 | CEB | NWP | Not tested | Not tested | D | Sri Lanka | 1983 | 400 | 1575 | 360 | In use | 21 |

| | Owner category | Geographical zone | PCB Test | Tested | Type | Country of Manufacture | Fabrication date | Power Kva | Total weight (kgs) | Weight of the dielectric fluid | Status of the equipment | Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 102 | CEB | NWP | negative (<50 ppm | Tested | D | Belgium | 1965 | 150 | 853 | 244 | In use | 39 |
| 103 | CEB | NWP | positive (>50 ppm) | Tested | D | France | 1973 | 100 | 865 | 244 | In use | 31 |
| 104 | CEB | NWP | Not tested | Not tested | D | France | 1967 | 100 | 810 | 244 | In use | 37 |
| 105 | CEB | NWP | Not tested | Not tested | D | Sri Lanka | 1983 | 250 | 1035 | 244 | In use | 21 |
| 106 | CEB | NWP | Not tested | Not tested | D | India | 1982 | 250 | 1330 | 244 | In use | 22 |
| 107 | CEB | NWP | negative (<50 ppm | Tested | D | S.Africa | 1960 | 100 | 1,218 | 244 | In use | 44 |
| 108 | CEB | NWP | Not tested | Not tested | D | India | 1971 | 250 | 1170 | 244 | In use | 33 |
| 109 | CEB | NWP | Not tested | Not tested | D | Japan | 1985 | 2000 | 7100 | 1,620 | In use | 19 |
| 110 | CEB | NWP | Not tested | Not tested | D | France | 1972 | 250 | 1010 | 244 | In use | 32 |
| 111 | CEB | NWP | Not tested | Not tested | D | France | 1981 | 2000 | 4800 | 1,930 | In use | 23 |
| 112 | CEB | NWP | Not tested | Not tested | D | India | 1973 | 2000 | 6610 | 1,510 | In use | 31 |
| 113 | CEB | NWP | Not tested | Not tested | D | Sri Lanka | 1984 | 160 | 1250 | 360 | In use | 20 |
| 114 | CEB | WP | Not tested | Not tested | D | Sri Lanka | 1983 | 160 | 1245 | 450 | In use | 21 |
| 115 | CEB | NWP | Not tested | Not tested | D | Sri Lanka | 1985 | 160 | 1250 | 355 | In use | 19 |
| 116 | CEB | NWP | Not tested | Not tested | D | Sri Lanka | 1984 | 250 | 1540 | 460 | In use | 20 |
| 117 | CEB | NWP | negative (<50 ppm | Tested | D | Italy | 1957 | 100 | 1100 | 253 | In use | 47 |
| 118 | CEB | WP | Not tested | Not tested | D | Unknown | 1977 | 150 | 1045 | 286 | In use | 27 |
| 119 | CEB | WP | Not tested | Not tested | D | UK | 1973 | 200 | 1050 | 286 | In use | 31 |
| 120 | CEB | WP | Not tested | Not tested | D | Belgium | 1985 | 50 | 521 | 130 | In use | 19 |
| 121 | CEB | WP | positive (>50 ppm) | Tested | D | UK | 1986 | 500 | 1,944 | 334 | In use | 18 |
| 122 | CEB | NWP | negative (<50 ppm | Tested | D | Unknown | 1987 | 500 | 2,290 | 400 | In use | 17 |
| 123 | CEB | NCP | positive (>50 ppm) | Tested | D | India | UK | 100 | 835 | 283 | In use | UK |
| 124 | CEB | NCP | negative (<50 ppm | Tested | D | India | UK | 250 | 835 | 270 | In use | UK |
| 125 | CEB | NCP | Not tested | Not tested | D | Sri Lanka | 1984 | 100 | 485 | 115 | In use | 20 |
| 126 | CEB | NCP | Not tested | Not tested | D | India | 1982 | 250 | 1330 | 350 | In use | 22 |
| 127 | CEB | NCP | Not tested | Not tested | D | Sri Lanka | 1984 | 100 | 485 | 115 | In use | 20 |
| 128 | CEB | NCP | negative (<50 ppm | Tested | D | Sri Lanka | 1984 | 200 | 1,250 | 355 | In use | 20 |
| 129 | CEB | NCP | positive (>50 ppm) | Tested | D | Sri Lanka | 1986 | 100 | 1,016 | 344 | In use | 18 |
| 130 | CEB | NCP | negative (<50 ppm | Tested | D | Yugoslavia | UK | 100 | 485 | 115 | In use | UK |
| 131 | CEB | NCP | Not tested | Not tested | D | Yugoslavia | UK | 100 | 485 | 115 | In use | UK |
| 132 | CEB | NCP | positive (>50 ppm) | Tested | D | India | UK | 160 | 1,250 | 288 | In use | UK |
| 133 | CEB | NCP | negative (<50 ppm | Tested | D | Romania | UK | 100 | 485 | 115 | In use | UK |
| 134 | CEB | NCP | Not tested | Not tested | D | France | UK | 300 | 1,075 | 298 | In use | UK |
| 135 | LECO | WP | Not tested | Not tested | D | France | 1953 | 250 | 1,640 | 380 | In use | 51 |
| 136 | LECO | WP | Not tested | Not tested | D | Yugoslavia | 1981 | 250 | 1044 | 313 | In use | 23 |
| 137 | LECO | WP | Not tested | Not tested | D | Japan | 1970 | 100 | 630 | 165 | In use | 34 |
| 138 | LECO | WP | Not tested | Not tested | D | Sri Lanka | 1983 | 230 | 1170 | 280 | In use | 21 |
| 139 | LECO | WP | Not tested | Not tested | D | Belgium | 1895 | 160 | 710 | 145 | In use | 109 |
| 140 | LECO | WP | negative (<50 ppm | Tested | D | Portugal | 1965 | 150 | 853 | 244 | In use | 39 |
| 141 | LECO | WP | Not tested | Not tested | D | Korea | 1978 | 250 | 1,240 | 275 | In use | 26 |
| 142 | LECO | WP | positive (>50 ppm) | Tested | D | Bulgaria | 1979 | 150 | 845 | 195 | In use | 25 |
| 143 | LECO | WP | Not tested | Not tested | D | Korea | 1981 | 250 | 2200 | 450 | In use | 23 |
| 144 | LECO | WP | positive (>50 ppm) | Tested | D | India | 1972 | 500 | 2360 | 510 | In use | 32 |
| 145 | LECO | WP | positive (>50 ppm) | Tested | D | Germany | 1967 | 500 | 1,820 | 430 | In use | 37 |
| 146 | LECO | WP | positive (>50 ppm) | Tested | D | UK | 1953 | 300 | 2,068 | 500 | In use | 51 |
| 147 | LECO | WP | Not tested | Not tested | D | Sri Lanka | 1985 | 160 | 880 | 245 | In use | 19 |
| 148 | LECO | WP | Not tested | Not tested | D | Korea | 1981 | 630 | 1900 | 390 | In use | 23 |
| 149 | LECO | WP | Not tested | Not tested | D | Korea | 1983 | 400 | 1900 | 390 | In use | 21 |
| 150 | LECO | WP | Not tested | Not tested | D | Sri Lanka | 1985 | 160 | 880 | 245 | In use | 19 |
| 151 | LECO | WP | positive (>50 ppm) | Tested | D | Germany | UK | 200 | 1,445 | 347 | In use | UK |
| 152 | LECO | WP | Not tested | Not tested | D | France | 1972 | 100 | 560 | 130 | In use | 32 |
| 153 | LECO | WP | positive (>50 ppm) | Tested | D | Korea | 1981 | 630 | 2200 | 506 | In use | 23 |
| 154 | LECO | WP | Not tested | Not tested | D | Romania | 1980 | 400 | 1772 | 385 | In use | 24 |
| 155 | LECO | WP | positive (>50 ppm) | Tested | D | India | 1982 | 63 | 240 | 55 | In use | 22 |
| 156 | CEB | WP | Not tested | Not tested | T | Unknown | 1983 | 31500 | 58,500 | 22,500 | In use | 21 |

