

# GUIDE FOR POLYCHLORINATED BIPHENYL (PCB) MANAGEMENT OF INSULATING OIL IN SOUTH AFRICA

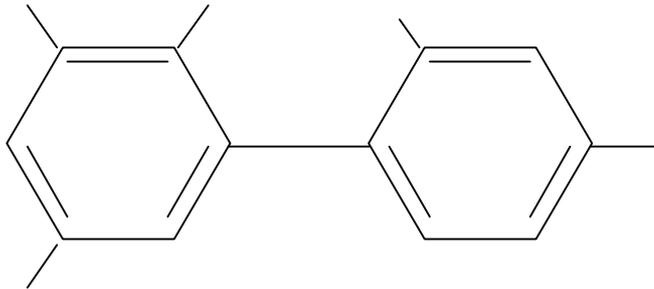
By  
I.A.R. Gray  
Dated: August 2004

## What are PCBs?

PCBs (polychlorinated biphenyls) are a group of synthetic oil-like chemicals of the organochlorine family. It was first described in technical literature in 1881 and commercial production commenced in the late 1920's.

Until their toxic nature was recognized and their use was banned in the early 1980s, they were widely used as insulation in electrical equipment, particularly transformers.

All commercially produced PCB's are complex mixtures of many different congeners-PCB molecule containing a specific number of chlorine molecules at specific sites)



PCB chemical structure

The PCB molecule consists of two phenyl molecules joined together with two or more hydrogen atoms replaced by chlorine atoms. 209 individual chlorinated biphenyl compounds (congeners) can be created by replacement of chlorine at the various corners of the carbon rings. Three types of PCB are normally used in electrical transformers: Aroclor 1242, 1254 and 1260. The first two digits, designate the number of carbon atoms in the molecule and the last two stand for the weight percentage respectively in each type. PCB has the chemical formula  $C_{12}H_{10-n}Cl_n$  where 'n' is 1-10. PCB is commonly known by various brand names. These include Askarel, Chlorectol, Elemex, Inerteen, and Pyranol.

## Why are they dangerous?

They are serious poisons, which have been shown to cause damage to the reproductive, neurological and immune systems of wildlife and humans and are known to cause cancer. Specifically, because PCBs in the body mimic estrogen, women of child-bearing age and their infants are particularly susceptible to a variety of development and reproductive disorders. A National Academy of Sciences committee has stated that "PCBs pose the largest potential carcinogenic risk of any environmental contaminant for which measurements exist."

One of the most important problems with PCBs is that they are collected in the fatty parts of microorganisms. This concentration factor between the organism and the water can be as much as a million. Concentrations may be further amplified, as the microorganisms become food for animals further up the food chain.

## When did they come into use?

In 1929 began the manufacture of an amber oily fluid formed of two bound carbon rings bristling with chlorine atoms. The new fluid was called polychlorinated biphenyl, or PCB. Its chemistry is similar to other members of the organochlorine family, such as dioxins and furans, which are among the most potent toxins known.

### What is the situation with PCBs today?

The uniform distribution of PCBs in both hemispheres, suggests that the atmosphere is a particularly important medium for the transport of PCBs.

Total world production of PCBs up to 1988 has been estimated to be 1.2 million tonnes. Of this quantity, 31% are now in the environment, 4% have been already destroyed, and 65% are still in use or in storage.

### Effects of PCBs on the human organism

	Known Effects	Possible Effects
	Cancer	Liver & Kidney Damage
	Headaches, Dizziness	Reproductive Damage
	Nervousness	Respiratory Illnesses like Asthma
	Fatigue	Decreased Learning Potential
	Low Birth Weight	Learning and Development Disabilities
	Poor Infant Habituation	Depression/Aggression (ADD & ADHD)
	Thyroid Dysfunction	
	Chloracne	

The main reasons for stopping further use are the risks to health and the environment. PCBs are very stable and its degradation process is slow, it is also biologically accumulative in the food chain.

PCB liquid is not more toxic than many other common fluids. The lower the figure, the higher the toxicity

Chemical	LD50 g/Kg
Polychlorinated biphenyl (PCB)	8.7
Trichloroethylene	5.2
Acetone	9.8
Methyl alcohol	12.9
Polychlorinated dibenzofuranes (PCDD's and PCDF's)	<0.001

Far more serious are the risks of a fire or an explosion. At temperatures around 500 degrees C extremely toxic compounds Polychlorinated dibenzofuranes are formed. Small amounts of these compounds have been found at accidents where transformers and capacitors have been exposed to fire or have exploded. Even if the amounts have been extremely small and have caused no personal injuries, it has been necessary to perform very extensive and costly decontamination work.

