Compilation of PCB applications for owners and public officials

UNEP

MAP

Regional Activity Centre for Sustainable Consumption and Production

Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem

MedPartnership

Together for the Mediterranean Sea

GEF UNEP

APRIL 2015

Index

Introduction

This compilation document is part of the capacity building material prepared by the Regional Activity Center for Sustainable Consumption and Production (SCP/RAC) (www.scprac.org) as part of its activities for the GEF funded Medpartnership project (www.themedpartnership.org) for the Environmentally Sound Management of Polychlorinated Biphenyls (PCBs) in the Mediterranean, and also as a Stockholm Convention Regional Center.

The Stockholm Convention (SC) on Persistent Organic Pollutants (POPs), including PCBs, is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have adverse effects to human health or to the environment.

In response to this global problem, the Stockholm Convention, which was adopted in 2001 and entered into force in 2004, requires Parties to take measures to eliminate or reduce the release of POPs into the environment. The Convention is administered by the United Nations Environment Programme (UNEP) and is based in Geneva, Switzerland.

This document is addressed to potential PCB owners of closed (transformers, capacitors, etc.) and open (plastics, paints, sealants, flooring, etc.) applications as well as to public officials able to regulate such dangerous substance.

This compilation lists different usages of PCBs in alphabetic order, not in order of importance. Besides the research implemented, the authors do not have a full overview of the amount of PCBs used in all applications, but they think that transformers, capacitors, paint and sealants may account for most of the PCB consumption. Due to the fact, PCB as such is a dangerous substance, it is important to take proper care of all occurrences of PCBs. The withdrawal and management of waste containing PCBs should only be implemented by authorized waste managers. In any case should be disposed as ordinary municipal waste as a minimum.

The document has been compiled by Mr. Eirik Waerner, Hjellnes Consult AS in Norway, and reviewed by Mr. Urs Wagner, ETI in Switzerland. If you have any comments or suggestions, we would appreciate you contact us.

All photos are by Eirik Waerner, if not otherwise stated.

PCB has a wide range of trade names, as it can be seen from Table 1. Some of the names are quite similar, this may be due to misspellings of the trade name in the literature.

Table 1. Brand names for PCBs

Abestol (t, c)	Dl(a)conal	Phenoclar DP6 (Germany)
Abuntol (USA)	DP 3, 4, 5, 6.5	Phenoclor (t, c) (France)
Aceclor (t) (France, Belgium)	Ducanol	Phenoclor DP6 (France)
Acooclor (Belgium)	Duconal (Great Britain)	Phyralene (France)
Adkarel	Duconol (c)	Physalen
ALC	Dykanol (t, c) (USA)	Plastivar (Great Britain)
Apirolia (t, c)	Dyknol (USA)	Polychlorinated biphenyl
Apirolio (t, c)	E(d)ucaral (USA)	Polychlorobiphenyl
Areclor (t)	EEC-18	Pryoclar (Great Britain)
Arochlor (t, c)	EEC-IS (USA)	Pydraul (USA)
Aroclor (t, c) (USA)	Elaol (Germany)	Pydraul 1 (USA)
Aroclor 1016 (t, c)	Electrophenyl (France)	Pydraul 11Y (USA)
Aroclor 1221 (t, c)	Electrophenyl T-60	Pyralene (t, c) (France)
Aroclor 1232 (t, c)	Elemex (t, c) (USA)	Pyralene 1460, 1500, 1501 (F)
Aroclor 1242 (t, c)	Elexem (USA)	Pyralene 3010, 3011 (France)
Aroclor 1254 (t, c)	Eucarel (USA)	Pyralene T1, T2, T3 (France)
Aroclor 1260 (t, c)	Fenchlor 42, 54, 70 (t, c) (Italy)	Pyramol (USA)
Aroclor 1262 (t, c)	Hexol (Russian federation)	Pyranol (t, c) (USA)
Aroclor 1268 (t, c)	Hivar (c)	Pyrochlor
Arubren	Hydol (t, c)	Pyroclar (Great Britain)
Asbestol (t, c)	Hydrol	Pyroclor (t) (USA)
ASK	Hyvol	Pyromal (USA)
Askarel (t, c) (USA)	Hywol (Italy/USA)	Pyronal (Great Britain)
Auxol (USA)	Inclar (Italy)	Pysanol
Bakola	Inclor (Italy)	Saf(e)-T-Kuhl (t, c) (USA)
Bakola 131 (t, c)	Inerteen 300, 400, 600 (t, c)	Safe T America
Bakolo (6) (USA)	Kanechlor (KC) (t, c) (Japan)	Saft-Kuhl
Biclor (c)	Kanechor	Sanlogol
Chlorextol (t)	Kaneclor (t,c)	Sant(h)osafe (Japan)
Chlorinated Diphenyl	Kaneclor 400	Sant(h)othera (Japan)
Chlorinol (USA)	Kaneclor 500	Sant(h)othern FR (Japan)
Chlorintol (USA)	Keneclor	Santosol
Chlorobiphenyl	Kennechlor	Santoterm
Chloroecxtol (USA)	Leromoli	Santotherm (Nippon)
Chorextol	Leromoll	Santotherm FR
Clophen (t, c) (Germany)	Leronoll	Santovac
Clophen Apirorlio	Magvar	Santovac 1
Clophen-A30	Man(e)c(h)lor (KC) 200,600	Santovac 2
Clophen-A50	Manechlor (Nippon)	Santovec (USA)
Clophen-A60	MCS 1489	Santowax
Cloresil	Montar (USA)	Santvacki (USA)
Clorinol	Nepolin (USA)	Saut(h)otherm (Japan)
Clorphen (t)	Niren	Siclonyl (c)
DBBT	No-Famol	Solvol (t, c) (Russian Federation)
Delorene	NoFlamol	Sorol (Russian Federation)
Delor (Czech Republic)	No-Flamol (t, c) (USA)	Sovol (Russian Federation)
DI 3,4,5,6,5	No-flanol (t,c) (USA)	Sovtol (Russian Federation)
Diachlor (t,c)	Nonflammable liquid	Terpenylchlore (France)
Diaclor (t, c)	Non-flammable liquid	Therainol FR (HT) (USA)
Diaconal	Orophen (Former East Germany)	Therminol (USA)
Dialor (c)	PCB	Therminol FR
Diconal	Pheneclor	Therpanylchlore (France)
Disconon (c)	Phenochlor	Ugilec 141, 121, 21
Dk (t, c) (decachlorodiphenyl)	Phenochlor DP6	
t = transformers, c = capacitors		