| | Owner category | Geographical zone | PCB Test | Tested | Type | Country of Manufacture | Fabrication date | Power Kva | Total weight (kgs) | Weight of the dielectric fluid | Status of the equipment | Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 157 | CEB | WP | Not tested | Not tested | T | Unknown | 1983 | 31500 | 58,500 | 22,500 | In use | 21 |
| 158 | CEB | WP | Not tested | Not tested | T | Unknown | 1983 | 31500 | 58,500 | 22,500 | In use | 21 |
| 159 | CEB | WP | Not tested | Not tested | T | Unknown | 1983 | 31500 | 58,500 | 22,500 | In use | 21 |
| 160 | CEB | WP | negative (<50 ppm | Tested | T | Sri Lanka | 1983 | 27000 | 44,200 | 11,300 | In use | 21 |
| 161 | CEB | WP | positive (>50 ppm) | Tested | T | Sri Lanka | 1982 | 27000 | 44,200 | 11,300 | In use | 22 |
| 162 | CEB | WP | Not tested | Not tested | T | Sri Lanka | 1982 | 27000 | 44,200 | 11,300 | In use | 22 |
| 163 | CEB | WP | Not tested | Not tested | T | Unknown | 1971 | 31500 | 58,000 | 15,500 | In use | 33 |
| 164 | CEB | WP | Not tested | Not tested | T | Unknown | 1983 | 31500 | 58,000 | 15,500 | In use | 21 |
| 165 | CEB | WP | Not tested | Not tested | T | Unknown | 1983 | 31500 | 58,000 | 15,500 | In use | 21 |
| 166 | CEB | WP | Not tested | Not tested | T | Unknown | 1983 | 31500 | 58,000 | 15,500 | In use | 21 |
| 167 | CEB | WP | Not tested | Not tested | T | Unknown | 1983 | 31500 | 58,000 | 15,500 | In use | 21 |
| 168 | CEB | WP | Not tested | Not tested | T | Unknown | 1983 | 31500 | 58,000 | 15,500 | In use | 21 |
| 169 | CEB | WP | Not tested | Not tested | T | Sri Lanka | 1983 | nknown | 58,000 | 15,500 | In use | 21 |
| 170 | CEB | WP | negative (<50 ppm | Tested | T | Sri Lanka | 1979 | 30000 | 48,700 | 14,200 | In use | 25 |
| 171 | CEB | WP | negative (<50 ppm | Tested | T | Sri Lanka | 1981 | 30000 | 48,700 | 14,200 | In use | 23 |
| 172 | CEB | WP | Not tested | Not tested | T | Austria | 1981 | 31500 | 46,550 | 14,200 | In use | 23 |
| 173 | CEB | CP | Not tested | Not tested | T | Austria | 1986 | 31500 | 46,550 | 13,500 | In use | 18 |
| 174 | CEB | CP | Not tested | Not tested | T | Belgium | 1986 | 31500 | 46,550 | 15,300 | In use | 18 |
| 175 | CEB | CP | Not tested | Not tested | T | Belgium | UK | 31500 | 65,500 | 17,300 | In use | UK |
| 176 | CEB | NWP | Not tested | Not tested | T | Belgium | UK | 31500 | 65,500 | 17,300 | In use | UK |
| 177 | CEB | NWP | Not tested | Not tested | T | Unknown | UK | 31500 | 58,000 | 13,500 | In use | UK |
| 178 | CEB | UP | Not tested | Not tested | T | France | 1983 | 31500 | 32,000 | 9,800 | In use | 21 |
| 179 | CEB | NCP | Not tested | Not tested | T | France | 1968 | 10000 | 32,000 | 9,800 | In use | 36 |
| 180 | CEB | NCP | negative (<50 ppm | Tested | T | Austria | 1968 | 31500 | 46,550 | 9,350 | In use | 36 |
| 181 | CEB | WP | negative (<50 ppm | Tested | T | Austria | UK | 31500 | 46,550 | 9,350 | In use | UK |
| 182 | CEB | WP | negative (<50 ppm | Tested | T | France | UK | 31500 | 32,000 | 9,800 | In use | UK |
| 183 | CEB | EP | Not tested | Not tested | T | France | 1978 | 10000 | 32,000 | 9,800 | In use | 26 |
| 184 | CEB | EP | Not tested | Not tested | T | France | 1968 | 31500 | 32,000 | 9,800 | In use | 36 |
| 185 | CEB | EP | Not tested | Not tested | T | France | 1970 | 5000 | 4,000 | 920 | In use | 34 |
| 186 | CEB | EP | Not tested | Not tested | T | France | 1970 | 5000 | 4,000 | 1,100 | In use | 34 |
| 187 | CEB | SP | Not tested | Not tested | T | France | 1980 | 1200 | 56,600 | 15,600 | In use | 24 |
| 188 | CEB | SP | Not tested | Not tested | T | Denmark | 1980 | 23100 | 56,600 | 15,600 | In use | 24 |
| 189 | CEB | SP | Not tested | Not tested | T | Germany | 1986 | 23100 | 56,600 | 15,600 | In use | 18 |
| 190 | CEB | EP | Not tested | Not tested | T | Germany | 1983 | 1600 | 4,690 | 1,067 | In use | 21 |
| 191 | CEB | EP | Not tested | Not tested | T | France | 1983 | 1000 | 32,000 | 9,800 | In use | 21 |
| 192 | CEB | NP | Not tested | Not tested | T | France | 1972 | 10000 | 32,000 | 9,800 | In use | 32 |
| 193 | CEB | NP | Not tested | Not tested | T | France | 1969 | 10000 | 32,000 | 9,800 | In use | 35 |
| 194 | CEB | SP | positive (>50 ppm) | Tested | T | France | 1972 | 10000 | 32,000 | 9,800 | In use | 32 |
| 195 | CEB | SP | positive (>50 ppm) | Tested | T | France | 1969 | 10000 | 32,000 | 9,800 | In use | 35 |
| 196 | CEB | SP | positive (>50 ppm) | Tested | T | France | 1975 | 10000 | 32,000 | 9,800 | In use | 29 |
| 197 | CEB | SabP | Not tested | Not tested | T | France | UK | 71000 | 68,000 | 15,640 | In use | UK |
| 198 | CEB | SabP | Not tested | Not tested | T | France | UK | 71000 | 68,000 | 15,640 | In use | UK |
| 199 | CEB | CP | Not tested | Not tested | T | France | 1972 | 72000 | 41,100 | 10,000 | In use | 32 |
| 200 | CEB | CP | Not tested | Not tested | T | Czechoslova | 1972 | 72000 | 41,100 | 10,000 | In use | 32 |
| 201 | CEB | SabP | Not tested | Not tested | G | Czechoslova | 1966 | 350 | 1800 | 360 | In use | 38 |
| 202 | CEB | SabP | Not tested | Not tested | G | Czechoslova | 1966 | 5000 | 16200 | 4600 | In use | 38 |
| 203 | CEB | SabP | negative (<50 ppm | Tested | G | Czechoslova | 1966 | 5000 | 16200 | 4600 | In use | 38 |
| 204 | CEB | SabP | Not tested | Not tested | G | Unknown | UK | 5000 | 16,200 | 4600 | In use | UK |
| 205 | CEB | CP | Not tested | Not tested | G | Unknown | 1983 | 32000 | 44,400 | 8,900 | In use | 21 |
| 206 | CEB | CP | negative (<50 ppm | Tested | G | Unknown | 1983 | 32000 | 44,400 | 8,900 | In use | 21 |
| 207 | CEB | CP | Not tested | Not tested | G | Denmark | 1983 | 32000 | 48,700 | 8,900 | In use | 21 |
| 208 | CEB | CP | Not tested | Not tested | G | Denmark | 1982 | 30000 | 48,700 | 14,200 | In use | 22 |
| 209 | CEB | CP | Not tested | Not tested | G | Germany | 1982 | 30000 | 48,700 | 14,200 | In use | 22 |
| 210 | CEB | CP | Not tested | Not tested | G | Germany | 1983 | 31500 | 45,000 | 14,200 | In use | 21 |
| 211 | CEB | CP | Not tested | Not tested | G | Germany | 1985 | 27000 | 45,000 | 10,000 | In use | 19 |

