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UNIDO

GUIDELINES FOR ENVIRONMENTALLY SOUND MANAGEMENT OF POLYCHLORINATED BIPHENYLS (PCBS) IN TURKEY

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FOREWORD

This guideline provides the best practices developed in the context of the Principles of Stockholm Convention (SC) to apply it is in Turkey. Some international conventions have been published and ratified to reduce cross-contamination and unintended emissions of Polychlorinated Biphenyls (PCBs) and other Persistent Organic Pollutants (POPs).

The framework of this guideline covers only the closed applications of PCBs and not partially open applications or open applications. Transformers and capacitors[1] are the main PCB-containing equipment; but the same rules apply for the storage of PCB-contaminated oil and pure PCBs, which are the most dangerous. PCB could be found not only in transformers or capacitors but also in closed applications as drums and condensers. In this guideline, the relevant information provides regarding this specific PCB containing equipment.

This guideline addresses the following items:

1) The international and national regulations about PCB (Chapter 1),
2) Data Collection, Identification, Sampling, and Monitoring (Chapter 2)
3) Maintenance and storage of transformers in use (Chapter 3),
4) Prioritization of transformers and equipment based on their residual operation life/use/level of PCB concentration and contamination and existence of alternatives (Chapter 4),
5) Handling of PCB-contaminated equipment including emergency response (Chapter 5).

This guideline aims to help stakeholders and potential PCB stockpile owners apply the requirements of these conventions. This guideline proposes some practical approaches and solutions for professionals, technicians, field engineers and on-site operational personnel. It does not offer an academic point of view.

The potential users of the guideline include the owners of transformers and capacitors such as electricity suppliers and industrial producers. Local communities who manage electric lighting in public areas and rights-of-way, and telecommunication companies who manage networks for mobile or fixed phones shall be, also interested parties,

[1] In this guideline, the wording “transformer” is generic and covers transformers, capacitors and drums used to store the dielectric oil, and all PCB-polluted materials.

CHAPTER 1: NATIONAL AND INTERNATIONAL STANDARDS AND GUIDANCE DOCUMENTS

1.1 THE INTERNATIONAL CONVENTIONS RELATED TO PCBS

These guidelines are related to PCB – which are one of POPs directly named and covered by the Stockholm Convention (SC).

1.1.1 Polychlorinated Biphenyls

PCBs do not exist as a natural substance. Human activities produced PCBs and belong to a broad family of human-made organic chemicals known as chlorinated hydrocarbons. Monsanto, a company in the USA, manufactured PCBs from 1929 until manufacturing banned in 1979.

The SC[2]is international convention with 180 Parties which gives the framework to limit the production, the import and the export of PCBs and defines a schedule plan to eliminate PCBs in the 152 signed countries[3].

PCBs have a range of toxicity and vary in consistency from thin, light-colored liquids to yellow or black waxy solids. Due to their non-flammability, chemical stability, high boiling point and electrical insulating properties, PCBs have used in hundreds of industrial and commercial applications including:

- ✓ Electrical, heat transfer and hydraulic equipment;
- ✓ Plasticisers in paints, plastics, and rubber products;
- ✓ Pigments, dyes and carbonless copy paper;
- ✓ Other industrial applications[4].

PCBs as POPs are persistent, and thus they can be transported by wind and water, most PCB generated in one country can and do affect people and wildlife far from where they are used and released. They persist for long periods of time in the environment and can bio-accumulate and pass from one species to the next through the food chain.[5]

1) Human activities produce toxic chemicals, intentionally or unintentionally
    a. Intentionally production: Pesticides are created by the chemical industry to limit agricultural losses due to insect infestations.
    b. Intentionally production PCBs– due to their insulating qualities – are produced by the chemical industry to insulate houses (fire protection) and to reduce the risk of burning when they used as a dielectric additive in refrigerant oil. Combatting hunger and protecting humans against fire are at the origin of chemical production, but the consequences for human health or biodiversity losses were not evaluated or identified in a parallel way.
    c. Unintentionally production dioxins or furans are also POPs, but they created by burning when high temperatures dissociate the chemical molecules and create a toxic substance such as furans. Intentional fires such as waste burning or unintentionally in case of accidental fires have created some chemical reactions and produced dioxins or furans.
2) Affect human health and the environment

2 All the abbreviations are listed in APPENDIX 1 ABBREVIATIONS
3 At the end of October, 2017
4 EPA https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls-pcbs
5 US EPA https://www.epa.gov/international-cooperation/persistent-organic-pollutants-global-issue-global-response

a) Scientific studies revealed as in the case of accumulative pollution in the sediment of the Great Lakes (USA),

- ✓ animal mortality
- ✓ or a high level of cancers in sensitive populations such as school children

demonstrated the negative health effects in humans that resulted from exposures to POPs like DDT used in agriculture and PCBs used in transformers.

In Turkey, the results of the study "Prediction of the PCB pollution in the soils of Bursa, an industrial city in Turkey[6]" revealed predicted soil concentrations ranged from 25 pg/g to 690 pg/g, while the atmospheric concentrations fluctuated between 35 pg/m^3 and 1112 pg/m^3. The soil concentrations were found to agree with the lower range of European and global values, and below the regulatory limits. The urban and residential sites yielded higher PCB concentrations and a higher degree of heavier congeners than the sites characterized as suburban. The urban and residential sites were dominated by hexa-chlorinated biphenyls (CBs), followed by tri-CBs, while the industrial site was dominated by tri-CBs, followed by tetra-CBs. PCB congeners of 153, 180, 138, 118, and 101 were higher in all locations.

b) Scientific studies have demonstrated links from POP leakage to food consumed by humans. POPs found in sediments are taken up by plants which are the main food of fish or animals and the substance then accumulates in animal fatty tissues, including those of fish.

The major dates are:

- ✓ 1976: the USA banned PCBs and the "twelve dirty substances."
- ✓ 1983: The Federal Republic of Germany banned PCB production
- ✓ 1987: France banned PCBs
- ✓ 1989: Basel Convention
- ✓ 1993: PCBs were banned in Turkey
- ✓ 1995: Barcelona Convention to protect Mediterranean Sea (after some international conventions in 1992)
- ✓ 1996: Europe banned PCBs
- ✓ 2001: Stockholm Convention to reduce persistent organic pollutants (POPs)
- ✓ 2004: When the Stockholm Convention entered into force in that year, PCBs were banned worldwide.

1.1.2 Stockholm Convention on POPs

The SC (2001) was published to limit the uses of PCB-containing products and to ban the import and export of an original list of twelve POPs, modify by different agreements of the convention of the parties (COP).

The SC website[7] describes POPs as POPs are organic chemical substances, that is, they are carbon-based. They possess a particular combination of physical and chemical properties such that, once released into the environment, they:

- remain intact for exceptionally long periods of time (many years);

[6] Salihoglu G[1], Tasdemir Y. Prediction of the PCB pollution in the soils of Bursa, an industrial city in Turkey J Hazard Mate (journal of hazardous materials) 2009 May 30
[7] http://chm.pops.int/TheConvention/ThePOPs

- become widely distributed throughout the environment as a result of natural processes involving soil, water and, most notably, air;
- accumulate in the fatty tissue of living organisms including humans, and are found at higher concentrations at higher levels in the food chain; and
- are toxic to both humans and wildlife.

As a result of releases to the environment over the past several decades due especially to human activities, POPs are now widely distributed over large regions (including those where POPs never use) and, in some cases, they found around the globe. This extensive contamination of environmental media and living organisms include many foodstuffs and has resulted in the sustained exposure of many species, including humans, for periods of time that span generations, resulting in both acute and chronic toxic effects.

Also, POPs concentrate in living organisms through another process called bioaccumulation. Though not soluble in water, POPs are readily absorbed in fatty tissue, where concentrations can become magnified by up to 70,000 times the background levels. Fish, predatory birds, mammals, and humans are high up the food chain, and so absorb the greatest concentrations. When they travel, the POPs travel with them. As a result of these two processes, POPs find in people and animals living in regions such as the Arctic, thousands of kilometres from any major POPs source.

Specific effects of POPs can include cancer, allergies and hypersensitivity, damage to the central and peripheral nervous systems, reproductive disorders, and disruption of the immune system. Some POPs are also considered to be endocrine disrupters, which, by altering the hormonal system, can damage the reproductive and immune systems of exposed individuals as well as their offspring; they can also have developmental and carcinogenic effects

In the SC, the list of POPs includes the following chemical list:

Table 1.1 List of Chemical Substances in the SC

Annex A Elimination

1) Aldrin, pesticide
2) Chlordane, pesticide
3) Chlordecone, pesticide
4) Decabromodiphenyl ether (commercial mixture c-decaBDE) – industrial chemical
5) Hexabromocyclododecane (HBCD) – industrial chemical
6) Hexabromodiphenyl ether and heptabromodiphenyl ether -c-octaBDE – industrial chemical
7) Hexachlorobenzene -HCB – industrial chemical
8) Hexachlorobutadiene - HCBD – industrial chemical
9) Alpha hexachlorocyclohexane, - α-*HCH* -pesticide
10) Beta hexachlorocyclohexane, β-HCH pesticide
11) Lindane, pesticide
12) Mirex, pesticide
13) Pentachlorobenzene, PeCB pesticide and industrial chemical,
14) Pentachlorophenol -PCP- and its salts and esters, pesticide
15) Polychlorinated biphenyls (PCBs) – industrial chemical
16) Polychlorinated naphthalenes, - PCN – industrial chemical
17) Short chain chlorinated paraffins (SCCPs) – industrial chemical
18) Technical endosulfan and its related isomers, pesticide
19) Tetrabromodiphenyl ether and pentabromodiphenyl ether, - C-pentaBDE – industrial chemical

Annex B (restriction of production and uses)

1) Dichlorodiphenyltrichloroethane, DDT, pesticide

2)	Perfluorooctane sulfonic, PFOS, acid, its salts and perfluorooctone sulfonyl fluoride, pesticide and industrial chemical

ANNEX C (unintentional production)

1)	Hexachlorobenzene (HCB)
2)	Hexachlorobutidiene (HCBD)
3)	Pentachlorobenzene (PeCB)
4)	Polychlorinated biphenyls (PCBs)
5)	Polychlorinated dibenzo- p dioxins (PCDD)
6)	Polychlorinated dibenzofurans (PCDF)
7)	Polychlorinated naphthalenes (PCN)

For the PCBs, the SC makes in place a schedule as hourglass[8] (past time is lost, and it is difficult to eliminate the past pollution) shows the intended progress by SC in achieving the goal of Environmentally Sound Management (ESM)

- **2008** 2.8 million tonnes of PCB oils and equipment to be disposed
- **2010** Launch of PCB elimination network (PEN)
- **2015** 2.2 million tonnes of PCB oils and equipment to be disposed
- **2020** 1.74 million tonnes of PCB oils and equipment to be disposed
- **2025** All equipment containing PCBs shall make out of use
- **2028** Environmentally sound waste management of PCBs shall achieve

This guideline aims to apply the requirements of SC for all equipment (transformers, capacitors, condensators and drums) which contain PCB more than 500 ppm, and to remove and replace them. All transformers and capacitors containing PCB more than 50 ppm but less than 500 ppm can remain in use until 2025, but no transformers, capacitors or other equipment can contain PCBs after 2028.

1.1.3 The Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean

In 1975, 16 Mediterranean countries and the European Community adopted the Mediterranean Action Plan (MAP), the first-ever Regional Seas Program under United Nations Environmental Program (UNEP)'s umbrella.

In 1995, the Action Plan for the Protection of the Marine Environment and the Sustainable Development of the Coastal Areas of the Mediterranean (MAP Phase II) was adopted by the Contracting Parties to replace the Mediterranean Action Plan of 1975.

The Secretariat of the Barcelona Convention (BrC) expresses at the UNEP assembly in Nairobi, Kenya in 4-5 December 2017:
« Only in the past biennium, we have delivered technical guidelines on Best Available Technologies and Best Environmental Practices for several sectors such as Industry, Solid Waste, and Waste Water. We achieved the disposal of more than 930 tons of polychlorinated biphenyl (PCB) from the electricity and industrial sectors in Egypt, Turkey, and Bosnia and Herzegovina. »

[8] http://chm.pops.int/Implementation/PCBs/Overview/tabid/273/Default.aspx

Today, the Barcelona Convention (BrC) and MAP are more active than ever. The Contracting Parties are now 22*, and they are determined to protect the Mediterranean marine and coastal environment while boosting regional and national plans to achieve sustainable development.[9]

The MAP was published to protect the Mediterranean Sea from the pollution of ships, aircraft and the wastes of regional countries. This guideline could help the potential holders of PCBs to eliminate all the PCB-containing products or equipment before spills release PCBs to nature

The Convention's main objectives are:

- to assess and control marine pollution
- to ensure sustainable management of natural marine and coastal resources;
- to integrate the environment in social and economic development;
- to protect the marine environment and coastal zones through prevention and reduction of pollution, and as far as possible, elimination of pollution, whether land or sea-based;
- to protect the natural and cultural heritage;
- to strengthen solidarity among Mediterranean coastal States;
- to contribute the improvement of the quality of life.

1.1.4 Basel Convention

The Basel Convention (BC) was published (1989) to limit the transboundary movement of hazardous wastes. This guideline reinforces the rules to limit the international transfer of wastes, specifically from developed countries. As soon as possible, waste needs to be treated and eliminated proximity to its place of production or use. For PCB-containing products and equipment, if local treatments are not available, treatments should be made abroad to reach a level of destruction of 99.99%.

To prevent the movement of hazardous wastes from developed countries to others and to limit the “black market” of hazardous wastes, the BC was the first step to limit unregulated transboundary transport and to apply the 1972 London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters.

1.1.5 The Rotterdam Convention

The Rotterdam Convention (RC) was published in 2004 to develop an informative document about the international transfer of toxic pesticides and other chemical hazardous products.

1.2 RELEVANT DIRECTIVES AND GUIDELINES

1.2.1 European Union Directives and Guidelines

The relevant EU Legislation[10] about PCB are developed in conformity with the International Conventions as SC, BC, and RC. The main texts are

- ✓ Regulation (EC) No 850/2004 of the European Parliament and Council of 29 April 2004 on persistent organic pollutants and amending Directive 79/117/EEC
- ✓ Council Directive 96/59/EC of 16 September 1996 on the disposal of polychlorinated biphenyls and polychlorinated terphenyls (PCB/PCT) is transposed to our legislation as By-law on Control of PCB and PCTs dated 27/12/2007 and numbered 26739

[9] http://ec.europa.eu/environment/marine/international-cooperation/regional-sea conventions/barcelona-convention/index_en.htm
[10] Based on the report on Legal GAP Analysis of Persistent Organic Pollutants (POPs) LEGAL GAP ANALYSIS OF POPS REGULATION IN TURKEY

- ✓ PCB/PCT Directive aims to completely dispose of PCBs and equipment containing PCBs as soon as possible and equipment with PCB volumes of more than 5 litres before the end of 2010. It also sets requirements for the environmentally sound disposal of PCBs.

The PCBs are classified as proven endocrine disruptors (category 1) by the European Union (EU), with a degree of exposure that is very disturbing especially for children breast feeding considered as a population at risk[11].

In the 1970s, owing to severe concerns about their human toxicity, suspected carcinogenicity, and environmental persistence, several countries limited the use of PCBs. Finally, in 1985, the use and marketing of PCBs in the European Community were very heavily restricted.

On 24 October 2001, the European Union (EU) adopted a strategy to limit the presence of dioxins, furans, and PCBs in the environment. To protect the human and animal health and the environment, the EU published the Communication Commission, on 24 October 2001, the Council, European Parliament and the Economic and Social Committee. Community strategy for dioxins, furans, and the PCBs).
The three main objectives of the strategy are:

- ✓ to assess the current state of the environment and the ecosystem,
- ✓ to reduce short-term human exposure to these substances and hold them in the medium and long-term to harmless levels,
- ✓ to reduce the effects on the environment.

Directive 96/59/EC on the disposal of PCBs and PCTs aims at disposing completely of PCBs and equipment containing PCBs as soon as possible. This Directive sets the requirements for environmentally sound disposal of PCBs. Member States have to make an inventory of big equipment containing PCBs, have to adopt a plan for disposal of inventoried equipment, and outlines for collection and disposal of non-inventoried equipment (small electrical equipment very often presents in household appliances manufactured before the ban on marketing of PCBs). The PCB Directive further mandates that Member States had to dispose of big equipment (equipment with PCB volumes of more than 5 liters) by the end of 2010 at the latest. The Commission verifies the implementation of this provision.

Furthermore, the Commission has adopted a Community Strategy on Dioxins, Furans and PCBs aimed at reducing as far as possible the release of these substances in the environment and their introduction in the food chains.

Also, Regulation (EC) No 850/2004 on POPs covers PCBs. The Commission has carried out a study to facilitate the implementation of the waste-related provisions of this Regulation.

The subject of the guideline is not to comment on the Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) but for the small size condensers. Some talks are always on the table about the limit of acceptance of PCB containing condensers less than one kilogram, and if the REACH regulation shall be applied to the condensers, and specifically the REACH Article 33 notification, the debate is opened and continues.

[11] INERIS DRC-11-118962-11081A Version juin 2012 in French

The REACH Regulation includes an obligation (Article 33) on suppliers of articles that they notify recipients if an article contains >0.1% of a Substance of Very High Concern (SVHC). “Articles” are physical products, such as electrical components, fasteners, cables, moldings, equipment, etc.[12]

The ECHA supported by the European Commission has published guidance which states that the 0.1% concentration limit applies to the supplied item. However, six EU States; France, Germany, Denmark, Sweden, Belgium, and Norway have disagreed with this interpretation and believe instead that the concentration limit should apply to the first article that makes with the SVHC and that this information passes on whenever a product that contains this supplied part.

These two examples explain the different interpretations and their implication:

Table 1.2 Analysis of the REACH Talks about Capacitors

ECHA Guidance	**Alternative Interpretation**
Capacitors encapsulated with polymer that contains DEHP	Capacitors encapsulated with polymer that contains DEHP
The DEHP content of capacitor is > 0.1%, so must notify recipients	The DEHP content of capacitor is > 0.1%, so must notify recipients
Recipients use capacitors to make a printed circuit board (PCB)	Recipients use capacitors to make a printed circuit board (PCB)
DEHP contents of PCB is now < 0.1% so no need to inform recipients of PCB	Although the DEHP contents of PCB is < 0.1% of PCB, the PCB supplier must inform recipients that the PCB contains a capacitor with > 0.1% DEHP
PCB used to make equipment.	PCB used to make equipment.
Total DEHP content from all sources in equipment below 0.1%, so no Article 33 notification required	Equipment supplier must inform recipient that equipment contains a capacitor with >0.1% DEHP

DEHP: Bis(2-ethylhexyl) phthalate

Compliance with ECHA’s interpretation has advantages and disadvantages but to apply the regulation shall be an onerous obligation if the REACH regulation is applying less than 0.1%.

The main advantage is that the presence of SVHCs in imported parts into the EU is usually not known. However, the maximum content that could theoretically occur is known (e.g., Plasticisers used at Ca.20% of PVC, flame retardants are used at Ca.7 – 10% of the estimate if the dilution effect means that there is no possibility that an SVHC could exceed 0.1%)

A disadvantage is that suppliers who admit the presence of SVHCs usually state that the content is >0.1% and not provide the actual concentration which is a situation occasionally happens.

It is difficult for a supplier to calculate whether their products have an SVHC at >0.1%.

The rule is difficult to apply for the PCB containing condensators due to the small size of the electrics condensers.

[12] http://ecsn-uk.org/Legislation/REACH/

To apply the regional conventions, the European Commission published Directive 96/59/EC to ban PCBs and PCTs in 1996 was adopted and the regulation published in Turkey's Official Gazette dated 27.12.2007 number 26739

Some guidelines published;

- ✓ Communication from the Commission to the Council, the European Parliament and the Economic and Social Committee on Community Strategy for Dioxins, Furans and Polychlorinated Biphenyls COM (2001) 593[13]
- ✓ Study on waste related issues of newly listed POPs and candidate POPs: Final report (2010) [14](Corrigendum of 29 September 2005)
- ✓ Final report on the study to Facilitate the Implementation of Certain Waste Related Provisions of the Regulation on Persistent Organic Pollutants (POPs) (2005) [15]
- ✓ UNEP March 5, 2015, Guidance for Environmentally Sound Management of PCBs (Mediterranean Region) [16] **"**PCB Management Guidance, Maintenance, Handling, Transport and Interim Storage of Liquids Containing PCB and Equipment Contaminated with PCB" prepared by UNEP and PEN for Stockholm Convention**[17]**
- ✓ "Preparation of a National Environmentally Sound Management Plan for PCBs and PCB-Contaminated Equipment" prepared by UNEP for the Basel Convention. [18]

1.2.2 US EPA Regulations and Guidelines [19]

US Environmental Protection Agency (EPA) banned PCBs in 1976 and developed some regulations and guidelines from 1976[20], specifically to limit soil and water pollution after the Great Lakes pollution by PCB (Westinghouse case).

The first text was the "Toxic Substances Control Act of 1976."

- ✓ 40 Code of Federal Regulations (CFR), section 761.125 Requirements for PCB Spill Clean-up**,**

  The regulation[21] applies to all spills PCB concentration of 50 ppm or greater, the owners shall clean the PCB contents, included the spills exclude from the application of the final numerical clean-up standards certain spill situations from its scope: Spills directly into surface waters, drinking water, sewers, grazing lands, and vegetable gardens.

  The responsible party shall notify the appropriate EPA regional office no later than 24 hours after discovery.

  1) If the spill exceeds 10 pounds (4.5 kg), the responsible party shall proceed to decontaminate in concordance with guideline for the Toxic Chemical Elimination policy (The Toxic Substances Control Act, TSCA).

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[13] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31996L0059
[14] http://ec.europa.eu/environment/waste/studies/pops.htm
[15] http://ec.europa.eu/environment/waste/studies/pdf/pops_waste_full_report.pdf
[16] /wedocs.unep.org/bitstream/handle/20.500.11822/7753/-Guidelines_for_environmentally_sound_management_of_PCBS_in_the_Mediterranean-2015guidelines_sound_management_oil_PCBS.pdf.pdf
[17] http://chm.pops.int/Implementation/PCBs/Guidance/tabid/665/Default.aspx
[18] http://www.basel.int/Portals/4/Basel20Convention/docs/pub/pcbManualE.pdf
[19] All the relevant information's shall be found on US EPA website
[20] Administering the Ocean Dumping Act [EPA Journal - July/August 1975]
[21] Synthesis of the text based on Legal information institute of the Cornell Law school (NY City- USA)

2) Spills of 10 pounds and less, must be cleaned but notification of EPA is not required, soils, solvents, rags and others materials resulting from the cleanup of PCB shall be stored, labeled and disposed.
3) For spills where are insufficient visible traces, the boundaries of the spill determines by using a statistically based sampling scheme.

The regulation applies to low concentration spills which involve less than 1 pound (0.45 kg) of PCB by weight (less than 270 gallons (1022 l) of untested mineral oil containing less than 500 ppm PCBs) shall be cleaned in the following manner :

1) Solid surface must be double washed/rinsed except that all indoor, residential surfaces other than vault areas must cleaned to 10 micrograms per 100 square centimeters (10 µg/100 cm^2)
2) All soil within the spill area must excavate, and the ground restores to its original configuration by backfilling with clean soil (i.e., containing less than 1ppm PCBs)

All the requirements must make under 48 hours, except in case of emergency or adverse weather. Completion of cleanup may be delayed only for the duration of the adverse conditions.

The responsible party shall document the cleanup with records and certification of decontamination.

The regulation expresses the same requirements for decontaminating spills in outdoor electrical substations cleaners to 25 ppm PCB by weights or to 50 ppm PCB by weight provided that a label or notice places in the area visible.

Nonrestricted access areas such as residential or commercial areas shall be decontaminated, cleaned to 10 µg/100 cm^2 or encapsulated and shall be verified by post-cleanup sampling.

The records shall be maintained for 5 years

✓ 40 CFR, Section 761.62 - Disposal of PCB Bulk Product Waste.

This regulation expresses the PCB dispersion requirements generally as waste products (plastics, cables, varnishes residues) in case of new deposit on an authorized landfill.

PCB storage or disposal approval must provide written notice to the facility a minimum of 15 days in advance of the first shipment. The notice may include components containing PCB at ≥50 ppm and the PCB bulk product waste is known or presumed to leach <10 µg/L PCBs.

A risk analysis must perform based on disposal approval. A daily landfill should be cover the followings; waste is not released or dispersed by wind or other actions (e.g. under asphalt as part of the roadbed) in the landfill.

EPA has published a guideline named as "Planning for PCB-Containing Disaster Debris[22]" in June 2011, and it gives management recommendations for communities in case of PCB-containing debris after a disaster. In the US, PCBs used for many industrial applications such as electrical cable insulation and floor carpet insulation used in housing built with wood. In case of fire, storm, or natural events such as floods, PCBs released to the environment. The guideline gives some suggestions for preventing unintended emissions of PCBs.

[22] /www.epa.gov/sites/production/files/2015-08/documents/pcb-disposal.pdf

1.3 TURKISH REGULATION ON PCBS

Turkish regulations are consistent with the international movement to reduce the effects of POP on Turkish population and the environment. Turkey signed and ratified the SC in 2001 and 2009, respectively[23].