PCB applications

The following applications are listed in alphabetic order.

Ceiling tiles

In Germany and Switzerland, it has been reported the use of acoustic ceiling tiles impregnated with 20% Clophen A50 or A60. The tiles were called "Wilhelmi" and were widely used in schools.

In the U.S., similar tiles manufactured by Armstrong (Armstrong Travertone Sanserra) have been used, especially in offices and shops. In 1969-70, these tiles were coated with 4-12% PCBs in surface material as plasticizer and flame retardant.

Cables, oil filled

You will often find oil filled cables in power stations and other places where electrical energy is produced or transported. Underground cables may also contain PCB oil. Underground cables have been covered by the so-called "closed system", i.e. it does not emit PCBs to the environment. This is only theoretically a “closed system”. For example, in Oslo, Norway only, it was necessary to re-fill cables with 7000 liters of oil in 2012.

High voltage cables often contain flame retardants in the cable sheeting. Old cables can thus contain PCB in the sheeting.

Capacitors, small

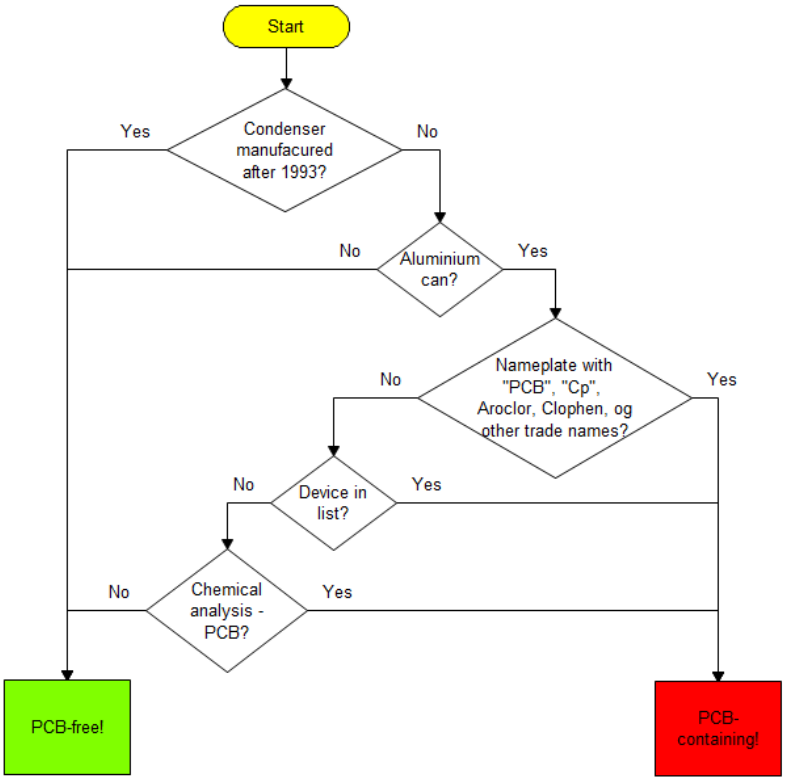
Small capacitors (less than 1 kg) have been used in all major installations by inductive loads on the mains. It is associated with fluorescent lighting, mercury vapor and sodium vapor lamps, neon lights, street lighting, oil burners, motors (dishwashers, washing machines, hair dryers, dryers, pumps, ventilation fans and facilities, dry cleaning machines, machine tools, industrial motors, switches, etc.). PCB-containing capacitors have also been used in microwave ovens and old TV sets without transformer (most TVs with vacuum tubes had no transformer but a simple voltage regulation system with many capacitors).

These capacitors consisted of two aluminum foils, with one layer of paper between. The paper was coated with oil so that it would lead the charge from one aluminum foil to the other (dielectric). In order to prevent fire, PCB was added to the oil. PCBs also had dielectric properties.