## *Effects of the dioxins*

### **Introduction**

The chlorinated dibenzo-p-dioxins are a class of compounds that are loosely referred to as dioxins. There are 75 possible dioxins. The one with four chlorine atoms at positions 2, 3, 7 and 8 of the dibenzo-p-dioxin chemical structure is called 2,3,7,8- tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). It is a colorless solid with no known odor. 2,3,7,8-TCDD does not occur naturally nor is it intentionally manufactured by any industry, except as a reference standard. It can be inadvertently produced in very small amounts as an impurity during the manufacture of certain herbicides and germicides and has been detected in products of incineration of municipal and industrial wastes. At the present time, 2,3,7,8-TCDD is not used for any purpose than scientific research.

From now on, we are going to speak many times about the dioxin 2,3,7,8-TCDD, because it is one of the more common dioxins, and maybe the most dangerous of them. But many other dioxins can appear during the following processes. The most toxic member of the dioxin family is PCDD and it is mostly from studies on this compound that we know about the mechanism of the other chemicals in the same group (Silbergeld & Gasiewicz, 1989).

### **Exposure Pathways**

The main environmental sources of polychlorinated dioxins (PCDD) are:

- Use of herbicides containing 2,4,5-Trichlorophenoxy acids (2,4,5-T)
- Production and use of 2,4,5-Trichlorophenol in wood preservatives
- Production and use of hexachlorophene as a germicide
- Pulp and paper manufacturing plants
- Incineration of municipal and certain industrial wastes
- Small amounts formed during the burning of wood in the presence of chlorine
- Accidental transformer/capacitor fires involving chlorinated benzenes and biphenyls
- Exhaust from automobiles powered with leaded gasoline
- Improper disposal of certain chlorinated chemical wastes

### **Exposure pathways are**

- Skin contact with surfaces such as soil and vegetation contaminated by the chemical
- Skin contact and inhalation of wood dust from use of pentachlorophenol-treated woods
- Inhalation of air near improperly maintained dump sites or municipal incinerators
- Consumption of fish and cow's milk from contaminated areas
- Consumption of breast milk containing PCDD by babies
- Minute exposure from the use of paper towels, napkins, coffee filters, computer papers, and other contaminated paper products
- According to one estimate of ambient exposure, breathing air constitutes 2 percent, drinking water less than 0.01 percent, and consuming foods 98 percent of the total human exposure to PCDD. No estimate of relative intake of PCDD due to skin absorption is available.

### **PCDD produces a range of toxic effects:**

- Lethal effects: animals die from a wasting disease in two to six weeks at levels ranging from 1 ug/kg to 5000 ug/kg
- Immune system damage at similar levels in all animals examined, because of damage to the thymus gland causing changes in cell immunity: especially likely in children
- Damage to other organs such as liver, kidney and digestive tract
- Reproductive effects: miscarriage, sterility
- Birth defects, including neurological effects
- Cancer: most potent cancer promoter known, also evidence of some tumour initiation; animal carcinogen

Chloracne - persistent skin eruptions in humans and some animals

### **Health Effects**

Chloracne is a skin disease, often accompanied by severe disfigurement, severe joint pain, headaches, fatigue, irritability and chronic weakness; and it can persist in the body for at least 30 years after exposure (Kimbrough & Grandjean, 1989). No one disputes that it is caused by dioxin-like compounds, but it is not an infallible marker of dioxin exposure (Gough, 1991).

There is suggestive evidence that PCDD causes liver damage in humans, as indicated by an increase in levels of certain enzymes in the blood, although these effects might also have resulted from the concomitant exposure to the chemicals contaminated with PCDD or to the solvents in which these chemicals are usually dissolved.

Animal studies have demonstrated severe liver damage in some species. There is suggestive evidence that PCDD causes loss of appetite, weight loss, and digestive disorders in humans, although these effects might also have resulted from the concomitant exposure to the chemicals contaminated with PCDD or to the solvents in which these chemicals are usually dissolved. Animal exposure to PCDD results in severe loss of body weight prior to death.

Although not demonstrated in humans, in animal studies PCDD produced toxicity to the immune system. This toxicity can result in greater susceptibility to infection.

Although not demonstrated in humans, in some animal species exposure to PCDD resulted in adverse reproductive effects including spontaneous abortions. The monkey is very sensitive to this toxic property of PCDD. Although not demonstrated in humans, in some animal species exposure to PCDD during pregnancy resulted in malformations in the offspring. Low levels of PCDD have been detected in human milk, but the effects on infants and children are unknown.

The human evidence for PCDD alone is inadequate to demonstrate or reflect a carcinogenic hazard, although certain herbicide mixtures containing a PCDD as an impurity provide limited evidence of causing cancer in exposed humans.

Based on the positive evidence in animal studies, PCDD is probably carcinogenic in humans.

Everyone in industrialized countries has a potent mixture of dioxins, furans, co-planar PCBs, PCNs and other similar compounds stored and accumulated in their body fat. This chemical concoction of compounds in our bodies is likely to add together, making up a total dioxin-like toxicity: dioxins plus PCBs is equivalent to more dioxins.

