

Clean-up time!

PCB-filled transformers – environmental threat and commercial opportunity

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Transformer oils based on polychlorinated biphenyls (PCBs) were widely used in industry up until the late 1970s, when it became apparent that PCBs build up in the environment and have the potential to be harmful. Bans on their use followed, so that many owners of electrical equipment containing PCBs now face the immense task of replacing their units in time to meet national deadlines for phasing out these toxins.

ABB offers turnkey replacement programs for PCB-filled transformers and capacitors that help customers translate the cost of replacing their older units into long-term savings by installing more efficient, state-of-the-art equipment.

Polychlorinated biphenyls (PCBs) are a class of chlorinated hydrocarbons that have been used extensively in industry since the 1930s. They consist of two benzene rings joined by a carbon-carbon bond, with chlorine atoms substituted on any or all of the remaining 10 hydrogen atoms. PCBs include mobile oily liquids and hard transparent resins, depending on the degree of substitution. The value of PCBs for industrial applications derives from their chemical inertness, resistance to heat, non-flammability,

low vapor pressure and high dielectric constant.

As electrical equipment found its way into all branches of industry in the early to mid-1900s, equipment suppliers became major users of PCBs. For the most part they were used as coolant in transformers (thereby replacing air-cooling, which was difficult, expensive and unreliable) and as a dielectric in capacitors. But PCBs were also included in a wide range of other products, like lubricants, cutting oils, sealing compounds (for the construction

industry), and in paint, varnishes, and other surface coatings, including carbonless copying paper.

Where the dangers lie

Many of the characteristics that make PCBs ideal for industrial applications create problems when they are released into the environment, eg as a result of accidents or in the disposal of defective or damaged transformers. The effects on humans and the environment primarily follow chronic exposure. Like many

1 Replacing the oil is often enough to bring transformers which are only slightly PCB-contaminated down to levels below the legally permitted limits.



other chlorinated hydrocarbons, PCBs associate with the organic components of soils, sediments, and biological tissues, as well as with dissolved organic carbon in aquatic systems.

Once in the environment, PCBs do not readily break down and therefore may remain for very long periods of time. They can easily cycle between air, water and soil. In air, PCBs can be carried long distances and have been detected in air, water and organisms far away from where they were released, for example in the Arctic [1].

Innovative solutions to the PCB problem

As the world's largest manufacturer of transformers, ABB recognizes that it has a responsibility to customers and to society at large. Accordingly, the issue of PCBs in transformers was addressed by ABB very early on, and methods were sought to help users comply with the

regulations that were being put into place.

For transformers in which there are only small quantities of PCB, replacement of the contaminated oil is often sufficient to bring the units down to PCB levels below the legally permitted limits (50 ppm, or parts per million, in many