|  | Owner category | Geographical zone | PCB Test | Tested | Type | Country of Manufacture | Fabrication date | Power Kva | Total weight (kgs) | Weight of the dielectric fluid | Status of the equipment | Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 212 | CEB | CP | negative (<50 ppm | Tested | G | Germany | 1985 | 27000 | 45,000 | 10,000 | In use | 19 |
| 213 | CEB | CP | Not tested | Not tested | G | Germany | 1985 | 27000 | 61,000 | 15,300 | In use | 19 |
| 214 | CEB | CP | Not tested | Not tested | G | Germany | 1984 | 34000 | 61,000 | 15,300 | In use | 20 |
| 215 | CEB | CP | Not tested | Not tested | G | Germany | 1984 | 34000 | 61,000 | 15,300 | In use | 20 |
| 216 | CEB | CP | Not tested | Not tested | G | Canada | 1984 | 34000 | 45,000 | 10,000 | In use | 20 |
| 217 | CEB | CP | negative (<50 ppm | Tested | G | Canada | 1965 | 17500 | 27,409 | 6,955 | In use | 39 |
| 218 | CEB | CP | positive (>50 ppm) | Tested | G | Canada | 1965 | 17500 | 27,409 | 6,955 | In use | 39 |
| 219 | CEB | CP | Not tested | Not tested | G | Canada | 1965 | 17500 | 27,409 | 6,955 | In use | 39 |
| 220 | CEB | CP | Not tested | Not tested | G | France | 1965 | 17500 | 27,409 | 6,955 | In use | 39 |
| 221 | CEB | SP | Not tested | Not tested | T | France | 1966 | 400 | 1,027 | 236 | In use | 38 |
| 222 | CEB | SP | Not tested | Not tested | T | France | 1980 | 30000 | 56,600 | 15,600 | In use | UK |
| 223 | CEB | SP | Not tested | Not tested | T | France | 1980 | 200 | 4,000 | 1,100 | In use | UK |
| 224 | CEB | CP | Not tested | Not tested | G | France | 1972 | 32000 | 41,100 | 10,000 | In use | 32 |
| 225 | CEB | CP | negative (<50 ppm | Tested | G | Germany | 1972 | 32000 | 44,000 | 10,000 | In use | 32 |
| 226 | CEB | CP | positive (>50 ppm) | Tested | G | Germany | 1985 | 32000 | 44,000 | 9,300 | In use | 19 |
| 227 | CEB | CP | Not tested | Not tested | G | Japan | 1985 | 32000 | 44,000 | 9,300 | In use | 19 |
| 228 | CEB | CP | Not tested | Not tested | G | Japan | 1980 | 38000 | 44,000 | 9,300 | In use | 24 |
| 229 | CEB | CP | Not tested | Not tested | G | Japan | 1976 | 50000 | 57,000 | 33,500 | In use | 28 |
| 230 | CEB | CP | Not tested | Not tested | G | France | 1975 | 32000 | 38,000 | 10,000 | In use | 29 |
| 231 | CEB | EP | positive (>50 ppm) | Tested | G | Unknown | 1963 | 15000 | 38,000 | 9,850 | In use | 41 |
| 232 | CEB | EP | positive (>50 ppm) | Tested | G | Unknown | 1963 | 15000 | 38,000 | 9,850 | In use | 41 |
| 233 | CEB | CP | Not tested | Not tested | G | Unknown | 1963 | 5333 | 20,860 | 5,910 | In use | 41 |
| 234 | CEB | CP | negative (<50 ppm | Tested | G | Unknown | 1963 | 5333 | 20,860 | 5,910 | In use | 41 |
| 235 | CEB | CP | Not tested | Not tested | G | Unknown | 1963 | 10700 | 20,860 | 5,910 | In use | 41 |
| 236 | CEB | CP | negative (<50 ppm | Tested | G | France | 1968 | 10700 | 20,860 | 5,910 | In use | 36 |
| 237 | CEB | CP | Not tested | Not tested | G | France | 1963 | 500 | 2,630 | 500 | In use | 41 |
| 238 | CEB | CP | Not tested | Not tested | G | France | 1963 | 32000 | 41,200 | 15,000 | In use | 41 |
| 239 | CEB | WP | Not tested | Not tested | G | France | 1961 | 32000 | 41,200 | 15,000 | In use | 43 |
| 240 | CEB | WP | positive (>50 ppm) | Tested | G | France | 1961 | 32000 | 41,200 | 15,000 | In use | 43 |
| 241 | CEB | WP | Not tested | Not tested | G | France | 1961 | 2000 | 6,390 | 1,390 | In use | 43 |
| 242 | CEB | WP | Not tested | Not tested | GA | Belgium | 1962 | 32000 | 65,000 | 15,000 | In use | 42 |
| 243 | CEB | WP | Not tested | Not tested | GI | Belgium | 1980 | 60000 | 65,000 | 17,000 | In use | 24 |
| 244 | CEB | WP | Not tested | Not tested | GI | France | 1980 | 60000 | 49,000 | 17,000 | In use | 24 |
| 245 | CEB | WP | Not tested | Not tested | G | UK | 1980 | 28700 | 38,070 | 6,600 | In use | 24 |
| 246 | CEB | WP | Not tested | Not tested | G | UK | 1980 | 28700 | 38,070 | 7,600 | In use | 24 |
| 247 | CEB | WP | Not tested | Not tested | G | France | 1980 | 28000 | 38,000 | 6,600 | In use | 24 |
| 248 | CEB | WP | Not tested | Not tested | G | France | 1980 | 31500 | 36,000 | 13,200 | In use | 24 |
| 249 | CEB | WP | Not tested | Not tested | G | France | 1980 | 28700 | 49,400 | 13,200 | In use | 24 |
| 250 | CEB | WP | Not tested | Not tested | GA | France | 1962 | 750 | 7,600 | 1,130 | In use | 42 |
| 251 | CEB | WP | negative (<50 ppm | Tested | GA | France | 1962 | 750 | 7,600 | 1,130 | In use | 42 |
| 252 | CEB | WP | Not tested | Not tested | GA | France | 1962 | 750 | 7,600 | 1,130 | In use | 42 |
| 253 | CEB | WP | positive (>50 ppm) | Tested | GA | France | 1962 | 2000 | 6,390 | 1,390 | In use | 42 |
| 254 | CEB | WP | Not tested | Not tested | G | France | 1983 | 50000 | 74,000 | 18,000 | In use | 21 |
| 255 | CEB | WP | negative (<50 ppm | Tested | G | France | 1983 | 50000 | 74,000 | 18,000 | In use | 21 |
| 256 | CEB | CP | negative (<50 ppm | Tested | G | Sri Lanka | 1972 | 24000 | 41100 | 10,000 | In use | 32 |
| 257 | user | EP | Not tested | Not tested | D | Germany | 1984 | 400 | 2,420 | 510 | In use | 20 |
| 258 | user | EP | Not tested | Not tested | D | Germany | UK | 500 | 2,420 | 550 | In use | UK |
| 259 | CEB | EP | Not tested | Not tested | D | France | 1977 | 150 | 1,045 | 286 | In use | 27 |
| 260 | CEB | EP | Not tested | Not tested | D | Italy | 1953 | 50 | 353 | 78 | In use | 51 |
| 261 | user | WP | Not tested | Not tested | D | UK | 1953 | 1000 | 4,350 | 851 | In use | 51 |
| 262 | user | WP | Not tested | Not tested | D | UK | 1953 | 400 | 1,218 | 600 | In use | 51 |
| 263 | user | WP | Not tested | Not tested | D | Sweden | 1976 | 800 | 2880 | 495 | In use | 28 |
| 264 | user | WP | Not tested | Not tested | D | India | 1980 | 500 | 2,220 | 440 | In use | 24 |
| 265 | user | WP | Not tested | Not tested | D | UK | 1953 | 750 | 4,890 | 1,410 | In use | 51 |
| 266 | user | WP | Not tested | Not tested | D | UK | 1953 | 750 | 4,890 | 1,410 | in use | 51 |

| | Owner category | Geographical zone | PCB Test | Tested | Type | Country of Manufacture | Fabrication date | Power Kva | Total weight (kgs) | Weight of the dielectric fluid | Status of the equipment | Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 267 | user | WP | Not tested | Not tested | D | Norway | UK | 600 | 4,630 | 1,065 | In use | UK |
| 268 | user | EP | Not tested | Not tested | D | Germany | 1965 | 1600 | 4,690 | 1,067 | In use | 39 |
| 269 | user | EP | Not tested | Not tested | D | Norway | 1955 | 2000 | 9700 | 2400 | In use | 49 |
| 270 | CEB | NCP | Not tested | Not tested | D | France | 1977 | 250 | 970 | 210 | In use | 27 |
| 271 | CEB | WP | Not tested | Not tested | D | India | UK | 500 | 1,710 | 343 | In use | UK |
| 272 | user | WP | Not tested | Not tested | D | UK | UK | 400 | 3700 | 600 | In use | UK |
| 273 | CEB | SP | Not tested | Not tested | D | Unknown | UK | 35 | 144 | 36 | In use | UK |
| 274 | user | SP | Not tested | Not tested | D | Unknown | UK | 35 | 148 | 37 | In use | UK |
| 275 | user | SP | Not tested | Not tested | D | France | 1967 | 400 | 1400 | 312 | In use | 37 |
| 276 | user | NWP | Not tested | Not tested | D | Germany | 1969 | 45 | 1,400 | 610 | In use | 35 |
| 277 | user | NWP | Not tested | Not tested | D | Germany | 1969 | 400 | 1400 | 322 | In use | 35 |
| 278 | user | WP | Not tested | Not tested | D | Italy | 2000 | 560 | 1600 | 330 | In use | 4 |
| 279 | user | NWP | Not tested | Tested | D | Pakistan | 1999 | 2000 | 6,930 | 1320 | In use | 5 |
| 280 | user | NWP | Not tested | Not tested | D | Germany | 1970 | 4000 | 10,150 | 2,660 | In use | 34 |
| 281 | user | WP | Not tested | Not tested | D | Germany | 1966 | 2000 | 6,930 | 1,660 | In use | 38 |
| 282 | user | NWP | Not tested | Tested | D | Germany | 1970 | 2000 | 6,930 | 1,470 | In use | 34 |
| 283 | user | NWP | Not tested | Not tested | D | Germany | 1970 | 2000 | 7,180 | 1,470 | In use | 34 |
| 284 | user | WP | Not tested | Not tested | D | Germany | 1966 | 2000 | 7,180 | 1,660 | In use | 38 |
| 285 | user | NWP | Not tested | Not tested | D | Germany | 1966 | 2000 | 7,180 | 1,680 | In use | 38 |
| 286 | user | WP | Not tested | Not tested | D | Germany | 1965 | 1000 | 2,910 | 575 | In use | 39 |
| 287 | user | WP | Not tested | Not tested | D | Germany | 1970 | 4000 | 10,510 | 2,420 | In use | 34 |
| 288 | user | WP | Not tested | Not tested | D | Germany | 1970 | 4000 | 11,700 | 2,420 | In use | 34 |
| 289 | user | WP | Not tested | Not tested | D | Germany | 1966 | 4000 | 11,700 | 3,468 | In use | 38 |
| 290 | user | WP | Not tested | Tested | D | Germany | 1966 | 4000 | 11700 | 3,468 | In use | 38 |
| 291 | user | SP | Not tested | Not tested | D | Romania | 1982 | 250 | 1,770 | 470 | In use | 22 |
| 292 | CEB | SabP | negative (<50 ppm | Tested | D | Italy | UK | 75 | 353 | 78 | In use | UK |
| 293 | CEB | SabP | Not tested | Not tested | D | India | 1982 | 100 | 1,125 | 270 | In use | 22 |
| 294 | CEB | SabP | Not tested | Not tested | D | India | 1976 | 100 | 1,200 | 423 | In use | 28 |
| 295 | CEB | SabP | positive (>50 ppm) | Tested | D | Korea | 1978 | 150 | 2,085 | 567 | In use | 26 |
| 296 | CEB | SabP | Not tested | Not tested | D | France | 1973 | 500 | 2,865 | 570 | In use | 31 |
| 297 | CEB | SabP | positive (>50 ppm) | Tested | D | Italy | 1965 | 200 | 1,302 | 352 | In use | 39 |
| 298 | CEB | SabP | negative (<50 ppm | Tested | D | Unknown | UK | 200 | 1,010 | 180 | In use | UK |
| 299 | CEB | SabP | positive (>50 ppm) | Tested | D | France | 1978 | 250 | 1,125 | 185 | In use | 26 |
| 300 | CEB | SabP | positive (>50 ppm) | Tested | D | India | 1976 | 100 | 1,540 | 425 | In use | 28 |
| 301 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1985 | 250 | 930 | 460 | In use | 19 |
| 302 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1989 | 100 | 930 | 300 | In use | 15 |
| 303 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1989 | 100 | 1,384 | 300 | In use | 15 |
| 304 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1989 | 250 | 930 | 214 | In use | 15 |
| 305 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1989 | 100 | 1,016 | 300 | In use | 15 |
| 306 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1987 | 100 | 1,125 | 344 | In use | 17 |
| 307 | CEB | UP | Not tested | Not tested | D | India | 1970 | 100 | 1,125 | 480 | In use | 34 |
| 308 | CEB | UP | Not tested | Not tested | D | France | 1967 | 75 | 1,095 | 231 | In use | 37 |
| 309 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1987 | 160 | 1,095 | 345 | In use | 17 |
| 310 | CEB | UP | positive (>50 ppm) | Tested | D | France | 1973 | 500 | 2,085 | 570 | In use | 31 |
| 311 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1978 | 100 | 1,500 | 300 | In use | 26 |
| 312 | CEB | UP | positive (>50 ppm) | Tested | D | Germany | 1936 | 400 | 1,785 | 440 | In use | 68 |
| 313 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1989 | 400 | 880 | 485 | In use | 15 |
| 314 | CEB | UP | Not tested | Not tested | D | Romania | 1982 | 250 | 1,250 | 470 | In use | 22 |
| 315 | CEB | UP | Not tested | Not tested | D | India | 1969 | 100 | 1,445 | 332 | In use | 35 |
| 316 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1989 | 250 | 1,445 | 460 | In use | 15 |
| 317 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1989 | 250 | 1,445 | 460 | In use | 15 |
| 318 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1989 | 250 | 835 | 460 | In use | 15 |
| 319 | CEB | UP | positive (>50 ppm) | Tested | D | India | 1983 | 100 | 1,095 | 238 | In use | 21 |
| 320 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1989 | 160 | 970 | 345 | In use | 15 |
| 321 | CEB | UP | positive (>50 ppm) | Tested | D | Sri Lanka | 1985 | 100 | 1,016 | 334 | In use | 19 |