In addition to these dioxin and dioxin-like molecules, we must also be concerned with other organochlorine compounds in our bodies, which are not part of this family but are likely to interact with it. We do not know enough at present about these compounds, which include pesticides such as DDT.

2,3,7,8-PCDD (often known simply as PCDD) is known for its lethal effects at very low concentrations: a millionth of a gram will kill a guinea pig.

### **Neurological Effects**

Proper development of the nervous system is critical for early learning and can provoke significant consequences for the health of individuals.

### **Methods of PCB Analysis**

Current methods of analysis can be divided into two major groups: PCB Specific and PCB Non-specific.

Non-specific methods test for PCBs indirectly by detecting one of the components of the PCB compound, usually Chlorine. In general, non-specific methods are quicker and less expensive than the specific methods.

The most widely used techniques are X-ray fluorescence, micro-coulometry, colorimetric methods, and electro-chemistry.

This test is susceptible to false positive results, i.e. the test indicates the presence of PCBs when actually there are none present.

Specific methods utilize some type of chromatography to separate PCB congeners from each other and interfering compounds, is not a case of simply finding an easily quantifiable compound, but of quantifying a complex mixture of compounds. Of the three major chromatography types, gas chromatography (GC), thin layer chromatography (TLC) and liquid chromatography, GC is the preferred and most extensively used method.

The most frequently used method of detection for GC is the electron capture detector (ECD). This is not truly PCB specific where Mass spectrometry (MS) is the most specific detector that is used with GC. This technique reveals the actual mass of the compound being analysed, providing a "fingerprint" of the compound that can be mistaken for no other. GC-MS analysis requires highly trained analysts and expensive equipment.

### **Which method to use**

Specific techniques such as gas chromatography are most appropriate when samples may be contaminated with sources of chlorine other than PCBs.

The detection limit needs to be considered if Environmental legislation changes to more stringent levels of PCB. A properly equipped gas chromatography, can easily separate the PCBs from the other chlorinated organics to detection limits of less than <0.1 parts per million.

Laboratories that are certified and registered by South African Bureau of Standard (SABS) should carry out analysis, or accredited and registered with the South African National Accreditation Society (SANAS). The approved equivalents in other countries can be considered. PCB analysis should incorporate quality control programs in accordance with the SABS/SANAS requirements.

## Regulatory levels

PCBs is one of twelve (so called 'dirty dozen') Persistent Organic Pollutants (POP's) governed by UNEP (United Nations Environmental Program) according to the outcome of the Basel Convention that was held in March 1999 and the treaty that was ratified in Sweden in May 2001, with South Africa being a signatory.

### *Stockholm Convention on persistent Organic Pollutants.*

Each part shall:

(a) With regard to the elimination of the use of polychlorinated biphenyls in equipment (e.g. transformers, capacitors or other receptacles containing liquid stocks) by 2025, subject to review by the conference of the Parties, take action in accordance with the following priorities:

(i) Make determined efforts to identify, label and remove from use equipment containing greater than 10 percent polychlorinated biphenyls and volumes greater than 5 litres.

(ii) Make determined efforts to identify, label and remove from use equipment containing greater than 0.05 percent polychlorinated biphenyls and volumes greater than 5 litres.

(iii) Endeavor to identify, label and remove from use equipment containing greater than 0.005 percent polychlorinated biphenyls and volumes greater than 0.05 litres.

(b) Consistent with the priorities in subparagraph (a) promote the following measures to reduce exposures and risks to control the use of polychlorinated biphenyls.

(i) Use only intact and non-leaking equipment and in only in areas where the risk from environmental releases can be minimized and quickly remedied.

(ii) Not use in equipment in areas associated with production or processing of food or feed.

(iii) When used in populated area's, including schools and hospitals, all reasonable measures to protect from electrical failure which could result in a fire and regular inspection for leaks.

(c) Notwithstanding paragraph 2 of Article 3, ensure that equipment containing polychlorinated biphenyls as described in subparagraph (a) shall be exported or imported except for the purpose of environmentally sound waste management

(d) Except for maintenance and servicing operations, not allow recovery for the purpose of reuse in other equipment of liquids with polychlorinated biphenyls content above 0.005 percent.

The current legislation is limited but the principle of the Polluter Pays is in force. (Water Act – Government Gazette vol. 398 No 19182-26 August 1998)

#### *Water Act Part 4: Pollution prevention*

“The person who owns, controls, occupies or uses the land in question is responsible for taking measures to prevent pollution of water resources. If these measures are not taken, it will done on your behalf by the authorities and you will be responsible for the costs. “

#### *Water Act Part 5: Emergency Incidents*

“The responsibility for remedying the situation rests with the person responsible for the incident or the substance involved. If these measures are not taken, it will done on your behalf by the authorities and you will be responsible for the costs”

The “Polluter Pays Principle” implies that the generator of a waste will retain responsibility and hence the financial responsibility for ensuring that the waste is handled, stored, transported and disposed of in accordance with relevant legislation and in an environmentally acceptable manner. One of the most important ramifications of this principle is that pollution of the environment by a waste or a component of that waste at any time in the future, even though the waste may have been disposed of by a method approved of at the time of disposal, will result in additional costs to the generator for any clean-up and rehabilitation resulting from the pollution.