Prepared by harmonization of the European Commission Directive 96/59 / EC of 16.09.1996 on the elimination of PCBs and PCTs, Turkish Regulation on the Control of PCB and PCTs has been published in the Official Gazette (OG) dated 27.12.2007 and numbered 26739

The first National Implementation Plan (NIP), discussing the inventories and strategic action plan for the first twelve (12 developed POPs in the period 2007-2010, and officially transmitted to the SC's Secretariat on April 5, 2011.

NIP has been upgraded for the newly added chemicals and submitted in 2016. A draft by-law on POPs has been prepared for Turkey considering EU POPs Regulation.

1.3.1 Purposes

The purpose of By-Law on the Control of Polychlorinated Biphenyl and Polychlorinated Terphenyls is to ensure that removes completely used PCB and PCB containing materials and equipment in a way that does not harm the environment and human health.

1.3.2 General Principles of the Regulation

- The production and import of PCBs are restricted. However, the use of scientific experiments and in laboratory analysis and measurement as a reference standard is out of this restriction.
- The provisions of the Waste Management Regulation apply to the export of used PCB and PCB containing materials and equipment.
- It is forbidden to refill the transformers with reduced insulation capacities again with insulating materials of PCB.
- PCB substances and equipment (more than 5 liters in total and at a concentration higher than 50 ppm) must record in inventory and treated or disposed of the end of 2025.
- Equipment containing PCBs or PCBs with other equipment not subject to inventory (less than 5 Litters in total) disposes of hazardous waste disposal facilities with the environmental license.
- The maintenance of the transformers containing PCBs continues until they are cleaned, taken out of service and disposed of, provided they are in good working order and sealed. However, damaged transformers repairs containing PCBs, and ensures their direct disposal
- Those who possess used PCB and PCB containing-materials and equipment are obliged to take all kinds of precautions to protect the environment and human health.
- Expenditures made to eliminate any environmental damage caused by the management of PCBs cover by natural or legal persons that cause pollution according to the principle of "polluter pays.

[23] http://www.resmigazete.gov.tr/eskiler/2007/12/20071227-3.htm

1.3.3 Transportation

The provisions of the Communiqué on the Transport of Waste on the Road (R.G. 20/03 / 2015-29301) apply to the transport of used PCBs and PCB containing materials and equipment.

- Hazardous waste treatment performs on all kinds of materials contaminated with PCB during transportation and disposal is ensured.
- If there is no compulsory condition, the equipment transport before the empty liquid.
- Liquids discharged in forced conditions transported in containers placed on the pallet to prevent collision and collision.
- Vehicles must be enclosed, and the vehicles, tools, and chemicals needed to clean the PCBs must be kept in the vehicle.

1.3.4 Temporary Storage

- The materials and equipment taken out of service temporarily stored in the closed designated areas within the facility with floor permeability, and ventilation capabilities.
- Equipment with leakage risk temporarily stored after discharging liquid part. The containers to which the liquids transferred marked according to the label example in Appendix-1 (A) part and disposal ensured as soon as possible. Information on equipment and items are taken into temporary storage shall communicated to the Ministry through the PCB Inventory Form (Appendix-3).

Figure 1.1 Type of Label for Temporary Storage Warning

1.3.5 Decontamination

(1) Transformers are containing 50 ppm or more PCBs clean by the following conditions.

a. The purpose of the treatment is to reduce the PCB level below 50 ppm, if the treatment cannot reduce pollution below 50 ppm, then another final disposal solutions should be applied to the equipment.
b. PCB-free replacement fluids used in transformers for less environmental and human health risks.
c. The liquid change makes in the transformers is done in such a way that it completely clean once without the further need for PCB disposal.
d. After the decontamination finalized, the transformer labels are replaced to include the new information.

(2) Transformers containing PCBs with insulating fluids in the range of 50 ppm-500 ppm shall be cleaned by paragraphs (b) and (c) of the first paragraph or disposed of at the end of their effective service life. The Ministry shall consider the extension of the time for efficient use of transformers exceeding 2025.

(3) Decontamination procedures to be applied to other equipment other than transformers shall be carried out with the approval of the Ministry.

(4) Excluding the absorbent materials like paper, wood, cardboard, metal, porcelain, sheet metal, and other materials, of which PCB levels reduce to less than 50 ppm after purification, can be recovered. The related certification principles determine within the context of decontamination license.

1.3.6 Final Disposal

(1) All liquid, solid and pasty materials, equipment and wastes containing 50 ppm or more of PCB disposed of in environmentally licensed facilities.

(2) In the recycling and disposal of PCB-containing oils, the principles specified in the Waste Oils Control Regulation published in the Official Gazette dated 30/07/2008 and numbered 26952 shall apply.

(3) It is obligatory to observe the technical standards specified in the Regulation on Waste Incineration published in the Official Gazette dated 06/10/2010 and numbered 27721 for the disposal of the PCB by burning it with D10 (Landfill) method. Methods apart from incineration, such as biological or physical/chemical processes may applied for the disposal of PCBs, provided that the safe disposal standards as of incineration (D10) and the requirements of the best available technologies met.

(4) The provisions of the Waste Management Regulation published in the Official Gazette dated 02/04/2015 and numbered 29314 shall apply to the close of the disposal facilities.

1.3.7 Notice and Record Keeping Obligation

The producers, the market-distributors, the waste producers, the holders of PCB and PCT containing equipment, the waste carriers and the waste processing facilities are responsible for keeping a chronological record according to their area of activity, to register and make a notification to the online systems defined by the Ministry, to provide information and to keep the records for at least five years and keep them ready for any review and inspection of the Ministry and/or its provincial directorate. The records of military units and military institutions shall be notified to the Ministry in written form by the Ministry of National Defence and Turkish General Staff.

1.4 DATA COLLECTION AND INVENTORY

The inventory aims to identify, count and keep records of the equipment and the materials prone to containing or being contaminated with PCBs. These pieces of information are indispensable when preparing a plan for PCB management, which should encompass the entire cycle of these products, as follows:

- ✓ Use
- ✓ Management
- ✓ Storage
- ✓ Decontamination
- ✓ Elimination

The type of transformers, capacitors or condensers to be identified could be in different situations:

- ✓ Transformers, capacitors or condensers in use,
- ✓ Transformers, capacitors or condensers in maintenance for re-use,
- ✓ Transformers, capacitors or condensers in storage in end of life.

CHAPTER 2: DATA COLLECTION, FIRST IDENTIFICATION, SAMPLING, AND LABELLING ALONG THE PCB LIFE CYCLE

To ensure a complete identification of PCB products, it is needed to list what is the usage areas and contents type we can follow before to describe holders of PCBs[24]. Because of the PCB's various properties (e.g. fire resistance, isolation, stability, etc.) after you used as an additive in the ingredient of the products, it has been caused to use at many different places in the industry area.

Table 2.1 Possible Usage Areas of PCB-Containing Equipment or Materials

Electric Utilities	Maintenance companies
Industrial Facilities	Hospitals
Railroad systems	Research Laboratories
Mining industries	Manufacturing plants
Army installations	Waste Water Discharge facilities
Residential or commercial buildings (built before the 1980s)	Car service stations
Holidays Resorts/hotels	Small/medium sized companies
School buildings	Airports
Cold Storage depots	Wood Processing companies
Suppliers	Disposal and recycling companies
Greenhouses	Transformer Maintenance Dept.

(UNEP Environmental Sound PCB Management Guide (Mediterranean Region), 2015)

According to the SC, the potential PCB holders should fulfil the following obligations:

- ✓ identify the PCB containing equipment,
- ✓ label the PCB containing equipment by the level of PCB identified
  - o PCB quantity < 50 ppm (label green);
  - o 50 ppm < PCB quantity < 500 ppm (label orange); and
  - o PCB quantity > 500 ppm (label red),
- ✓ identify the equipment in the national database,
- ✓ remove the PCB containing equipment more than 500 ppm by an authorized company based on the "Destruction Efficiency" provisions,
- ✓ survey the PCB containing equipment under a label orange to limit the cross contamination and remove it before 2025,
- ✓ ensure all the equipment shall be PCB free (or less than 50 ppm) before 2028.

2.1 RESPONSIBILITIES OF OWNERS

Potential PCB-holders must ensure its equipment and activities do not cause injuries to the workers and the neighbors or environmental pollution. A general principle of law requires that

[24] UNEP Environmentally Sound PCB Management Guide (Mediterranean Region), 2015

the owners assess the risks and take the responsibilities of their activities and their use of the equipment.

Any owner of potential PCB-containing equipment can prosecuted under the polluter pays principle (PPP). PPP was laid down as Principle 16 of the UN Declaration on Environment and Development. Since 1987 the principle has also been enshrined in the Treaty of the European Communities and numerous national legislation worldwide.

Under this Principle, all polluters shall prosecuted in case of environmental pollution. PCB production, sales, and storage are banned in Turkish legislation, and the owners of PCB-containing equipment must limit the risk of pollution. This guideline gives approaches for reducing the risk of pollution and helps owners of PCB-containing equipment put in place best practices to avoid the risk of prosecution.

Owners of PCB-containing equipment face different regulatory deadlines depending upon the concentration of PCBs in their equipment:

1. In case PCB concentration is less than 50 ppm, to ensure avoidance of cross-contamination from the other PCB-containing equipment during handling operations, all PCB-containing equipment shall be removed by 2028 – including in the case of low PCB concentration rates.
2. In case the PCB concentration is higher than 50 but less than 500 ppm, to implement some safeguards described in this guide and remove the affected equipment by 2025,
3. In case the PCB concentration is more 500 ppm, to remove the equipment and ensure the destruction of PCBs in authorized destruction facilities.

2.2 DATA COLLECTION FOR EQUIPMENT CONTAINING PCB AND PCB LIFECYCLE RISK

Due to its nature, PCB has potential to cause cross contamination. So the maintenance and transport of PCB containing equipment may cause to release PCB into the environment. For this reason, the owners of PCB containing equipment must have a comprehensive technical data on its implementation, location, maintenance, retro-filling operations during different phases of PCB usage areas.

As mentioned before, the type of insulation liquid and the commercial names of the PCBs are the easiest way to identify the PCB content in an equipment or a material.

PCB, like all chemical substances, has a life cycle and since the SC entered into force, some PCB has been replaced or destroyed. However, the professionals state that 1 million tons of PCBs had produced and 40% of this material has remained in use[25]. Another estimation says that the total global production of PCBs is in the order of 1.5 million tons. The United States was the single largest producer with over 600,000 tons of production between 1930 and 1977. The European region follows with nearly 450,000 tons through 1984. It is unlikely that a full inventory of global PCB production is accurately tallied, as there were factories in Poland, East Germany, and Austria that produced unknown amounts of PCBs.[26]

[25] Rossberg, Manfred; Lendle, Wilhelm; Pfleiderer, Gerhard; Tögel, Adolf; Dreher, Eberhard-Ludwig; Langer, Ernst; Rassaerts, Heinz; Kleinschmidt, Peter; Strack, Heinz; Cook, Richard; Beck, Uwe; Lipper, Karl-August; Torkelson, Theodore R.; Löser, Eckhard; Beutel, Klaus K.; Mann, Trevor (2006). "Ullmann's Encyclopedia of Industrial Chemistry - Chlorinated Hydrocarbons". ISBN 3527306730. doi:10.1002/14356007.a06_233.pub2

[26] Breivik, K; Sweetman, A; Pacyna, J; Jones, K (2002). "Towards a global historical emission inventory for selected PCB congeners — a mass balance approach1. Global production and consumption". The Science of the Total Environment. **290** (1–3): 181–98. *PMID 12083709. doi:10.1016/S0048-9697(01)01075-0.*

We shall consider that limited amount of PCB produced for some specific uses as to protect arms and ammunition against the electric shock. In this case, PCB shall be produced in a specific factory and a closed process (chemical process).

Figure 2.1 Theoretical Life Cycle Assessment of a Product, Substance

The PCB life cycle take into account because during each phase; it could be released into the environment and accumulate in nature. As a biological substance, PCB could also accumulate in the fat tissues of the wild or farm animal and thus integrated into the food chain. The mother milk or cow milk is a strong way for transmission to the young children.

One should focus on the closed uses, such as transformers, capacitors, and condenser, as the main risk to release into the environment due to leakage. A visual inspection is enough to prevent such a risk. Moreover, some preventive measures shall taken while adding dielectric oil. During the operation of retro-filling, the users try to replace a PCB containing oil by a non-PCB, but the heating process on the transformer may contaminate the new oil causing continuous pollution.

The transportation of PCB has some risks of PCB oil release in the transformer tank or in drums used to transport the dielectric oil from one site to another.

The major risk for dispersion in the environment is the end of life of the product. For the big transformers, a refurbishing and recycling market exist, but for the condensers, the cables with PCB placed in some landfills without copper recycling.

Figure 2.2 Different Type of Electric Materials in a Landfill

2.3 DATA COLLECTION FOR EQUIPMENT CONTAMINATED WITH PCB

The inventory and analysis should provide information needed to manage the equipment contaminated by PCBs:

1) The number of transformers contaminated with PCBs
2) The level of contamination
    a. Less than 50 ppm – equipment may be kept in use, but all the PCBs it contains shall be destroyed before 2028
    b. Greater than 50 ppm and less 500 ppm – equipment may be kept until 2025 but removed after this date
    c. Greater than 500 ppm
3) Oil samples representing the level of pollutions
4) The quantity of polluted materials in tons

The results should be recorded to the inventory database including various information such as location of the transformer, equipment type, weight, production date, level of PCB concentration etc.

2.4 MANAGEMENT OF TRANSFORMERS PRIOR TO TESTING

Transformers should be visually inspected and examined according to their plates. At the same time, the company managers should get prepared to label the transformers in order to compare the national inventory and the actual situation for each department. These labels should also indicate content of the insulation liquid. The company should design a sampling plan to prioritize the sampling in accordance with the following standards: EN 14899:2006-04 standard and applied the issues of FD CEN/TR 15310-1:2007-03 technical specification.

2.4.1 Interested Parties

Interested parties are all the parties who have a particular interest to be informed on the PCB inventory results.

- ✓ Turkish government
- ✓ Turkish industries and electricity providers and their staffs

2.4.2 Sampling Program Objectives

The testing program aims to figure out if the transformers contain PCBs according to the relevant provisions specified in SC, follows with the following priorities:

- ✓ Make determined efforts to identify, label and remove from use equipment containing greater than 10 percent polychlorinated biphenyls and volumes greater than 5 liters;
- ✓ Make determined efforts to identify, label and remove from use equipment containing greater than 0.05 percent polychlorinated biphenyls and volumes greater than 5 liters;
- ✓ Endeavour to identify and remove from use equipment containing greater than 0.005 percent polychlorinated biphenyls and volumes greater than 0.05 liters."

2.4.3 Requested Tests

All the transformers, capacitors, condensers and drums should be analyzed to determine the level of PCB contamination.

Limiting the cost of the analysis, the first level of analysis shall be made to analyze the chlorine with L2000DX analyzer and its reagents, but if the result of the analysis is higher than 50 ppm, it is mandatory to perform a Gas Chromatography (GC) analysis. Classification regarding PCB shall made under the following concentration levels:

- ✓ Less than 50 ppm: not contaminated
- ✓ 50 ppm to 500 ppm: contaminated
- ✓ Greater than 500 ppm: strongly contaminated

According to the results of the analysis, the owner's company shall put a label to indicate the level of PCB content.

2.4.4 Determining the Characteristics of the Existing Inventory of Transformers

This guideline describes the best and repeatable procedures for taking representative samples to learn if a transformer, capacitor, condenser, and drum is active or in the form of waste (product or equipment for abandonment), and polluted by PCBs.

Two types of components shall found:

A) Solid Wastes

Samples must be analyzed to figure out if the solid waste contaminated with PCBs.

1) Stored former transformers considered for technical reasons to be at the end of their useful lives
2) Former transformers having lost the insulating liquid or having caught fire, are covered by the generic term solid waste

Figure 2.3 After Transformer Explosion, Soil Should Be Checked for any Possible Soil Pollution

3) Solid wastes polluted by PCB (concrete, soil, vegetation)

In this case of fire, all disparate components should examined:

- ✓ The transformer pieces, metals making up the carcass, the transformer body with paper, copper, and some residues
- ✓ The limited area polluted by fire
- ✓ Additionally, oils and the fire suppression products (foam or CO_2) are sources of the pollution, too.

4) Solids contaminated by PCB dispersal (land, vegetation, concrete)

Examined items are very disparate: the transformer's constituents,the land polluted by fire in a defined perimeter, pollution sources are oils and products that were used to extinguish the fire (foam or CO2), metals making up the carcass, the body of the transformer, with paper, copper or what was left.

Pollution shall be found in some composite samples, which are "samples – discrete or continuous – stirring at least two basic samples/sub-samples in appropriate proportions (mixed composite samples) and which are used to determine the average value of a sought-after feature" (ISO 11074-2:1998)

B) In used and maintenance transformers

The main object is to find the potential PCB contamination in the transformers

Figure 2.4 Nature of Equipment Form Characterization

The liquid insulation (clear oil) shall be analyzed to see if the oil contains PCBs and whether the transformer must be decontaminated, after its replacement.

These operating instructions apply to liquids whose viscosity at sampling temperature is less to 1 500 mm/s (cSt). It relates to mineral and non-mineral oils (e.g., synthetic esters, natural esters or plant oils and silicone fluids).

2.4.5 On-Site Samplings

a) Companies should take the oil samples with trained personnel. If there are no trained personnel, a specific on-site training can be organized for the target companies, to manage the first samplings. The followings should be taking into account in the course of the sampling procedure: Reference unit to show the PCB-containing equipment

The reference unit is the transformer or more exactly, the insulation liquid container. Liquid insulation is contained in a tank and the transformer.

The oil weight of a transformer is correlated with the power capacity. If the power increases the oil weight is increase in same time.

Oil weight is 19.9% ±2% of the total weight of a transformer.

b) Variability

To make homogeneous, samples on a site must take within the same day.

c) The sampling approaches

Due to the different volumes, different sampling modes should be specified and applied.

- From the top of the storage tank, in the upper part

Figure 2.5 Getting Sample from the Top of the Transformer

- From the top, in the middle part

Figure 2.6 Sampling by the Middle of Transformer

- From a valve to drain the liquid (lower part)

Figure 2.7 Sampling from the Valve of the Transformer

When access is possible, the samples taken must correspond to three levels (upper, middle, and lower level).

d) The scale

The minimum volume of the test sample must be 90 ml (in a 0.1 l bottle), to ensure the sampling shall be representative of the total amount of the liquid and the potential polluted equipment. In the case of the electric equipment, the oil sampling can give the pollution level of the transformer itself. It is not needed to make a sampling of each part -metal, copper and oil. The 90 ml oil bottle gives a result, and this result expresses the potential pollution of each part of the transformer but requires statistical parameter as the number of empty equipment, the number of the tank under the middle of the contents. For example, a transformer of 450 kg identified as polluted at a level of 5000 ppm. The result is taken into account due to the pollution of the oil samples. Technically, the PCB oil during the transformer used is connected to all the internal parts of the transformer to ensure the insulation and limit the internal temperature. Oil is representative of all the PCB pollution of the transformer.

All results expressed in ppm of PCB.

e) The desired level of reliability, as the error margin acceptable for the company

f) Representative sampling of oil ±2%

g) Representative measurement

Each instrument measures the result according to its characteristic, for example, for the L2000DX analyser, when the PCB containing oil is upper than 40 ppm, the system gives more than 50 ppm. Therefore, the results which are higher than 50 ppm should be sent to be analysed by GC for a double control as required by UNEP.

h) Safety requirements

Site safety

a) Trained personnel should have clearance for working in an electricity environment. According to the Electricity Market Grid Regulation (Published in Official Gazette no. 25001 on 22/01/2003), Article *26 Working let request. For maintenance and repair works on the equipment that affect the transmission and/or distribution system or creates interruption in the electricity supply to the users. application of a person authorized by the license holding legal entity to RLDC in writing before beginning such works.*

b) For the transformers to be shut off or neutralized for taking one or more samples:

- ✓ Information should be issued to all stakeholders on the company site to assure safe sample collection.
- ✓ Perimeter of the intervention area should be marked using colored barrier tapes,
- ✓ Equipment lock-out keys of the transformer should be used to avoid electric shock.

Shutdowns can be rotated (sampling procedure from one transformer to another), to ensure the continuous service.

Personal protective equipment for technical personnel involved in sampling operations should use a single-use suit, protective gloves, safety glasses or a helmet with visor and safety shoes

i) Analysis safety

2.4.6 Critical Instructions

A sampling plan should be set up by all the transformers owners to be able to control the process properly and to give responsibilities to the technical team. Before the sampling, calibration of all the equipment should be made through the manufacturer's recommendations to ensure the quality of the measurement. The owner of the transformer should guarantee that the on-site sampling done by trained operators who know the equipment. Moreover, required safety conditions should performed while collecting the samples.

After proper sampling, the oil samples can be tested in the field for its PCB content with the L2000 DX analyzer. In case a database/web portal exists, the results can be transferred to update the existing inventory of the country. If the results are higher than 50 ppm, a GC analysis should be performed by an accredited laboratory to determine the exact PCB concentration of the oil sample. Once the PCB concentrations in the oil samples are determined, the transformers should be labelled as follows:

- ✓ Green, the result < 50 ppm
- ✓ Orange, 50 ppm < the result < 500 ppm
- ✓ Red, the result > 500 ppm
- ✓ Responsible person name who approved the analysis
- ✓ Identification of the transformer with the plasticized label with Colour Label Green /Orange/ Red

2.4.7 Best Practices for Sampling

To ensure the effectiveness of safety training and plans, the following actions should taken:

- ✓ Mark the perimeter of the safety zone
- ✓ Lockout the transformer with a visible tool as a safety key (red)

Figure 2.8 Safety Shut Down System

- ✓ Ensure that personal protective equipment (one use suit, safety glasses, gloves) is available and worn
- ✓ Use the sampling kit (see appendix A the content of sampling kit)

2.4.7.1 Materials Needed: Content of the Sampling Kit

In appendix 4, you may see how to use the sampling kit and the procedure of usage, also the sampling kit is support to ensure the followings:

1) The technical team can perform the sampling in safety conditions
2) The sampling shall have identified and record in a unique form
3) The sampling must limit the cross-contamination,
4) The hazardous waste which result from the sampling shall be identified and correctly treated

Figure 2.9 Sampling Kit

(The upper left corner, respectively, 1- Plastic bag- 2- Absorbent paper- 3- Colring- 4- Jumbo pipette- 5- APROCHIM label- 6- Bottle, sticker, and specific number- 7- Inventory form- 8 – Sampling safety pack label- 9- Nitrile gloves)

An identification system must be performed to ensure the followings:

a) Each sampling should have a unique identity
b) The oil sample bottles will be kept in a storage in case of double check needed.

EXAMPLES

For the transformer TR5701 for the transformer owner' name

Each sample is unique, preprint on an adhesive label and shall be identified using the name found on the website with a predefined code

2.4.7.2 Instructions to Make a Sampling with a Sampling Kit

Carefully open the cap of the transformer oil tank

Open the cap or valve with proper gloves

Put on and wear the sample gloves (9)

From the sampling kit

Use the sampling pipette (4)

From the sampling kit

Figure 2.10 Using the Jumbo Pipette

Close each sample with a specific sticker (5)

from the sampling kit

Close carefully the transformer oil tank's cap

Add the sample numbers on the sampling sheet (5)

E.g. Company name site name

xxxxxx ISTANBUL

TR7501

TR7502

TR7503

TR7504

Etc.

Check the samples with the sampling sheet (7)

Clean the transformer oil tank hole and the surface with a cleaning paper

Put the cleaning paper and the samples pipettes in hazardous industrial waste bins (see Figure 2.11).

Figure 2.11 Waste Disposal Bin for Hazardous Waste

Put the absorbent paper (7) in the sampling kit

↓

Use the sampling kit to put the samples inside.

Each glass sample shall be packed by absorbent paper and plastic zip bag (7)

↓

Close the zip bag and put the safety label on the pack (8)

Call the shipping company with the preformatted address

↓

The transformer shall be placed back in service by authorized personnel

2.4.8 Preliminary Sampling and Testing, False Positive Results

The best results of the analysis acquired by Gas Chromatography method, but this process is:

- Long to prepare and conduct (around two days for a 45-min. analysis)
- Costly in equipment and materials
- Done only by professional accredited technicians

Therefore, to decrease the cost of the GC analyses, preliminary screening can be performed. For this purpose, the following questions can raise:

1) Do the equipment contaminated by PCB, yes or no?
2) Does the contamination less than 50 ppm?
3) What is the accurate level of PCBs?

The laboratories may use a preliminary screening to separate the samples based on the level of PCB to limit the number of analyses made using GC. Accordingly, GC methods can be used only for the samples containing PCB concentrations of 50 ppm (UNEP requirements).

Under the Stockholm convention rules, the differentiation based on the 50 ppm – 500 ppm categorization, by international rules;

50 ppm is not zero, and the international consensus had fixed the 50-ppm limit as acceptable, due to limited risk of exposure for human health, but the global goals are to reduce PCB exposures under the best economic and technical conditions.

The laboratory could use different methods as mentioned in the following sections to screen and differentiate the samples.