PCB-capacitors have the advantage that they were not destroyed by short voltage spikes caused by inductive loads. Voltage spikes could cause overheating, and a capacitor with paper and oil was a potential bomb.

In workshops and other places with large inductive load, capacitors can also be mounted in the fuse box. Most fluorescent light fixtures were supplied with a capacitor installed. Some capacitors were leaking a brown PCB-containing fluid, which in many cases led to the fitting replacement. But the majority of capacitors had a life expectancy that surpassed the fixture.

In the U.S., there was a demand for PCB-free capacitors after 1978, and these were always labeled as "No PCBs". One must assume that there are PCBs in capacitors if it expressly says "No PCBs" on the label. All capacitors with aluminum must be regarded as PCB-containing if not otherwise proven. Use the below flowchart to determine if a capacitor is PCB-free or not.



The Australian and New Zealand Environment and Conservation Council (ANZECC) have elaborated and published a capacitor list which can be downloaded from:

http://www.scew.gov.au/sites/www.scew.gov.au/files/resources/378b7018-8f2a-8174-3928-2056b44bf9b0/files/anzecc-gl-identification-pcb-containing-capacitors-information-booklet-electricians-and-electrical.pdf

A similar list is available from the Swiss Authorities (in German, French or Italian).

http://www.chemsuisse.ch/downloads/kondensatorenverzeichnis-v3.1_d.pdf
http://www.chemsuisse.ch/downloads/repertoire-des-condensateurs-3.1-f.pdf
http://www.chemsuisse.ch/downloads/elenco-dei-condensatori-4.0-i.pdf

None of these lists are complete, but they might provide some help.

Modern electrolytic capacitors are constructed with semiconductive polypropylene without PCBs. Capacitors in aluminum cans can be regarded as PCB-containing, whilst plastic cans probably do not contain PCB.

Figure 1. Typical aluminum can capacitor, might contain PCB.

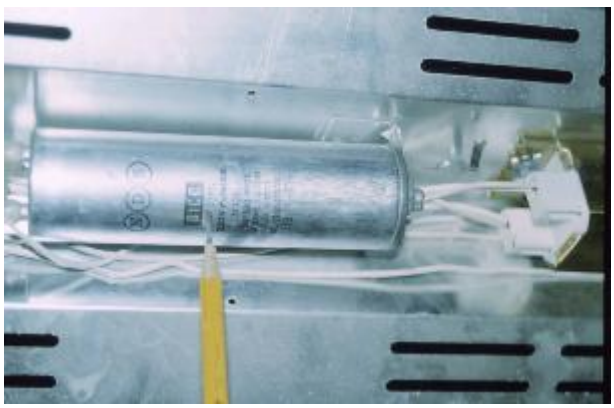


Figure 2. A typical PCB-capacitor, inside a lighting fixture.

Figure 1 Here you can see PCB-capacitors in a fuse box.