### **Treatment and disposal options**

The first consideration for disposal of a transformer is its PCB level. The PCBs associated terminology is defined in table below.

<b>PCB REGULATION TERMINOLOGY</b>	
<b>Term</b>	<b>Definition</b>
Non PCB	Any fluid, including that in electrical equipment and any item, which has a measurable PCB concentration of less than 50 ppm of PCB, is considered a non-PCB item.
PCB contaminated	Any fluid, including that in electrical equipment, and any item which has a measurable PCB concentration of 50 ppm or greater but less than 500 ppm is regarded as being PCB contaminated
PCB item	Any fluid, including that in electrical equipment and in any item, which has a measurable PCB concentration equal to or greater than 500 ppm, is regarded as a PCB item.
PCB contaminated item	PCB contaminated items include any equipment (for example transformer, electric motor, pump, or pipe), that contains PCB, or container (for example package, can, bottle, bag, barrel, drum, tank or any other device that contains PCB or whose surfaces have been in contact with PCB) or PCB equipment that deliberately or intentionally contains or has as part of it, any PCB at a concentration of between 50 ppm and 500 ppm. Articles (for example container, oil, water, soil, personal protective equipment), which have been in contact with PCB or PCB contaminated equipment, are also PCB contaminated items.

Note: Insulating oil that has not been tested must be classified as PCB contaminated. See Identification and labeling -Annex A-below.

As economics dictate replacement of PCB equipment a cost-benefit analysis will determine if replacement is an option. The value of recovery of the metals contained in a transformer must be balanced against the potential environmental liability of improper disposal and recovery methods.

### **Transformers classified Non PCB**

In the 1990’s, mineral oil became regulated as an environmental contaminant by virtue of being a hydrocarbon. Spills of non-PCB mineral oil still need to be treated as an environment cleanup situation to prevent hydrocarbons from entering the water table.

Although the current legislation does not regulate this classification, the review system will entail more stringent levels of PCB contamination in the future.

## **Transformers classified PCB contaminated**

Transformers that contain only small quantities of PCB, replacement of the contaminated oil is sufficient to bring the units down to PCB levels of less than 50 parts per million-ppm. The primary concern is disposing of and controlling the oil. (See Decontamination and disposal of PCB liquids)

The insulating oil used as a replacement should meet the requirements of SANS 555 (2002)-See table.

Blending PCB contaminated oil with virgin or other oil to meet the legal requirements is a violation of the outcome of the Basel convention that specifically states “Many cases of illegal traffic will take the form of deliberate mixing of hazardous waste with non-hazardous waste, it spreads PCB’s into virgin oil and thus ensure that we will never have PCB free oil in future”.

A transformer that contained oil with regulated amounts of PCB cannot be disposed of and processed as scrap metal, even if the oil was drained and the interior of the transformer flushed. The paper (cellulose), wood of the core and coil assembly, as well as many of the metal surfaces, still contain or are covered with PCB contaminated oil. If the drained transformer carcasses are handled in the same manner as other “scrap metal” they will inadvertently spread PCB contamination through out their operation.

Before sending scrap transformers to a recycling facility, the owner should conduct an environmental audit to be assured that the materials will be handled in a way that does not allow the mineral oil out of the processing area and into the environment. Without such assurances the equipment owner may face legal and financial liabilities for the contamination caused by the actions of the disposal firm

### **How did my transformer become contaminated?**

Over the years PCBs have found its way into many mineral oil filled transformers. Both PCB and non-PCB transformers may have been repaired in the same works facility and had their fluids processed by the same equipment, i.e cross contamination. Once some PCB found its way into a few mineral transformers, oil handling and processing equipment spread it around to many others.

## **Transformers classified PCB items**

Safe disposal and recycling of these transformers is a tricky task. The owner of this PCB contaminated equipment may be tempted to dispose of the equipment through unregulated channels. This is not advisable. No-body wants to introduce PCB into the environment. It cost much more to dispose of PCB equipment through unqualified vendors and then to pay to clean up their mess later than it does to dispose of it the right way in the first place.

Encapsulation, Incineration and recycling are options available.

Complete or drained and flushed PCB transformer carcasses can be encapsulated and stored in a Class H hazardous site. The disadvantage is the initial owner remains liable and responsible for the items, rendering it to be merely a very costly long-term storage solution. PCB owners must consider the future potential expense of being involved in a remediation project at the landfill site.

Incineration ensures the total destruction of all contaminated items. High-temperature incinerators, if properly operated, destroy all of the organic matter in the waste material by complete oxidation. Adequate temperatures and proper operation are very important. Because the energy requirements for incinerators are high and air emission requirements are strict, incinerators tend to be the most expensive type of treatment. The ash and slag from the incinerator are still land filled.