2.4.9 Density Method

This method is a simple analysis based on the density difference between PCB (>1) and water. It is cheaper, easy to make by a non-chemist specialist, the result is clear but limited to stating whether PCBs exist or not.

2.4.10 Chlorine Identification

2.4.10.1 Simplified Method

This method is cheaper, easy to make with some precautions, based on the color identification due to the burning reaction from the suspicious material on a copper wire. The presence of chlorine indicated by the greenish or greenish-blue color of the flame. This method should be made in a large ventilated space or under lab hoods.

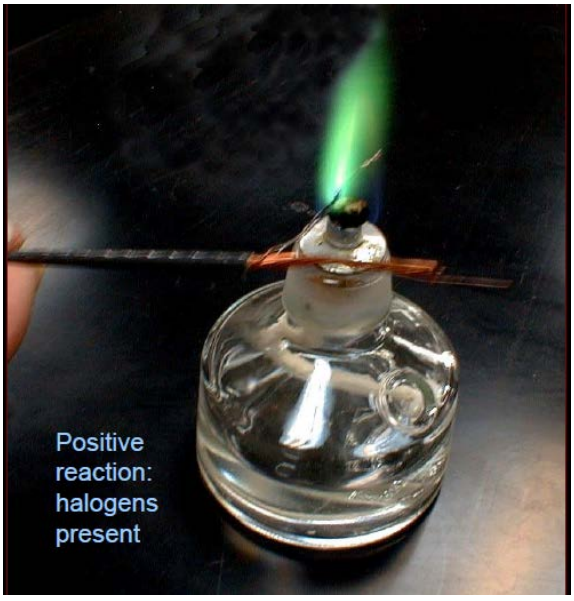


Figure 2.12 Test on Positive Reaction for Halogen on a Copper Wire

2.4.10.2 Fluorescence X

Some other preliminary tests shall made in the laboratory like using Fluorescence X equipment, where a radiative source analyses the samples.

Figure 2.13 Fluorescent X system

This system is different from L2000DX because a radiative source replaces the reagents. This system does not separate the potential silica from the chlorine.

Experience shows that a double check with GC should performed when the result is greater than 24.

This phase is needed to segregate the samples which are supposed to be PCB-containing materials.

2.4.10.3 L2000DX Analyser

For dielectric oil, screening qualitative/quantitative method such as L2000 DX analyzer with reagents should be used, with the chloride ion specific electrode, to measure chlorine content and to calculate Aroclor equivalent concentration.

Any waste generated during the screening activity (used screening tests, PPE, etc.) should be collected as hazardous waste and disposed of in compliance with the national and international rules on hazardous waste.

CAUTION: Some of the reagents used with this testing procedure have flammable solvents, dilute acids, and metallic sodium. Wear gloves and safety glasses while performing the test. Read all Safety Data Sheets and warnings included with the kit before starting the testing procedure.

WARNING: Mercury waste must be properly disposed of.

All the sampling wastes shall be stored in a hazardous industrial waste container and treated by a hazardous waste company as required by Turkish regulation.

On-site, it is possible to use an L2000DX analyzer which can used on a table with an electric plug. The safety precautions should explained to people in the facility due to the use of mercury and hazardous metals as reagents. Its system is based on a chemical reaction and gives the quantity of chlorine in the oil. Some bias could change the results, e.g. the chlorine products used can influence the analysis.

Figure 2.14 L2000 DX System

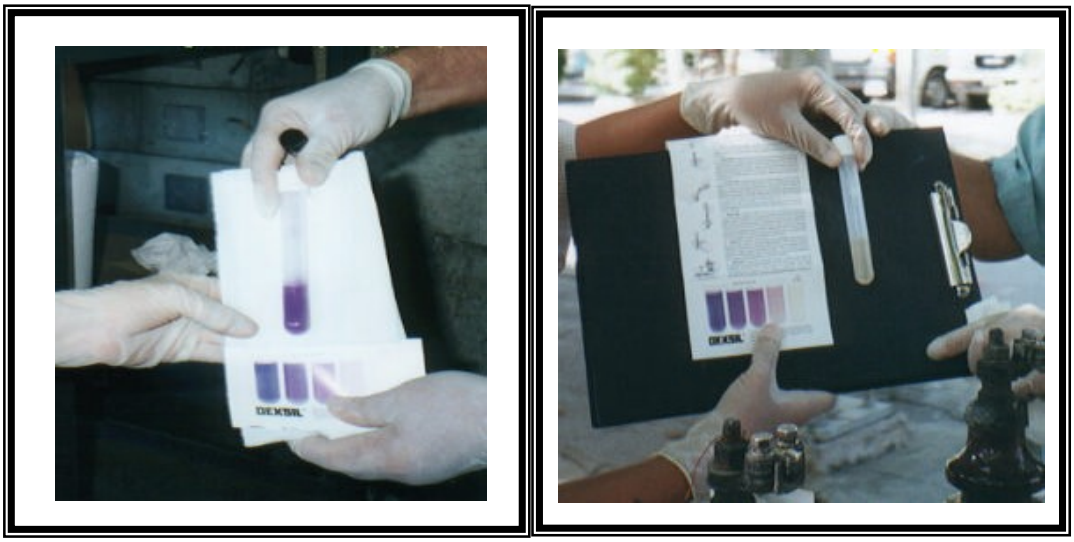


Figure 2.15 Single Use Test Kit (Clor-N-Oil) Negative result (Left), Positive result (Right)

It is mandatory to make a double check in case the results are greater than 50 ppm (see 2.5.11).

False Positive Results

A false positive result could obtained in case of

1) cross-contamination of the analyzer during a plural analysis (analysis made on different samples from diverse origins
2) a lack of clean procedure after an analysis

To prevent the false positive result, the laboratory or the technical team in charge of the analysis should

a) never used the reagent twice or analysis products
b) take care of the contamination of the used pieces as electrode, vial or others elements,
c) clean the electrode with a one-use cleaner,
d) store all the cleaning materials in the hazardous bin after use

2.4.11 Laboratory Analysis to Confirm Preliminary Results

According to accreditation rules, only GC analysis can provide proof of detection of PCBs in a material.

A GC is an analytical instrument that measures the content of various components in a sample. The analysis performed by a GC is called gas chromatography.

For dielectric/insulating oil, waste oil, and other waste matrices laboratory methods, the following standards are mandatorily used for the GC:

- ✓ European standard EN 61619 International Electro technical Commission (IEC) 61619: insulating liquids - Contamination by polychlorinated biphenyls (PCBs) – Method of determination by capillary column gas chromatography;
- ✓ EN 12766-1, EN-12766-2, and EN 12766-3: Methods for determination of PCBs in petroleum products and used oils;
- ✓ ASTM D4059: Standard Test Method for Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography; ASTM D6160-98(2013): Standard Test Method for Determination of Polychlorinated Biphenyls (PCBs) in Waste Materials by Gas Chromatography.

The Principle of Gas Chromatography:

The sample solution injected into the instrument enters a gas stream which transports the sample into a separation tube known as the "column." (Helium or nitrogen used as the so-called carrier gas). The various components separated inside the column. The detector measures the quantity of the components that exit the column. A standard sample with known concentration injected into the instrument to measure a sample with an unknown concentration. The standard sample peak retention time (appearance time) and area are compared to the test sample to calculate the concentration.

The gas chromatography gives two types of results

1) The identified PCBs in the sampling
2) The type of PCBs named congeners which are the sign of one specific substance

Figure 2.16 Extraction of Sampling Materials by Sampling Injector

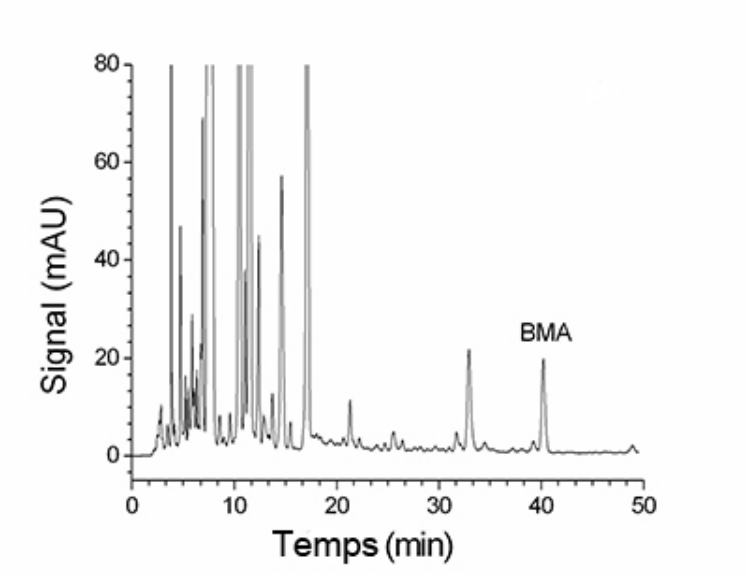


Figure 2.17 Table of Results Comparing the Reference Congeners on the Left to the Sampling Results on the Right

The GC gives different results could expressed as in following way:

Table 2.2 Results from GC Analysis

	Units	Limit of liability	Intermediate result	Uncertainty	Standards	Final result (PCB+PCT +PCBT)	Final uncertainty
PCB	mg/kg (ppm)	2	200	**+/- 5**	*List*	**275**	**+/- 2.5%**
PCT	mg/kg (ppm)	<2	75	**+/- 2**	EN 12766-3:2005		
PCBT	mg/kg (ppm)	<2	<2		EN12766-3:2005		

2.5 MAINTAINING THE COLLECTED DATA AND MONITORING EQUIPMENT

The collected data should represent the actual situation. Owners of PCB-containing equipment should update the database in case of the replacement or removal of PCB-polluted equipment.

Data shall be in agreement with maintenance and investment data. In case of equipment removal, a certificate of destruction shall be sent to ensure that the equipment can deleted from the database.

CHAPTER 3: MAINTENANCE & STORAGE OF TRANSFORMERS AND CAPACITORS, CONDENSERS AND DRUMS CONTAINING/CONTAMINATED BY PCBS

3.1 BACKGROUND INFORMATION

Existing transformers and capacitors shall managed by the status of potentially PCB-containing equipment. The types of equipment can be[27]:

1) No PCB-containing equipment, or PCB free equipment, all the procedures and practices are implemented to ensure the absence of PCB contamination,
2) PCB-containing equipment with less than 50 ppm, shall be managed to limit the risks of cross-contamination and shall be removed from service by 2028,
3) PCB-containing equipment with more than 50 ppm and less than 500 ppm must be managed as hazardous equipment and shall removed from service by 2025.
4) PCB-containing equipment with more than 500 ppm must be disposed and treated by authorized companies

3.1.1 Safety Precautions and Protection Plans of In-Service PCB Containing Equipment

The maintenance of a device should performed according to the procedures issued by the manufacturer when they are available and apply the national regulations to limit the cross-contamination.

When performing light repair or maintenance work on PCB-containing equipment, the following safety precautions for the protection of employees and the environment have to take:

- ✓ Direct contact of the skin with PCB-contaminated materials must avoided by wearing gloves and safety goggles. According to the type of work to be performed, protective clothing and a respiratory mask must also put at the workers' disposal,
- ✓ The working area must ventilated,
- ✓ Spills must prevented in every case by using drip trays or adequate plastic tarps,
- ✓ Every contact of PCBs with a flame or any other heat source over 300 °C and use of a grinder must absolutely avoided (risk of highly toxic Dioxins and Furans),
- ✓ All used tools and other working materials that got in contact with PCBs must be disposed of as PCB-contaminated waste in an environmentally sound manner or otherwise must be decontaminated with a proper solvent (technical acetone). The only materials to be decontaminated are steel, glass, and ceramics,
- ✓ Operations which involve draining, rewinding of the coil may only be performed by companies approved for such tasks by the competent country authorities.

The company should be organized with the maintenance team a Prevention/Protection Plan to apply these rules which describes:

[27] UNITED NATIONS ENVIRONMENT PROGRAMME MEDITERRANEAN ACTION PLAN Agenda item 4: Review of ESM Guidance and factsheets Environmental Sound PCB Management Guide (Mediterranean Region) April 2015

- ✓ The risks related to the environment
- ✓ The risks related to the other activities
- ✓ The risks related to the other equipment (tank, engine, motors, etc.)
- ✓ The risks related to the storage of the hazardous products
- ✓ The risks related with the PCB-containing equipment itself
- ✓ The environmental measures to be put in place (closed area, limited access area)
- ✓ The maintenance of engines and tools needed
- ✓ The Personal Protective Equipment needed

The Prevention/Protection plan should coordinated with the safety manager and the management team, and all observations, remarks, and decisions should recorded on a Prevention/Protection sheet file (see table 3.1.), including:

1) Name of the person in charge of the safety of the site
2) Name and number of people who maintain the PCB-containing equipment
3) The qualification of the maintenance person and copy of the license or Company authorization (to use the safety equipment)
4) The location of the equipment and its condition (leakage, shocks, external aspects)
5) The date and the duration of the maintenance work
6) The status of the workers (internal team, temporary staff)
7) Identification of specific dangers
8) Location of emergency alarms
9) Instructions in case of cold accident emergency
10) Instructions in case of hot accident emergency
11) Safety support staff if required (internal or external firefighters)

The Prevention/Protection Plan must be signed and retained with the maintenance file of the PCB-containing equipment.

Table 3.1 Prevention/Protection Plan Template

Site-specific Fall Protection Plan

Planning plays a key role in protecting workers from fall hazards. This fall protection plan template can assist the planning process. Employers should ensure that fall protection plans are designed to address site-specific conditions and comply with *Safety Acts* and *General Safety Regulations*.

Site address:	Start date:
Site description:	Employer:
Work area:	
Tasks:	

Site-specific fall hazards *(see diagram on page 2 for more details)*

Max. height (peak):	Max. height (eaves):	Max. height (other):
Roof slope(s), if applicable:		
Proximity to high voltage power lines:		
Ground cover/hazards:		
Other/comments:		

Type of fall protection you will use *(see definitions on page 3)*

☐ Fall restraint	☐ Fall arrest	☐ Temporary guardrail system

Equipment inspection

Item	Comment/defect	Item	Comment/defect
☐ Full body harness		☐ Anchors	
☐ Vertical lifelines		☐ Ladders	
☐ Lanyards		☐ Ladder hoist	
☐ Rope grabs		☐ Toeboards	

3.1.2 Best Working Practices for Safety Issues During Maintenance and Storage Operations

1) Personal Protective Equipment by the prevention plan analysis (see 3.1.1)

Figure 3.1 Type of Personal Protective Equipment (PPE) for Suspected PCB-Containing Equipment[28]

PPE should be included the followings;

- ✓ helmet to protect against head shocks
- ✓ safety glasses to protect against liquid spraying
- ✓ disposable coverall
- ✓ masks, and in case of suspected presence of pure PCB (greater than 2000 ppm), a respiratory mask
- ✓ nitrile gloves (according to conditions several types of nitrile gloves)
- ✓ safety shoes and galoshes

Personal Protective Equipment shall be complete with labels to ensure that workers provided with necessary information.

[28] UNITED NATIONS ENVIRONMENT PROGRAMME MEDITERRANEAN ACTION PLAN Agenda item 4: Review of ESM Guidance and factsheets Environmental Sound PCB Management Guide (Mediterranean Region) April 2015

Figure 3.2 Type of Personal Protective Equipment (PPE) for PCB Treatment Area (APROCHIM Site)

Table 3.2 List of Best Practices to Implement for PCB-Containing Equipment Maintenance (from UNEP2015)

Best Working Practices[29]	
When performing light repair or maintenance work with PCB-containing equipment, the following safety precautions for the protection of the employees and the environment must followed:	
	**Direct contact of PCB-contaminated materials with the skin and eyes must be absolutely avoided by wearing gloves and safety goggles. According to the type of the work performed, protective clothing and a respiratory mask have also to place at the worker's disposal.**
	**The working area must ventilated.**
	Spills must be prevented in every case by use of drip trays or adequate plastic tarps.
	**Every contact of PCBs with a flame or any other heat source over 300°C must absolutely avoided (risk of highly toxic dioxins and furans).**
	**All used tools and other working materials, which got in contact with PCBs, must be disposed of as PCB-containing waste in an environmentally sound manner or otherwise must be decontaminated. The only suitable materials to be decontaminated with a proper solvent (technical acetone) are steel, glass, and ceramics.**
	**Operations which involve decanting, rewinding of the coil, etc. must only be performed by companies approved for this task by the competent authorities.**

[29] From UNEP Environmental sound management guide 2015

2) Management of hazardous materials should implemented with appropriate storage of hazardous waste. Cross-contamination can occur when a cleaning material or a polluted tool used for another maintenance job. Some single-use materials include gloves, cleaning paper, spill protection should be placed in a hazardous waste bin. This bin shall packed in a hazardous waste container for treatment. Hazardous waste containers shall collected in conformity with local regulations.
3) For maintenance work, environment spill protection shall implemented in case of leakage and the maintenance team shall work with a pollution spill kit near the maintenance work.

Figure 3.3 Pollution Spill Kit for Use During Maintenance Work

Figure 3.4 Label Close to a PCB-Containing Equipment Area

3.1.3 Inspection of PCB-Containing Transformers

3.1.3.1 Performance Tests

Transformers must be periodically checked to detect any change which the first signs of degradation in the performance of the transformer may be, and therefore of possible risks arising. Among others, the following characteristics have to check:

- Functioning of all protection devices
- Electrical performance of the transformer
- Oil quality (physical and chemical tests)

Some actions shall implemented to ensure the performance of the transformer:

1) Survey of dielectric fluid condition to prevent
   a) Breakdown voltage,
   b) Water content
   c) Total acid number
2) Survey on condition of electrically-live parts (coil)
   a) Analysing of 13 dissolved gas
   b) Ageing state or deterioration of the cellulosic insulators
3) Pollution by PCBs

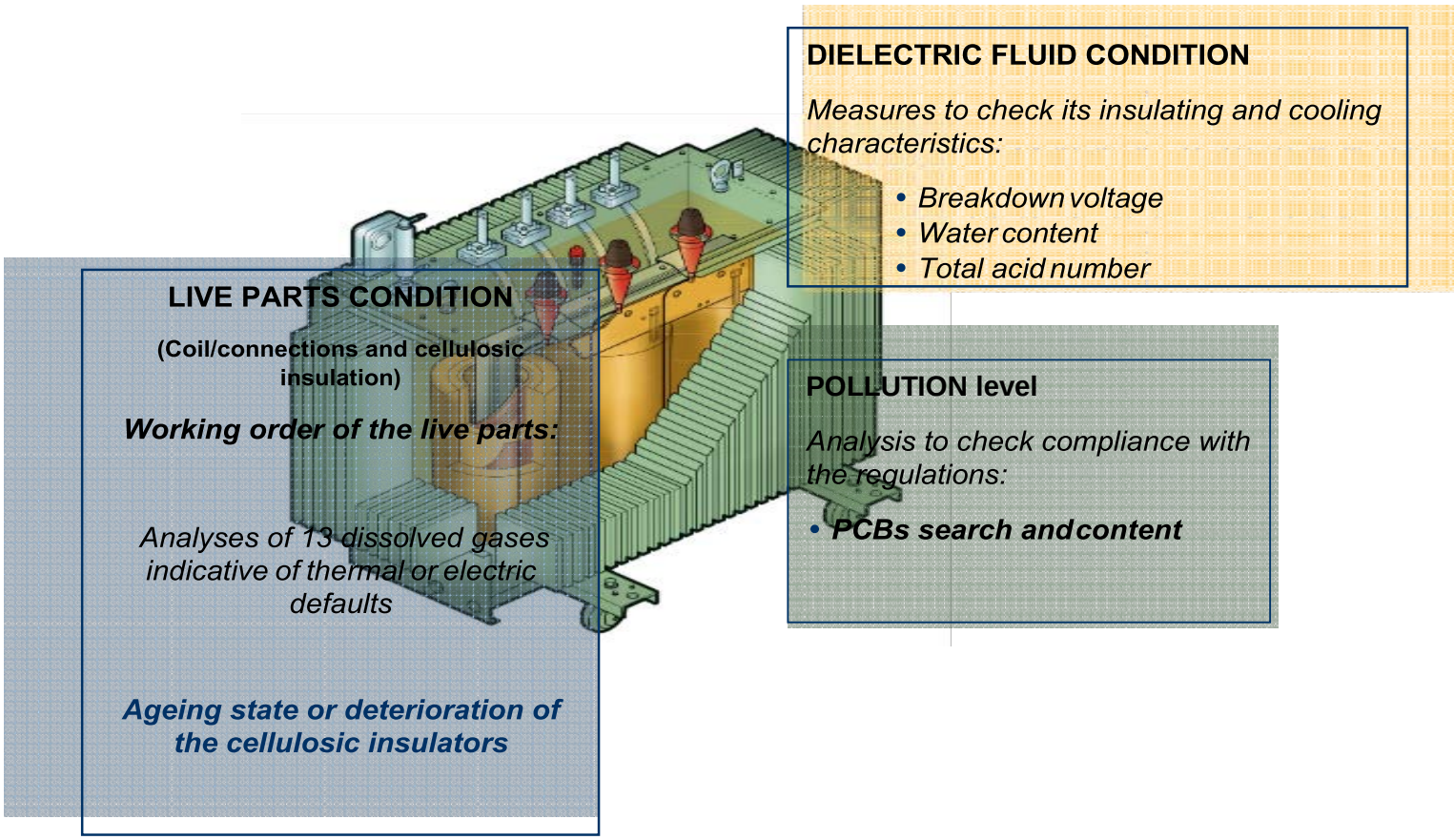


Figure 3.5 List of Survey Actions

Dissolved gas is created and could be detected

- ✓ When cellulosic insulators deteriorate, there is a production of specific compounds called “furanic derivatives” dissolved in oil.

- ✓ When cellulosic insulators deteriorate, a decomposition of the cellulose due to the breaking of intramolecular connections occurs, resulting in a drop in the polymerization degree.

- ✓ The presence of corrosive sulfur compounds contained in some insulating oils, in contact with the metal materials of the transformer, can cause the deterioration of these metals at a level depending on their quantity, the length of the contact and the temperature. The method for corrosive sulfur test performed according to IEC 62535 (2008).

- ✓ An excessive presence of hydrocarbons can affect the nonflammability characteristic of the Askarel® which, beyond a certain threshold, becomes a flammable material.

One method is to analyze dissolved gas in the transformer oil to ensure the quality of the active part of the transformer coil in copper for the connections. This analysis can detect early a malfunction of the active part of the transformer (thermal or electrical fault) which generates the production of characteristic gases dissolved in the dielectric fluid in proportions and concentrations known as abnormal. The transformer oil is the memory of the events on the device. So, from the sampling of transformer oil, by analyzing 13 characteristic gases, from their concentrations, proportion, and speed of production, we can interpret what created the phenomenon or fault.

Visual Checks

The simplest and the cheapest test of a transformer in service or storage is the visual check. PCB transformers shall be visually inspected quarterly by the equipment owner, who is also responsible for maintaining records of inspections.

The following areas shall examined:

- ➢ Oil stains near the equipment
- ➢ Oil stains or weep marks on the equipment (welding seams, gaskets, valves).
- ➢ Gross physical damage
- ➢ Tightness in drip tray

Table 3.3 List of Routine Inspection Items for Transformers[30]

Inspection	What to look for (and corrective action)
Condition of gauges	➢ Cracked faceplates or damaged gauges (install a Plexiglas sheet over gauges for protection).
Reading of gauges	➢ Change in readings since the last inspection. ➢ Readings within the safe or acceptable range (if they are not, consider the addition of make-up fluid).
Corrosion on tank and radiator fins	➢ The condition of fins. They are manufactured of thin steel to obtain the greatest cooling and rust through more quickly than the rest of the transformer, especially in a caustic environment (clean to bare metal and paint if rusted).
Paint finish of tank and radiator fins	➢ Weathering paint (repaint as often as necessary).
Leakage of PCB from: ➢ tank ➢ radiator fins ➢ top cover (if gaskered) ➢ utility access hole cover ➢ top or bottom drain spout ➢ high and low voltage bushings	➢ Wet slickness and gummy residue. ➢ Deteriorating gaskets or seals. (Important – if there has been leakage, take steps to clean it up promptly and report to the proper provincial authority. All materials used for cleaning up the PCB leakage must safely stored as PCB-contaminated waste.)
Pressure-relief valve	➢ Improperly seated valve due to displaced gaskets.
High and low voltage bushings	➢ Cracking or chipping. (Replace cracked or chipped bushings.)
Colour of PCB	➢ Colour changes. ➢ Take a small sample. If the color is changing from clear to a blue, green, red, or black, the PCB is becoming contaminated (consider a laboratory test to check its quality).

Leaks of Transformers

When a leak or spills detected on or near a transformer, it is necessary to investigate the cause of the leak to take remedial action. Most common leaks are at seals and gaskets. Various options for effective repairs are possible, and they can help to avoid impacts on the main body of the transformer. However, only experienced electrical specialists aware of the dangers of PCBs shall perform such work.

[30] From UNEP Environmental sound management guide 2015

Figure 3.6 Leakage on an Old Transformer (Manufacture Year: 1975)

Oil Level of Transformers

During the use phase, the cooling fluid could heated, and the maintenance team should add some dielectric fluid. However, before that, the maintenance team need to check the PCB content of the oil to prevent the risk of cross-contamination. Simplified methods should be used to detect the chlorine in oil.