| | Owner category | Geographical zone | PCB Test | Tested | Type | Country of Manufacture | Fabrication date | Power Kva | Total weight (kgs) | Weight of the dielectric fluid | Status of the equipment | Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 322 | CEB | UP | positive (>50 ppm) | Tested | D | Sri Lanka | 1982 | 100 | 1,045 | 344 | In use | 22 |
| 323 | CEB | UP | positive (>50 ppm) | Tested | D | France | 1977 | 150 | 1,016 | 286 | In use | 27 |
| 324 | CEB | UP | positive (>50 ppm) | Tested | D | Sri Lanka | 1987 | 100 | 1,446 | 344 | In use | 17 |
| 325 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1988 | 250 | 1,445 | 460 | In use | 16 |
| 326 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1988 | 250 | 1,206 | 445 | In use | 16 |
| 327 | CEB | UP | Not tested | Not tested | D | France | 1967 | 200 | 1,445 | 347 | In use | 37 |
| 328 | CEB | UP | Not tested | Not tested | D | Sri Lanka | 1988 | 250 | 2,906 | 460 | In use | 16 |
| 329 | CEB | UP | Not tested | Not tested | D | India | 1969 | 500 | 2,200 | 540 | In use | 35 |
| 330 | CEB | CP | negative (<50 ppm | Tested | D | Yugoslavia | 1983 | 100 | 2,200 | 550 | In use | 21 |
| 331 | CEB | CP | positive (>50 ppm) | Tested | D | Yugoslavia | 1982 | 400 | 1,540 | 540 | In use | 22 |
| 332 | CEB | CP | Not tested | Not tested | D | Sri Lanka | 1984 | 250 | 1,540 | 460 | In use | 20 |
| 333 | CEB | CP | positive (>50 ppm) | Tested | D | Korea | 1983 | 750 | 7,500 | 3,100 | In use | 21 |
| 334 | CEB | CP | positive (>50 ppm) | Tested | D | France | 1978 | 250 | 1,560 | 342 | In use | 26 |
| 335 | CEB | CP | positive (>50 ppm) | Tested | D | Yugoslavia | 1979 | 250 | 1,010 | 342 | In use | 25 |
| 336 | CEB | CP | positive (>50 ppm) | Tested | D | France | 1978 | 250 | 1,010 | 185 | In use | 26 |
| 337 | CEB | CP | positive (>50 ppm) | Tested | D | France | 1978 | 250 | 1,010 | 185 | In use | 26 |
| 338 | CEB | CP | positive (>50 ppm) | Tested | D | India | 1978 | 250 | 2,470 | 590 | In use | 26 |
| 339 | CEB | CP | positive (>50 ppm) | Tested | D | Yugoslavia | 1979 | 50 | 200 | 46 | In use | 25 |
| 340 | CEB | CP | negative (<50 ppm | Tested | D | Belgium | 1975 | 100 | 2,200 | 550 | In use | 29 |
| 341 | CEB | CP | negative (<50 ppm | Tested | D | Yugoslavia | 1981 | 160 | 620 | 195 | In use | 23 |
| 342 | CEB | CP | positive (>50 ppm) | Tested | D | Yugoslavia | 1979 | 60 | 200 | 54 | In use | 25 |
| 343 | CEB | WP | negative (<50 ppm | Tested | T | France | 1990 | 31500 | 36,000 | 13,200 | In use | 14 |
| 344 | CEB | WP | negative (<50 ppm | Tested | T | France | 1990 | 31500 | 36,000 | 13,200 | In use | 14 |
| 345 | CEB | CP | positive (>50 ppm) | Tested | D | Unknown | UK | 160 | 620 | 195 | In use | UK |
| 346 | CEB | WP | positive (>50 ppm) | Tested | D | Yugoslavia | 1979 | 150 | 680 | 156 | In use | 25 |
| 347 | CEB | CP | positive (>50 ppm) | Tested | GA | Canada | 1966 | 300 | 9263 | 3520 | In use | 38 |
| 348 | CEB | CP | positive (>50 ppm) | Tested | GA | Canada | 1966 | 300 | 9263 | 3520 | In use | 38 |
| 349 | CEB | CP | positive (>50 ppm) | Tested | GA | France | 1972 | nknown | Unknown | Unknown | In use | 32 |
| 350 | CEB | CP | positive (>50 ppm) | Tested | GA | France | 1972 | nknown | Unknown | Unknown | In use | 32 |
| 351 | CEB | CP | positive (>50 ppm) | Tested | GA | France | 1963 | nknown | Unknown | Unknown | In use | 41 |
| 352 | CEB | CP | positive (>50 ppm) | Tested | GA | France | 1963 | nknown | Unknown | Unknown | In use | 41 |
| 353 | CEB | CP | positive (>50 ppm) | Tested | GA | Unknown | UK | nknown | Unknown | Unknown | In use | UK |
| 354 | CEB | CP | positive (>50 ppm) | Tested | GA | Unknown | UK | nknown | Unknown | Unknown | In use | UK |