There are numerous fixed location (permanent) incinerators around the world capable of destroying PCBs, however the majority of these are in the United States and Western Europe.

In an environmental recycling process, the solid insulation (paper and wood) of the transformer core is separated from its metal components and incinerated with fluid insulation. The metal components are cleaned of PCB contamination and recycled.

Recycling technology has also successfully decontaminated and re-classified transformers for subsequent re-use, from any level of PCB contamination before the treatment, including transformers filled with Askarel. Transformers, mainly with high PCB content, can be decontaminated and disassembled, with all inorganic materials recovered with low residual PCB contamination close to the detection limit.

After draining of the PCB liquid, PCB residues remaining in the transformer (mainly in transformer core and windings) are removed by means of a cleaning fluid under appropriate and safe process conditions. The distillate processing of the solvent permits the minimisation of liquid waste. The transformers can be decontaminated to remain below the legally permitted limit for PCBs, and thus can be put back into use.

Circumstances can make decontamination of the equipment and its continued use unattractive from an either technical or commercial point of view, i.e. a transformer has come close to the end of its technical lifetime, a transformer's power rating is no longer adapted to the actual need and should be replaced with a different size unit. In these circumstances it is important to do a cost-benefit analysis.

Again the operators of this Recycling technology exist mainly in the United States and Western Europe.

The Basle convention allows for the export of PCB's providing the receiving country has suitable disposal technology. The export is strictly controlled according to international regulations.

There are many PCB disaster stories (See New Mexico Incident) therefore the owners of PCB transformers should consider treatment and disposal options at the fastest rate the organization can afford.

### **Decontamination of PCB liquids**

UNEP's *Survey of Currently Available Non-Incineration PCB Destruction Technologies* (First Issue, August 2000) states that sodium treatment is the "most common technology [...] to dechlorinate the PCB molecules and yield an oil which can be re-used". The basic chemical principle is the cleavage of the C - Cl bond to give sodium chloride (NaCl) and an organic molecule without any chlorine.

The residues from the treatment process include sodium salts and various aromatic, non-halogenated hydrocarbons. The quantity of residues generated by the dechlorination procedure is in proportion to the PCB content of the treated liquid. For oil with a PCB content of 1000 ppm, for instance, the total quantity of residues is less than 1% of the oil weight.

The technology of dechlorination is available in South Africa but can only treat PCB contaminated fluids up to 2000 ppm. Although the oil is re-refined to SANS 555 (2002) there is some concern as to the effect of polyaromatic hydrocarbons (PAH). These structures are not fully understood and their long-term effect on the life span of electrical equipment has not yet been proven.

The options in South Africa for treating PCB liquids above 2000 ppm are limited with encapsulated being the preferred option. The disadvantage being the "Polluter Pays Principle".

### **Future Legislation**

Control of Pollution has relied on voluntary compliance by industries; this has been far from adequate. There is legislation pending providing regulators to take action against polluters and impose "heavy fines"

In the meantime all owners of PCB equipment have a moral and environmental responsibility to handle this waste in the right way.

### Annex A



Labels for the warning symbol:

- BACKGROUND: WHITE
- BACKGROUND: GOLDEN YELLOW B.49
- BLACK

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**Non-PCB, certified**

The dielectric fluid in this unit has been tested to determine the amount of Polychlorinated Biphenyl (PCB content). We certify that, based on the test sample, the fluid contained less than 50 ppm PCB and is therefore classified non-PCB.

BACKGROUND: GREEN

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Chlorine/PCB content \_\_\_\_\_ ppm

Date \_\_\_\_\_

Analyst \_\_\_\_\_

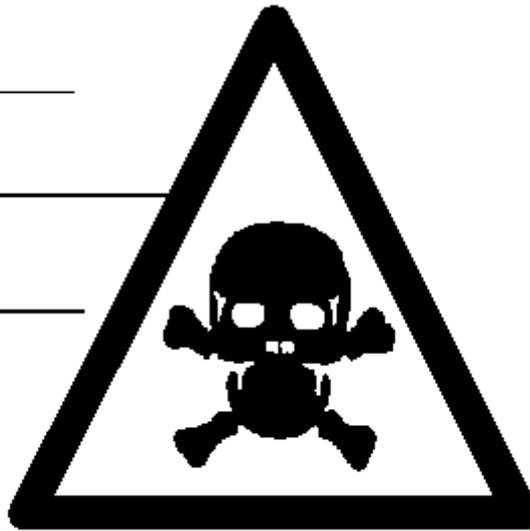
Equipment serial number \_\_\_\_\_

## Annex A

BACKGROUND:  
WHITE

BACKGROUND:  
GOLDEN YELLOW  
B.49

BLACK



### Warning

#### PCB contaminated electrical equipment

The dielectric fluid in this equipment has been tested to determine the amount of Polychlorinated Biphenyl (PCB) content. We certify that, based on the test sample, the fluid contained between 50 ppm and 499 ppm of PCB and is therefore classified as PCB Contaminated electrical equipment