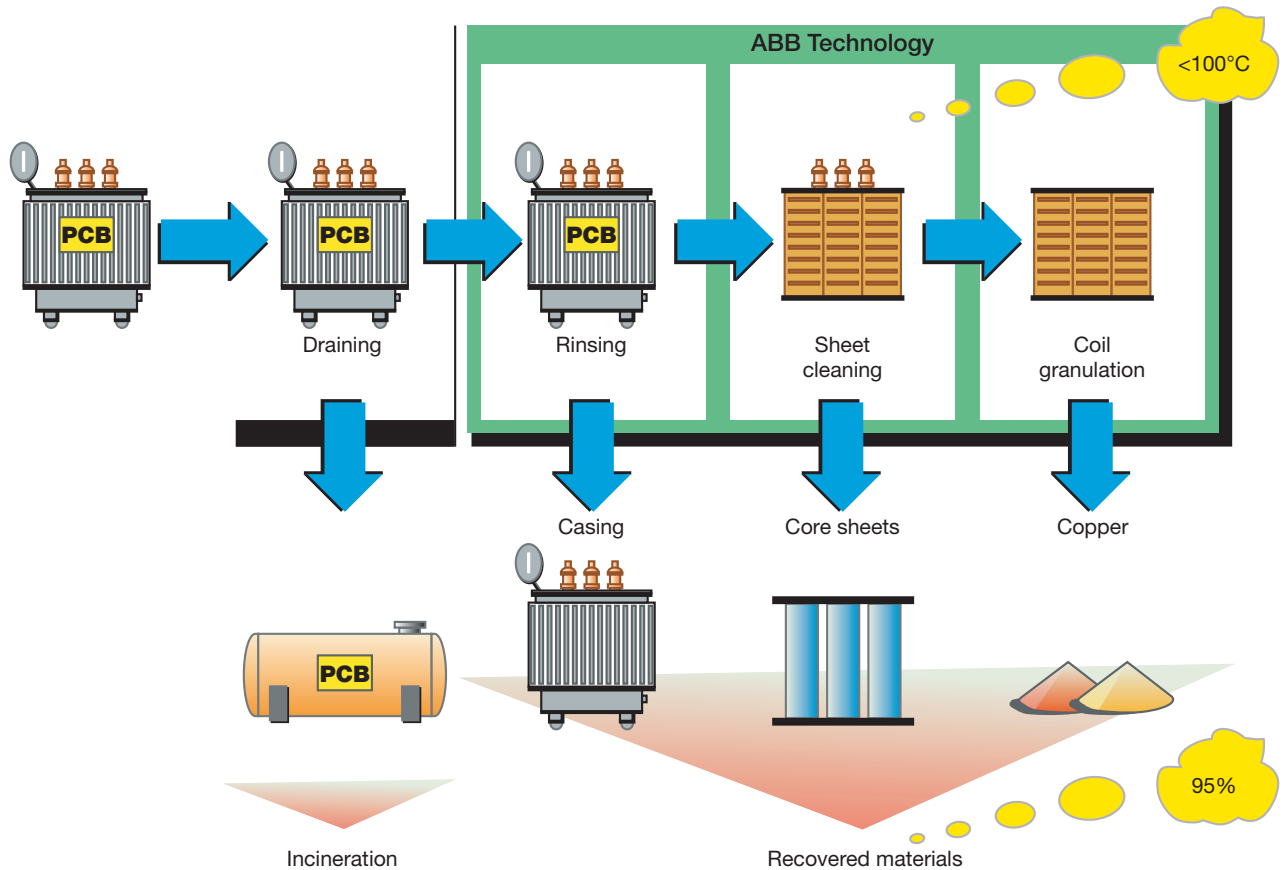
countries). We do this when we can guarantee that the quantity of PCB remaining in the organic materials used inside the transformers (eg, the insulating paper and wooden mounting fixtures) is so small that the contamination of the new oil will not exceed the legal limit over the transformer's remaining lifetime.

An oil by any other name...

It is important to make a distinction between 'Askarel transformers' and 'contaminated oil transformers'. PCB liquids are known generically as 'askarels', but PCBs used in transformers are also known by their product names, such as Clophen, Pyralene, Inerteen, Apirolio or Kaneclor. Transformers filled with one of these liquids are called 'Askarel' transformers (typically 40–60% PCBs).

Significant PCB contamination can be found, however, even in transformers supposedly filled with pure mineral oil. It may be introduced during the manufacturing process (due to the same manufacturing plant being used for Askarel and mineral oil transformers) or during subsequent maintenance work. Such transformers are known as 'contaminated oil transformers' (<1% PCBs in most cases).

2 ABB has developed a recycling technology for PCB transformers that is among the most advanced and eco-friendly of its kind.



PCB oil replacement can be carried out *in-situ* by sending experienced field service personnel, equipped with the necessary tools and safety equipment, to the customer's site 1. The precautions we take when handling PCBs on a customer's premises are very strict to ensure that neither the environment nor personnel are put at risk.

For transformers filled from the beginning with oils containing higher levels of PCB – so-called 'Askarel' transformers (see box on previous page) – simply changing the oil is not enough. Safe disposal of the PCBs and recycling

these contaminated transformers is a tricky task. The complete separation of dangerous PCBs from the re-usable metallic parts of the unit, and the ultimate destruction of all the organic materials soaked with PCBs, requires special knowledge and expertise.

This has motivated ABB to develop, in close cooperation with the German Ministry for the Environment, a technology for recycling PCB transformers that is among the most advanced and eco-friendly of its kind. It avoids the high temperatures essential to competing technologies because thermally treating the solid transformer

components carries the intrinsic risk of producing and releasing dioxins, and should be avoided wherever possible.

This new recycling technology and ABB's experience as the world's largest manufacturer of transformers are a strong combination, and one of the key reasons for customers entrusting us with the recycling of their PCB wastes.

ABB turnkey PCB replacement solutions are based on three unique competencies

When called upon to replace PCB transformers, ABB has the advantage of

3 After disassembly, the transformer core sheets are cleaned with hot solvent in a special machine.

group-wide resources, to provide customers with an intelligent turnkey replacement solution adapted to their specific needs. By doing so, PCB replacement projects, which some transformer owners may initially regard as inopportune and unwelcome as they require what might be considered 'unnecessary' expenditure, can be turned into retrofit projects yielding efficiency improvements and cost savings that allow them to be paid back in just a few years.