The maintenance team should have a table with criteria to survey a transformer as

- ✓ PCB concentration – no longer suitable, more than 2000 ppm, could be identified with the L2000DX analyzer
- ✓ Operation temperature is 70°C – 200°C could identified if some heat vapors are visible in the tank
- ✓ Process pressure: Atmospheric to 3.5 bar (CDP) control with the Pressure-vacuum Gauge
- ✓ Using the reagents easily found on the market

Figure 3.7 Pressure Vacuum Gauge

Corrosion on Tank and Radiator Fins

A visual inspection shall be made twice a year to detect the potential corrosion and must recorded on the PCB containing equipment on the inventory. In case of suspicion, some corrective actions such as cleaning the metal and painting should be made.

Figure 3.8 Corroded Transformer Exposed to Salt (French West Coast)

3.1.4 Evaluation of PCB-Containing Capacitors and Condensers

In electric power distribution, capacitors and electric condensers used for power factor correction. Such capacitors often come as three capacitors connected as a three-phase load.

During the production line of capacitor at the factory, PCB is injected for increasing the quality of the systems and then the equipment is sealed. So, the capacitors are closed systems and their rate is not changing in time. The owners must identify the equipment, apply the SC requirements and remove the PCB containing equipment which has a rate upper than 50 mg per kg (50 ppm)

Individual motor or lam loads may have capacitors for power factor correction or larger sets of capacitors (usually with automatic switching devices) may installed at a load center within a building or in a large utility substation.

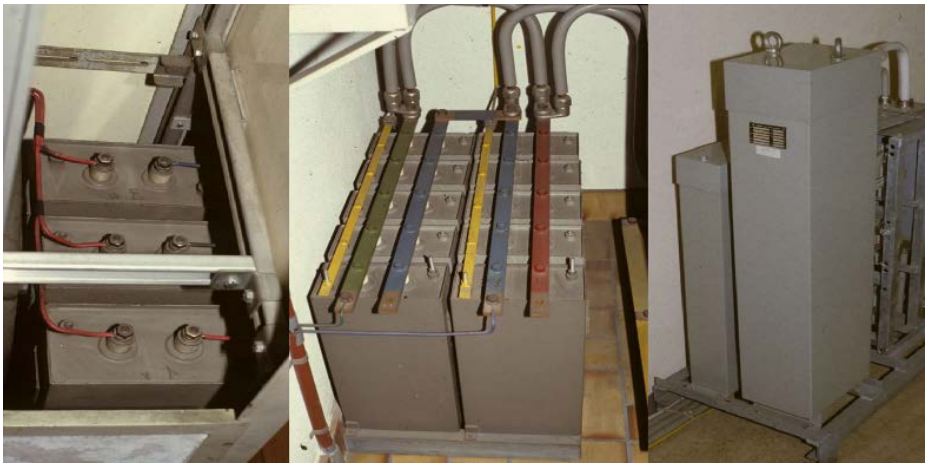


Figure 3.9 Identification of PCB-Containing Capacitors and Condensers before Removal

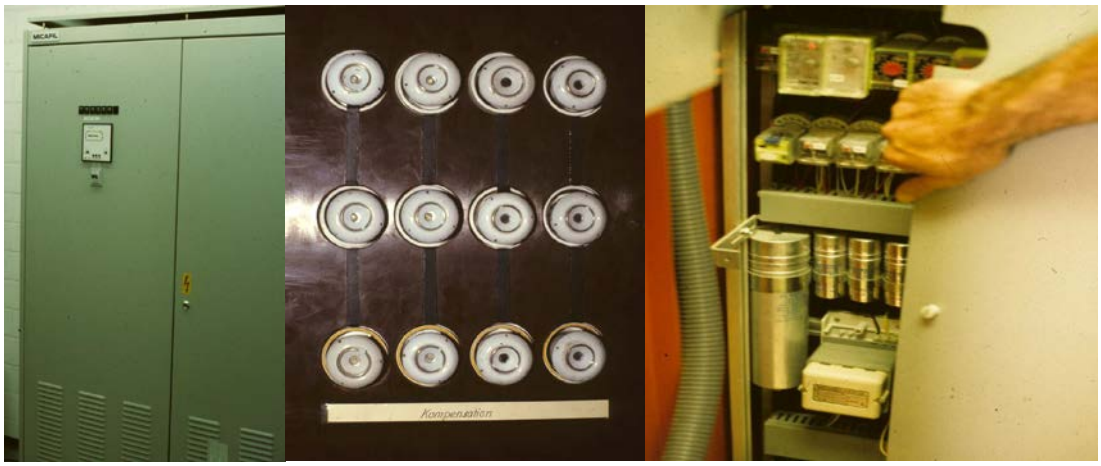


Figure 3.10 Different Types of Condensers and Capacitors in Storage or Use

Capacitors made with any dielectric material show some level of “dielectric absorption” or soakage.

The level of absorption depends on many factors, from design considerations to charging time, since the absorption is a time-dependent process. However, the primary factor is the type of dielectric material.

In some capacitors where dangerous voltages and energies exist, the dielectric absorption can recharge the capacitor to hazardous voltages after it has been shorted or discharged.

Any capacitor having over 10 joules of energy is considered hazardous, while 50 joules or higher is potentially lethal. A capacitor may regain anywhere from 0.01 to 20% of its original charge over a period of several minutes, allowing a safe capacitor to become surprisingly dangerous.

Leakage is equivalent to a resistor in parallel with the capacitor. Constant exposure to heat can cause dielectric breakdown and excessive leakage, a problem often seen in older vacuum tube circuits, particularly where oiled paper and foil capacitors used. In many vacuum tube circuits, interstate coupling capacitors are used to conduct a varying signal from the plate of one tube to the grid circuit of the next stage. A leaky capacitor can cause the grid circuit voltage to be raised from its normal bias setting, causing excessive current or signal distortion in the downstream tube. In power amplifiers, this can cause the plates to glow red, or current-limiting resistors to overheat, even fail. Similar considerations apply to part fabricated solid-state (transistor) amplifiers but owing to lower heat production and the use of modern polyester dielectric barriers this once-common problem has become rare.

Some old, large oil-filled paper or plastic film capacitors contain PCBs. It known that waste PCBs can leak into groundwater and landfill. Capacitors having PCBs were labelled as having "Askarel" and several other trade names. PCB-filled paper capacitors are found in very old (pre-1975) fluorescent ballasts, and other applications.

For the condensers, a limited list of PCBs containing products was established (see appendix 6 a partial list for ANZECC: Australian and New Zealand Environment and Conservation Council).

- Resonant start;
- A capacitor that is cylindrical or rectangular, encased in an aluminum container with a weld running all the way around the top edge with two terminals with quickly connect tags
- A date mark from the 1950s, 1960s or 1970s;[1]
- A capacitor encased in a rectangular tin container with soldered seams;
- Slightly heavier than similar types of capacitors manufactured after the 1970s

(which do not to contain PCBs).

The sampling shall be made by professional specialists as certified electric maintenance people to identify the PCB containing equipment,

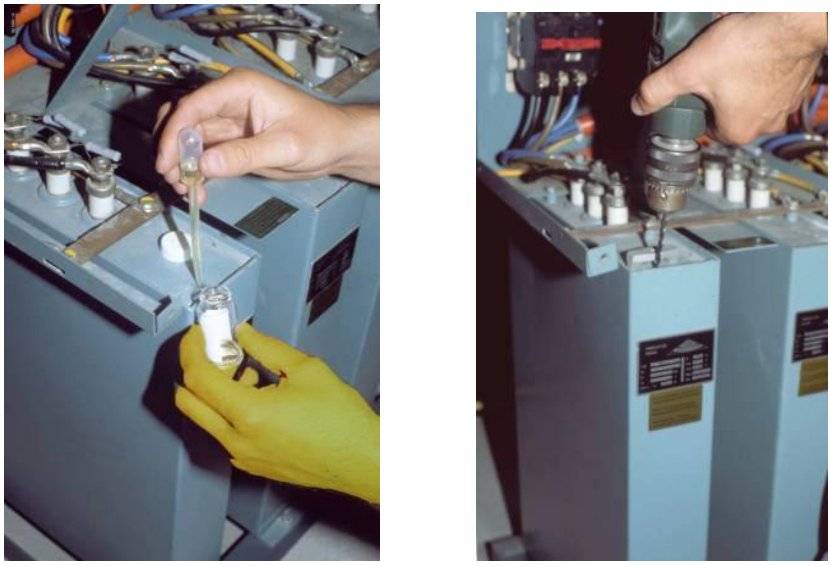


Figure 3.11 Identification of PCB Containing Capacitors

3.1.5 Temporary Storage

During the life cycle of a transformer, it may transferred into temporary storage for

- ✓ Maintenance
- ✓ For removal at the end of life

The transformer shall be labeled to identify its PCB-containing status.

For all temporary storage, to protect human and environmental health, the following requirements shall apply

1) The storage place should be on a closed site under surveillance (to reduce the risks for the environment)
2) A specific warning should implemented with a list of risks (hazardous exposure, chemical and electric danger),
3) Only authorized people could access with an identification and record procedure
4) Record the temporary storage in the prevention plan of the site and inform the safety specialist
5) All the equipment (transformer, capacitor, condenser and drums should be on a retention tray which is designed to retain 1.5 times the volume of the liquid
6) In case of temporary storage for maintenance, the equipment should be protected against rainwater, to limit the risks of water contaminating the insulation liquid.

In case of removal, transformers may be stored outdoors or indoors but always on a storage retention tray. When the transformer removed, the residual insulating oil shall be pumped and analyzed to identify the potential pollution by PCBs.

Staff who lift and carry the transformer should protected in relation to the prevention plan with the following PPE

- ✓ helmet against the head shocks
- ✓ safety glasses against the liquid spraying
- ✓ disposable coverall,
- ✓ masks, and in case of suspected pure PCB (greater than 2000 ppm), a respiratory mask
- ✓ gloves (2 types of gloves)
- ✓ safety shoes and galoshes

Figure 3.12 Retaining storage pan for PCB-containing transformers

3.2 FRAMEWORK

This chapter gives the following rules:

- ✓ to apply best practices to the possibly contaminated transformers and capacitors for the protection of the health and safety of the workers, all personnel on site and the environment
- ✓ to limit cross-contamination during the use and maintenance of the transformers and the capacitors, which have identified as polluted (based on values greater than 50 ppm)

This guideline does not replace the regulation but reflects, on a voluntary basis, current ISO/CEN voluntary standards), and should be useful for companies that participate in this system. For this reason, the text of this guideline oriented to quality management.

The chapter should help practitioners to use, maintain and store PCB-containing transformers that identified during the PCB inventory.

Two themes developed:

1) The best practices for health, safety, and environmental protection,
2) The rules to apply for use and maintenance – storage, handling and transport.

For each theme, we are using a Plan, Do, Check, Act (PDCA) approach, based on the quality management system:

The PCDA is a quality methodological system based on a systematic process to develop a project. This system could be very helpful for a complex system as the PCB inventory. Each

phase must be performed in the same order to ensure all the process is working. In the management practices, each phase can be identified by the term representative of the phase

PLAN, DO, CHECK and ACT

- ✓ The Plan phase describes the objectives and the resources needed to implement the objectives
- ✓ The Do phase describes the actions which should be implemented to apply the objectives
- ✓ The Check phase describes the actions performed to verify whether the objectives and the targets have been implemented and results achieved and whether corrective actions are needed
- ✓ The Act phase describes the steps needed to improve the established processes

3.2.1 Best Practices for Health, Safety, and Environment for PCB-Containing Transformers

The best practices offer some subjects to ensure the protection of the workers and the environment. The PCB inventory needs to implement a risk analysis about the number of PCB-containing transformers and their location.

The risk analysis includes some data points:

- ✓ The location and the concentration of PCB-containing transformers,
- ✓ The location where leakage observed in the environment (e.g., storm water drains and culverts or other possibilities. For instance, the 2008 Irish pork crisis was a dioxin contamination incident in Ireland that led to an international recall of pork products from Ireland produced between September and early December of that year, Yushō disease was a mass poisoning by PCBs which occurred in northern Kyūshū, Japan in 1968. Due to holes in the pipes, PCBs leaked into the rice bran oil. The contaminated rice bran oil sold to poultry farmers for use as a feed supplement and to consumers for use in cooking.)

The Prevention Plan as we describe in Chapter 3.1.1 is mandatory at the level of the company and for each site to cover the major risks related to the industrial process and storage of hazardous products.

The site and the company must design a specific Prevention Plan in case of PCB containing equipment like transformers, capacitors, condensers or drums. The prevention plan describes the risks to nature and the practices which should apply to protect workers, visitors, all people, and the environment, who are likely to be exposed to PCB risks.

Protection measures to be implemented include three levels (from the global level to the personal level):

- ✓ Global actions to reduce spills in the environment
- ✓ Global actions to protect workers (e.g., limitation of exposure)
- ✓ Specific actions to protect workers (e.g., PPE)

Based on the PCB inventory, each company must:

1) Design a risk analysis and prevention plan for each site,
2) Assign a responsible person for each site who lead, coordinate, supervise and report regarding the actions plans; the verifications made and suggestions for continual improvement to top management,

3) Evaluate the resources needed to manage and survey the information on actual PCB-containing transformers and capacitors,
4) Ensure the protection of workers, maintenance people and neighboring companies and individuals against cross-contamination by PCBs
5) Design an investment plan including the following subjects:
    a) a replacement plan for PCB-containing transformers and capacitors,
    b) development of a (BAT/BEP) treatment approach to recover the new/used contaminated oil using environmentally mobile/systems (If applicable) and to recycle the equipment,
    c) Removal of the end-of-life transformers containing PCBs from 50 ppm to 500 ppm to maintain the production and delivery of electricity.
    d) removal of PCB containing transformers which identified with PCB levels at 500 ppm or more

The manager in charge of the investment plan should apply it and transmit the conclusions for management review.

The managing director should prepare an investment plan for the replacement of the contaminated equipment in use. The Ministry of Environment and Urbanisation permits companies with PCB-containing equipment to schedule replacements until 2028. Under these circumstances, the managing director must arrange the replacement plan in a reasonable time and offer to company superiors for review an economically sound replacement schedule. This approach is valid for equipment in use. If the PCB-contaminated equipment is not in use by the company/institution, the company/institution must manage the equipment in an environmentally sound manner after it classified as out of use (treatment or final disposal if the equipment cannot meet a threshold of less than 50 ppm of PCBs).

Each company must implement and customize the following action plans to their inventory of equipment to implement best available practices:

ACTION 1: To ensure each leakage, incident or accident that potentially included pure PCBs, PCB-contaminated oil, or cross-contaminated equipment can be stored in a restricted area of the site in proximity to spill kit materials (i.e., absorbents pads should be highly absorbent, fine-fiber construction that won't leave liquids or fiber residue behind). Absorbents are using for most common industrial liquids – oils, water, solvents, coolants and more.

The prevention plan needs to identify the spills that contain PCBs (oil, pure PCB) in the environment due to rainwater, wastewater drains or other ways according to the natural gradient of the site by using labels or other signs such as a colored flag,

Technical Support:

- ✓ The risk analysis and prevention plan should identify all ways in which PCB pollution can spread,
- ✓ Some spill kit materials are using (bold "Spill Kit" lettering for quick identification, absorbent pads, pillows, all-purpose wipers, polyethylene disposal bags, socks, mat pad, nitrile gloves for heavy duties, temporary disposal bags help make clean-up easier,easy reachable, not locked boxes) close to the contaminated transformers/equipment. Cleaning rooms should established near interim area/points and before exiting the contaminated site. Only authorized people should be on site.
- ✓ Over pack drum container is UN Rated for shipping waste after spill clean-up (Over pack container is X-rated in Packing Groups I, II and III for shipping spill clean-up waste by land, sea or rail),
- ✓ Lift-out, prepacked baskets speed access and protect contents from UV light

- ✓ The capacity of the spill kit should absorb 1.5 times the volume of the PCB-containing liquid,
- ✓ A prevention exercise should be practiced at least once a year by workers on the site,
- ✓ Present the results of planning to management for review

ACTION 2: Each PCB-containing transformer should be provided with secondary containment (e.g. retention storage pan) to limit the effects of leakage and prevent cross-contamination.

Technical Support:

- ✓ Each PCB-containing transformer should be handled in an appropriate location, either indoors or outdoors, with secondary containment to manage any spills, and with equipment labeled by the PCB inventory rules,
- ✓ The risk analysis should evaluated twice a year and spill kits provided for areas where PCB-contaminated transformers remain in use if secondary containment cannot provided for these transformers
- ✓ Access for maintenance or other procedures to the PCB-containing transformer should be limited to reduce the risk of cross-contamination. Only authorized, trained (for PCB Management Certified) personnel should be authorized to enter the area.

ACTION 3: Protect the workers working on the PCB-contaminated transformers

Technical Support:

- ✓ The risk analysis should revised every 3 years or when a significant modification of the transformer stockpiles occurs
- ✓ A log of incidents or accidents should recorded and distributed to all personnel in the company
- ✓ In case of incident, local authorities should immediately informed
- ✓ In case of incident, neighbors should immediately informed and the needed action plans developed
- ✓ A physical audit should be made twice a year to verify the condition of spill protection equipment
- ✓ A physical audit should be made twice a year to verify the condition of PCB-contaminated transformers/equipment. In case of leakage or incident, a notification should be sent to a responsible person at the site and to company management to consider the need to replace it
- ✓ The risk analysis is a part of the management system and should audited in the ISO Certification context
- ✓ An audit should be developed to ensure that PPE and work practices adequately address identified risks
- ✓ Awareness information and a workshop should be provided to all employees describing the action plans to implement in each location
- ✓ The action plans made by the competence and awareness of the workers
- ✓ A continuous improvement plan should developed by the responsible person
- ✓ All workers should be able to propose voluntary actions to develop environmental best practices

3.2.2 Rules to Apply for Use, Maintenance, Handling, Transport, Storage, and Maintenance of PCB-Containing Transformers

The objectives of this part are to apply best practices during the use phase of PCB-containing transformers including maintenance, handling, storage, and transport.

Objectives:

1) Ensure that health, safety, and environment rules are applied
2) Ensure that electricity safety rules are applied
3) Develop maintenance and refilling actions in the framework of environmental best practices
4) Develop a replacement plan to transition from PCB-containing transformers to non-PCB transformers/equipment or PCB-free transformers/equipment.

Actions to implement the objectives

1) Ensure coordinated planning with all the services (production, maintenance, health, safety, environment (HSE)
2) Design an action plan to prevent cross-contamination in each phase of the transition
3) Design a prevention plan that is supported by a risk analysis. An appropriate HSE culture should developed through establishment of procedures and training
    a. The prevention plan should identify the risks for
        i. The workers who handle and perform maintenance operations
        ii. The workers who work around the potentially PCB-contaminated transformers/equipment or contaminated soil.
        iii. The site that potentially contaminated with PCB-cross-contaminated areas or warehouses/storage.
        iv. The neighbors and the environment (water resources, rivers, culverts, sewage mains and air emissions)
    b. The protection tools are
        i. First of all, ensure transformers located in areas with secondary containment
        ii. Organise and establish interim storage or special areas to prevent cross-contamination
4) Personal Protective Equipment (PPE)

Ensure that workers have adequate PPE to protect against PCB contamination and other hazards such as electrical shocks or chemical injuries.

PLAN

Objectives

1) Ensure all the PCB-free transformers are without cross-contamination during the maintenance of PCB-containing transformers or capacitors
2) Maintain all the transformers without cross-contamination,

DO

Actions to implement the objectives

1) Inspections should be made by workers to classify the condition of each transformer:
    a) High-risk level with an orange or red label
    b) Low-risk level with a green label,

Operators or maintenance workers should play an active role to limit the risks of cross-contamination.

2) If possible, identify the procedures, instructions, and tools for maintenance to reduce the risk of cross-contamination

a. use different maintenance tools following the risk level (specific tools)
    i. tools for the red labeled transformers
    ii. tools for the orange labeled transformers
b. Cleaning materials should be placed in the hazardous-waste bin and should not reused for other transformers or capacitors

3) If possible, establish a secondary containment area around the high-risk level transformer and put a spill kit close to the site that is easily accessible
4) Before adding virgin oil (new oil) in a refill operation to a PCB-contaminated transformer, the existing transformer oil should be sampled and analyzed to identify the level of concentration in the PCB-contaminated transformer
5) The restricted area should be systematic during the phase of handling and maintenance. Equipment decommissioning should be planned to avoid cross-contamination.
6) Ensure a contaminated transformer has the same label and number and matches existing inventory records (record on the inventory website)
7) Update all the records of the institutions (PCB inventory website, internal data, etc.

CHECK

Objectives

1) Ensure the policy on PCB-containing transformers is implemented, maintained and verified
2) Ensure resources are sufficient to implement the policy and develop actions

Actions to implement the phase:

1) Audit the maintenance plan for transformers and update the PCB inventory in case of changes (e.g., refill, replace)
2) In case of emergency, (PCB leakage, overload or fire) implement a nonconformity action plan to limit the risk of cross-contamination
3) Check all information after maintenance and reuse
4) Check the destination of hazardous waste in the framework of local legislation and regulations.

ACT

Ensure that the level of awareness and competence of all workers who perform maintenance and work with in-use PCB-containing transformers is up-to-date.

Encourage technical suggestions from workers of the company/institutions (idea box) with financial compensation and recognition.

Activate such a “think tank” approach reinforces policy decisions and contributes to institutional memory.

CHAPTER 4: DECOMMISSIONING OF TRANSFORMERS AND EQUIPMENT

4.1 BACKGROUND INFORMATION

The practical decommissioning of transformers starts with the de-energizing procedure, which must follow local safety rules for work on electrical equipment as well as (if available) the instructions of the manufacturer.

The owner of the transformer should dedicate a responsible person to inspect the decommissioning operation and specifically to ensure the electrical isolation of the equipment. If the responsible person does not have sufficient qualifications, the inspection should made by a person having expertise on maintenance.

4.1.1 Decommissioning of Transformers

The working area should be fenced off to avoid unauthorized access. A fire extinguisher must be positioned in a suitable place on site, ready to use in case of a fire hazard.

First, inspect the transformer for damage and leakage, then to avoid any further cross contamination it is, in case of leakage, essential to seal the leaking spots. Furthermore, remove all visible pollution on the metal parts, e.g. with acetone to enable safe handling of the transformer afterward.

Second, to avoid any risk of loss of PCB-containing cooling fluid during dismantling and transport, it is advisable to drain the transformer beforehand at its location according to a well-prepared work schedule and provision of all necessary equipment such as PCB pumps, drums, personal protective equipment, and tools. This procedure also has the advantage that it reduces the total weight of the transformer during transport.

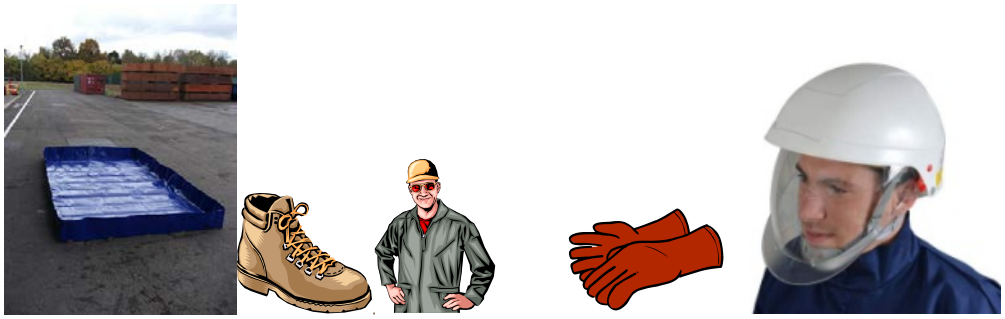


Figure 4.1 PPE and Pollution Prevention Tools for Decommissioning

Before draining the oil, precautions for a spill must taken by covering the ground with one or two layers of extra durable plastic tarp and drip trays under the crucial parts like the oil pump, hose joints. It is also advisable to have absorbents like sand, cement, or sawdust ready.

Due to the viscosity of the (pure) PCB cooling fluid, it might be difficult to open the drain tap. It must be considered in advance to find the best solution. In case it is not possible to open the tap, drain the transformer via the oil filling cap or by removal of an insulator.

Figure 4.2 Fill Out Oil on a Draining Table with a Pump

Before the transformer is entirely drained off, it should be positioned at an angle to drain as much cooling fluid as possible. It must be considered that there will still be some kilos of oil in the transformer after the draining off, which will be sweat out from the windings in time. The drain tap must be closed after the draining activities and, if possible, the transformer should be filled with an absorbent or some sawdust to bind the remaining PCB oil.

After removal of the device from its enclosure, investigate the area visually and decontaminate the floor, trench covers, walls and cables if necessary before installing a new transformer.

If a transformer is free from damage and has no leakage and a clean surface, and the drainage is not performed on site, then the removal can be done in normal working overalls.

4.1.2 Decommissioning of Capacitors

The decommissioning of capacitors starts with the power cut procedure, which must follow applicable safety rules for work on electrical equipment as well as manufacturer's instructions.

Before working on a capacitor or capacitor bank, the following operations must be carried out:

- ✓ Ensure that the circuit breaker or power switch and eventual line isolators for the affected capacitor are open and marked with a sign «do not switch works ahead»
- ✓ Short-circuit the incoming lines for the capacitor at the earliest 10 minutes after switching off.