BACKGROUND: YELLOW

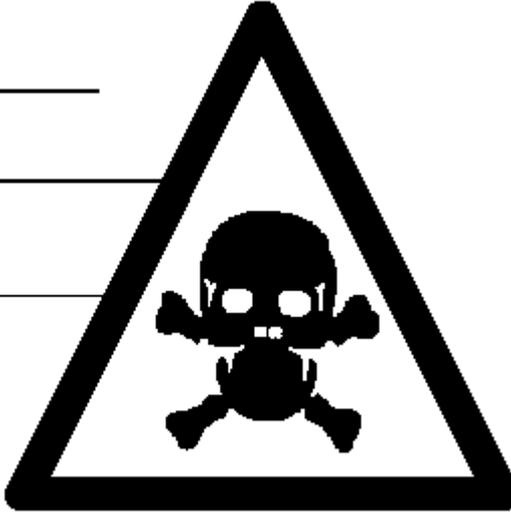
PCB Content \_\_\_\_\_ ppm

Date \_\_\_\_\_

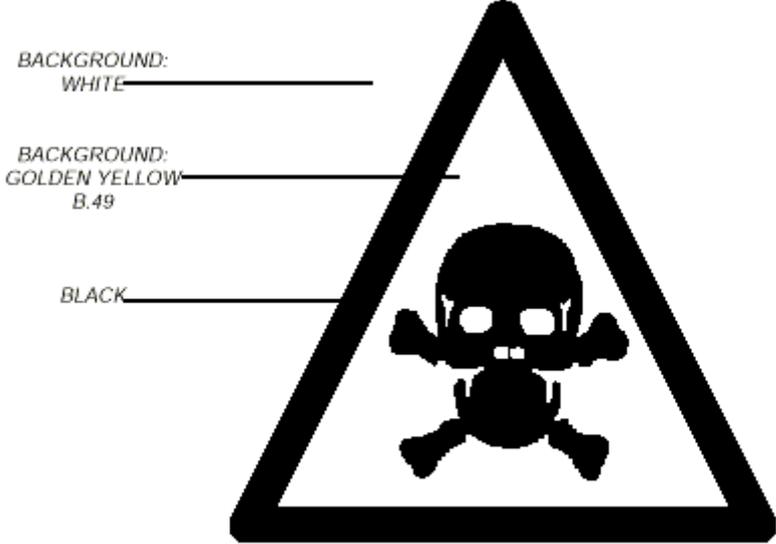
Analyst \_\_\_\_\_

Equipment serial number \_\_\_\_\_

### Annex A

<p>BACKGROUND: WHITE _____</p>	
<p>BACKGROUND: GOLDEN YELLOW B.49 _____</p>	
<p>BLACK _____</p>	
<p><b>Warning</b></p>	
<p><b>PCB item</b></p>	
<p>The dielectric fluid in this equipment has been tested to determine the amount of Polychlorinated Biphenyl (PCB) content. We certify that, based on the test sample, the fluid contained more than 500 ppm of PCB and is therefore classified as a PCB item.</p>	
<p>BACKGROUND: RED</p>	
<p>PCB Content _____ ppm</p>	
<p>Date _____</p>	
<p>Analyst _____</p>	
<p>Equipment serial number _____</p>	

**Annex A**



BACKGROUND: WHITE

BACKGROUND: GOLDEN YELLOW B.49

BLACK

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**Warning**

**Chlorine contaminated fluid**

The dielectric fluid in this unit is undergoing analysis to determine the amount of Polychlorinated Biphenyl (PCB content). A chlorine-screening test indicated the dielectric fluid to contain chlorine.

Until definite determination of PCB has been established the dielectric fluid in this unit must be treated as PCB contaminated

BACKGROUND: GOLDEN YELLOW B.49

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Chlorine content \_\_\_\_\_ ppm

Date \_\_\_\_\_

Analyst \_\_\_\_\_

## SANS 555 (2002)

	Unit	OLD SABS 555	SANS 555(2002)
Appearance		Clear, free of sediment and suspended matter	Clear, free of sediment and suspended matter
Density @ 20°C	kg/dm <sup>3</sup>	≤0.895 max	≤0.895 max
Kinematic Viscosity @ 40°C	mm <sup>2</sup> /s	≤16.5 max	≤16.5 max
Flash Point	°C	≥140 min	≥140 min
Pour Point:	°C	≤-21 max	≤-21 max
Neutralization value	mg KOH/g	≤0.03 max	≤0.03 max
Corrosive Sulfur		Non-corrosive	Non-corrosive
Moisture	Mg/Kg	35 max	
Moisture bulk delivery			≤20 max
Moisture drum delivery			≤30 max
Anit-oxidant additives	% by mass	No additives	No additives
Oxidation stability acidity After 164 h@100 ° C	mg KOH/g	≤ 0.4 max	≤0.15 max
Oxidation stability sludge After 164 h@100 ° C	% by mass	≤0.1 max	≤0.03 max
Dielectric Strength	kV/2.5 mm	≥30 min	≥30 min
Dissipation Factor @ 90°C		≤0.005 max	≤0.005 max
Total furfural and furans	mg/Kg		Not detectable
Polyaromatic hydrocarbon	%		≤3.0 max
Gassing tendency	mm <sup>3</sup> /min		≤ +5
Polychlorinated biphenyl	mg/Kg		Not detectable