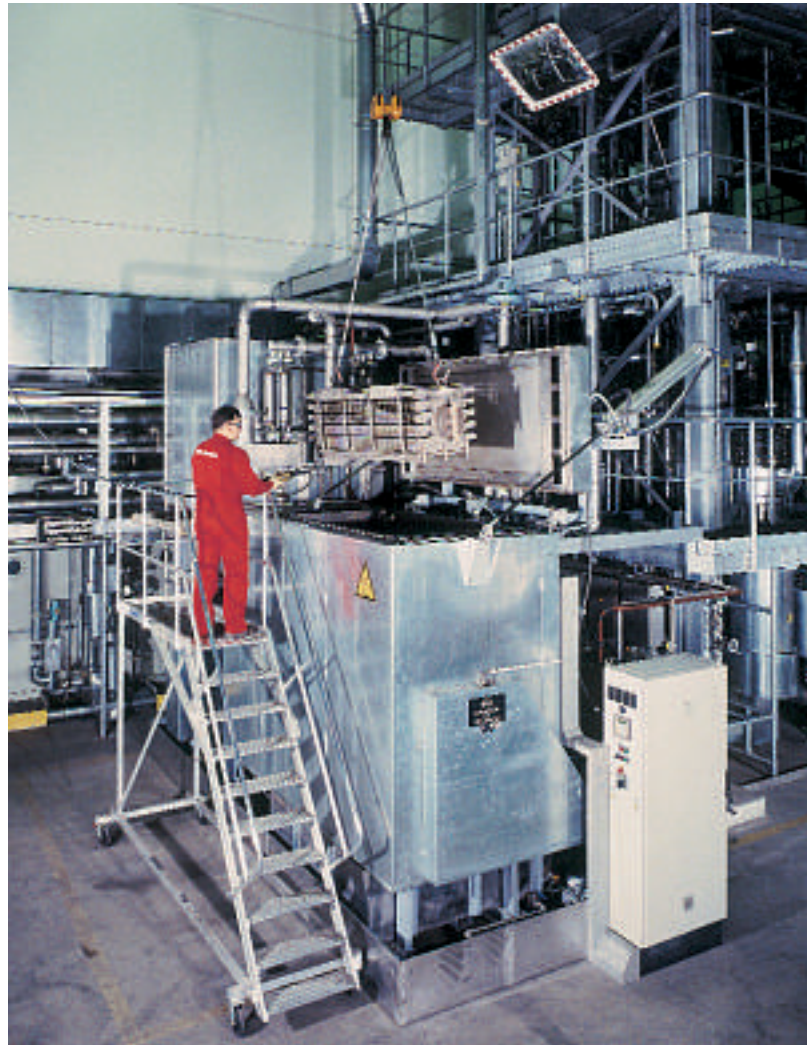
ABB's PCB replacement projects ensure these benefits through turnkey solutions that draw on three areas in which our company has unique expertise:

- Recycling of PCB-contaminated transformers and capacitors
- Production of quality transformers for a wide range of applications
- Electric Systems Consulting

A recycling technology that turns PCB transformers into valuable raw materials

The technology employed at the ABB recycling facility in Dortmund, Germany, is the most efficient and environmentally friendly technology available to date. In addition to the PCBs being totally destroyed, 95% of the solid mass of the transformer is recovered as secondary raw material of the highest quality **2**.

In the first phase of the decontamination process, the PCB liquid is drained off for later high-temperature destruction in special facilities in the chemical industry. (Unlike the solid components, PCB liquids are destroyed most efficiently and



economically by thermal means. The flue gases emanating from the hazardous waste incinerators pass through a combination of physical and chemical processes which ensure near total avoidance of all hazardous emissions, such as dioxins and furans.)

The transformers are then rinsed with solvent in hermetically closed cabinets to remove PCB from the inner surfaces of the transformer. (The solvent can be re-used after it has gone through a distil-

lation process.) After rinsing, residual quantities of PCB remain in the wooden mounting fixtures, in the paper insulation of the coils, and between the metal sheets of the transformer core. The core is subsequently disassembled and the metal sheets are cleaned with hot solvent in a special machine **3**.

The copper in the coils now has to be efficiently separated from the paper winding. This is done by granulating the coils; the resulting paper shreds are

4 The transformer coils are granulated to separate the copper from the paper winding. The paper shreds (left) are compacted and destroyed; the resulting copper scraps (right) are free of PCB and can be recycled.



compacted and destroyed together with the PCB oil and wood, while the scraps of copper which are obtained are PCB-free **4**.

As already mentioned, up to 95% of the solid material of a contaminated transformer is recovered using this method; the average contamination of

the recovered materials is around 2 ppm, well below the permitted limits [2] (see also www.abb.com/pcb).