Figure 4.3 Capacitors before Decommissioning

For high voltage capacitor banks connect earthing rods for each rack to the ground circuit by braids.

Most capacitors equipped with discharge resistors. Nevertheless, the terminals of the capacitor cases must shorted before any work is carried out on them, because the discharging circuits may be damaged.

The working area must be fenced off by red/white plastic bands to avoid unauthorized access. A fire extinguisher must positioned, ready to use in case of a fire hazard.

Before dismantling, it must checked if capacitors are leaking or if they are damaged. Leaks must be sealed. Contaminated surfaces have then to be cleaned, e.g. with rugs and acetone solvent. Puddles of PCB-containing dielectric must be sucked up by pumps or soaked up by adsorbents. All resulting waste must be collected and disposed of as hazardous waste.

Figure 4.4 Instruction to Carry Out the Capacitors

4.1.3 Pre-treatment, Treatment and Disposal

The transformers and capacitors should be dismantled on site in a holding tank with a pollution kit to limit the risks of leakage to the environment.

After switching off the energy, the transformer or capacitor shall be dismantled in a safe place by workers with PPE. A visual inspection is done to ensure the liquid cannot spilled.

An on-site analysis must be made to figure out if the transformer has PCBs with a simplified method like the density method or by using an L2000DX analyzer.

If possible, oil shall refilled. The oil shall be regenerated if the system exists locally and the PCB concentration is less than 5000 ppm, or by thermal destruction if the PCB concentration is greater than 5000 ppm.

If corrosion or leakage found, the spilled oil shall be absorbed by an absorbent paper which shall disposed of in a hazardous waste bin.

Handling and packaging shall made by an authorized company, and in case of export, an adequate authorization shall requested by the Rotterdam and Barcelona Conventions in the export country and the importing country.

If a PCB-containing transformer has less than 50 ppm, the materials shall be dismantled and recycled.

If a PCB-containing transformer has greater than 50 ppm, the materials shall treated in a disposal system that destroys PCB at a destruction efficiency of 99.99%.

4.2 FRAMEWORK

PCB-containing transformers can managed for several years, but the decommissioning of these units is crucial to limit the spread of PCBs.

Based on its PCB inventory, the company should

1) Handle and transport PCB-containing transformers to a specific place where activities to refill the oil and dismantle contaminated materials of the equipment to be recycled be performed.
2) Develop a site analysis to protect the future users of the site against potential PCB pollution or cross-contamination.

4.2.1 Best environmental Techniques for Removal of PCB-polluted Materials

Owners of PCB-containing transformers and materials must treat and clean the equipment. Its materials should be decontaminated for reuse or recycle.

PLAN

a) Based on the PCB inventory, companies should implement a phase-out plan which takes the following into account:
    - The level of PCB contamination
    - The priority and importance of the process line. (Some processes are non-stop, so define break times)
    - The date of implementation and replacement of the site or company

b) The company should select a supplier that can decontaminate or dispose of the materials based on the following criteria:
    - PCBs should destroyed at 99.99% (UNEP concept, destruction efficiency DE). The DE concept is related to all processes in mass (kg) and based on an identification of the degree of decontamination and environmental release. In the case of a transformer, the calculation should include the different parts

in mass (steel, copper, oil, paper, and wood) and the environmental release resulting from the process (air, water, soil emissions and waste in the landfill)

- Recycling or reusing of materials with a concentration level lower than 50 ppm is the most appropriate environmental approach
- İncineration is one solution, but it should be done based on an environmental protection system (based on the EU or US air, soil and water regulations)
- Landfilling is limited to the hazardous waste which cannot environmentally and economically be recycled or reused or incinerated
- As soon as possible, a local solution should be implemented to limit trans-border waste movement so that the supplier conforms to the relevant regulations.

All these actions should based on environmental and economic evaluation, and the company should choose the best compromise between the pollution level and the cost of removal. For example, paper and wood in the parts of a transformer cannot be reused or recycled after decontamination; the segregation yields a non-commercial paper for recycling, and the final disposal is using them as energy materials.

DO

a) Removal plan

The transformers should be classified based on the previous criteria

1) The first step of the removal process should take the following into account:
    a. the transformers which include PCBs greater than 500 ppm,
    b. end of life and having leakage risks,
    c. The transformers having less role in the process (based on the number of maintenance actions needed, capacity or other technical criteria)
2) The second step concerns the transformers that polluted less than 500 ppm but more than 50 ppm. Since the transformer had included a dielectric oil, it was not supposed to have operated at high temperatures. Also, some pollution could result in a PCB cross-contamination during maintenance in the use phase (e.g., refill with polluted oil). If transformers do not need to be handled and transported, they may continue to remain in use.
3) The third step is relative to the hazardous waste generated during the phase of decontamination and dismantling of the transformer. All the tools, gloves, spills, absorbents used for the decontamination and dismantling should be put in a hazardous waste bin and treated in a hazardous waste disposal site.

b) Decontamination and removal of the transformer

For one transformer, we should have many PCB end-of-life solutions:

- ✓ For PCB oil less than 5000 ppm, a sodium reaction could drop the PCB level by 5 to 10 ppm following the application of the process
- ✓ The empty transformer (the oil refills and retaining the wood and paper inside the transformer) could treated, and the different parts should show a concentration of less than 10 ppm after vacuum treatment.
- ✓ Active carbon treats the air with a destruction efficiency of 99.97%
- ✓ Air emission monitoring could detect the level of environmental pollution

The technologies and methods of treatment and disposal may separated into two categories:

- ✓ The first is to separate and concentrate a pollutant (e.g., solvent extractions and thermal desorption). EU regulations mandate a plan to reduce solvent uses
- ✓ The second is to destroy the contaminant (e.g. incineration, dechlorination or biodegradation)

Globally, the existing destruction technologies are;

- Autoclaving
- Alkali metal reduction
- Base catalyzed decomposition
- Co-incineration in cement kilns
- Supercritical water oxidation
- Thermal desorption
- Waste to gas conversion
- Hazardous waste incineration
- Plasma Arc destruction

The company should choose the best technologies:

1) the global environmental and economic cost of the treatment and disposal including the risks for the protection of workers' health and safety,
2) the guarantee of DE – destruction efficiency in the global process including the release to the environment in % of mass,
3) the location of the technology and the extent of reuse of stockpiled equipment

CHECK

The removal plan, the treatment, and the removal of the materials should based on indicators that monitor the process.

The company should determine the following for removal plans:

1) The duration of the action plan that achieves a zero-PCB objective. Based on the PCB inventory, the company should measure and fix the number of investments needed to replace all PCB transformers.
2) The PCB inventory should give an amount of PCB in mass, and this indicator should be a management indicator.

For the treatment and removal action, the company should base the evaluation of treatment on:

1) The best offer is assuring the DE including the measurements, which support DE and the indicators to monitor it. In the case of incineration, air and combustion residues should considered,
2) The best offer assuring the maximum reuse or recycle of materials in mass
3) The location of the system and in case of transport, the implementation of transport safety rules,

Some indicators should be implemented and sent to the company in each phase (e.g., results of decontamination process) [31]

[31] Source APROCHIM

Table 4.1 Table of PCB Decontaminated Materials on 6000 t

Materials	Quantity(Ton)	Contamination (ppm)
Metal Plates	1446	6
Steel	1097	4
Dechlorinated Oil	910	6
Copper	417	3
Electric cabinet	400	2
Oil <50 ppm	348	14
Electrical terminal	275	1
PCB liquid	183	PCB
Non Polluted transformer	114	12
Wood paper	104	PCB
Capacitors	100	PCB
Aluminium	79	11
Resin Block	27	1
Porcelain	25	1
Oil 5000-10000 ppm	22	PCB
Non Polluted Wood	19	4
Non Polluted Capacitors	13	12
Brass	10	7
Red Copper	9	4

ACT

The process should implemented with a sustainable method and management should determine the level of the resources that can be budgeted and expensed.

1) Environmental clean-up of PCBs due to unintended releases

A transformer's life cycle analysis should take account of potential pollution due to the use, storage of PCB oil or pure PCBs in the past, and of the potential for cross-contamination.

To ensure the clean-up of the site and prepare it for some future activities, the company should:

- ✓ Identify the level of PCB pollution,
- ✓ Develop a removal and remediation plan,
- ✓ Use the best available technologies to decontaminate and recover materials, and
- ✓ Replace (if needed) the polluted materials.

In this context, the PCBs included in a closed system are not a threat, but the emission from open and partially open equipment may pollute materials in the nearby vicinity. The origins of this pollution include the internal part of a transformer, the tools used for the maintenance of contaminated equipment, leakage to the soil, wastewater and by rainwater, and hazardous and non-hazardous waste.

Fortunately, PCBs are hydrophobic and cannot dissolve in water or a liquid. PCBs are not an oil/lubricant but can be used as an oil to support its dielectric and heat isolation properties.

2) Implementation of a sampling plan to identify the pollution level of the site

The most difficult issue is to identify the different cross-contaminated areas and parts of the equipment. the implementation of a sampling plan based on the following items can clarify this situation:

- ✓ Identify the sources of PCB pollution

- ✓ The duration of the pollution
- ✓ The nature of potential pollution around each source of pollution (e.g., leakage, decanting)

In the case of soil pollution, the sampling plan should include a 3D simulation due to the capacity of the medium (oil or other).

The media in which PCB pollutants found include:

- Soil
- Sediments in case of wastewater discharge
- Vegetation

Sampling should be done as soon as possible at all potentially polluted areas (soil, grass, sludge, etc.) and the results should normalized in a representative form (one hectare of grass, one m^3 of soil).

The sampling, which is composed of different materials such as soil plus stone and others, is considered as a "complex sampling." One sampling with one material is named “simple sampling.”

The different results are represented as a part of the system and should expressed in ppm. A result greater than 50 ppm considered as polluted.

3) Strategy to decontaminate PCB pollution resulting from the use of PCB- containing transformers

After conducting the PCB inventory for the site(s), the company should design a decontamination plan which considers:

a) The capacity to disperse PCB pollution (e.g., in case of PCB pollution following a permanent leakage, the area of the potential pollution must be defined)
b) The potential cross-contamination (e.g., spill materials used to make a sampling should destroyed as hazardous waste).

The decontamination process for the site is related to the contaminated material. The choice of technology is directly related to:

- ✓ pollution level,
- ✓ future uses of the site (industrial, commercial or housing activities), and
- ✓ duration of site usage (short, medium or long-term)

The management approach should take into account that decontamination is the best way to ensure workers’ health and safety, maintain the value of the site, ensure the future of the company, and demonstrate due diligence to protect the company assets.

From an economic perspective, it is less costly to decontaminate than to mitigate the impacts of pollution in affected communities (external health and environment costs). Moreover, companies that decontaminate may benefit from engaging stakeholders in local communities about the results they have achieved in partnership with the government and with private investment funds.

Sometimes clean-up technologies should be performed in-situ to limit the transportation (e.g., biological treatment of soil; or with transformers, the use of in-situ dechlorination or vacuum process). The objectives should also take into account the DE concept.

CHAPTER 5: HANDLING PCB-CONTAMINATED EQUIPMENT, INCLUDING EMERGENCY RESPONSE

5.1 BACKGROUND INFORMATION

For several reasons, PCB-contaminated equipment may need to be handled and transported. Waste management activities associated with handling and transporting are subject to extensive international as well as national regulations.

5.1.1 Packing According to International Agreements

An accredited company shall verify the conformity of the handling and packaging by ADR, RID, IATA or IMDG rules.

Each system is specific, but the rules are similar

1) The packaging must protect the content against shocks, fire or accident
2) The packaging must protect the environment
3) The packaging must be labeled to identify the hazardous goods

Each package shall labelled with an adequate sign

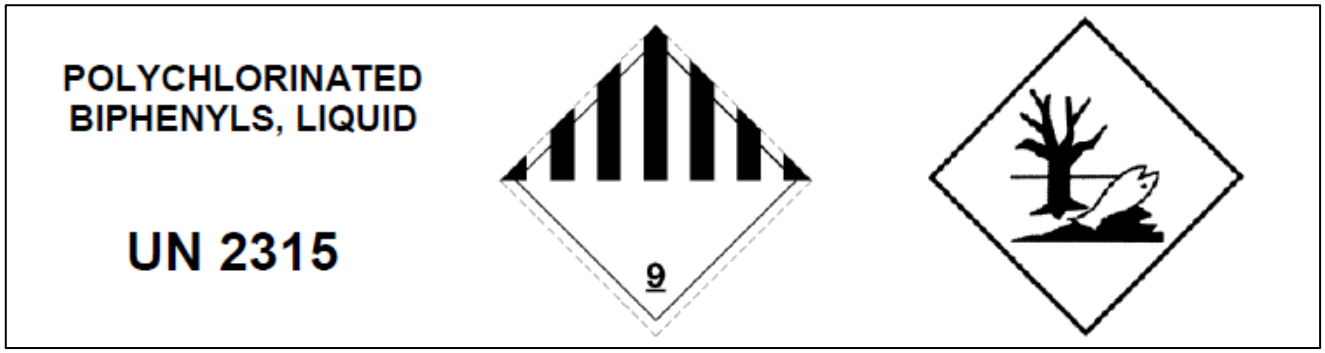


Figure 5.1 Transport Labeling for PCB Containing Transformer

4) The documentation shall conform to applicable international conventions such as the BC which limit the international transfer of dangerous waste

5.1.2 Labelling of Containers for PCB Transports

As early as possible in handling and transporting, packaging must conform to international standards (UN packaging codes) including MARKS and Labels

MARKS: **Proper Shipping Name**
and
UN Number
and
Marine pollutant mark (if applicable to the substance)

LABELS: **Hazard class label for each class and sub-risk**
(diamond-shaped at least 100mm x 100mm)
Labels may be stencilled, printed or stuck on the package.

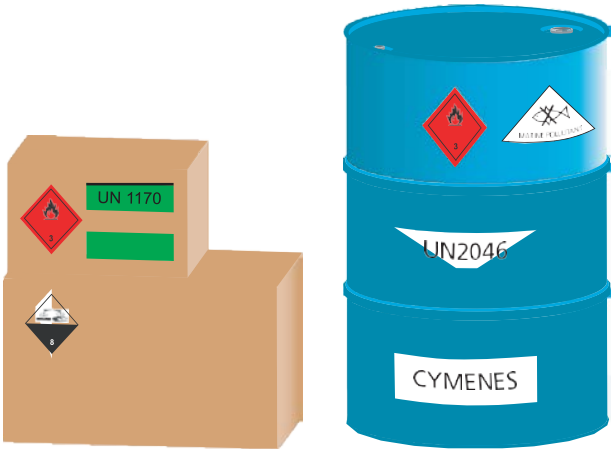


Figure 5.2 Packaging, Mark, and Labels for IMDG Rules (Sea Transport)

Figure 5.3 Over Pack Labels

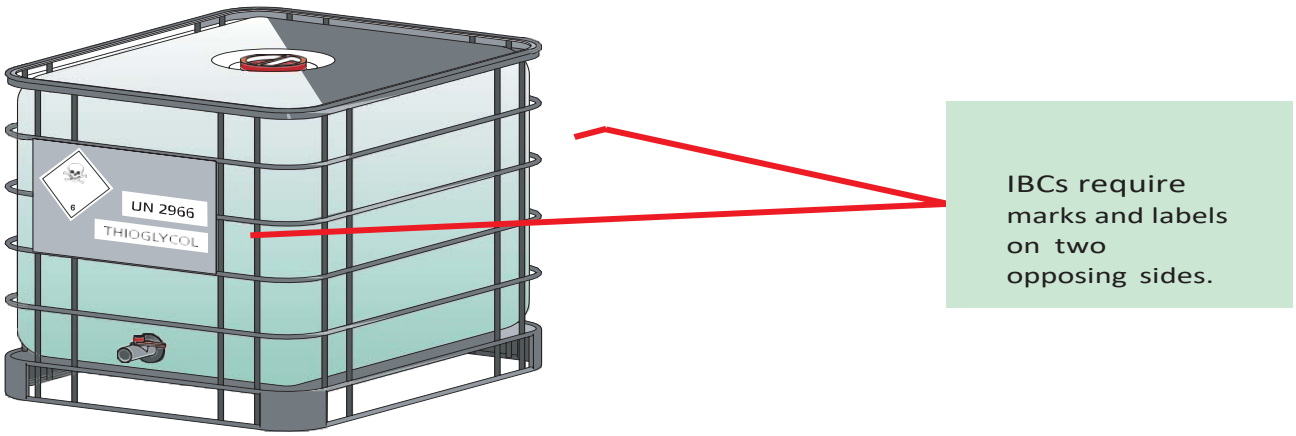


Figure 5.4 Marks and Labeling Requirements

Dangerous goods shall segregated, but some compatible products may be packaged together

Figure 5.5 Compatible Hazardous Products for Shipping

Figure 5.6 UN Marks for Highly Dangerous Goods

5.1.3 Handling of Packed Waste

All steps in the transport solution (pick-up to delivery) shall keep the same packaging

Figure 5.7 Truck Platform Double with a Liquid Retention Steel Tank

Figure 5.8 Handling of Capacitors

5.1.4 Transport

The transport mode shall be

- ✓ by truck (road)
- ✓ by train
- ✓ by sea
- ✓ by air

The specific codes are the following issues

- ✓ ADR is related to the road transport rules
- ✓ RID is related to the train transport rules
- ✓ IATA is related to the air transport rules
- ✓ IMDG is related to the sea transport rules

The key logistics challenges facing business can be broken down into the following major categories:

An Integrated Logistics Approach: Sound logistics practices require a strategic approach to transport goods between suppliers, manufacturing or distribution locations, warehousing facilities and clients and all intermediate points of the supply chain in between. Known in the logistics industry as "supply chain management," your first consideration should be towards establishing the integration of the many links in the supply chain to eliminating duplication of effort and minimizing expense. Strategic planning in procurement, transportation, receiving, materials management, sales, import and export logistics is, therefore, the first crucial consideration for anyone planning a transportation logistics strategy. Here, establishing an integrated supply chain network through the services of a third-party logistics provider may prove an effective means of developing the right transportation strategy for your particular business.

Carriers, Containers, and Transportation Options: To maximize efficiencies regarding both cost and timeliness, businesses must familiarize themselves with the range of

transportation options available and attempt to organize the most effective modes, efficient use of equipment, routing, packaging and containerization methods. For some businesses, the freight forwarder, an expert in arranging the movement of freight domestically and internationally, proves an invaluable ally in the negotiation of the most efficient, cost-effective approach to these considerations.

International Trade Regulations- Compliance Issues: International Trade law is constantly evolving. For example, recent initiatives by Customs regulators in Canada and the USA have resulted in a changed approach to customs compliance, from the transaction-by-transaction review to the responsibility of the importer/exporter to maintain self-compliance. Fulfilment of the reasonable care requirement demands vigilance. Importers and Exporters must keep abreast of all developments in the law and must be prepared to adapt their business to a changing trading environment. To ensure that your firm minimizes the risk of monetary penalties, seizures, and forfeitures that can result from Customs non-compliance, it is vital to adopt a pro-active approach.

For goods moving internationally, not only do procedures and legislation imposed by the Customs and Revenue Agency has to considere. The international trade has to be aware of the requirements of Other Government CME Transportation Best Practices- Logistics Consultants PF Collins International Trade Services ii Departments, quotas, sanctions and restrictions, and, in many cases, the special regulations imposed by foreign governments to control the movement of goods across their borders. Professional expertise and guidance are available through customs brokers and consultants who can help you navigate the maze of legislation governing international trade.

While there are certainly myriad regulations and considerations to be made in managing risk and following best practices for the transportation program, exporters and manufacturers should rest assured that assistance is available through wide variety of sources. The world of international trade, like all new adventures, can be as complex or as simple as you choose to make it. Good navigators can help to avoid pitfalls and misadventures. Seek help and keep a critical eye. Find out what services apply to you and then you be the judge as to your requirements.

The Best practices of logistics: 10 steps [32]

- ✓ Step 1: Select Key Carriers/ Forwarders and Improve Freight Tariffs
- ✓ Step 2: Assess Internal/External Resources for the Transportation Program
- ✓ Step 3: Freight Consolidations: Making the Best Transportation Choices
- ✓ Step 4: The Right Equipment for the Job
- ✓ Step 5: Freight Bids and Spot Market
- ✓ Step 6: Import/Export Considerations- Maximize Compliance
- ✓ Step 7: Consider Incoterms 2000 (Shipping Terms) with Suppliers and Clients
- ✓ Step 8: Establish Strategic Partnerships
- ✓ Step 9: Optimize Freight- Think Strategically
- ✓ Step 10: Link the Entire Supply Chain

The choice of the transport cannot be based only on the economic considerations but also the risk analysis to limit handling and of course, the risks of an accident.

In the modern system, the main system to transport PCB materials is containers.

[32] http://www.tw.gov.nl.ca/publications/bestpracticesmanual.pdf

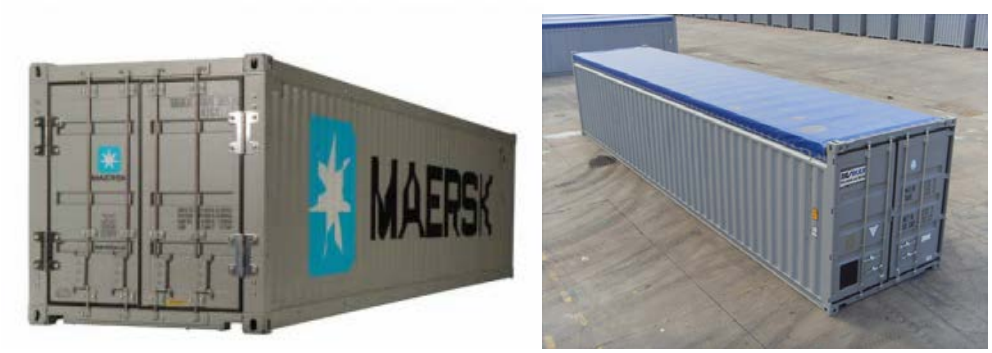


Figure 5.9 Container 40HQ" and Open Top Container

5.1.5 Documents for Transboundary Movements

The international transport need a long list of documents

1. Locate international supplier. Negotiate transaction and payment terms (Letter of Credit or other terms) Set Contracts Payment terms/ Incoterms.
2. Purchase Order
3. Packing List
4. Commercial Invoice Prepares Export Documents required by originating country.
5. Transportation Waybill(s)
6. Arrange Customs Clearance (Buyer/ Seller responsibility per Incoterms)
7. Commercial Invoice, Customs Invoice Copy of carrier waybill Certificate of Origin Permits (if required)
8. Customs Coding Form presented for final accounting/payment of duties and taxes.
9. Receiving Report. Inventory Report. Payment issued, entered in General Ledger Customs Compliance

For the hazardous goods, the RC requires an export license and an import license and a double check for the international information about the transboundary transfer in case of hazardous waste (PCB containing equipment). Some administrative licenses could demand 6 months or more delay.

At the national level, we can use also the following letter

Letter for Carrier

Several types of letters shall be printed to transport the dangerous goods,

e.g., letter for carrier in the CMR system (road)

Table 5.1 Letter for Carriage (French and English)

<table>
<tr><td colspan="3">1 Sender</td><td colspan="6">INTERNATIONAL CONSIGNMENT NOTE
This carriage is subject notwithstanding any clause to the contrary to de Convention on the Contract for Carriage of Goods by Road (CMR)</td></tr>
<tr><td colspan="3">2 Consignee</td><td colspan="6">16. Carrier</td></tr>
<tr><td colspan="3">3 Place of delivery of the goods</td><td colspan="6">17. Successive Carriers</td></tr>
<tr><td colspan="3">4 Loading places of the goods</td><td colspan="6" rowspan="2">18. Carrier´s reservations and observations</td></tr>
<tr><td colspan="3">5 Documents attached</td></tr>
<tr><td>6- Marks moreover, numbers</td><td>7 Number of packages</td><td>8 Method of packing</td><td>9 Nature of the goods</td><td>10. Statist. No .</td><td>11 Gross weight, kg</td><td>12 Volume m3</td><td></td></tr>
<tr><td colspan="3" rowspan="8">13 Sender´s Instructions</td><td colspan="6">19. Special agreements /</td></tr>
<tr><td colspan="2">20 To be paid by</td><td>Sender</td><td colspan="3">Consignee</td></tr>
<tr><td colspan="2">Carriage charges</td><td></td><td colspan="3"></td></tr>
<tr><td colspan="2">Reductions</td><td></td><td colspan="3"></td></tr>
<tr><td colspan="2">Balance</td><td></td><td colspan="3"></td></tr>
<tr><td colspan="2">Supplem. charge</td><td></td><td colspan="3"></td></tr>
<tr><td colspan="3" rowspan="3">14 Instruction as to payment for carriage / Instructio pour le transport</td><td colspan="2">Other charges</td><td></td><td colspan="3"></td></tr>
<tr><td colspan="2">Seguro Assurance</td><td></td><td colspan="3"></td></tr>
<tr><td colspan="2">TOTAL</td><td></td><td colspan="3"></td></tr>
<tr><td colspan="3">21 Established in .... on .... /</td><td colspan="6">15 Cash on delivery</td></tr>
<tr><td colspan="2">22
Signature and stamp of the sender</td><td colspan="3">23
Signature and stamp of the carrier</td><td colspan="4">24 Goods received / Merchandises reçues
Place on
Signature and stamp of the consignee</td></tr>
</table>

Letter of Indemnity

A shipping line may request a Letter of indemnity form as a condition of acceptance for controlled temperature dangerous goods. These state that while the line carries out due diligence to care for the machinery in the shipping container controlling the temperature, the line bears no responsibility for consequences of failure or malfunction of that machinery.