# Annex 3

## Inventory of Decommissioned transformers studied

| | Owner category | Geographical zone | PCB Test | Type | Manufacturer name | Country of Manufacture | Fabrication date | Power Kva | Total weight (kgs) | Weight of the dielectric fluid | Status of the equipment | Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | LTL | WP | Not tested | D | Electrical Company Ltd. | India | 1983 | 250 | 835 | 270 | Decom. | 21 |
| 2 | LTL | WP | Not tested | D | Electric Construction Equipment | India | 1977 | 400 | 1,260 | 440 | Decom. | 27 |
| 3 | LTL | WP | Not tested | D | Woden Bilston | UK | 1977 | 630 | 2,700 | 730 | Decom. | 27 |
| 4 | LTL | WP | Not tested | D | Crompton | UK | 1971 | 250 | 675 | 270 | Decom. | 33 |
| 5 | LTL | WP | Not tested | D | Unknown | Sri Lanka | 1983 | 350 | 1,575 | 355 | Decom. | 21 |
| 6 | LTL | WP | Not tested | D | Alsthom | France | 1964 | 400 | 1,395 | 410 | Decom. | 40 |
| 7 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1986 | 350 | 1,610 | 339 | Decom. | 18 |
| 8 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 600 | 2,705 | 715 | Decom. | 19 |
| 9 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 500 | 2,170 | 444 | Decom. | 19 |
| 10 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1984 | 500 | 2,400 | 480 | Decom. | 20 |
| 11 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1981 | 700 | 3,000 | 700 | Decom. | 23 |
| 12 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1983 | 630 | 2,520 | 480 | Decom. | 21 |
| 13 | LTL | WP | Not tested | D | Crompton | UK | 1970 | 630 | 2,600 | 835 | Decom. | 34 |
| 14 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 500 | 2,500 | 650 | Decom. | 19 |
| 15 | LTL | WP | Not tested | D | Unelec | France | 1967 | 350 | 1,556 | 432 | Decom. | 37 |
| 16 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1979 | 315 | 950 | 311 | Decom. | 25 |
| 17 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1984 | 310 | 1,400 | 322 | Decom. | 20 |
| 18 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1978 | 450 | 2,000 | 390 | Decom. | 26 |
| 19 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1983 | 500 | 2,095 | 455 | Decom. | 21 |
| 20 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1983 | 500 | 2,110 | 456 | Decom. | 21 |
| 21 | LTL | WP | Not tested | D | Bonar Long & Co | UK | 1982 | 500 | 2,320 | 449 | Decom. | 22 |
| 22 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1983 | 250 | 835 | 238 | Decom. | 21 |
| 23 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1983 | 250 | 835 | 238 | Decom. | 21 |
| 24 | LTL | WP | Not tested | D | G.C.Egener Elec | UK | 1936 | 400 | 1,395 | 410 | Decom. | 68 |
| 25 | LTL | WP | Not tested | D | South Walse Switches | UK | 1959 | 1200 | 4,932 | 1,233 | Decom. | 45 |
| 26 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1982 | 100 | 485 | 115 | Decom. | 22 |
| 27 | LTL | WP | Not tested | D | France Transfo | France | 1980 | 100 | 745 | 215 | Decom. | 24 |
| 28 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1986 | 350 | 1,032 | 352 | Decom. | 18 |
| 29 | LTL | WP | Not tested | D | MINEL Trafo. | Yugoslavia | 1981 | 315 | 1,275 | 314 | Decom. | 23 |
| 30 | LTL | WP | Not tested | D | E.C.E | India | 1976 | 400 | 1,125 | 423 | Decom. | 28 |
| 31 | LTL | WP | Not tested | D | Unelec | France | 1973 | 300 | 1,075 | 298 | Decom. | 31 |
| 32 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1982 | 300 | 1,075 | 290 | Decom. | 22 |
| 33 | LTL | WP | Not tested | D | MINEL Trafo. | Yugoslavia | 1981 | 315 | 1,275 | 314 | Decom. | 23 |
| 34 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1983 | 500 | 1,800 | 480 | Decom. | 21 |
| 35 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1983 | 250 | 835 | 238 | Decom. | 21 |
| 36 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1984 | 500 | 1,540 | 460 | Decom. | 20 |
| 37 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1984 | 500 | 1,540 | 460 | Decom. | 20 |
| 38 | LTL | WP | Not tested | D | Unelec | France | 1967 | 350 | 1,206 | 347 | Decom. | 37 |
| 39 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 125 | 580 | 182 | Decom. | 19 |
| 40 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1984 | 250 | 1,110 | 275 | Decom. | 20 |
| 41 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1984 | 600 | 2,500 | 650 | Decom. | 20 |
| 42 | LTL | WP | Not tested | D | Mitsuibishi | Japan | 1979 | 160 | 630 | 163 | Decom. | 25 |
| 43 | LTL | WP | Not tested | D | Johnson Electric Company | India | 1979 | 75 | 353 | 78 | Decom. | 25 |
| 44 | LTL | WP | Not tested | D | Johnson Electric Company | India | 1979 | 75 | 353 | 78 | Decom. | 25 |
| 45 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1983 | 400 | 1,910 | 610 | Decom. | 21 |
| 46 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1986 | 400 | 1,032 | 409 | Decom. | 18 |
| 47 | LTL | WP | Not tested | D | Unelec | France | 1973 | 300 | 1,075 | 298 | Decom. | 31 |
| 48 | LTL | WP | Not tested | D | Unelec | France | 1967 | 350 | 1,206 | 347 | Decom. | 37 |
| 49 | LTL | WP | Not tested | D | Electro Export EM | Romania | 1982 | 400 | 1,110 | 390 | Decom. | 22 |
| 50 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 125 | 580 | 182 | Decom. | 19 |
| 51 | LTL | WP | Not tested | D | Distribution Trano Ltd | Muebroxbur | 1968 | 100 | 3,400 | 782 | Decom. | 36 |

| | Owner category | Geographical zone | PCB Test | Type | Manufacturer name | Country of Manufacture | Fabrication date | Power Kva | Total weight (kgs) | Weight of the dielectric fluid | Status of the equipment | Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 52 | LTL | WP | Not tested | D | English Elec. | UK | 1936 | 100 | 585 | 134 | Decom. | 68 |
| 53 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1982 | 250 | 835 | 238 | Decom. | 22 |
| 54 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1977 | 315 | 930 | 320 | Decom. | 27 |
| 55 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 250 | 978 | 275 | Decom. | 19 |
| 56 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1984 | 500 | 2,400 | 480 | Decom. | 20 |
| 57 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1986 | 400 | 1,870 | 510 | Decom. | 18 |
| 58 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1986 | 350 | 1,032 | 352 | Decom. | 18 |
| 59 | LTL | WP | Not tested | D | Electro Export EM | Romania | 1982 | 400 | 1,110 | 390 | Decom. | 22 |
| 60 | LTL | WP | Not tested | D | Electro Export EM | Romania | 1979 | 300 | 1,240 | 279 | Decom. | 25 |
| 61 | LTL | WP | Not tested | D | Unelec | France | 1977 | 250 | 1,045 | 286 | Decom. | 27 |
| 62 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1986 | 350 | 1,523 | 355 | Decom. | 18 |
| 63 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1988 | 250 | 880 | 248 | Decom. | 16 |
| 64 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1978 | 1500 | 6,460 | 2,000 | Decom. | 26 |
| 65 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 200 | 700 | 190 | Decom. | 19 |
| 66 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1984 | 400 | 1,910 | 510 | Decom. | 20 |
| 67 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1984 | 350 | 1,250 | 355 | Decom. | 20 |
| 68 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1986 | 350 | 1,225 | 355 | Decom. | 18 |
| 69 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 350 | 1,250 | 355 | Decom. | 19 |
| 70 | LTL | WP | Not tested | D | MINEL Trafo. | Yugoslavia | 1981 | 315 | 1,275 | 314 | Decom. | 23 |
| 71 | LTL | WP | Not tested | D | Electro Export EM | Romania | 1982 | 400 | 1,110 | 390 | Decom. | 22 |
| 72 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1986 | 350 | 1,032 | 352 | Decom. | 18 |
| 73 | LTL | WP | Not tested | D | Schorch Werke Co.Ltd | Germany | 1978 | 500 | 2,420 | 550 | Decom. | 26 |
| 74 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1984 | 350 | 1,575 | 355 | Decom. | 20 |
| 75 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1986 | 250 | 919 | 245 | Decom. | 18 |
| 76 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1982 | 300 | 1,075 | 290 | Decom. | 22 |
| 77 | LTL | WP | Not tested | D | Crompton | UK | 1971 | 500 | 2,420 | 625 | Decom. | 33 |
| 78 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1979 | 350 | 1,650 | 297 | Decom. | 25 |
| 79 | LTL | WP | Not tested | D | Johnson Electric Company | India | 1975 | 630 | 3,025 | 800 | Decom. | 29 |
| 80 | LTL | WP | Not tested | D | Unelec | France | 1967 | 350 | 1,556 | 432 | Decom. | 37 |
| 81 | LTL | WP | Not tested | D | Unelec | France | 1967 | 500 | 2,130 | 370 | Decom. | 37 |
| 82 | LTL | WP | Not tested | D | Unelec | France | 1967 | 500 | 2,130 | 370 | Decom. | 37 |
| 83 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1984 | 500 | 2,500 | 650 | Decom. | 20 |
| 84 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1984 | 500 | 2,500 | 651 | Decom. | 20 |
| 85 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 300 | 1,410 | 300 | Decom. | 19 |
| 86 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 250 | 1,110 | 275 | Decom. | 19 |
| 87 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 300 | 1,170 | 280 | Decom. | 19 |
| 88 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1981 | 700 | 3,000 | 700 | Decom. | 23 |
| 89 | LTL | WP | Not tested | D | Ferrante | UK | 1951 | 500 | 2,150 | 560 | Decom. | 53 |
| 90 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1979 | 500 | 1,950 | 380 | Decom. | 25 |
| 91 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1978 | 160 | 640 | 200 | Decom. | 26 |
| 92 | LTL | WP | Not tested | D | Mitsuibishi | Japan | 1979 | 350 | 630 | 340 | Decom. | 25 |
| 93 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1986 | 350 | 1,225 | 355 | Decom. | 18 |
| 94 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1983 | 250 | 880 | 265 | Decom. | 21 |
| 95 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 300 | 1,170 | 280 | Decom. | 19 |
| 96 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1982 | 350 | 1,450 | 410 | Decom. | 22 |
| 97 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1986 | 350 | 1,032 | 352 | Decom. | 18 |
| 98 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1979 | 350 | 950 | 348 | Decom. | 25 |
| 99 | LTL | WP | Not tested | D | Denis Ferrant Ltd | UK | 1967 | 1000 | 4,030 | 1,340 | Decom. | 37 |
| 100 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 350 | 1,540 | 460 | Decom. | 19 |
| 101 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 250 | 880 | 245 | Decom. | 19 |
| 102 | LTL | WP | Not tested | D | Ejprom | Bulgaria | 1979 | 250 | 1,046 | 246 | Decom. | 25 |
| 103 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1978 | 160 | 680 | 155 | Decom. | 26 |
| 104 | LTL | WP | Not tested | D | Bonar Long & Co | UK | 1971 | 300 | 1,285 | 290 | Decom. | 33 |
| 105 | LTL | WP | Not tested | D | Unelec | France | 1973 | 160 | 615 | 194 | Decom. | 31 |
| 106 | LTL | WP | Not tested | D | Electo Co. | India | 1976 | 400 | 1,125 | 423 | Decom. | 28 |
| 107 | LTL | WP | Not tested | D | Tyree Industries | Australia | 1965 | 2000 | 5,500 | 1,912 | Decom. | 39 |
| 108 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1982 | 100 | 835 | 238 | Decom. | 22 |
| 109 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1982 | 100 | 835 | 238 | Decom. | 22 |
| 110 | LTL | WP | Not tested | D | Siemens | Germany | 1959 | 500 | 2,340 | 520 | Decom. | 45 |
| 111 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1983 | 250 | 1,170 | 280 | Decom. | 21 |
| 112 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1986 | 100 | 1,032 | 352 | Decom. | 18 |
| 113 | LTL | WP | Not tested | D | Crompton | UK | 1971 | 300 | 2,420 | 625 | Decom. | 33 |
| 114 | LTL | WP | Not tested | D | ETC | India | 1977 | 100 | 970 | 355 | Decom. | 27 |
| 115 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1986 | 100 | 978 | 275 | Decom. | 18 |