Capacitors in fluorescent light fixtures contain 30-100 grams of PCB, while other small capacitors can contain up to 300 grams of PCB. Because a capacitor can have widely different sizes, this data is imprecise. A Norwegian manufacturer stated that they mainly produced 4µF capacitors, and these contained 20 grams Clophen, a PCB oil. These capacitors were mostly used in indoor lighting fixtures. The Norwegian producer also produced some 12 µF capacitors with 500-1000 grams Clophen. For road lighting, it is most often used 8 to 25 µF capacitors, and these contain even more PCBs.

Capacitors, large

Large capacitors (size from a few kilograms to over 100 kg - average probably about 40 kg) have mainly been used in the distribution grid, factories (aluminum, copper, iron, steel, cement, chemical and petrochemical industry and refineries), office buildings, schools, hospitals, shops, railways and in the military. It is difficult to detect such capacitors, because they are rarely marked, and because they are often hidden behind control panels. Capacitors manufactured before 1986 are assumed to contain PCBs. We guess a lifetime of minimum 20 years of these capacitors.

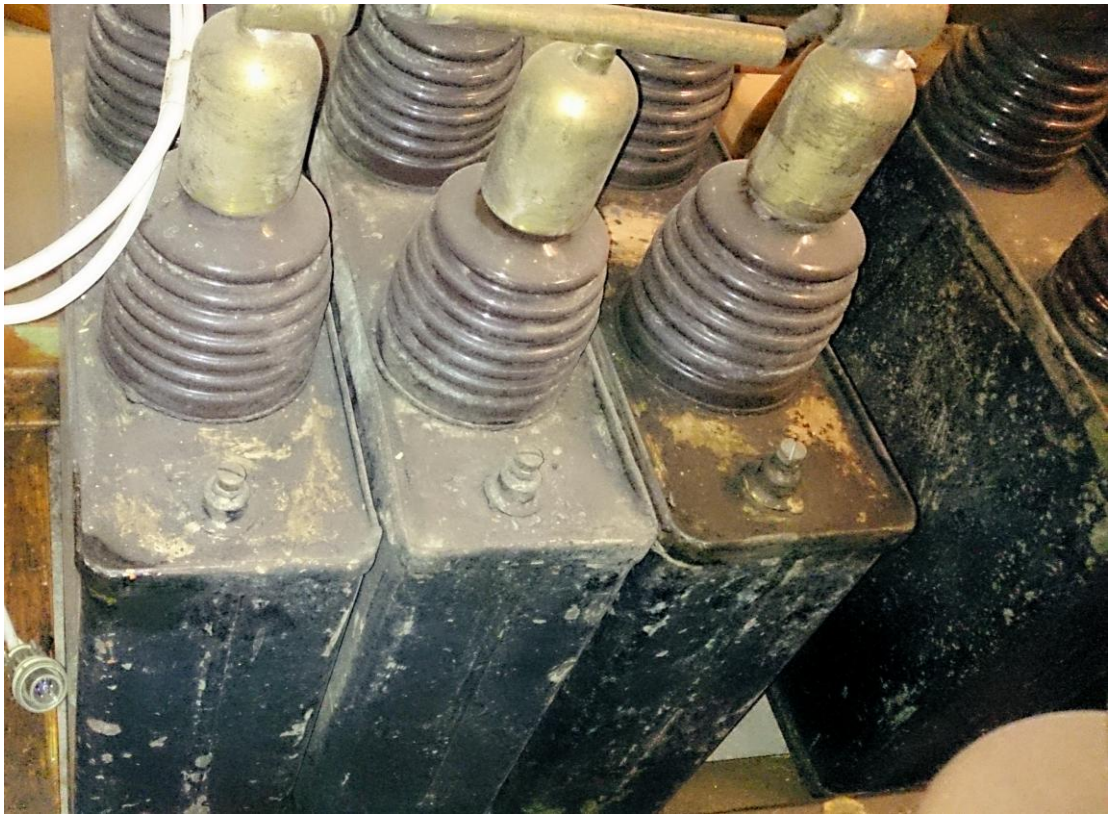


Figure 2 Discarded PCB-containing large capacitors from the 1950s.

Figure 3 The name plate on these capacitors clearly indicate that these are manufactured by General Electric Corporation, USA.