Competent Authority Approval

There are occasional circumstances when a shipment made under conditions that are prohibited by the IMDG Code but are nevertheless safe, because of special circumstances. In such a case the competent authority of the country of shipment is requested (in advance) to issue a certificate of approval for the shipment to go ahead. There may be conditions attached, and a time limit.

The competent authority considers the request and only if convinced that there is no increased risk, issue a certificate of approval for the transport to go ahead. It must send to the shipping line, and a copy must travel with the goods.

5.1.6 Emergency Plans

Each company is supposed to have an emergency response plan, and the personnel who perform sampling are supposed to be informed what to do in case of emergency.

- ✓ Natural events like earthquakes
- ✓ Floods or hurricanes,
- ✓ Fires or chemical incidents around the site

A PCB emergency can occur with equipment in service, in storage, during transport or at a disposal facility. Types of emergencies include:

- ✓ A leak or spill of PCB liquid
- ✓ The failure of a piece of in-service equipment
- ✓ The accidental breach of a container of PCBs
- ✓ Fires

PCB Emergencies Types

- ✓ **A cold incident** caused by unintended mechanical damage to the transformer's cooling fins causing the seeping of PCBs from a device to the environment or other situations (draining activities)
- ✓ **Hot Incidents** caused by short circuits or a fire in the vicinity of the equipment. In case of a «hot incident» the temperature in the device exceeds the boiling point of PCBs (approx. 300°C).

The PCB emergency plan is a part of the company's overall Emergency plan which should tested at least once a year.

In earthquake-prone regions, each company is supposed to have a specific emergency plan (e.g., office workers sheltering under a desk).

If there is a problem with PCB-containing transformers, the emergency plan is not the same.

The emergency plan of the company should cover the PCB containing transformer as a part of risk analysis and emergency response.

The following two cases that should be covered in the emergency plan:

1) Emergency response to cold PCB incidents (leakage, dumping during maintenance, discharge)
2) Emergency response to hot PCB incidents (electric arc, hot temperature in the transformer due to a lack of dielectric oil)

5.1.7 Procedure in Case of Leaks and Spills

A. Emergency response for cold PCB incidents should implemented in the following order (the incident can be a leak into a containment system, a spill on concrete or asphalt, a spill on soil or a spill into water). The response should adapted to the situation[33]
    1) Notify the plant chemical response personnel and relevant authorities,
    2) Inform the responsible doctor and put on adequate PPE
    3) If applicable, disconnect the concerned equipment from power and check earthing
    4) Plug or dike all drains to sewers and ditches, use absorbents (e.g., sand, cement)
    5) Stop the source of the leak by using appropriate materials and place a drip-tray under the leak
    6) Spill confinement: build dikes to hold PCBs in a small area
    7) Cover with plastic to minimize runoff from rain
    8) Dam area if possible and close navigable water to vessels
    9) Confine contaminated area, erect tent with compartments
    10) Use the pump to transfer liquids containing PCBs into drums. Soak up PCB with absorbents
    11) Use dredges to collect the contaminated soil/sediment
    12) Repeat solvent scrub process followed by a sorbent clean-up
    13) Take core samples to determine remaining contamination – 2.5 cm depth in concrete and asphalt, 60 cm on soil
    14) Break off contaminated concrete
    15) Pack wastes according to ADR and dispose of as hazardous waste
    16) Monitor wells and other bodies of water in the vicinity of PCB contamination

[33] Based on UNEP Environmental Sound PCB Management Guide 2015

Figure 5.10 Different Types of Spill in the Environment

Figure 5.11 How to prevent pollution

- If there is not proper PPE, get one.
- Put drained liquid in appropriate containers
- If possible, a drip tray should placed under the leak
- Prevent the contamination of watercourses by PCBs
- Drains, as well as culverts and pipes that lead to open waters, must be sealed
- PCB pollution is invisible (PCBs are heavier than water)
- Fence off and mark the contaminated area.
- In the case of large spill erect a tent at the boundary of the emergency area and the rest of the site
- Use the tent to put on/take off personal protective equipment every time personnel enter/leave the contaminated zone
- In the contaminated area, use shoe protection


Figure 5.12 Galoshes for a Contaminated Area and Tent to Limit Cross-Contamination

- After a cause investigation, the different types of polluted materials shall segregated:
    - Water and mixed liquids in drums
    - Oil in drums
    - Polluted soils in containers
    - Mechanical pieces on trays
- The tent shall protect against rain and wind dispersal
- In a building, evacuate all the people inside
- Alert the administrative authorities
- Initiate risk communications

5.1.8 Procedure in Case of Fire

Hot incidents should managed with greater caution

- High temperature may develop
- Fire and combustion can create a toxic cloud and an internal and external disaster

Figure 5.13 Fire in Chemical Industry

If this happens locally, even for a short time only (e.g., short circuit), PCB vapors can be released, and they can contain highly toxic Furans (PCDFs). If PCBs get in contact with oxygen (fire), not only Furans but also Dioxins (PCDDs) can be formed. PPE respiratory protection is needed.

Professional firefighters are competent to limit and stop a fire. The local team shall give some information about the site and the associated risks (storage of flammable materials, stormwater drains) to help limit the spread of pollution.

Emergency actions shall developed:

4) Call the firemen and describe the situation,
5) Implement the chemical response plan,
6) Switch off the power supply,
7) Hermetically seal the rooms or the entire building. Switch off ventilation systems
8) Evacuate people from all concerned buildings, and on a larger scale in the direction of the wind
9) Fence off the contaminated zone and strictly control access
10) Implement the emergency action plan in case of hot incidents
11) After the fire extinguished, complete the following check-list:

Table 5.2 Checklist for Emergency Actions in Case of Hot Incidents, UNEP 2015

	Nature of Incident		
	Internal failure No Bursting of equipment	Internal failure of capacitor Bursting of equipment with spill	Fire in vicinity of equipment
		Beware of highly toxic furans!	Beware of highly toxic furans and dioxins!
Notify fire brigades			1
Notify plant personal chemical response and competent authorities		1	2
Inform responsible doctor and put on adequate Personal Protective Equipment (respiration masks)		2	3
Prevent people from entering the contaminated areas		3	4
Disconnect the concerned equipment from power	1	4	5
Phase out equipment	2		
Evacuate and close the building, cut out air circulation by plugging vents		5	6
Stop source: Seal leak with appropriate materials, place drip tray under link		6	
Confine contaminated area		7	7
If not protected by heavy protection overall keep clear from the danger zone. Let the specialists extinguish the fire			8
Erect tent with compartments		8	
Repeated solvent scrub process followed by a sorbent clean-up		9	10
Take core samples to determine penetration (MEP)		10 (2.5 cm deep)	11 (60 cm deep)
Take wipe samples for dioxin (MEP)			12
Break off contaminated concrete		11	13
Use dredges to collect the contaminated soil/sediment		12	14
Pack wastes according to ADR and dispose of as hazardous waste		13	15

9) Identify the cause, such as

- ✓ Internal failure like an electrical short circuit (arc)
- ✓ Other fire sources (e.g., maintenance works)

Figure 5.14 Electric Arc

5.2 FRAMEWORK FOR THE HANDLING OF PCB CONTAINING EQUIPMENT

PCB containing transformers and capacitors are closed systems (not partially open or open applications of PCBs). The best practices presented in this chapter for transportation or incident/accident cases.

During the life cycle of a transformer, the company may handle the transformer or face an emergency situation after a commissioning period.

As mentioned before, a PDCA approach is used to manage the situation when the company wishes to handle a transformer or a capacitor or when an emergency plan should be implemented.

5.2.1 Handling of PCB-Contaminated Equipment in a PDCA Approach

PLAN

For handling PCB-contaminated equipment, prepare a plan which includes:

- ✓ The area covered by the handling and transport of the equipment
- ✓ The human resources and materials needed for retention, a pump in case of refill or retro fill oil to the drums/equipment
- ✓ Safety rules to be followed
- ✓ Responsibilities
- ✓ Mandatory requirements by the management (e.g., time period for handling, guarantee of power supply)
- ✓ The co-connected activities such as production, maintenance
- ✓ The risk analysis

DO

The company should define the procedures and actions:

- ✓ To prepare an area for handling and transporting PCB-contaminated equipment
- ✓ To implement a collective protection plan for spilled materials, work limitations, a list of workers who are supposed to be on the site,
- ✓ To design the PPE needed in connection with each worker's risk analysis
- ✓ To apply the emergency rules about the electric safety (person in charge to shut off the electricity)
- ✓ To prepare the place for the restricted area of PCB-containing equipment
- ✓ To place an absorbent (plastic oilcloth) at the place in the restricted area for work.
- ✓ To check if all the safety rules are in place and the workers wear all the PPE
- ✓ To analyze the condition of all needed materials and equipment
- ✓ To install equipment for handling
- ✓ After handling and transport, all used safety materials placed in hazardous waste bins (gloves, galoshes, absorbent)

CHECK

The company should prepare an incident report about the response action, noting details about the incident, and reporting to the authorities in case of leakage or potential PCB pollution.

ACT

The company's response system should considered mature if all the actions are confirmed and verified by an internal or external audit.

5.2.2 Emergency Response

In case of emergency situations during the handling of PCB containing equipment, the principles and rules describe in *5.1.6* to *5.1.8* shall apply.

For each emergency incident, the company should prepare an incident report with a description of the event, the results of measurements taken, the effects on health, safety, and environment of the emergency. A cause analysis should be conducted a few days after (less than one week), with different participants such as witnesses, middle and top management. A formal method such as the ICHIKAWA method (Appendix 6) should be used and conducted by a trainer/ manager. Action plans should be designed to limit the occurrence of the type of incident in future.

Measures should be implemented to improve the efficiency of the emergency plan based on lessons learned.

REFERENCES

SC website http://chm.pops.int/TheConvention/

EPA **https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls-pcbs**

INERIS DRC-11-118962-11081A Version June 2012 in French

Communication from the Commission to the Council, the European Parliament and the Economic and Social Committee on Community Strategy for Dioxins, Furans and Polychlorinated Biphenyls COM (2001) 593

Study on waste related issues of newly listed POPs and candidate POPs: Final report (2010): **Corrigendum of 29 September 2005**

Final report on the study to Facilitate the Implementation of Certain Waste Related Provisions of the Regulation on Persistent Organic Pollutants (POPs) (2005)

UNEP March 5, 2015, Environmental Sound PCB Management Guide (Mediterranean Region)

"PCB Management Guidance, Maintenance, Handling, Transport and Interim Storage of Liquids Containing PCB and Equipment Contaminated with PCB" prepared by UNEP and PEN for the Stockholm Convention

"GUIDELINES FOR ENVIRONMENTALLY SOUND MANAGEMENT OF PCBS IN THE MEDITERRANEAN" prepared by UNEP.

Preparation of a National Environmentally Sound Management Plan for PCBs and PCB-Contaminated Equipment" prepared by UNEP for the Basel Convention

CHEMSSUISSE Identification and disposal for PCB containing condensators, information for electric safety professionals Identification et élimination des condensateurs contenant des PCB, Information Conseillers en sécurité électrique in french http://www.chemsuisse.ch/fr/type-d-activite/pcb

APPENDIX 1 ABBREVIATIONS

Term	Definition
ADR	European Agreement on the international road transport for hazardous goods
α-*HCH*	Alpha hexachlorocyclohexane
BAT	Best Available Techniques
B.C	Basel Convention
BEP	Best Environmental Practice
β-HCH	Beta hexachlorocyclohexane
Br.C.	BARCELONA CONVENTION
c-decaBDE	Decabromodiphenyl ether
c-Octo	Hexabromodiphenyl ether and heptabromodiphenyl ether
c-pentaBDE	Tetrabromodiphenyl ether and pentabromodiphenyl ether
DDT	Dichlorodiphenyltrichloroethane
DE concept	Destruction Efficiency - the DE concept is related to all the process in mass (kg) and based on an identification of the degree of decontamination and environmental release. For PCB destruction the level shall be 99.99%
DEHP:	Bis(2-ethylhexyl) phthalate
DIN	Deutsches Institut für Normung (German Institute for Standardisation)
e.g.	Exempli Gratia / for example
ECHA	European Chemicals Agency
ECD	Electron Capture Detector; Detector for GC
ELV	End of life-vehicles
EPA	Environmental Protection Agency, Federal United States agency responsible for developing environmental protection regulations and guidelines
ESM	Environmentally Sound Management
EU	European Union
GC	Gas chromatography; Procedure for the determination of evaporating substances
GEF	The Global Environment Facility (GEF) is an international financial entity with 177 countries as members
HBCCD	Hexabromocyclododecane
HCB	Hexachlorobenzene
HCBD	Hexachlorobutadiene

Term	Definition
HSE	Health, safety, and environment. Management practices developed at the worldwide level by standards such as ISO 14001, ISO 45001, and OHSAS 18001
HV	High voltage
IATA DGR	IATA regulations on the transport of hazardous goods/transport by air
IMDG	International maritime dangerous goods code/transport by sea
kV	Kilovolts
kVa	Kilovolt ampere
kW	Kilowatt
LRTAP	Long-range Transboundary Air Pollution
LV	Low voltage (230/400 V)
MAP	Mediterranean Action Plan
µg	Microgram
mg/kg	Milligram per kilogram
MV	Medium voltage (normally in the range between 11 and 66 kV)
MVA	Megavolt ampere
NAP	National Action Plan
NC	Non-conformity: Occurrence of a condition that does not conform to the specifications of the prescribed standards; Lack of conformity or agreement
ng	Nanogram (1000 ng = 1 µg)
NIP	National Implementation Plan
OECD	Organisation for Economic Cooperation and Development
PBB	Polybrominated Biphenyl
PCBs	Polychlorinated Biphenyls. Chemical substance largely used for insulation properties as for dielectric use, cables and electronic insulation
PCDD	Dibenzo-p-dioxins or dioxin; Highly toxic by-product of PCBs
PCDF	Dibenzofurans or furan; Highly toxic by-product of PCB
PCP	Pentachlorophenol
PCN	Polychlorinated naphthalenes
PCT	Polychlorinated Terphenyls
PeCB	Pentachlorobenzene
PEN	PCB elimination network under SC
PFOS	Perfluorooctane sulfonic
PIC	Prior Informed Consent

Term	Definition
POPs	Persistent Organic Pollutants
PPE	Personal Protective Equipment
ppm	Parts per million (mg/kg)
RC	Rotterdam Convention
REACH	Registration, Evaluation, Authorization, and Restriction of Chemicals
RID	Regulation of the international transport of hazardous goods/transport by rail
SC	Stockholm Convention
SCCPs	Short chain chlorinated paraffin
SVHC	Substance of Very High Concern
TCDF	Tetrachlorodibenzofuran
TDI	Tolerable daily intake
TSCA	Toxic Substances Control Act (USA)
UNEP	United Nations Environment Programme
UNEP/MAP	United Nations Environment Programme / Mediterranean Action Plan
UNIDO	United Nations Industrial Development Organization
WEEE	Waste electric and electronic equipment
WHO	World Health Organisation

APPENDIX 2 DEFINITIONS OF TERMS

Term	Definition
Askarel	Trade name of PCB cooling fluid (USA, Monsanto)
Capacitor	A capacitor is a passive two-terminal electrical component that stores electrical energy in an electric field. The effect of a capacitor is known as capacitance. While capacitance exists between any two electrical conductors of a circuit in sufficient proximity, a capacitytor is specifically to provide and enhance this effect for a variety of practical applications by consideration of size, shape, and positioning of closely spaced conductors and the intervening dielectric material. A capacitor was historically first known as an electric condenser Equipment or unit to supply lagging kilovars for power factor correction of an electric system; some capacitors manufactured with PCBs as cooling fluid
Capacitor Bank (General)	Practically there are three different ways of power factor (PF) correction: Capacitors for "individual" PF-correction; the capacitor directly connected to the terminals of equipment (motors, welding machine, etc.) producing the "lagging kilovars."
Capacitor Bank (LV)	Capacitors for "group" PF-correction; the capacitor(s) is (are) connected to the LV-busbar of a transformer station, which feeds some consumers with individual motors, welding machines, etc.
Capacitor Bank (MV)	Capacitors for "central" PF-correction; Large capacitor installation connected to the Middle- or High-Voltage busbars of a substation where many individual electrical appliances (motors, etc.) of various sizes operate at different times and periods.
Closed applications of PCBs	Capacitors and transformers, where the PCB itself is incompletely closed containers; PCBs rarely emit from closed applications (in good condition) (e.g., Transformers, Capacitors)
Congener	Depending on the number and position of the chlorine atoms in the Biphenyl molecule, 209 isomers and homolog Chlorine Biphenyls are theoretically possible. A single compound from this group is called PCB congener.
Container 20'	Internationally used expression for Transport or Storage Containers with the Standard size of 2 x 2 x 6 meters (40' Container – 2 x 2 x 12 meters)
Container Box	There are various types of 20' and 40' Containers available, the most common is the Box Container with a front door, from an open top Container the roof can removed for loading and off-loading activities (e.g., ideal for Transformers)
Cooling Fluid	Dielectric fluid
OECD	Organisation for Economic Cooperation and Development

Term	Definition
Open applications of PCBs	Applications where PCBs consumed during their use or not disposed of properly after their use or after the use of the products that contain PCBs; Open applications emit PCBs directly into the environment (e.g., softeners in PVC, neoprene and other rubbers containing chloride)
Partially Open Applications of PCBs	E.g., vacuum pumps, hydraulic fluids, switches, liquid filled electrical cables, liquid filled circuit breakers, voltage regulators, heat transfer fluids
PCDA approach	Plan–Do–Check–Act: Quality methodology used in management standards to help management implement an action plan
Persistent	Very slightly degradable in the environment
Primary source	A product to which PCB was added voluntarily to influence the product's characteristics (e.g., cooling fluids for transformers like Sovol, Sovtol, Askarel, Pyralene, Clophen). Such products emit PCBs continuously
Secondary source	A product that originally was free of PCBs, but later contaminated by PCBs emitted from primary sources (e.g., by emission from primary sources or use of contaminated pumps, hoses). Such products also emit PCBs.
Seveso	Place near Milan/Italy, where dioxin was released in 1976 during an accident and consequently contaminated wide areas of the region. EU regulations for industrial sites which can pollute the environment; the EU regulation since 1982 defines safety rules to protect people and the environment; the last text is DIRECTIVE 2012/18/UE named SEVESO II
Technical team	Internal or external group of people in charge of sampling, analysis and labeling the transformers
Transformer	Equipment used to increase or reduce voltage; PCB-containing transformers usually installed in sites or buildings where electricity distributed.
UN-approved	Equipment that fulfills the specific United Nations testing procedures

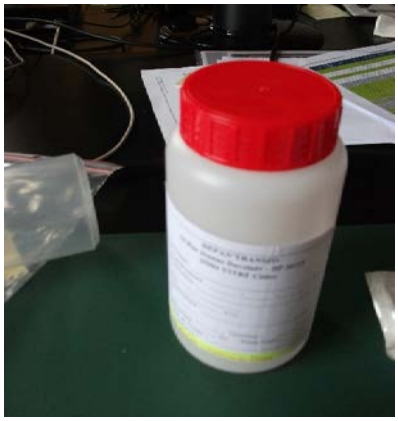
APPENDIX 3 USEFUL LINKS

Basel Convention (1989)	http://www.basel.int/
Capacitor Register, ANZECC	www.pops.int/documents/guidance/NIPsFinal/eagov.pdf
Ministry of Environment and Urbanization (Çevre ve Şehircilik Bakanlığı)	http://www.csb.gov.tr/turkce/index.php
POPs Turkey Project	http://kalicikirleticiler.com/en/
CP/RAC - Regional Activity Centre for Cleaner Production	http://www.cprac.org/
GEF - Global Environment Facility	www.thegef.org
MedPartnership	http://www.themedpartnership.org/
MEDPOL	http://www.unepmap.org/index.php?module=content2&catid=001017003
PEN – PCBs Elimination Network	http://chm.pops.int/Programmes/PCBs/PCBsEliminationNetworkPEN/tabid/438/language/en-US/Default.aspx
Rotterdam Convention (1998) PIC	www.pic.int
Stockholm Convention	www.pops.int
Stockholm Convention Training Tool	http://chm.pops.int/Portals/0/flash/popswastetrainingtool/eng/index.html
UNDP – United Nations Development Programme	www.undp.org
UNEP - United Nations Environment Programme	www.unep.org
UNEP Chemicals and waste	https://www.unep.org/chemicalsandwaste
UNEP Chemicals Manuals on PCB	https://www.unep.org/chemicalsandwaste/what-we-do/science-and-knowledge/persistent-organic-pollutants-pops/pcb-forgotten-legacy
UNEP/MAP - UNEP / Mediterranean Action Plan	http://www.unepmap.org/
UNIDO - United Nations Industrial Development Organization	www.unido.org
UNITAR - United Nations Institute for Training & Research	www.unitar.org

APPENDIX 4 SAMPLING KIT

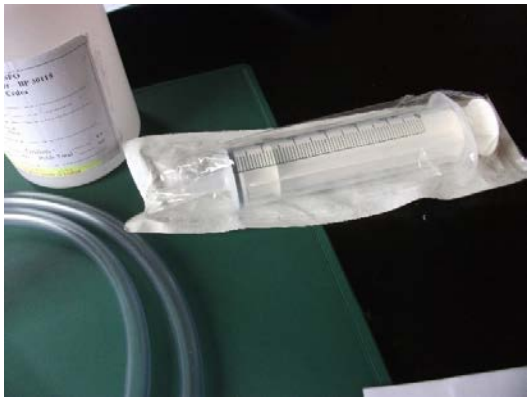
1. General view of sampling equipment

2. Pipe: « CRISTAL 8X1.5 1T/11 » and small glass bottle with a plastic cap



3. Plastic container with an inner cap of a capacity of 50cl for oil sampling

4. APROCHIM sampling document and identification label to be attached to the equipment or waste



5. Plastic sterile catheter tip of 60ml

6. Disposable resistant gloves and flexible pipe with a 3-way valve

7. 30 ml glass probe and plastic foam reinforced with rubber foam for dissolved gas.