| | Owner category | Geographical zone | PCB Test | Type | Manufacturer name | Country of Manufacture | Fabrication date | Power Kva | Total weight (kgs) | Weight of the dielectric fluid | Status of the equipment | Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 116 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1983 | 250 | 1,540 | 460 | Decom. | 21 |
| 117 | LTL | WP | Not tested | D | Ejprom | Bulgaria | 1979 | 250 | 1,830 | 570 | Decom. | 25 |
| 118 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1983 | 160 | 620 | 195 | Decom. | 21 |
| 119 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1983 | 100 | 835 | 238 | Decom. | 21 |
| 120 | LTL | WP | Not tested | D | Crompton | UK | 1971 | 500 | 2,470 | 570 | Decom. | 33 |
| 121 | LTL | WP | Not tested | D | Crompton | UK | 1971 | 500 | 2,420 | 530 | Decom. | 33 |
| 122 | LTL | WP | Not tested | D | Electrical Company Ltd. | UK | 1953 | 75 | 1,950 | 540 | Decom. | 51 |
| 123 | LTL | WP | Not tested | D | South Walse Switches | UK | 1982 | 500 | 1,840 | 485 | Decom. | 22 |
| 124 | LTL | WP | Not tested | D | E.E.I | Romania | 1963 | 100 | 945 | 200 | Decom. | 41 |
| 125 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 100 | 919 | 245 | Decom. | 19 |
| 126 | LTL | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1986 | 400 | 1,523 | 355 | Decom. | 18 |
| 127 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1973 | 380 | 3,520 | 690 | Decom. | 31 |
| 128 | LTL | WP | Not tested | D | Unelec | France | 1966 | 100 | 610 | 124 | Decom. | 38 |
| 129 | LTL | WP | Not tested | D | Schorch Werke Co.Ltd | Germany | 1966 | 100 | 700 | 160 | Decom. | 38 |
| 130 | LTL | WP | Not tested | D | E.E.I | Romania | 1981 | 250 | 1,240 | 275 | Decom. | 23 |
| 131 | LTL | WP | Not tested | D | NGEI | India | 1970 | 200 | 760 | 210 | Decom. | 34 |
| 132 | LTL | WP | Not tested | D | MINEL Trafo. | Yugoslavia | 1981 | 250 | 1,044 | 181 | Decom. | 23 |
| 133 | LECO | WP | Not tested | D | Pauwels Trafo | Belgium | 1986 | 50 | 345 | 85 | Decom. | 18 |
| 134 | LECO | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1990 | 50 | 400 | 130 | Decom. | 14 |
| 135 | LECO | WP | Not tested | D | Pauwels Trafo | Belgium | 1986 | 50 | 345 | 85 | Decom. | 18 |
| 136 | LECO | WP | Not tested | D | Pauwels Trafo | Belgium | 1986 | 50 | 345 | 85 | Decom. | 18 |
| 137 | LECO | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1990 | 50 | 400 | 130 | Decom. | 14 |
| 138 | LECO | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1990 | 50 | 400 | 130 | Decom. | 14 |
| 139 | LECO | WP | negative (<50 | D | Trand | India | 1969 | 75 | 750 | 160 | Decom. | 35 |
| 140 | LECO | WP | negative (<50 | D | Johnson Electric Company | India | 1979 | 50 | 353 | 78 | Decom. | 25 |
| 141 | LECO | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1990 | 50 | 353 | 78 | Decom. | 14 |
| 142 | LECO | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1990 | 100 | 555 | 185 | Decom. | 14 |
| 143 | LECO | WP | negative (<50 | D | Lepper | Germany | Jnknown | 150 | 845 | 195 | Decom. | UK |
| 144 | LECO | WP | negative (<50 | D | Electric construction Co. | UK | 1936 | 300 | 867 | 248 | Decom. | 68 |
| 145 | LECO | WP | negative (<50 | D | Ferrante | UK | 1964 | 500 | 6,300 | 1850 | Decom. | 40 |
| 146 | LECO | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1990 | 100 | 555 | 185 | Decom. | 14 |
| 147 | LECO | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1990 | 100 | 555 | 185 | Decom. | 14 |
| 148 | LECO | WP | positive (>50 | D | Pauwels Trafo | Belgium | 1986 | 100 | 510 | 115 | Decom. | 18 |
| 149 | LECO | WP | Not tested | D | Pauwels Trafo | Belgium | 1986 | 100 | 510 | 115 | Decom. | 18 |
| 150 | LECO | WP | Not tested | D | Pauwels Trafo | Belgium | 1986 | 100 | 510 | 115 | Decom. | 18 |
| 151 | LECO | WP | Not tested | D | Mitsuibishi | Japan | 1970 | 100 | 530 | 185 | Decom. | 34 |
| 152 | LECO | WP | negative (<50 | D | Schorch Werke Co.Ltd | Germany | 1936 | 100 | 700 | 160 | Decom. | 68 |
| 153 | LECO | WP | positive (>50 | D | Dominit | Germany | 1973 | 315 | 1370 | 480 | Decom. | 31 |
| 154 | LECO | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | Jnknown | 100 | 510 | 110 | Decom. | UK |
| 155 | LECO | WP | Not tested | D | Bonar Long & Co | UK | 1996 | 50 | 353 | 78 | Decom. | 8 |
| 156 | LECO | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1959 | 100 | 555 | 185 | Decom. | 45 |
| 157 | LECO | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1990 | 100 | 555 | 185 | Decom. | 14 |
| 158 | LECO | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1990 | 100 | 555 | 185 | Decom. | 14 |
| 159 | LECO | WP | Not tested | D | Lanka Transformers Limited | Sri Lanka | 1985 | 100 | 555 | 185 | Decom. | 19 |
| 160 | LECO | WP | Not tested | D | Siemens | Germany | 1993 | 250 | 1035 | 300 | Decom. | 11 |
| 161 | LECO | WP | Not tested | D | Takota auto | Unknown | 1990 | 250 | 58,500 | 22,500 | Decom. | 14 |
| 162 | user | WP | Not tested | D | Yorkshire Electric | UK | 1952 | 500 | 4,545 | 1,455 | Decom. | UK |
| 163 | user | EP | Not tested | D | Bonar Long & Co | UK | 1959 | 500 | 2,550 | 1,100 | Decom. | 45 |
| 164 | user | EP | Not tested | D | Bonar Long & Co | UK | 1959 | 500 | 2,550 | 1,100 | Decom. | 45 |
| 165 | user | EP | Not tested | D | Bonar Long & Co | UK | 1959 | 500 | 6500 | 1,495 | Decom. | 45 |
| 166 | LTL | WP | Not tested | D | Electrical Company Ltd. | India | 1983 | 250 | 835 | 270 | Decom. | 21 |
| 167 | LTL | WP | Not tested | D | Electric Construction Equipment | India | 1977 | 400 | 1260 | 440 | Decom. | 27 |
| 168 | LTL | WP | negative (<50 | D | Woden Bilston | UK | 1977 | 630 | 2700 | 730 | Decom. | 27 |
| 169 | LTL | WP | Not tested | D | Crompton | UK | 1971 | 250 | 675 | 270 | Decom. | 33 |
| 170 | LTL | WP | Not tested | D | Unknown | Sri Lanka | 1983 | 300 | 1575 | 355 | Decom. | 21 |
| 171 | LTL | WP | positive (>50 | D | Alsthom | France | 1964 | 400 | 1395 | 410 | Decom. | 40 |
| 172 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1986 | 300 | 1610 | 339 | Decom. | 18 |
| 173 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1985 | 630 | 2705 | 715 | Decom. | 19 |
| 174 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1985 | 400 | 2170 | 444 | Decom. | 19 |
| 175 | LTL | WP | positive (>50 | D | New Korea Electric Co | Korea | 1984 | 400 | 2400 | 480 | Decom. | 20 |
| 176 | LTL | WP | positive (>50 | D | New Korea Electric Co | Korea | 1981 | 630 | 3000 | 700 | Decom. | 23 |
| 177 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1983 | 630 | 2520 | 480 | Decom. | 21 |