Carbonless paper

Appleton Paper Company (USA) started the production of carbonless paper in 1954. "Paragon" was one well known trade mark, "NCR" was another. "NCR" is an acronym for National Cash Register, the manufacturer, and "No Carbon Required". PCBs are used in the pressure-sensitive component in such paper. Production stopped in the 1970s, when PCBs

were banned. PCBs were replaced by chlorinated paraffins and bisphenolA, both also environmentally troublesome substances. Old accounting archives may thus contain PCB.

Concrete admixture

PVA (polyvinyl acetate) has for a long time been used as a superplasticizer admixture in concrete. Some brands of superplasticizers had PCB added until approx. 1972. This application is only known from Norway, and products were named "Borvibet", "Elasticrete" and "Tranaved". Borvibet contained the PCBs Clophen A60 or Aroclor 1254. Elasticrete is basically a German product (marketed from 1954 to 1976), but the trade name is American today. It was marketed as "lightweight concrete, either precast or in-situ, having superior insulating, sound absorbent and moisture resistant qualities".

The range of application was:

- Primer for priming or slurry to ensure adhesive strength;
- Flooring (screed) to get durable cover that is dust-repellent and comfortable to operate;
- Repair lots for repairing damage and ulcers in concrete and plaster surfaces; and
- Self-leveling mass under linoleum, tiles and the like coverings.

PCBs are also found in terrazzo floors, in cement glue for ceramic or slate tiles and similar applications.

Floorings with 220 mg PCB/kg can be found in Norway. PCBs are also found in conventional concrete at various concentrations, up to 55 mg/kg. This was possible because Borvibet was added in portions of the concrete, where it was important to get the concrete to flow well into all nooks and corners of the formwork. PCBs can also originate from oil.

Figure 4 This is an illustration on the use of PCB in the top leveling mass (1). Picture by Weber corporation.

Glue

There are reports on the use of PCBs as a plasticizer in adhesives in special contexts, including waterproof wallpaper. For example, PCBs were found in glue in the ductwork in a building (Department of Transportation headquarters), in Philadelphia, USA.

Some contact glues may have contained PCB as plasticizer. This applies to bonding carpets, linoleum and panels. The same may apply to assembly glue to mouldings, base and wall panels.

Heat exchangers

Heat exchangers can be used anywhere, but usually in the chemical industry (both organic and inorganic), pharmaceutical industry, plastics industry, aboard ships, oil refining, as well as on food production facilities. PCB-containing heat exchangers were manufactured by mid-80s, and most of them for the temperature range of 150-300 degrees C. Heat exchangers are rarely labeled as containing PCBs.

Today, polydimethylsiloxane has replaced PCBs in such applications.

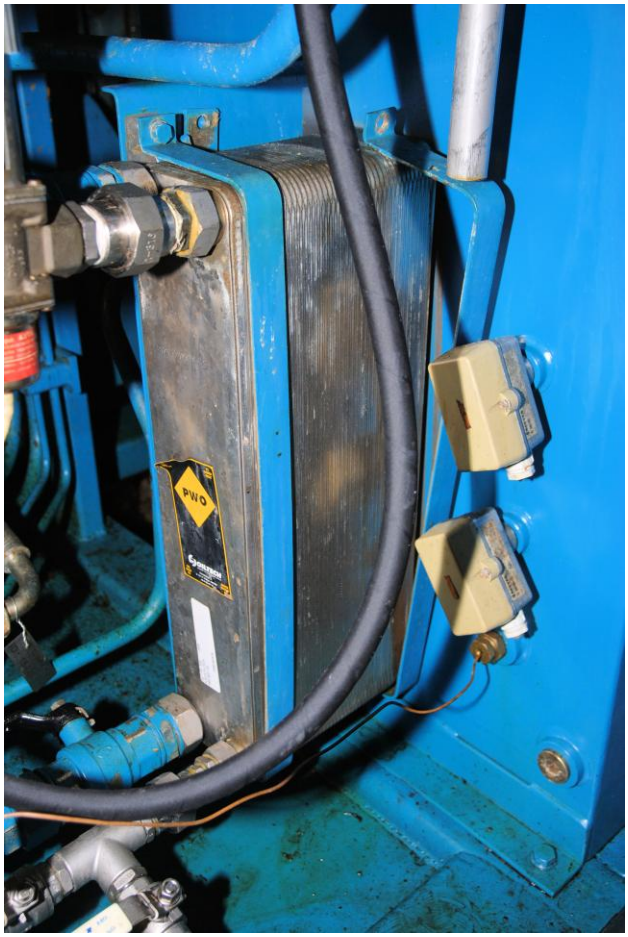


Figure 5 This is a modern heat exchanger (labeled "PWO"), but we assume old ones look similar to this.