Figure A.1 Sampling Kit

APPENDIX 5 AN EXAMPLE OF ICHIKAWA ANALYSIS

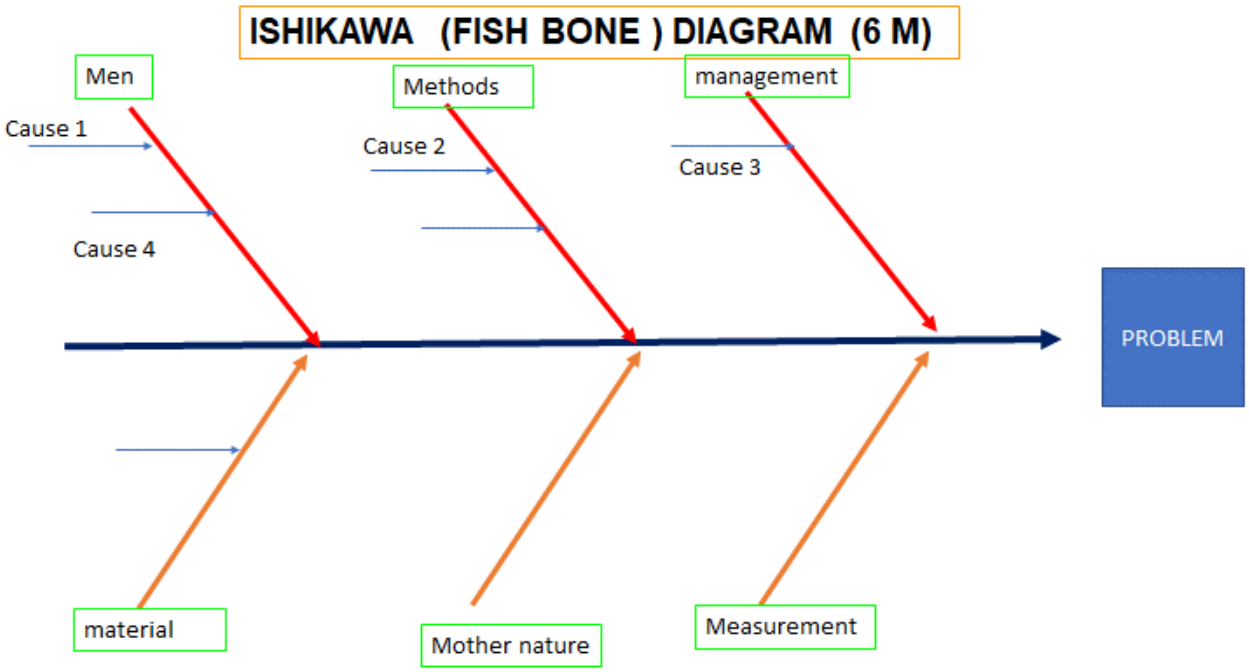


Figure A.2. Cause Analysis (ISHIKAWA)

The Ichikawa method is a cause analysis tool that performed in different situations like accident/incident analysis;

1) A team consisting of a methodology specialist (internal or external) reviews the accident/incident during a meeting (2 or 3 hours)
2) Meeting participants include the victim, the witness, the first level management and people who perform the same work as the victim
3) Questions based on the format WHY (e.g., Why was the victim at this place?)
4) The team explains the normal practices, the mandatory rules, and procedures which are applied
5) The answers reported as in the table named ICHIKAWA which designed around 5 or 6 issues named “5M” or “6M”:

i. Machine
ii. Method
iii. Material
iv. Man
v. Measurement
vi. Management

6) The questions and the answers give the cause of the accident or the incident

APPENDIX 6. LIST OF ELECTRIC PCB CONTAINING EQUIPMENT (SOURCE ANZECC)

Make	Type	Capacitance (µF)	Dimensions (cm)	Power (V)	Remarks
A.H. HUNT LTD.	14B/490D	8	14.5 x 9.0 x 6.5	440	PFCU
ACEC	SUPER VHO	3.5	7.2 x 4.8 x 3.5	400/860	Fluo. Lamp. Capacitor
AEE	PFCU		12.2 x 17.8 x 11.3	400	
AEE	RJK 90120				
AEE	RKA 1420		4.8 x 2.8 x 9.3		Paper Capacitor
AEE	RKA 1431		4.8 x 2.8 x 9.3		Paper Capacitor
AEE	RKA 1440		4.8 x 2.8 x 9.3		Paper Capacitor
AEE	RKA 14413				
AEE	RKA 14x20				
AEE	RKA 14x31		9.2 x 2.7 x 4.7		Paper Capacitor
AEE	RKA 2420				
AEE	THERMINOL FG				
AEE	THERMINOL TYPE FD				
AEE	THERMINOL TYPE FW				
AEE	THERMINOL TYPE GA				
AEE	RJL 90110	0.25	9.6 x 4.8 x 2.5		
AEE	RKA 1422	0.25	9.2 x 4.7 x 2.6		
AEE	920021 TYPE T117	0.68 + 0.39 +/- 10%	2.5 x 2.5 x 8.1	250	Polyester Capacitor
AEE	FW 61	1			
AEE	RKA 1442	1	9.5 x 4.8 x 2.8		
AEE	'TROPICAP', 710 working 782	2.0	5.1 x 1.9	150	
AEE	APO 2210	2			
AEE	No. 4, 60, A1842	2	4.1 x 2.5 x 8.1		
AEE	RKA 14413	2a2b2c2d	9.6 x 4.7 x 2.7		Paper Capacitor
AEE	RKA 14413	2 2 2 2			Paper Capacitor
AEE	RKS 14413	2 2 2 2			Electrolytic
AEE	RKA 2420	2	9.3 x 4.8 x 2.8		Paper Capacitor
AEE	FW	2.5		250	Therminol Capacitor
AEE	FW	2.7			
AEE	FW	2.8 +/-10%		250	
AEE	F 706	3			
AEE	FW	3		250	50 Hz
AEE	FW	3.25		250	50 Hz Therminol
AEE	PMN 5417	3.5			
AEE	FW	3.5 +/-10%		250	BS 4017 2368
AEE	FW	4 +/-10%		250	
AEE	RKA 14x20	4	9.3 x 4.8 x 2.8		Paper Capacitor
AEE	FW	4.5		250	
AEE	FW	5 +/-10%		250	50 Hz F911
AEE	PMG 5102	5 +/- 5%	5.0 x 2.5	250	MP Capacitor
AEE	FW	5.5			
AEE	FWF 539	5.5			
AEE		6			
AEE	FW	6			
AEE	PMN 5417	6			
AEE	PR 83	6			
AEE	FW	6./5			
AEE	NW	6.5			
AEE	FW 5714	7			
AEE	PMN 5417	7			
AEE	FW	7.5			

AEE	FW	9 +/-10%		250 VAC	50 Hz
AEE	FW	10 +/-10%		250	
AEE	FW 61	10			
AEE	RJK 90120	10	9.3 x 4.7 x 2.6		
AEE	FW	11		250	
AEE	FWF 720	12			
AEE	FW	13		250	50 cps. Therminol 61

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
AEE	FW	5 +/-10%		250	50 Hz F911
AEE	PMG 5102	5 +/- 5%	5.0 x 2.5	250	MP Capacitor
AEE	FW	5.5			
AEE	FWF 539	5.5			
AEE		6			
AEE	FW	6			
AEE	PMN 5417	6			
AEE	PR 83	6			
AEE	FW	6./5			
AEE	NW	6.5			
AEE	FW 5714	7			
AEE	PMN 5417	7			
AEE	FW	7.5			
AEE	FW	9 +/-10%		250 VAC	50 Hz
AEE	FW	10 +/-10%		250	
AEE	FW 61	10			
AEE	RJK 90120	10	9.3 x 4.7 x 2.6		
AEE	FW	11		250	
AEE	FWF 720	12			
AEE	FW	13		250	50 cps. Therminol 61

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
AEE	FW	14.0		250	50 Hz
AEE	FW	15 +/-10%		250	
AEE	FW	15 +/-10%		250	Therminol 61
AEE	FW	16 +/-10%		250 VAC	BS 4017:1966
AEE	PMN 5417	20		250	
AEE	FW	20.0 +15% -5%		250	50 Hz
AEE	RJA 2420	22			
AEE	GA	25 +15% -5%		250 VACWHG	50 cps
AEE	RKG 2023	0 + 50		64	
AEE	RKGP 2023	50a50b	9.2 x 4.7 x 2.7	64	Electrolytic
AEE	RKGP 2033	200	9.4 x 4.8 x 2.8	64	Electrolytic Capacitor
AEG (Logo Only)	900 0501	3.5 - 3.5 + 15%	6.8 x 4.5 x 3.5	380...400	Fluo. Lamp. Capacitor
AEG (Logo Only)	900250	3.6	7.0 x 4.5 x 3.5	400	Fluo. Lamp. Capacitor
AEG (Logo Only)	900213	6.3 +/-5%	6.7 x 4.8 x 3.6	250	Fluo. Lamp. Capacitor
AEG (Logo Only)	900201	8.5 +/-5%	9.8 x 4.5 x 35.2	250	Fluo. Lamp. Capacitor
AEG (Logo Only)	900210	8.5 +/-5%	9.7 x 4.5 x 3.5	250	Fluo. Lamp. Capacitor
AEG (Logo Only)	900 100a	9 -5 +15%	10.8 x 4.5 x 3.5	220...250	Fluo. Lamp. Capacitor
AEI	PL28-D/1	20 +/-10%	12.7 x 7.5 x 5.7	250	Fluo. Lamp. Capacitor
AEROVOX	1009	2	9.7 x 4.5 x 2.5	1000 DC	Fluo. Lamp. Capacitor
AEROVOX	P136F874	10.0	15.0 x 7.2 x 55.8	660	

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
AME	C2082TMC	3.5			
AME	TMC	3.5			
AME	C2241	5 +/-10%	13.0 x 3.2	250	Fluo. Lamp. Capacitor
AME (PYE TMC)	C2273	5.5 +/-10%	7.4 x 3.8	250	
AME (PYE TMC)	C2223	6.0 +/-10%		250	F/L Ballast Capacitor
AME (PYE TMC)	C2220	8.4 +/-5%		250	
AME BICC	C2224	3.5 +/-10%		250	
AME BICC	C2273	5.5 +/-10%	6.8 x 3.8	250	
AME BICC	900 101a	7 - 5.5 +10.5%	12.2 x 4.5 x 3.5	300...400	Fluo. Lamp. Capacitor
AME BICC	C2173	7.2 +/-5%	17.0 x 3.8	440	Fluo. Lamp. Capacitor
AME BICC	C2221	8 +/-10%	9.0 x 3.8	250	Fluo. Lamp. Capacitor
AME BICC	C2200	8.4 +/-5%	9.5 x 3.8	250	Fluo. Lamp. Capacitor
AME BICC	C2220	8.4 +/-5%		250	
AME BICC	C2274	10 +/-10%	11.2 x 3.8	250	Fluo. Lamp. Capacitor
AME DUBILIER	C2273 K.982	5.5 +/-10%	8.0 x 3.8	250	Fluo. Lamp. Capacitor
AME F	C2241	5 +/-10%		250	
AME F	C2273	5.5 +/-10%	7.4 x 3.8	250	
AME HUNTS	C2241	5 +/-10%	12.3 x 3.3	250	Fluo. Lamp. Capacitor
AME HUNTS	C2166 List No. ZG996A WNE	5.5 +/-10%	7.0 x 3.8	250	Fluo. Lamp. Capacitor
AME HUNTS	C2274 ZG1669AE	10 +/-10%	11.5 x 3.7	250	Fluo. Lamp. Capacitor

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
AME TMC	C2092	3.5 +/-10%	8.5 x 3.2	250	Fluo. Lamp. Capacitor
AME TMC	C2273	5.5 +/-10%	7.3 x 3.8	250	
AME TMC	C2203	6 +/-10%	7.3 x 3.8	250	F/L Ballast Capacitor
AT&E Co.	872, 102, H5/1, L68337	2	2.5 x 4.1 x 8.1		
ATE	305, 94, H47/1, QA, L68066	0.5 + 0.5	1.3 x 4.1 x 8.1		
ATE	105, H4711, L68072, 1448	1	8 x 4 x 2.5		
ATE	261, H59, No. 3	1			
ATE	873?, 105, H49/1, L68072	1 + 1	2.5 x 4.1 x 8.1		
ATE	110, 102A, H56/2, L68073	2	1.3 x 4.1 x 8.1	150	
ATE	L 68337, 102, H61/1	2			
ATE	L68337, 102, H60/2	2			
BICC	BF		2 units @ 23.0 x 15.0 x 10.5	415	PFCU
BICC	K25		3 units @ 29.5 x 15.0 x 10.5	415	PFCU
BICC	KC		16.0 x 15.0 x 11.5	400/415	PFCU
BICC	KF		10.3 x 15.0 x 10.2	400/415	PFCU
BICC	KH		16.5 x 15.0 x 10.5	415	PFCU
BICC	KK		17.0 x 15.0 x 10.5	400/415	PFCU
BICC	KL		23.0 x 15.0 x 10.5	400	PFCU
BICC	KM		23.0 x 15.0 x 10.5	400/415	PFCU
BICC	KP		29.5 x 15.0 x 10.5	415	PFCU

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
BICC	LD		10.0 x 15.0 x 10.3	400/415	PFCU. NEECO Capacitor.
BICC	V16132		12.0 x 17.0 x 9.5	400	PFCU
BICC	BB-4-70	3.7 +/-5%	9.4 x 3.8	380	Fluo. Lamp. Capacitor
BICC	AKE C2173	7.2 +/-5%	12.8 x 3.8	440	Fluo. Lamp. Capacitor
BICC	BB-11-69	15 +/-10%	7.8 x 7.8 x 5.2	250	Fluo. Lamp. Capacitor
BICC	GC 2384/b1/L	15 +/-10%	6.7 x 4.5	250	Fluo. Lamp. Capacitor
BICC	C2164	4/5.5	7.8 x 5.6 x 3.8	275	Fluo. Lamp. Capacitor
BICC - NEECO	LL		23.0 x 15.2 x 11.5	400/415	PFCU
BOSCH	FPO 670321469	3.5			
BOSCH	FPO 9670313333	3.5			
BOSCH	HPF 670321532	6.5			
BOSCH	FPDIN 48511	9			
BOSCH	HPF 670321478	12			
BTH	PL.28A/2		12.5 x 7.0		Fluo. Lamp. Capacitor
CDG	EJW 145.25	145/174			
CPL		6			
CPL		6.5			
CPL		7			
CPL		20			
DALY	MSML 457/85	120/150			

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
DANCO		9			
DAWCO	BS4017 1966	3			
DAWCO		9			
DICC		1			
DUBILIER	440		30.5 x 13.0 x 9.0	415	PFCU
DUBILIER	DS 21172		25.0 x 13.0 x 8.5	240/415	PFCU
DUBILIER	K 1132	10 +/-10%		250	
DUBILIER DUCONOL	6807		15. x 13.0 x 8.5	400	PFCU
DUBILIER DUCONOL	6850		12.0 x 12.5 x 9.0	415	PFCU
DUBILIER DUCONOL	6911		20.0 x 13.0 x 9.0	240/400	PFCU
DUBILIER DUCONOL	6941		12.5 x 8.5 x 6.3	415	PFCU
DUBILIER DUCONOL	6947		8.0 x 8.5 x 6.5	415	PFCU
DUBILIER DUCONOL	DS 20916		12.0 x 12.8 x 8.5	415	PFCU
DUBILIER DUCONOL	DS 20917		14.5 x 12.5 x 8.5	415	PFCU
DUBILIER DUCONOL	DS 20918		17.0 x 13.0 x 9.0	415	PFCU
DUBILIER DUCONOL	LL		25.5 x 13.0 x 9.0	400	PFCU
DUBILIER DUCONOL	SD		25.2 x 12.6 x 8.8	400	PFCU
DUBILIER DUCONOL	TH		17.6 x 12.6 x 8.8	400	PFCU
DUBILIER DUCONOL	TJ		17.5 x 12.5 x 8.5	400	PFCU
DUBILIER DUCONOL	UG		15.5 x 8.5 x 6.5	400	PFCU

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
DUBILIER DUCONOL	VL		17.8 x 12.8 x 8.8	400	PFCU
DUBILIER DUCONOL	WH		18.0 x 12.5 x 9.0	400	PFCU
DUBILIER DUCONOL	XG		7.6 x 12.8 x 8.8	400	PFCU
DUBILIER DUCONOL	XM		12.5 x 13.0 x 8.8	415	PFCU
DUBILIER DUCONOL	YK		10.0 x 13.0 x 8.8	415	PFCU
DUBILIER DUCONOL	K 454 VD 2837	8 +/-10%	7.7 x 6.7 x 4.0	250	Fluo. Lamp. Capacitor.
DUBILIER DUCONOL	K 951 6904 37	10 -5 +7.5%	11.7 x 5.5 x 3.6	250	Fluo. Lamp. Capacitor
DUBILIER DUCONOL	K 446 VE 0340	15 +/-15%	10.8 x 7.6 x 5.0	250	Fluo. Lamp. Capacitor
DUBILIER DUCONOL	K 677 WG 1442	15 +/-10%	10.8 x 7.6 x 5.0	275	Fluo. Lamp. Capacitor
DUBILIER DUCONOL	K109 QK 1941	20 +/-20%	11.5 x 8.5 x 6.5	275	PFCU
DUBILIER DUCONOL	K109 RG	20 +/-20%	11.5 x 8.5 x 6.5	275	PFCU
DUBILIER DUCONOL	K 427 VJ 0637	20 +/-10%	12.5 x 7.8 x 5.2	250	Fluo. Lamp. Capacitor
DUBILIER DUCONOL	K587 VE 1642	20 +/-10%	12.5 x 7.6 x 5.0	250	Fluo. Lamp. Capacitor.
DUBILIER DUCONOL	K 676 WH 2123	20 +/-10%	12.5 x 7.6 x 5.0	275	Fluo. Lamp. Capacitor
DUBILIER DUCONOL	K 805 XM 1434	25 +/-10%	11.5 x 7.5 x 5.0	250	Fluo. Lamp. Capacitor
DUBILIER DUCONOL	K985 7104 408	25 +/-10%	11.5 x 7.5 x 5.0	275	Fluo. Lamp. Capacitor
DUCATI	16.38.51	15 +/-10%	9.5 x 7.0 x 4.5	370	Fluo. Lamp.
DUCON	@1		8.1 x 4.1 x 2.5		
DUCON	10N05				
DUCON	10N40				

Make	Type	Capacitance	Dimensions (cm) Power (V) Remarks
		(µF)	
DUCON	11N100		
DUCON	11N20		
DUCON	11N40		
DUCON	11N80		
DUCON	12N70		
DUCON	12N80		
DUCON	12P01		
DUCON	14N40		
DUCON	17N10		
DUCON	1BS160		
DUCON	1BS80		
DUCON	1S100		
DUCON	1S40		
DUCON	2S160		
DUCON	3S01		
DUCON	3S05		
DUCON	3S10		
DUCON	3S12B		
DUCON	3S100		
DUCON	3S20		

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
DUCON	3S80				
DUCON	4N50				
DUCON	4S50				
DUCON	4S80				
DUCON	4S160				
DUCON	4S400				
DUCON	5S05				
DUCON	8N10				
DUCON	8N100				
DUCON	8N80				
DUCON	9N20				
DUCON	9N80				
DUCON	25500				
DUCON	EM 851				
DUCON	FPL 202449				
DUCON	GPM 435 LKA 42755				
DUCON	IP 1250				
DUCON	PN 351				
DUCON	PO630A				
DUCON	2P45D	?.5 +/-10%	7.8 x 5.8 x 3.8		F/L Ballast Capacitor

Make	Type	Capacitance (µF)	Dimensions (cm)	Power (V)	Remarks
DUCON	MN 10-32	0.0002		10000	
DUCON	MP 21/32	0.0002		7000	Mica Capacitor
DUCON	MO 15-21	0.001		15000	
DUCON	MP 15-22	0.002		15000	
DUCON	PST 197	0.1	6.4 x 4.3 x 1.6	200	
DUCON	HS4025	0.25			
DUCON	DPB 7502	0.5			
DUCON	HG401	0.5			
DUCON	PO630	0.5 + 0.5			
DUCON	PO747	0.68 + 0.39 +/- 10%	2.5 x 2.5 x 8.1	2000	Polyester Capacitor
DUCON	5S10	1	8.5 x 4.5 x 1.8	1000	Paper Capacitor
DUCON	IS 10	1			
DUCON	PO611D	1	8 x 4 x 2.5	200	Paper Capacitor
DUCON	RKA 1442	1a1b1c1d	4.8 x 2.8 x 9.3		Paper Capacitor
DUCON	3SI2B	1.25			
DUCON	LPM 42650 CPS	2 +/- 10%	11.6 x 4.6 x 2.8	440	Paper Capacitor
DUCON	PK7575A	2 +/-20%	15.5 x 13.5 x 11.5	4000	
DUCON	RJK 33047/2	2.0 +/-5%	3.7 x 2.0	250	Metallised Paper
DUCON	1B520	2	7 x 4.5 x 1.8	200	Paper Capacitor
DUCON	2820	2	6.2 x 4.5 x 2.0	100	

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
DUCON	PO 606	2			
DUCON	PO 606A	2			
DUCON	PO 606B	2.00	7.9 x 4.0 x 2.5	200	
DUCON	PO 642c	2.0	8 x 2.4 x 2.4	200	Paper Capacitor
DUCON	PO 671	2			
DUCON	RKA 14413	2a2b2c2d	4.8 x 2.8 x 9.3		Paper Capacitor
DUCON	RKA 14414	2	9.5 x 4.9 x 2.9		Paper Capacitor
DUCON	2S20	2 + 20% -10%	2.5 x 4.2 x 6.3	400	Paper Capacitor
DUCON	3S20P	2 + 20% -10%	5.5 x 5.0 x 4.5	600	Paper Capacitor
DUCON	PO748	2 + 2	4.0 x 8.0 x 5.3	2000	Polyester Capacitor
DUCON	RKA 14413	2 2 2 2			Paper Capacitor
DUCON	APD 225 AC	2.5 +/-10%		250 VAC	Paper Capacitor
DUCON	APF 228 CR	2.8			
DUCON	APF 228 SCR	2.8 +/-10%		250 VAC	Paper Capacitor
DUCON	APA 208A	3			
DUCON	APD 230 AC	3			
DUCON	APF 230 CR	3			
DUCON	APF 230 SCR	3 +/-10%		250 VAC	
DUCON	LPA 208 A	3			
DUCON	5 P 31 A	3.1			

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
DUCON	RPB 228	3.2			
DUCON	APB 232 A	3.25 +/-10%		250	Paper Capacitor
DUCON	APF 232	3.25			
DUCON	APF 232 CR	3.25 +/-10%		250 VAC	
DUCON	APF 232 SCR	3.25 +/-10%		250 VAC	Paper Capacitor
DUCON	APS 232	3.25			
DUCON	4P5D	3.5	7.8 x 5.8 x 3.8	400	Fluo. Lamp. Capacitor
DUCON	APD 235 AC	3.5			
DUCON	APF 235	3.5			
DUCON	APF 235 C	3.5 +/-10%		250 VAC	Paper Capacitor
DUCON	APF 235 CR	3.5 +/-10%		250 VAC	Paper Capacitor
DUCON	APF 235 SCR	3.5	5.2 x 4.6 x 2.7	250	
DUCON	APM 235	3.5 +/-10%		250 VAC	Round Paper Capacitor
DUCON	APM 235 R	3.5 +/-10%		250 VAC	Round Paper Capacitor
DUCON	APS 235	3.5 +/- 10%		250 VAC	
DUCON	4P36	3.6 +/-5%	7.8 x 5.8 x 3.8	400	Paper Capacitor
DUCON	APU 436	3.6 +/-5%	6.3 x 5.8 x 3.8	400	F/L Ballast Capacitor
DUCON	APF 235 CR	3.8	5 x 5 x 3	250	
DUCON		4.0		400	Paper Capacitor
DUCON	1 S 40	4			

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
DUCON	3 S 40	4			
DUCON	5S40	4	12 x 5.3 x 4.5	1000	Paper Capacitor
DUCON	6S40	4	12.5 x 7.5 x 5.0	1500	Paper Capacitor
DUCON	APB 240	4 +/-10%		250 VAC	Paper Capacitor
DUCON	APD 240 C	4 +/-10%		250 VAC	Paper Capacitor
DUCON	APF 240 C	4 +/-10%		250 VAC	Paper Capacitor
DUCON	APF 240 CR	4 +/- 10%		250 VAC	
DUCON	APF 240 SCR	4 +/-10%		250 VAC	
DUCON	GCB 340	4			
DUCON	GPM 440	4			
DUCON	GPM 440	4 +/-10%	6.4 x 58.4 x 4.8	440	Paper Capacitor
DUCON	GPM 440 L	4 +/-10%	6.5 x 5.2 x 4.8	440	Atlas Thermowave Stove
DUCON	RKA 14x20	4	9.6 x 4.8 x 2.8		Paper Capacitor
DUCON	APF 245 CR	4.5 +/-10%		250 VAC	
DUCON	APM 260	5			
DUCON	APB 250	5 +/- 10%		250 VAC	Paper Capacitor
DUCON	APF 250 CR	5 +/-10%		250 VAC	
DUCON	GPU 451	5.1			
DUCON	4P55	5.5 +/-5%	10.0 x 5.7 x 3.8	400	Paper Capacitor
DUCON	APD 255 C	5.5 +/-10%		250 VAC	Paper Capacitor

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
DUCON	FPB 216	5.5			
DUCON	APA 260	6	11.6 x 4.9 x 2.9	150	Paper Capacitor
DUCON	APB 260	6			
DUCON	APD 260 C	6			
DUCON	APF 260 CR	6			
DUCON	FPL 208	6			
DUCON	2P63	6.3 +/-5%	7.8 x 5.8 x 3.8	250	Paper Capacitor
DUCON		6.5			
DUCON	APB 265	6.5			
DUCON	APD 265 C	6.5			
DUCON	APF 265 C	6.5 +/- 10%		250 VAC	Paper Capacitor
DUCON	APF 265 CR	6.5			
DUCON	APS 265	6.5 +/-10%		250 VAC	Paper Capacitor
DUCON	FPB 218	6.5			
DUCON	APU 263 No. 36650	6.8 +/-10%	6.5 x 5.8 x 3.8	250	Fluo. Lamp. Capacitor
DUCON	4P70A	7	13.0 x 5.8 x 3.8	400	Paper Capacitor
DUCON	APD 270C	7			Paper Capacitor
DUCON	APF 270 C	7 +/- 10%		250 VAC	
DUCON	APF 270 CR	7			
DUCON	APF 270 NCR	7 +/-10%		250 VAC	

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
DUCON	APF 270 SCR	7 +/-10%		250 VAC	Paper Capacitor
DUCON	APF 370 NCB	7			
DUCON	APM 270	7			
DUCON	APM 270 C	7			
DUCON	APM 270 R	7			
DUCON	APM 472 R	7.2			
DUCON	APM 472 R	7.2 +/-5%	22.0 x 3.8	440	Paper Capacitor
DUCON	APB 275	7.5			
DUCON	APF 275 CR	7.5 +/-10%		250 VAC	Paper Capacitor
DUCON	22P80C	8.0 +/-10%	10.8 x 5.0 x 4.2	240	Fluo. Lamp. Capacitor
DUCON	1S80	8			
DUCON	APB 280	8 +/-10%		250 VAC	Paper Capacitor
DUCON	APD 280 C	8 +/-10%		250 VAC	Paper Capacitor
DUCON	APD 280 CR	8 +/-10%		250 VAC	Paper Capacitor
DUCON	APF 280 CR	8			
DUCON	3S80	8 +20% -10%	11.0 x 5.0 x 4.0	600 DC	Fluo. Lamp Capacitor
DUCON	APF 265 CR	8.5			
DUCON	APU 285	8.5 +/-5%	7.8 x 5.8 x 3.8	250	Fluo. Lamp. Capacitor
DUCON	2P90B	8.5 +/-5%	11.5 x 5.2 x 3.8	250	Paper Capacitor
DUCON	2P90B	9.0 +/-10%	11.2 x 5.8 x 3.8	250	Paper Capacitor