Quality transformers for a wide range of applications

ABB's turnkey replacement solutions also depend on the unique expertise that the company has built up in the area of transformer development and manufacture over nearly a century. Reflecting the crucial role they play in production processes, ABB transformers are built to the highest standards and guarantee levels of performance and safety that add genuine value to customers' activities. A comprehensive range that includes liquid-filled transformers rated to 25 MVA and 72 kV, dry-type and cast transformers rated to 30 MVA at 41.5 kV, as well as specialty transformers, covers a wide spectrum of industrial applications. And allows us to offer customized retrofit projects with the best technical solution to every problem: (see www.abb.com/transformers).

Electric Systems Consulting – maximizing your assets in a competitive marketplace

Industrial companies, utilities and independent power producers all have to do business in increasingly competitive markets. In light of this, it is imperative to maximize system reliability, performance and efficiency.

System analysis is the first step toward a solution that gives you a competitive edge in the energy marketplace, and therefore a core expertise in ABB's turnkey replacement program. ABB Electric

Legal regulations

The European Community requires products, including transformers, with a PCB concentration in excess of 50 mg/kg to be disposed of by the year 2010. Some European countries have set even earlier deadlines, eg 1999 for countries bordering on the North Sea. Strict regulations also apply to the use, handling and transport of liquids and waste contaminated with PCB.

Similar legislation exists in other industrialized countries, such as the USA, Canada and Japan, while many other countries are in the process of establishing regulations for the handling of PCBs. Some countries, however, have still not embarked on programs for PCB disposal.

The drive to eliminate PCBs completely has gained new momentum with the adoption of the Stockholm POPs Convention Treaty of 2001, which calls for the elimination of all PCBs by the year 2025. Ratification by 50 countries – expected to take about five years – is necessary for the treaty to become international law. POPs (Persistent Organic Pollutants) are chemical substances which are extremely stable and are known to accumulate in biological tissue, thereby posing a risk to human health and the environment; PCB is one of the 12 POPs covered by the Stockholm Convention.

Here, there and everywhere...

Between 1929 and 1989, PCB production totaled some 1.5 million tonnes worldwide (excluding the Soviet Union, where no data are available) – an average of about 26,000 tonnes per year. Even after the USA banned the manufacture, sale and distribution of PCBs except in ‘totally enclosed’ systems in 1976, world production remained at a high 16,000 tonnes per year from 1980–1984 and 10,000 tonnes per year from 1984–1989.

Although many countries stopped producing them in the mid-1970s, PCBs continue to be a major cause of concern. One reason is that a substantial amount of PCB is still in use, partly because transformers have long lifetimes and

partly due to many countries exempting users from the need to comply with bans, at least for a limited time, providing the PCBs are ‘contained’. Other problems are the quantities of PCB in storage, awaiting disposal, and the relatively high concentrations that can be found in the soil. Besides all this, there are indications that PCB production has not completely stopped in all countries. So part of the total production has been safely destroyed, part remains in use or awaits destruction, and a substantial proportion has been released to the environment, where it creates problems that are considerably more difficult and costlier to solve than properly disposing of PCB before it can enter the environment.

Systems Consulting (www.abb.com/esc) has accumulated significant experience in this area, having conducted analyses and provided recommendations for electrical systems around the world. With this kind of support, customers can maximize the effective value of their assets as well as evaluate new installations and retrofits, right through to turnkey solutions, long-term maintenance packages and creative financing strategies.

A full range of environmental services

In addition to turnkey solutions for recycling PCB-filled equipment, ABB offers many other services in the envi-

ronmental sector. Among these are the decontamination and rejuvenation of buildings or industrial installations, disposal of other types of industrial waste and site cleaning, consulting services and services relating to the redeployment of used industrial assets. Reference projects include the dismantling of a processing plant for PCB transformers, and decommissioning of the PCB-filled hydraulics systems installed in a German state theater.

ABB’s turnkey PCB replacement solutions are custom-designed, to turn what some customers might perceive as ‘unnecessary’ expenditure into retrofit projects yielding efficiency improvements

and cost savings that allow them to be paid back in just a few years. Thus, what has been seen until now as an environmental threat may justifiably be looked on as a commercial opportunity in the future.

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References

- [1] United Nations Environment Program (UNEP): Inventory of worldwide PCB destruction capacity, Geneva, 1998.
- [2] **D. Neupert**: The ABB technology – safe and eco-friendly recycling of electrical equipment contaminated with PCBs. First Continental Conference for Africa on Environmentally Sound Management of Unwanted Stockpiles of Hazardous Waste and their Prevention. Rabat, Morocco, 2001.