Hydraulic oil

The major use of PCB-containing hydraulic oil has probably been in the mining industry, but also in the aluminum, copper, iron and steel industry and in shipyards, foundries and military applications. It has also been used in aircraft, ships, submarines and other circumstances where it was important to avoid fire. Most mines in Western Europe stopped using PCB oil around 1975, but West Germany continued to use it after 1986. In 1980, 1.154 tonnes of PCB oil were refilled in German mines.

Paint

The first application of paint containing PCBs was probably as marine coatings, in other words, in the metal hull. PCB provided to the paint, toughness that avoided cracking up, PCBs contributed to rust prevention and was also toxic to algae growth. Aroclor 1254 or Clophen A 60 has been the most common PCB-congener used in paint.

Applications have expanded, and these areas are found in the literature:

- Ship painting;
- Paint other metal objects, piping, steel bridges, silos in agriculture, power lines, industry, aircraft hangars, rail cars, nuclear power plants, etc.;
- Non-slip flooring in the food industry, hospitals and canteens, industry, printing offices and military facilities, as well as balconies and stairs;
- Cowsheds, manure pits, swimming pools and elevated water reservoirs;
- Toilets, particularly in schools;
- Floor paint (on concrete): Basements, engineering and manufacturing facilities, wet rooms (toilets, laundry) and technical rooms (boiler houses etc.);
- Fire retardant paint;
- Walls and eternite sheets;
- Technical equipment such as rolling mills, welding equipment, furnaces, heat pumps, mills, crushers, water heaters, etc.;
- Road marking paint;
- Pipelines, pipes, flanges;
- Turbines, generators, pumps, motors, cranes;
- Fuel oil tanks;
- Gas tanks; and
- Weirs and sluices.

It appears that PCBs were added to a few main types of paint and specifically to:

- Chlorinated rubber paint. Chlorinated rubber paint has great resistance to acids, alkalis, salt solutions and water;
- Epoxy paint; and
- Vinyl acetate-paint.

Non-slip floors

Non-slip flooring may contain PCBs, in particular so-called akrydur floor. Such coatings have been used in industry (particularly in the food industry - slaughterhouses for animals and fish, dairy, etc.), and possibly also in hospitals and company canteens.

Barns, manure pits and swimming pools

PCB paint has been applied inside the barn, because this was the only coating at that time strong enough to withstand gases arising from the manure.

Figure 6 Equipment for removing PCB-containing paint (picture: Pentek USA).

Plastics

PCBs have been used as additives in PVC, both as a plasticizer and flame retardant. This is suggested in an article in the “Electrical Review” in 1951, where an employee of Monsanto describes that Aroclor 1254 can be used with dioctyl phthalate as plasticizer and flame retardant in PVC plastic. The article notes that the "flame-out" time is reduced from 76 seconds to 3 seconds by adding Aroclor.

Flooring

PCBs were detected in the flooring in a laboratory building at Haukeland Hospital in Bergen, Norway. The concentration was up to 100 mg/kg, and this coating was manufactured as "Crestalline". This coating was a flame-retardant coating specifically marketed for use in aircrafts. It is also found PVC flooring with PCBs in Denmark from the period 1950-1970.

Cables

PCBs may be added in cable insulation in several ways: PCB can be added to the outer layer of the insulation, it can be painted into a layer of intumescent paint, or might be added to the whole insulation material.

Sealants

The use of sealants has mostly been applied between concrete panels in buildings, bridges, etc., and between concrete and other building components. Sealants around windows, doors and in swimming pools have often contained PCBs. The sealant (polysulfide) could contain up to 50% PCBs, but about 15-20% PCB is more common. The company who hold this patent was Thiokol company, and this name became synonymous with this kind of sealant, although there were others such as Thioflex, Vulkseal, Vulkfil, Lasto-meric, 1K, Terostat, PRC and Rubberseal.

PCBs are also found in other sealant types: polyurethane, epoxy, mercaptan, acrylic and bitumen.

The operating time is long, up to 50 years. Some sealants are discarded when windows are replaced. All PCB-containing material must be handled as hazardous waste.

A calculation from a Swedish study found out that there can be 45 kg pure PCBs in sealants in a three-storey block of concrete. In Sweden, it was estimated in 1995 that about 10-20% of the PCB-containing sealant is still found in buildings and construction. Approximately 50% of the sealant in insulating glass units is believed to be still in use.