### REFERENCES

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Environment Conservation Act (Act 73 of 1989)

Hazardous Substances Act (Act 15 of 1973)

National Environmental Management Act (Act 107 of 1998)

Occupational Health and Safety Act (Act 85 of 1993), Regulations on hazardous Chemical Substances.

Water Act (Act 36 of 1998)

ESKOM STANDARD ESKASAAC2 Rev1

POLYCHLORINATED BIPHENYL (PCB) MANAGEMENT AND DISPOSAL IN SOUTH AFRICA  
*AE Lombard ESKOM TSI*

Polychlorinated biphenyls: our treatment and disposal option by *DA Baldwin, Waste-Tech*

PCBs available options for the Analysis of PCBS by *Stephen Finch, Dexsil Corporation*

PCB-FILLED TRANSFORMERS-Environmental threat and commercial opportunity by Dr Dirk Neupert, *ABB Transformatoren, GmbH Enviromental Services, Dortmund, Germany*

Basel Convention PCB, PCT and PBB Technical Guidelines: *Mike Harris, Delamere Consulting*  
*Member of the Small Working Group on POPs under the Technical WG of the Basel Convention 21<sup>st</sup>*  
*October 2002*

ICS-UNIDO PUBLICATIONS “*Proceedings of Expert Group Meetings on POPs and Pesticides*  
*Contamination: Remediation Technologies (April 2000) and on Clean Technologies for the Reduction*  
*and Elimination of POPs (May 2000)* Published in November 2000

DESTRUCTION TECHNOLOGIES FOR POLYCHLORINATED BIPHENYLS (PCBs)  
*By M.S.M. Mujeebur Rahuman, Luigi Pistone<sup>§</sup>, Ferruccio Trifiro<sup>¶</sup> and Stanislav*

POLYCHLORINATED BIPHENYLS MANAGEMENT PLAN-Revised Edition April 2003  
*ANZECC-Australian and New Zealand Environmental and Conservation Council-*

## Polychlorinated Biphenyl Transformer Incident -- New Mexico

On June 17, 1985, a transformer located in the basement of the New Mexico State Highway Department building in Santa Fe was found to have overheated and released an oily mist containing polychlorinated biphenyls (PCBs) and their pyrolysis by-products. The transformer contained 245 gallons of askarel\*, most of which was vented from the transformer. The askarel was tested for PCBs, and the result was interpreted as negative. Therefore, clean-up began under the assumption that PCBs were not present. By that afternoon, however, a laboratory identified PCBs in an askarel fluid sample from the site. By that time, the three-story building had been extensively contaminated, compounded in part by the clean-up efforts.

Contamination occurred in several ways: (1) mist containing PCBs and pyrolysis by-products entered two rooms in the basement adjacent to the transformer vault and two rooms on the ground floor above the vault via vents and unsealed electrical conduits; (2) direct spread of mist and fumes occurred through three stairwells located in the building, none of which had fire doors; (3) air drafts created by open windows and exhaust fans spread fumes throughout the building; (4) foot traffic by employees and emergency-response teams extended the contamination; (5) the exhaust vent in the transformer room, located near the intake vents for the building's air-conditioning system, allowed further contamination through fumes drawn into the air-conditioning system.

The askarel contained 87% polychlorinated biphenyl (PCB) (Aroclor 1260\*\*) and a mixture of tri- and tetra-chlorinated benzenes (13%). Air samples obtained within 14 hours after the incident showed PCB levels of 48 ug/m((3)) in the transformer vault and 20 ug/m((3)) in the room above the vault. Wipe samples of surfaces showed PCB levels ranging from 30 million ug/m((2)) for grossly contaminated surfaces to 4,700 ug/m((2)) for a desk top with no visible contamination.\*\*\*

Additional air and surface samples were collected June 22-24. Analysis of these samples demonstrated potential pyrolysis products of PCBs and polychlorinated benzenes. The 2,3,7,8 isomer of tetrachlorodibenzofuran (TCDF) was identified in concentrations averaging 48 pg/m((3)) of air in the most heavily contaminated areas of the building. For wipe samples, levels ranged from 41,224 ng/m((2)) on grossly contaminated surfaces to 5 ng/m((2)) in areas with no visible contamination. The 2,3,7,8 isomer of tetrachlorodibenzo-p-dioxin (TCDD) was not detectable in air samples or on surface wipes (detection limit 0.5-5.0 pg/m((3)) for air samples and 180 ng/m((2)) for surface wipes). The highest levels of chlorinated benzenes were found on the second floor, where air levels of 168 mg/m((3)) and 3.9 mg/m((3)) were recorded for 1,2,4-trichlorobenzene and 1,2,3,4-tetrachlorobenzene, respectively.