|  | Owner category | Geographical zone | PCB Test | Type | Manufacturer name | Country of Manufacture | Fabrication date | Power Kva | Total weight (kgs) | Weight of the dielectric fluid | Status of the equipment | Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 178 | LTL | WP | negative (<50 | D | Crompton | UK | 1970 | 700 | 2600 | 835 | Decom. | 34 |
| 179 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1985 | 600 | 2500 | 650 | Decom. | 19 |
| 180 | LTL | WP | positive (>50 | D | Unelec | France | 1967 | 400 | 1556 | 432 | Decom. | 37 |
| 181 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1979 | 300 | 950 | 311 | Decom. | 25 |
| 182 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1984 | 630 | 2400 | 480 | Decom. | 20 |
| 183 | LTL | WP | positive (>50 | D | New Korea Electric Co | Korea | 1978 | 350 | 2000 | 390 | Decom. | 26 |
| 184 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1983 | 400 | 2095 | 455 | Decom. | 21 |
| 185 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1983 | 400 | 2100 | 456 | Decom. | 21 |
| 186 | LTL | WP | Not tested | D | Bonar Long | UK | 1982 | 400 | 2320 | 449 | Decom. | 22 |
| 187 | LTL | WP | positive (>50 | D | Apex Elec. Ltd | India | 1983 | 100 | 835 | 238 | Decom. | 21 |
| 188 | LTL | WP | positive (>50 | D | Apex Elec. Ltd | India | 1983 | 100 | 835 | 238 | Decom. | 21 |
| 189 | LTL | WP | Not tested | D | G.C.Egener Elec | UK | 1936 | 200 | 745 | 215 | Decom. | 68 |
| 190 | LTL | WP | negative (<50 | D | South Walse Switches | UK | 1959 | nknown | 4932 | 1134 | Decom. | 45 |
| 191 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1982 | 100 | 485 | 115 | Decom. | 22 |
| 192 | LTL | WP | Not tested | D | France Transfo | France | 1980 | 200 | 745 | 215 | Decom. | 24 |
| 193 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1986 | 315 | 1032 | 352 | Decom. | 18 |
| 194 | LTL | WP | positive (>50 | D | MINEL Trafo. | Yugoslavia | 1981 | 300 | 1275 | 314 | Decom. | 23 |
| 195 | LTL | WP | Not tested | D | E.C.E | India | 1976 | 400 | 1125 | 423 | Decom. | 28 |
| 196 | LTL | WP | positive (>50 | D | Unelec | France | 1973 | 250 | 1075 | 298 | Decom. | 31 |
| 197 | LTL | WP | positive (>50 | D | Apex Elec. Ltd | India | 1982 | 160 | 1075 | 290 | Decom. | 22 |
| 198 | LTL | WP | Not tested | D | MINEL Trafo. | Yugoslavia | 1981 | 300 | 1275 | 314 | Decom. | 23 |
| 199 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1983 | 400 | 1800 | 480 | Decom. | 21 |
| 200 | LTL | WP | positive (>50 | D | Apex Elec. Ltd | India | 1983 | 100 | 835 | 238 | Decom. | 21 |
| 201 | LTL | WP | positive (>50 | D | LTL Lanka | Sri Lanka | 1984 | 400 | 1540 | 460 | Decom. | 20 |
| 202 | LTL | WP | negative (<50 | D | LTL Lanka | Sri Lanka | 1984 | 400 | 1540 | 460 | Decom. | 20 |
| 203 | LTL | WP | positive (>50 | D | Unelec | France | 1967 | 315 | 1206 | 347 | Decom. | 37 |
| 204 | LTL | WP | negative (<50 | D | LTL Lanka | Sri Lanka | 1985 | 160 | 580 | 182 | Decom. | 19 |
| 205 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1984 | 250 | 1110 | 275 | Decom. | 20 |
| 206 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1984 | 600 | 2500 | 650 | Decom. | 20 |
| 207 | LTL | WP | Not tested | D | Mitsuibishi | Japan | 1979 | 150 | 630 | 163 | Decom. | 25 |
| 208 | LTL | WP | positive (>50 | D | Jonsan Elec.Co | India | 1979 | 70 | 353 | 78 | Decom. | 25 |
| 209 | LTL | WP | positive (>50 | D | Jonsan Elec.Co | India | 1979 | 70 | 353 | 78 | Decom. | 25 |
| 210 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1983 | 500 | 1910 | 610 | Decom. | 21 |
| 211 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1986 | 350 | 1032 | 409 | Decom. | 18 |
| 212 | LTL | WP | positive (>50 | D | Unelec | France | 1973 | 300 | 1075 | 298 | Decom. | 31 |
| 213 | LTL | WP | positive (>50 | D | Unelec | France | 1967 | 315 | 1206 | 347 | Decom. | 37 |
| 214 | LTL | WP | negative (<50 | D | Electro Export EM | Romania | 1982 | 350 | 1110 | 390 | Decom. | 22 |
| 215 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1985 | 160 | 580 | 182 | Decom. | 19 |
| 216 | LTL | WP | positive (>50 | D | Distribution Trano Ltd | Muebroxbur | 1968 | 100 | 3400 | 782 | Decom. | 36 |
| 217 | LTL | WP | Not tested | D | English Elec. | UK | 1936 | 100 | 585 | 134 | Decom. | 68 |
| 218 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1982 | 100 | 835 | 238 | Decom. | 22 |
| 219 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1977 | 300 | 930 | 320 | Decom. | 27 |
| 220 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1985 | 250 | 978 | 275 | Decom. | 19 |
| 221 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1984 | 400 | 2400 | 480 | Decom. | 20 |
| 222 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1986 | 450 | 1870 | 510 | Decom. | 18 |
| 223 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1986 | 315 | 1032 | 352 | Decom. | 18 |
| 224 | LTL | WP | positive (>50 | D | Electro Export EM | Romania | 1982 | 350 | 1110 | 390 | Decom. | 22 |
| 225 | LTL | WP | positive (>50 | D | Electro Export EM | Romania | 1979 | 250 | 1240 | 279 | Decom. | 25 |
| 226 | LTL | WP | positive (>50 | D | Unelec | France | 1977 | 250 | 1045 | 286 | Decom. | 27 |
| 227 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1986 | 315 | 1523 | 355 | Decom. | 18 |
| 228 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1988 | 200 | 880 | 248 | Decom. | 16 |
| 229 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1978 | 160 | 6460 | 2000 | Decom. | 26 |
| 230 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1985 | 160 | 700 | 190 | Decom. | 19 |
| 231 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1984 | 500 | 1910 | 510 | Decom. | 20 |
| 232 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1984 | 315 | 1250 | 355 | Decom. | 20 |
| 233 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1986 | 315 | 1225 | 355 | Decom. | 18 |
| 234 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1985 | 315 | 1250 | 355 | Decom. | 19 |
| 235 | LTL | WP | negative (<50 | D | MINEL Trafo. | Yugoslavia | 1981 | 300 | 1275 | 314 | Decom. | 23 |
| 236 | LTL | WP | Not tested | D | Electro Export EM | Romania | 1982 | 350 | 1110 | 390 | Decom. | 22 |
| 237 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1986 | 315 | 1032 | 352 | Decom. | 18 |
| 238 | LTL | WP | Not tested | D | Schorch Werke Co.Ltd | Germany | 1978 | 500 | 2420 | 550 | Decom. | 26 |
| 239 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1984 | 315 | 1575 | 355 | Decom. | 20 |
| 240 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1986 | 200 | 919 | 245 | Decom. | 18 |
| 241 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1982 | 250 | 1075 | 290 | Decom. | 22 |

| | Owner category | Geographical zone | PCB Test | Type | Manufacturer name | Country of Manufacture | Fabrication date | Power Kva | Total weight (kgs) | Weight of the dielectric fluid | Status of the equipment | Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 242 | LTL | WP | Not tested | D | Crompton | UK | 1971 | 600 | 2420 | 625 | Decom. | 33 |
| 243 | LTL | WP | negative (<50 | D | New Korea Electric Co | Korea | 1979 | 250 | 1650 | 297 | Decom. | 25 |
| 244 | LTL | WP | Not tested | D | Jonsan Elec.Co | India | 1975 | 700 | 3025 | 800 | Decom. | 29 |
| 245 | LTL | WP | positive (>50 | D | Unelec | France | 1967 | 400 | 1556 | 432 | Decom. | 37 |
| 246 | LTL | WP | negative (<50 | D | Unelec | France | 1967 | 315 | 2130 | 370 | Decom. | 37 |
| 247 | LTL | WP | positive (>50 | D | Unelec | France | 1967 | 315 | 2130 | 370 | Decom. | 37 |
| 248 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1984 | 600 | 2500 | 650 | Decom. | 20 |
| 249 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1984 | 600 | 2500 | 651 | Decom. | 20 |
| 250 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1985 | 250 | 1410 | 300 | Decom. | 19 |
| 251 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1985 | 250 | 1110 | 275 | Decom. | 19 |
| 252 | LECO | WP | Not tested | D | LTL Lanka | Sri Lanka | 1985 | 250 | 1170 | 280 | Decom. | 19 |
| 253 | LTL | WP | positive (>50 | D | New Korea Electric Co | Korea | 1981 | 630 | 3000 | 700 | Decom. | 23 |
| 254 | LECO | WP | Not tested | D | Ferrante | UK | 1951 | 500 | 2150 | 560 | Decom. | 53 |
| 255 | LTL | WP | negative (<50 | D | New Korea Electric Co | Korea | 1979 | 350 | 1950 | 380 | Decom. | 25 |
| 256 | LTL | WP | negative (<50 | D | Apex Elec. Ltd | India | 1978 | 160 | 640 | 200 | Decom. | 26 |
| 257 | LTL | WP | negative (<50 | D | Mitsuibishi | Japan | 1979 | 100 | 630 | 145 | Decom. | 25 |
| 258 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1986 | 315 | 1225 | 355 | Decom. | 18 |
| 259 | LTL | WP | negative (<50 | D | LTL Lanka | Sri Lanka | 1983 | 250 | 880 | 265 | Decom. | 21 |
| 260 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1985 | 250 | 1170 | 280 | Decom. | 19 |
| 261 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1982 | 350 | 1450 | 410 | Decom. | 22 |
| 262 | LTL | WP | positive (>50 | D | LTL Lanka | Sri Lanka | 1986 | 315 | 1032 | 352 | Decom. | 18 |
| 263 | LTL | WP | Not tested | D | New Korea Electric Co | Korea | 1979 | 315 | 950 | 348 | Decom. | 25 |
| 264 | LTL | WP | Not tested | D | Denis Ferrant Ltd | UK | 1967 | 250 | 4030 | 1340 | Decom. | 37 |
| 265 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1985 | 400 | 1540 | 460 | Decom. | 19 |
| 266 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1985 | 200 | 880 | 245 | Decom. | 19 |
| 267 | LTL | WP | negative (<50 | D | Ejprom | Bulgaria | 1979 | 200 | 1046 | 246 | Decom. | 25 |
| 268 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1978 | 150 | 680 | 155 | Decom. | 26 |
| 269 | LTL | WP | Not tested | D | Bonar Long & Co | UK | 1971 | 100 | 1285 | 290 | Decom. | 33 |
| 270 | LTL | WP | Not tested | D | Unelec | France | 1973 | 160 | 615 | 194 | Decom. | 31 |
| 271 | LTL | WP | Not tested | D | Electo Co. | India | 1976 | 400 | 1125 | 423 | Decom. | 28 |
| 272 | LTL | WP | negative (<50 | D | Tyree Industries | Australia | 1965 | 1,800 | 5500 | 1912 | Decom. | 39 |
| 273 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1982 | 100 | 835 | 238 | Decom. | 22 |
| 274 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1982 | 100 | 835 | 238 | Decom. | 22 |
| 275 | LTL | WP | positive (>50 | D | Siemens | Germany | 1959 | 500 | 2340 | 538 | Decom. | 45 |
| 276 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1983 | 250 | 1170 | 280 | Decom. | 21 |
| 277 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1986 | 100 | 1032 | 352 | Decom. | 18 |
| 278 | LTL | WP | positive (>50 | D | Crompton | UK | 1971 | 300 | 2420 | 625 | Decom. | 33 |
| 279 | LTL | WP | Not tested | D | ETC | India | 1977 | 100 | 970 | 355 | Decom. | 27 |
| 280 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1986 | 100 | 978 | 275 | Decom. | 18 |
| 281 | LTL | WP | negative (<50 | D | LTL Lanka | Sri Lanka | 1983 | 250 | 1540 | 460 | Decom. | 21 |
| 282 | LTL | WP | Not tested | D | Ejprom | Bulgaria | 1979 | 250 | 1830 | 570 | Decom. | 25 |
| 283 | LTL | WP | Not tested | D | LTL Lanka | Sri Lanka | 1983 | 160 | 620 | 195 | Decom. | 21 |
| 284 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1983 | 100 | 835 | 238 | Decom. | 21 |
| 285 | LTL | WP | positive (>50 | D | Crompton | UK | 1971 | 500 | 2470 | 570 | Decom. | 33 |
| 286 | LTL | WP | positive (>50 | D | Crompton | UK | 1971 | 500 | 2420 | 530 | Decom. | 33 |
| 287 | LTL | WP | Not tested | D | Electrical Company Ltd. | UK | 1953 | 75 | 1950 | 540 | Decom. | 51 |
| 288 | LTL | WP | Not tested | D | Alsthom | France | 1953 | 250 | 1640 | 380 | Decom. | 51 |
| 289 | user | WP | Not tested | D | South Walse Switches | UK | 1982 | 500 | 1840 | 485 | Decom. | 22 |
| 290 | LECO | WP | Not tested | D | E.E.I | Romania | 1963 | 100 | 945 | 200 | Decom. | 41 |
| 291 | LTL | WP | Not tested | D | Apex Elec. Ltd | India | 1973 | 380 | 3520 | 690 | Decom. | 31 |
| 292 | LECO | WP | Not tested | D | Unelec | France | 1966 | 100 | 610 | 124 | Decom. | 38 |
| 293 | LECO | WP | Not tested | D | Schorch Werke Co.Ltd | Germany | 1966 | 100 | 700 | 160 | Decom. | 38 |
| 294 | LECO | WP | Not tested | D | E.E.I | Romania | 1981 | 250 | 1240 | 275 | Decom. | 23 |
| 295 | LTL | WP | Not tested | D | NGEI | India | 1970 | 100 | 760 | 210 | Decom. | 34 |
| 296 | LECO | WP | Not tested | D | MINEL Trafo. | Yugoslavia | 1981 | 250 | 1044 | 181 | Decom. | 23 |