Inappropriate handling and disposal of PCBs containing building materials during clean-up or renovation activities pose the highest risk for exposure.

Open systems emit PCBs directly in the environment and influence the PCB content in indoor air. Buildings frequented by numerous people (e.g. schools, hospitals, etc.) or with a long duration of stay (e.g. flats) pose the greatest risks.

Figure 7 Removal of sealant around a window.

Sealant for double glazing windows

Special glue for bonding glass plates to aluminum frame in sealed double glazed windows might contain PCBs. In Norway, a collecting system with manufacturer responsibility is established for PCB-containing windows. This ensures that all PCB-windows are treated as hazardous waste.

The operating life is long, more than 20 years. Each window unit might hold approximately 60 grams of PCB.

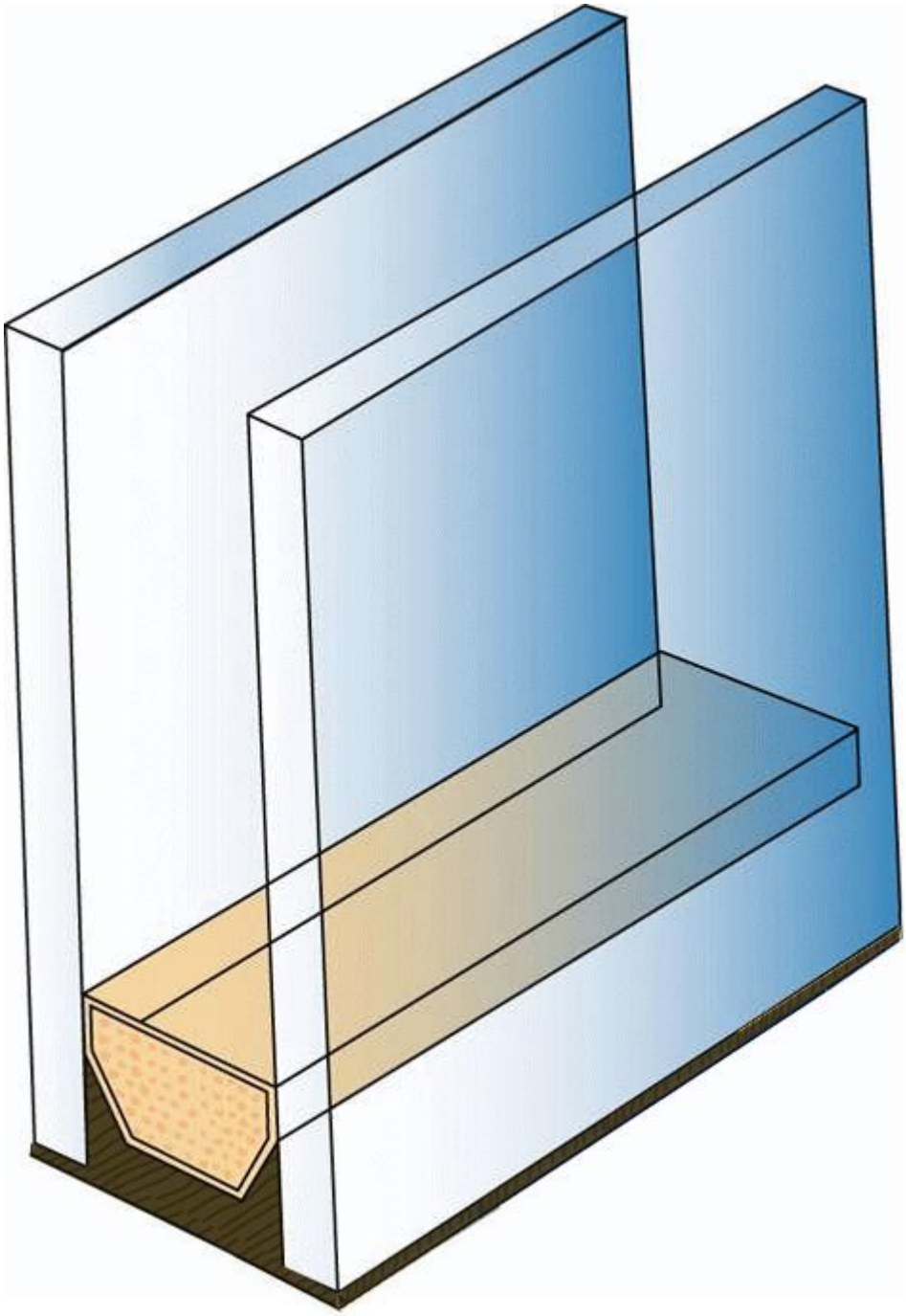


Figure 8. Drawing of a double glazing window. The black area can contain PCBs, if produced before approx. 1986.