The Office of Epidemiology, New Mexico Health and Environment Department, conducted a study to determine whether exposure to fumes or oil at the transformer incident site had caused illness. Exposed persons were identified by highway department officials, by police and fire department attendance logs, and by self-reporting. A questionnaire was administered to exposed and unexposed employees and to emergency-response team members. Eighty (79.2%) of the 101 persons with known exposure completed questionnaires. The most commonly observed symptoms were: nausea (27.5%), eye irritation (22.5%), sore throat (21.2%), nose irritation (18.8%), chest tightness (15.0%), and headache (15.0%). Symptoms were transient and usually resolved as soon as the person left the site. However, two people reported headaches persisting more than 1 day. Nine persons were evaluated at a local emergency room and then released. Analysis of symptom-prevalence data showed that, for individuals not wearing self-contained breathing apparatuses, the number of symptoms was correlated with time at the site ( $r = 0.236$ ,  $p = 0.039$ ) and time in the building ( $r = 0.340$ ,  $p = 0.035$ ).

Fifty-six persons with known exposure submitted sera for PCB analysis, as did 20 controls (unexposed firefighters and highway department employees). Serum PCBs were calculated using Aroclor 1260 as the standard. All but four persons had levels below 10 parts per billion (ppb). The median for exposed persons was 4.1 ppb (range 1.2-41.8 ppb) compared to 2.4 ppb (range 0.9-8.0 ppb) for controls. The values observed in exposed persons were greater than in controls ( $p = 0.002$ ). Persons who entered the

building had higher serum PCB levels than persons exposed to fumes outside (median: 4.8 ppb inside; 3.4 ppb outside;  $p = 0.014$ ). Neither individual symptoms nor total numbers of symptoms were correlated positively with serum PCB level.

The affected building has not been reopened. Reported by K Sherrell, RF Meyerhein, MS, Organics Section, Scientific Laboratory Div, SA Rogers, MES, WT Slade, MES, C Oppenheimer, Occupational Health and Safety Bureau, D Fort, Environmental Improvement Div, HF Hull, MD, State Epidemiologist, New Mexico Health and Environment Dept; Div of Field Svcs, Epidemiology Program Office, Div of Surveillance, Hazard Evaluations, and Field Studies, National Institute for Occupational Safety and Health, CDC.

### *Editorial Note*

Editorial Note: According to Environmental Protection Agency estimates, approximately 77,600 PCB transformers were being used in or near commercial buildings at the end of 1984 (e.g., office buildings, hospitals, schools, and shopping centers) (1). While past attention has focused mainly on spills of PCBs from this equipment, the recent occurrence of several fires (2,3) involving PCB-containing transformers has focused attention on what may be a more important threat to public health: fires resulting in widespread contamination of structures with PCBs and, in some cases, polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-p-dioxins (PCDDs), including 2,3,7,8-TCDD. In addition to these soot-producing incidents, release of PCBs from the pressure-relief valves of overheated transformers have also resulted in contamination. Although a previous incident of this type did not result in detected concentrations of PCDFs and PCDDs (4), the Santa Fe incident demonstrates that significant formation of PCDDs and PCDFs, including 2,3,7,8-TCDF can occur from overheated transformers. The formation of PCDFs and PCDDs from the pyrolysis of electrical fluids is of paramount concern as some of the congeners are much more toxic than PCBs. Groups at risk from these exposures include firefighters and other emergency-response personnel, clean-up workers, and occupants of these structures.

In experimental animal studies, exposure to PCB, PCDFs, and PCDDs at a wide range of exposure concentration may cause various systemic effects, including immunologic dysfunction and teratogenesis. In addition, PCBs and TCDDs are carcinogenic in rats and mice (5,6). Humans exposed to PCBs, TCDDs, or PCDFs have developed chloracne, metabolic disorders, and other systemic problems (5,6). Epidemiologic studies of humans chronically exposed to PCBs or PCDDs in the workplace suggest an association between exposure to these compounds and increased incidence of cancer (7-9). However, the long-term health effects of acute exposure, such as this, are not known.

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9. Hardell L, Sandstrom A. Case-control study: soft tissue sarcomas and exposure to phenoxyacetic acids or chlorophenyls. *Brit J Cancer* 1979;39:711-7. \*Fire-resistant, electrically insulated coolant liquid used in PCB transformers. \*\*Use of trade name is for identification only and does not imply endorsement by the U.S. Department of Health and Human Services and the Public Health Service.