# Annex 4

List of Pure PCB transformers identified during the survey

| | Ownership | Company site | Sub area 1 | Geographical zone | Serial number | PCB Test | Type of Transformer | Country of Manufacture | Fabrication date | Power Kva | Trade name of the dielectric | Total weight (kgs) | Weight of the dielectric fluid (kgs) | Status of the equipment | Status of Dielectric leaking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CEB | Samanala, Polpitiya, PS | Polpitiya | CP | 560729 | positive (>50 ppm | Gen Aux 1 | Canada | 1966 | 300 | PYRANOL 151 | 9263 | 3520 | In use | Leaking |
| 2 | CEB | Samanala, Polpitiya, PS | Polpitiya | CP | 560730 | positive (>50 ppm | Gen Aux 2 | Canada | 1966 | 300 | PYRANOL 151 | 9263 | 3520 | In use | Not Leaking |
| 3 | CEB | New Laxapana, PS | Luxapana | CP | Unknown | positive (>50 ppm | Gen Aux 1 | France | 1972 | 71 mVA | PyralenE | UK | UK | In use | Not Leaking |
| 4 | CEB | New Laxapana, PS | Luxapana | CP | Unknown | positive (>50 ppm | Gen Aux 2 | France | 1972 | 72 mVA | PyralenE | UK | UK | In use | UK |

# Annex 5

## Some of the common trade names of PCB transformer oils

| Trade Name | Country/Manufacturer | Trade Name | Country/Manufacturer |
|---|---|---|---|
| Abuntol | American Corp, USA | Elemex | USA |
| Aceclor | France | Eucarel | USA |
| Adine | France | Fenchlor | Italy |
| Apirolio | Italy | Firemaster | USA |
| Apirorolio | Italy | Flammex | UK |
| Aroclor | UK, USA | HFO 101 | UK |
| Asbestol | Monsanto, USA | Hywol | Italy, USA |
| Askaral | UK, USA | Inclor | Italy |
| Auxol | Monsanto, USA | Inerteen | USA |
| Bakola | USA | Kanechlor | Japan |
| Cholophen | Bayer, Germany | Leromoll | Germany |
| Chlorextol | Allis Chalmers, USA | Noflamol | USA |
| Chlorinol | USA | Phenclor | France |
| Chlorphen | Jard Corp, USA | Plastivar | UK |
| Diachlor | USA | Pydraul | USA |
| DK | Italy | Pyranol | USA |
| Ducanol | UK | Pyralene | France |
| EEC-IS | Transforme, uSA | Saft-Kuhl | USA |
| Elaol | France | Santothern | France, UK |
| Electrophenyl | France | Salvol | Russian Federation |

Tradenames of some of the commonly seen PCB mixtures and countries of manufacture

# Annex 6

## Information regarding the Clor-n-oil 50 PCB Screening Test Kit

1. The Clor-N-Oil Test Kit works on the principle of chloride determination, since PCBs are chlorine based materials. The quantitative conversion of the chlorine atoms in PCB in oil to chloride ions, which in turn are extracted into an aqueous solution and measured calorimetrically.

2. An oil sample containing more than 50 ppm of PCBs will respond to the test.

3. However the test cannot distinguish between any other chlorine containing compounds such as trichlorobenze, which may also be found in transformer oil. Presence of such compounds may cause a result known as the 'false positive'. That is the oil will indicate the presence of over 50 ppm PCBs, but when analyzed by gas chromatography will show a different result.

4. Other contaminations with salt, sea water, perspiration etc will give a false positive results.




Affirmative test


Negative test

5. In order to confirm the Field test kit, it is necessary to subject positive samples to Gas Chromatography test.

**Methodology of Testing:**



1. Each test kit contains 2 tubes – a plastic test tube with a black dispensing cap containing 2 ampules and a white capped plastic test tube containing 7 ml of buffer solution and 2 ampules within.
2. Unscrew the black dispenser cap from the first tube. Transfer 5ml of transformer oil into it using the pipette. Close the cap.
3. Press the ampule at the bottom of the tube with fingers. Mix thoroughly by shaking the tube for 10 seconds. Break the ampule at the top of the tube in the same manner. Mix thoroughly for 10 seconds. Allow the reaction to occur for 50 seconds, while shaking.
4. Pour the buffer solution in the latter tube in to the mixture. Replace cap and shake for 10 seconds. Vent by partially unscrewing the cap. Shake again and vent.
5. Tighten the cap and stand the tube upside down and leave to separate for 2 minutes. If the oil layer is below the buffer, the sample is pure PCB.
6. If the oil layer is above the buffer, open the black cap and dispense 5ml of the clear solution into the tube 2. Replace the white cap on tube 2. Break the ampule

at the bottom of the tube 2. Shake for 10 seconds. Break the ampuble at the top of the tube and shake for 10 seconds.

7. Observe the resultant color and compare with the color chart given. If the solution appear purple, the oil contain less than 50 ppm. If the solution appear yellow, it may contain more than 50 ppm PCB.

# Annex 7

## Gas Chromatography (GC) Test

In the study, GC was used for a limited number of samples. Objective of using GC was to confirm the presence of PCBs in the samples that indicated positive by the field test kit. The GC tests were carried out by the ITI.

ASTM D4059 Protocol was used for the test, which was modified as follows;

**Method**

Standards used – Archlor 1260 and NIST standard

Amount injected – 1 micro liter

Solvent – Iso octane (5ml) and Florosin (2.5ml)

Acid wash – with Conc. $H_2SO_4$ acid (2ml)

Injection mode – Speedless



Detector – Micro Electron Detector with $Ni^{63}$ source

Description of the Column – HP5 6% Phenyl Methyl Silozan

Flow rate - 2ml per mint.

Pressure – 12.8 psi

Temperature program – adjusted to 36.5 mints.

Ramp 1 – Initially $20^0$C and hold time zero. Ramp 2 – An increase of temperature $8^0$C per minute. Increased to $200^0$C and hold time 4 minutes. Ramp 3- Increasing temperature of $10^0$C per mint, a brought up to $250^0$C and hold time 10 minutes.

0.1g of the transformer oil sample was diluted with solvent. Shake well and acid wash with 2ml of Conc. $H_2SO_4$. 1 micro liter of the supernatant was injected to the column through the inlet port.

The high sensitive micro electron capture detectors at the end of the column generate a signal that is proportional to the amount of PCBs present in the sample.

The detector used for the detection of PCBs is the electron capture detector. They do not respond to the non-chlorinated chemicals that may also be present. This detector is sensitive to a minimum of 2 ppm PCBs.