Transformers

Large transformers for power supply, the supply network in lamp posts and inside buildings often contain oil that acts as a coolant. Trichlorobenzene and PCB were added to the oil for fireproofing. If transformers are from before 1986 must be regarded as PCB-containing. Such mixtures are called "Askarel". Fireproof transformers in buildings and nuclear power plants might also contain PCBs.

PCB-containing transformers may be found both at the power utility and large consumers including all kinds of industrial activities, railways, subways, nuclear power plants, military, and on board ships. Many transformers which originally did not contain PCBs have also been filled with PCB oil, since this was considered to be better. Therefore, conventional transformers may also contain PCBs.

Only in the EU, it was estimated that in 1986, approximately 260,000 transformers were present, totaling 100,000 tonnes of PCBs, see table below.

Country	**No of transformers**	**Average size (kVA)**	**Askarel (tons)**
Belgium	12.000	500	8.400
France	120.000	400	70.800
Great Britain	6.000	630	5.640
Netherlands	1.200	1000	1.620
Italy	25.000	500	17.500
Luxembourg	2.000	630	1.800
Spain	25.000	500	17.500
West Germany	55.000	630	49.500
Rest EU(86)	10.000	500	7.000
Total EU (86)	256.200		179.760
179.760 tons of Askarel (60% PCB) = PCB-amount			107.856

One must assume that all transformers contain more than 500 ppm PCBs if they do not have a name plate stating the oil type (i.e. unknown oil). If the transformer has mineral oil and no name plate, one must assume that they contain PCBs in the range 50-499 ppm. It is important to mention that PCB-containing transformers where PCB oil is replaced with PCB-free oil, will still contain PCBs because it is very difficult to get out all PCBs. The level will probably remain at 3000-5000 ppm (0.3-0.5% PCB), but can be reduced to a few hundred ppm if oil is replaced after six months. Transformers which are manufactured after the "PCB-period" can still contain PCBs, because the practice in the 70s and 80's of mixing different oils was widespread. Therefore, the so called “PCB-free transformers” may contain up to several thousand ppm of PCBs. It is considered almost impossible to get a PCB-contaminated transformer completely PCB-free, because there are many contact surfaces inside the transformer.

Today, polydimethylsiloxane has replaced PCBs in transformers.

More than 30 years’ service life

PCB's are enclosed in the transformer, but spread to the environment through leaks, accidents or if the transformer is emptied after it is discarded (so-called "closed systems" turned out not be very "closed" anyway). Cooling fins on a radiator is made of welded steel plates, and there

are many welds that have the potential for leakage. Askarel-filled transformers were considered very reliable, and therefore received little attention. A leak can continue for a long time before anyone discovered it. A special phenomenon with askarel is that leaks also creeps upwards outside the transformer, so that the transformer is covered by a thin film of oil containing PCB.

In the past, there was little focus on separating Askarel oil from non-PCB-oil. If anyone was thinking about it, it was in order to avoid Askarel oil being diluted with regular oil because this would reduce the flash point for Askarel-oil.

Transformer stations, industrial companies, scrap businesses and ordinary buildings can have PCB contamination in the concrete floor or ground on-site due to spills and leaks from PCB transformers. Askarel fluid is often seen as a dirty-brown stain, because PCBs are sticky after trichlorobenzene evaporates and absorbs dust.

The most famous scandal of PCB-contaminated oil originating in the U.S., was when President Ronald Reagan had to redeem the entire city “Times Beach”, after "smart" personnel spread PCB-contaminated waste oil in the gravel of city roads to reduce dust dispersion.

PCB oil has low flammability, and therefore is of little value as fuel oil. It has therefore, been greatly diluted with other oil. It is usually very expensive to treat PCB-containing equipment and there is a tendency to illegally get rid of it.

Figure 9 Typical PCB-containing transformer.

Regional Activity Center for Sustainable Consumption and Production (SCP/RAC)
c/Anglí, 31
08017 Barcelona
Tel +34 93 553 8790, Fax +34 93 553 8795
www.scprac.org

This document can be downloaded at:
www.pcbsmed.org
www.scprac.org