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
DUCON	2P90	9.0	10.8 x 5.8 x 4.5	240	Fluo. Lamp. Capacitor
DUCON	7P90	9	12.8 x 11.5 x 7.5	660	PFCU
DUCON	APA 290	9			
DUCON	APD 290 C	9 +/-10%		250 VAC	Paper Capacitor
DUCON	APF 290 CR	9			
DUCON	4RL054E	9.9 +10 -0%	9.0 x 11.5 x 7.5	400	PFCU Paper Capacitor
DUCON	1 S 100	10			
DUCON	APD 2100 C	10			
DUCON	APF 21OO CR	10			
DUCON	APS 2100 R	10 +/-10%		250 VAC	Paper Capacitor
DUCON	APB 2110	11 +/-10%		250 VAC	Paper Capacitor
DUCON	APD 2110	11			
DUCON	APD 2110 C	11			
DUCON	APF 2110 CR	11 +/-10%		250 VAC	Paper Capacitor
DUCON	APD 2120 C	12 +/-10%		250 VAC	Paper Capacitor
DUCON	APD 3130 C	12			
DUCON	APF 2120	12 +/-10%			No. 36650
DUCON	APF 2120 CR	12 +/-10%		250 VAC	Paper Capacitor
DUCON	APF 2120 NCR	12 +/-10%		250 VAC	
DUCON	GPM 412 G 7	12			

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
DUCON	APD 2130 C	13 +/-10%		250 VAC	Paper Capacitor
DUCON	APF 2130 CR	13			
DUCON	APD 3130 C	13			
DUCON	GPC 2130	13 +/-10%	11.8 x 8.5 x 3.2	250	Paper Capacitor
DUCON	GPF 2130	13			
DUCON	APF 2140 CR	14 +/- 10%		250	
DUCON	4RL081E	15 +10 -0%	12.6 x 11.0 x 7.5	400	PFCU Paper Capacitor
DUCON	APB 2150	15 +/-10%	11.7 x 8.5 x 3.2	250	Paper Capacitor
DUCON	APD 2150 C	15			
DUCON	EPC 336	15 +15 -5%	18.5 x 8.0 x 4.8	400	Fluo. Lamp. Capacitor
DUCON	OPM 4160	16			
DUCON	4RL11E	19.8 +10 -0%	11.5 x 7.5	400	PFCU
DUCON	APA 2200 CR	20			
DUCON	APB 2200	20 +/-10%	11.5 x 11.0 x 3.2	250	PFCU Paper Capacitor
DUCON	APF 2000 CR 2571	20			
DUCON	APF 2200 CR	20 +/-10%		250	Paper Capacitor
DUCON	APT 4200 WN	20 +/-10%	17.0 x 9.0 x 4.7	400	Paper Capacitor
DUCON	GPA 2200	20 +/-10%	11.8 x 8.0 x 4.8	250	Paper Capacitor
DUCON	GPC 2200	20 +/-10%	11.5 x 8.0 x 4.7	250	PFCU Paper Capacitor
DUCON	GPF 2200 DR	20 +/-10%		250 VAC	

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
DUCON	GPM 2200 WDCR	20 +/-10%		250 VAC	
DUCON	ET3C	25	4.0 x 1.3	250	Electrolytic
DUCON	LPM 407	25			
DUCON	GPM 235 HCR	35			
DUCON	GPM 4350 L	35 +/-10%	12.0 x 11.5 x 7.5	440	PFCU Paper Capacitor
DUCON	PFK 642/1	39.8 +10	23.0 x 13.0 x 8.8	400	PFCU Paper Capacitor
DUCON	EMC 283	40			
DUCON	2QN081	45	16.0 x 11.5 x 7.5	230	PFCU
DUCON	R5228	49.5	17.0 x 26.5 x 12.0	400	PFCU
DUCON	EMU 6512	65			
DUCON	5 P 700 D	70			
DUCON	GPM 4800	80 +/-10%	23.0 x 13.0 x 9.8	400	PFCU Paper Capacitor
DUCON	EMB 826	150			
DUCON	EMB 823	180			
DUCON (NZ) LTD	8785		16.0 x 11.5 x 7.5	400	PFCU
DUCON (NZ) LTD	4P35B	?.5 MU-F	11.0 x 5.0 x 3.56	400	Fluo. Lamp. Capacitor
DUCON (NZ) LTD	4P35C	3.5 MU-F	5.4 x 6.2 x 5.0	400	Fluo. Lamp. Capacitor
DUCON (NZ) LTD	2P45	4.5	11.0 x 5.0 x 3.5	240	Fluo. Lamp. Capacitor
DUCON Condensor Ltd.	PO605/1, 50	1	1.3 x 4.1 x 8.1	200	
DUCON Condensor Ltd.	QA, RS502/285, 3/48	1.0	6.5 x 4.4 x 1.6	200	

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
DUCON Condensor Ltd.	PO 606A	2	8.1 x 4.1 x 2.5	200	
DUCONOL	4P35	3.5	5.5 x 6.0 x 5.0	440	Fluo. Lamp. Capacitor
DUCONOL	Part No. 5458 114, 787	4.5	11.1 x 4.9 x4.0	240	'A' CAPACITOR
DUCONOL	APF 260 CR	6	12.0 x 4.8 x 3.0	250	Paper Capacitor
DUCONOL 'A'	4RN054	10	9.5 x 11.5 x 7.5	400	PFCU
DUCONOLA	PST 569	0.5			
ELNA	93 E 60SV	250	4.9 x 1.8	50	
ELNA	CE-W	2500		63	
ENDURANCE	PPU 148				
ENDURANCE	AA10	2.8		250	
ENDURANCE	APR 1968	6 +/-10%		250	
FAC		2.5			
FIRBOURG	31740-18	1.4 +/-10%	5.0 x 4.5 x 3.5	310	Fluo. Lamp. Capacitor
FRAKO	M 280/20 RKB 18	20	16.5 x 5.0	280	PFCU
FUJI KEN	FS-4055	5.5 +/-5%			Capacitor
FUJI KEN	FS-2557	5.7 +/-5%	7.5 x 5.5 x 3.4	250	Fluo. Lamp. Capacitor
FUJI KEN	FS-2580	8.0 +/-10%	8.0 x 5.4 x 3.3	250	Fluo. Lamp. Capacitor
FUJI KEN	FS-2585	8.5 +/-5%	9.5 x 5.4 x 3.4	250	Fluo. Lamp. Capacitor
G.E.	45 F				
G.E.	72F6056	0.1		600	60 Hz

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
G.E.	72F6914FB	0.5		1000VAC	60 Hz
G.E.	23F1054FC	2		600 VDC	
G.E.	72F6037	3		500	60 Hz
G.E.	23F1056FC	4		600 VDC	
G.E.	23F1095	4		2000 VDC	
G.E.	25F156G2	4.0	5.5 x 5.0	330	Fluo. Lamp Capacitor
G.E.	72F6059	4		660	60 Hz
G.E.	ED CAT 211 139-2	4.5	11.8 x 5.2 x 2.5	230	Fluo. Lamp Capacitor
G.E.	25FS4362	4.8	5.5 x 6.4 x 5.5	330	Pyranol Capacitor
G.E.	72F6060	6		660 VAC	60 CY
G.E.	28F1060FC	8		1000 VDC or 440 VAC	60 Hz
G.E.	49F4690	8		660 VAC	60 Hz
G.E.	49F6761	10		660 VAC	60 Hz
G.E.	72F6041	10		500	60 Hz
G.E.	28F1396FC	15		1000 VDC or 440 VAC	60 Hz.
G.E.	49F6763FC	15		660 VAC	60 Hz
G.E.	28F1397FC	20		1000 VDC or 440 VAC	60 Hz
G.E.	72F932	20		525	60 Hz
GEC	F8501				
GEC	F8601				

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
GEC	FS501		19.5 x 5.5 x 3.6		Fluo. Lamp. Capacitor
GEC	FS529	4.5 +/-10%	11.0 x 6.0 x 4.5	275	Fluo. Lamp. Capacitor
GEC	F8572P	4.7 -5% +10%	5.7 x 3.8	250	Fluo. Lamp Capacitor
GEC	F8630	6.85 +/-5%	12.0 x 7.5 x 5.0	440	Fluo. Lamp. Capacitor
GEC	Z1671	10 +/-10%	8.4 x 5.8 x 3.8	250	Fluo. Lamp Capacitor
GEC	Z1790XL	10 +/-10%	9.0 x 7.7 x 5.2	440	Fluo. Lamp Capacitor
GEC	Z1871L	10 +/-10%		250	
GEC	F8531	10.5 -6 +10%	8.2 x 7.5 x 5.0	275	Fluo. Lamp Capacitor
GEC	Z1773	15 +/-10%	12.0 x 7.5 x 5.0	275	Fluo. Lamp Capacitor
GEC	Z1774	18 +/-10%	12.0 x 7.5 x 5.0	275	Fluo. Lamp Capacitor
GEC	Z1766	20 +/-10%		250	
GEC	Z1775	20 +/-10%		250	
GEC	Z1775XL	20 +/-10%	9.0 x 7.7 x 5.2	250	Fluo. Lamp Capacitor
GEC	Z1781XL	25 +/-10%	11.5 x 7.8 x 5.4	250	Fluo. Lamp Capacitor
HUNTS	ZE5134/2		11.5 x 13.0 x 9.0	400	PFCU
HUNTS	ZJ307		8.0 x 9.0 x 5.8	380/400	PFCU
HUNTS	ZJ313		13.5 x 14.4 x 8.6	380/440	PFCU
HUNTS	ZL315		17.5 x 15 x 12.5	380/440	PFCU
HUNTS	ZG714	0.25 +/-10%	4.0 x 2.5	440	Fluo. Lamp Capacitor
HUNTS	ZG715	0.5 +/-10%	5.3 x 2.5	440	Fluo. Lamp Capacitor

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
HUNTS	ZG720AY	2.75 +/-10%	6.5 x 3.5	250	Fluo. Lamp Capacitor
HUNTS	ZG168Q	3.7 +/-8%	8.0 x 5.5 x 3.5	400	Fluo. Lamp Capacitor
HUNTS	ZG1384	4 +/-10%	5.8 x 3.8	250	Fluo. Lamp Capacitor
HUNTS	ZG629A	4 - 5	6.5 x 5.5 x 3.5	2580	Fluo. Lamp Capacitor
HUNTS	ZG989AE	5 +/-10%	7.7 x 3.8	250	Fluo. Lamp Capacitor
HUNTS	ZC781AY	5.5 +/-10%	9.5 x 3.8	250	Fluo. Lamp Capacitor
HUNTS	ZC758A	6 +/-10%	11.5 x 3.5	250	Fluo. Lamp Capacitor
HUNTS	ZG989A	6 +/-10%	7.6 x 3.7	250	Fluo. Lamp Capacitor
HUNTS	ZG167Q	7.1 +/-5%	14.3 x 5.4 x 3.5	400	Fluo. Lamp Capacitor
HUNTS	C1117	7.4 Min.	8.8 x 5.5 x 3.7	250	Fluo. Lamp Capacitor
HUNTS	ZG962A	8 +/-10%	12.0 x 3.8	250	Fluo. Lamp Capacitor
HUNTS	ZG985	8.4 +/-10%	8.5 x 3.8	250	Fluo. Lamp Capacitor
HUNTS	ZG166	9.0 Min.	10.0 x 5.5 x 3.6	240	Fluo. Lamp Capacitor
HUNTS	ZG330	15 +/-10%	13.0 x 7.5 x 5.0	440	Fluo. Lamp Capacitor
HUNTS	ZL1152W	40	14.2 x 10 x 10	300	PFCU
ICAR	Type Protex/5				
INCO	ELECTRONICA	5.5	11.3 x 4.4		
INCO	MASSALAMBARDA	5.5	11.3 x 4.4		
INTERCAP		6.0			
ITAL FARAD	MFR-78-D 12545	2.5			

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
ITAL FARAD	MFR-A 18040	18			
JARD	A 370	3			
JOHNSON & PHILLIPS					
LTD.	U6719		20.0 x 22.0 x 11.5	415	PFCU
KCC		6			
MALLORY	375 461 107	105/136			
METALECT			8.0 x 11.5 x 7.5	400	PFCU
METALECT	55995		10.0 x 11.5 x 7	415	PFCU Metalised Polypropylene Capacitor
METALECT	56229		10.0 x 11.5 x 7	415	PFCU Metalised Polypropylene Capacitor
METALECT	56230		10.0 x 11.5 x 7	415	PFCU Metalised Polypropylene Capacitor
MF	C 120 BA	4.5 +/-5%	5.7 x 5.5 x 3.8	250	Fluo. Lamp Capacitor
MF PHILLIPS	C120BB	3.5 +/-5%	5.7 x 5.5 x 3.8	380	Fluo. Lamp Capacitor
MF PHILLIPS	C120BA	6.3 +/-5%	7.0 x 5.5 x 3.8	250	Fluo. Lamp Capacitor
MF PHILLIPS	C120BA	9 +/-5%	10.0 x 5.5 x 3.8	250	Fluo. Lamp Capacitor
MKP	MMKU 610 420 SP	10			
MOTOR START	EMU 9026	100			
MP		3.6			
MP	EUV 939 401 442 W	3.6			
NICHICON	TPF-C25LV3RBW		25 x 22 x 10	400	PFCU
NICHICON		0.95			

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
NICHICON	S1-10LP BVCI	3		250	50 c/s
NICHICON	SF-S4P BVCI	3.0		250	50 c/s
NICHICON	SF-10 LBL	3			
NICHICON	SF-10LP4 BVCL	3.25 +/-10%		250 VAC	Paper Capacitor
NICHICON	SF-3HBL	3.5 +/-10%		250 VAC	Paper Capacitor
NICHICON	SF-S455P4	3.5	5.5 x 4.5 x 2.5	250	Paper Capacitor
NICHICON	SF-SG55P4	3.6		400	Paper Capacitor
NICHICON	SF-SGP4	3.6	5.8 x 5.3 x 3.3	400	Paper Capacitor
NICHICON	SF-SG55P4	3.6	5.5 x 5.5 x 3.3	400	Paper Capacitor
NICHICON	SF-S455P	4		250	Paper Capacitor
NICHICON	SF-SGHLP4	5.5	8.5 x 5.2 x 3.3	400	Paper Capacitor
NICHICON	SF-KA58P4	5.7	5.5 x 5.4 x 3.3	250	Paper Capacitor
NICHICON	SFKA55P4	5.7	5.5 x 5.2 x 3.0	250	Paper Capacitor
NICHICON	SF-S4MLP4	6	8.5 x 4.4 x 2.7	250	Paper Capacitor
NICHICON	SF-SGP	6.3	5.5 x 5.5 x 3.5	250	F/L Ballast Capacitor, Paper Capacitor
NICHICON	TCS S4MLP4R	6.3	8.5 x 4.4 x 2.7	250	Paper Capacitor
NICHICON	SF-GGMLP4	8.5	8.5 x 5.3 x 3.3	250	Paper Capacitor
NICHICON	SF-SGMLP4	8.5	8.5 x 5.5 x 3.3	250	Paper Capacitor
NICHICON	SF-GHP4	10.6	11.4 x 5.3 x 3.3	250	F/L Ballast Capacitor, Paper Capacitor
NICHICON	SF-SGMLP4	10.6	8.5 x 5.2 x 3.2	250	Paper Capacitor

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
NICHICON CAPACITOR CO.	TPF-812PG3RBB		10 x 11.5 x 9.3	400	PFCU
NICHICON CAPACITOR CO.	TPF-A10PG3RBB		10 x 11 x 6	400	PFCU
NICHICON CAPACITOR CO.	TPF-B18U3RBB		18 x 11.5 x 9.3	400	PFCU
NICHICON CAPACITOR CO.	TPF-B22PG3RBB		22 x 11.5 x 9.3	400	PFCU
NICHICON CAPACITOR LTD	TPF-A12PG3RBB		12 x 11.5 x 6.5	400	PFCU
NICHICON CAPACITOR LTD	SF-GP4	3.7	5.7 x 5.5 x 3.5	380-400	Paper Capacitor
NICHICON CAPACITOR LTD	SF-GHP4	10.6	11.4 x 5.3 x 3.3	250	Paper Capacitor
NTK	CPBMWB1	1	5.5 x 4.4 x 2.9	1000	
NTK	RTS-C-159-10	2	12.8 x 9.5 x 4.0	7000	
NTK	CP711C	4	11.1 x 6.0 x4.0	1600	
NTK	63AT220	220	4.0 x 2.2	63	Electrolytic
PLESSEY	APF 250 SERIES				
PLESSEY	Date Codes Between 60 and 75				
PLESSEY	25/3, SPEC, 409	1 +/-10%	1.3 x 4.1 x 8.1	200	
PLESSEY	436 1 25560 030	1.5			
PLESSEY	RKA 14413	2a2b2c2d	9.6 x 4.7 x 2.7	175	Paper Capacitor
PLESSEY	RKA 14x31	2	9.6 x 4.6 x 2.6	75	Paper Capacitor
PLESSEY	APF 230 CR	3.0 +/-10%		250 VAC	
PLESSEY	APU 431	3.1			
PLESSEY	APF 235 SCR	3.5 +/-10%		250 VAC	

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
PLESSEY	427/1/06207/001	5.0 +/-10%	7.2 x 4.0	440	Fluo. Lamp Capacitor
PLESSEY	APU455 No. 26650	5.3 +/-5%	7.8 x 5.8 x 3.8	400	Fluo. Lamp Capacitor
PLESSEY	APF 250 CR	6			
PLESSEY	APF 260CR	6.0 +/-10%		250 VAC	50 Hz
PLESSEY	APF 265 PC	6.5			
PLESSEY	APF 265 CR	6.5 +/-10%		250 VAC	
PLESSEY	36850	8.5 +/-5%	7.8 x 5.8 x 3.8	250	Fluo. Lamp Capacitor
PLESSEY	APF 265 CR	8.5 +/-10%		250 VAC	
PLESSEY	APF 290 CR	9 +/-10%		250 VAC	
PLESSEY	APF 2100 CR	10 +/-10%		250 VAC	
PLESSEY	APF 2110 CR	11.0 +/-10%		250 VAC	
PLESSEY	522/1/14626/200	15 +/-10%	11.5 x 7.5 x 5.2	415	Fluo. Lamp Capacitor
PLESSEY	GPM 2200 WDCR	20 +/-10%		250 VAC	
PLESSEY	GPM 4350	35			
PLESSEY	APF 265 CR	40			
PLESSEY	M 826 4	40			
PLESSEY CAPACITORS	435/1/00005/007	6 +/-10%		250	
PLESSEY CAPACITORS	SH	6 +/-10%		250	
PLESSEY CAPACITORS	522/1/14625/600	8 +/-10%	7.5 x 7.5 x 5.2	440	Fluo. Lamp Capacitor
PLESSEY CAPACITORS	435/1/00005/013	10 +/-10%		250	

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
PLESSEY UK	CE 22162/12	200	4.9 x 1.6	6	Electrolytic
PLESSEY UK	CE 22186/13	250	5.0 x 2.6	25	Electrolytic
PLESSEY UK	CE 22191/13	500	7.5 x 3.4	50	Electrolytic
RIC	1349	3.6 +/-5%	6 x 5.5 x 3.5	400	Fluo. Lamp Capacitor
RIC	2633	3.6 +/-5%	9.8 x 3.8	400	Fluo. Lamp Capacitor
RIC	1295	8.5 +/-5%	7.5 x 5.5 x 3.5	250	Fluo. Lamp Capacitor
RIC	1290	10.6 +/-5%	10 x 5.5 x 3.5	250	Fluo. Lamp Capacitor
RIC	4070 SH	20 +/-10%		250	
RIC CAPACITORS LTD.	1229	3.6 +/-5%	7.5 x 5.4 x 3.5	400	Fluo. Lamp Capacitor
RIC CAPACITORS LTD.	2085	4 +/-5%	5.3 x 3.8	250	Fluo. Lamp Capacitor
RIC CAPACITORS LTD.	2085	4.0 +/-10%	5.4 x 3.8	250	Fluo. Lamp Capacitor
RIC CAPACITORS LTD.	1117	5.5 +/-5%		400	F/L Ballast Capacitor
RIC CAPACITORS LTD.	2344	5.5 +/-5%	7.4 x 3.8	250	Fluo. Lamp Capacitor
RIC CAPACITORS LTD.	1298	5.7 +/-5%	6.0 x 5.5 x 3.5	250	Fluo. Lamp Capacitor
RIC CAPACITORS LTD.	2352	5.7 +/-5%	7.5 x 3.8	250	Fluo. Lamp Capacitor
RIC CAPACITORS LTD.	0791	6.3 +/-10%	7.3 x 3.8	250	Fluo. Lamp Capacitor
RIC CAPACITORS LTD.	2355	6.3 +/-10%	7.3 x 3.7	250	Fluo. Lamp Capacitor
RIC CAPACITORS LTD.		8.5 +/-5%	7.5 x 5.5 x 3.5	250	Fluo. Lamp Capacitor
RIC CAPACITORS LTD.	1295	8.5 +/-5%	7.5 x 5.5 x 3.5	250	Fluo. Lamp Capacitor
RIC CAPACITORS LTD.	2351	8.5 +/-5%	9.8 x 3.8	250	Fluo. Lamp Capacitor

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
RIFA	PHN	3			
RIFA	PHN	6.5			
RS		15000			
SCC	86650				
SEI	SV 3536B	5.7 +/-5%	9.5 x 3.8	250	Fluo. Lamp Capacitor
SEI	SV 3537	6.3 +/-10%	9.5 x 3.8	250	Fluo. Lamp Capacitor
SEI	SV 3539	8 +/-10%	11.8 x 3.8	250	Fluo. Lamp Capacitor
SELENIUM	2SR250/.005/1 SER 274				RECTIFIER
SHIZUKI	DF Capacitor	3.6 +/-5%	7.5 x 5.7 x 3.8	400	Fluo. Lamp Capacitor
SHIZUKI	DF	3.7 +/-5%	7.5 x 5.5 x 3.8	400	Fluo. Lamp Capacitor
SHIZUKI	DF	4	5.5 x 5.2 x 3.2	250	Fluo. Lamp Capacitor
SHIZUKI	DF	6.3 +/-10%	7.5 x 5.4 x 3.5	250	Fluo. Lamp Capacitor
SHIZUKI	20524	6.3		250	F/L Ballast Capacitor
SHIZUKI	DF	7 +/-5%	11.6 x 5.2 x 3.2	400	Fluo. Lamp Capacitor
SHIZUKI	DF	8 +/-5%	9.5 x 5.2 x 3.2	250	Fluo. Lamp Capacitor
SHIZUKI	DF Capacitor	8.5 +/-5%	7.5 x 5.5 x 3.5	300	Fluo. Lamp Capacitor
SHIZUKI	DF Capacitor	8.5 +/-5%	9.5 x 5.4 x 3.4	250	Fluo. Lamp Capacitor
SHIZUKI	DF	10.6 +/-5%	11.6 x 5.2 x 3.2	250	Fluo. Lamp Capacitor
SIEMENS	B11153, AIK, 250		5.0 x 4.3 x 1.5	250	
SIEMENS	A0, 1/250,“K”, B2106	0.1	4.9 x 4.3 x 0.8	250	

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
SIEMENS	A0, 2/250, “K”, B2106	0.2	4.9 x 4.3 x 0.8	250	
SIEMENS	B21074-A1504-KS, W	0.25 + 0.2	5.0 x 4.3 x 0.9	160	
SIEMENS	2x0.25/160, DIN41154	2 x 0.25	5.0 x 4.4 x 0.9	160	
SIEMENS	B21074-A1504-K5	2 x 0.25	5.2 x 4.3 x 0.9	160	
SIEMENS	A0, 5/250, “K”, B2106	0.5	4.9 x 4.2 x 0.8	250	
SIEMENS	B21074-A-K	0.5 + 0.5	5.0 x 4.3 x 0.9	160	
SIEMENS	A1/160, “K”43, B2106	1	4.9 x 4.3 x 0.8	160	
SIEMENS	B11153, A1K160, DIN41153SP	1	5.0 x 4.4 x 0.9	160	
SIEMENS	B21064-A2105-K	1	5.0 x 4.3 x 1.4	250	
SIEMENS	B25040 A1k300	1 +/-10%	4.70 x 2.0	300	
SIEMENS	D2/10/160, B2521	2 +/-10%	2.9 x 2.8 x 1.9	160	MP Capacitor
SIEMENS	B21064-A2205-K	2	4.3 x 4.9 x 2.4	250	
SIEMENS	A4/160, DIN41153	4	5.0 x 4.5 x 3.4	160	
SIEMENS	A2x4/160, “K”, B2111	2x4	6.8 x 5.0 x 4.2	160	
SIEMENS	Elko rauh W2	2500	4 x 5 x 11.5	35/40	
SPRAGUE	200P1466		15.6 x 9.0 x 4.6	25 -440	Fluo. Lamp Capacitor
SPRAGUE	271 P277				
SPRAGUE	200P1699	6.0	11.8 x 7.0 x 4.6	660	
SPRAQUE		33			
STABILAC PTY. LTD.	50V 20A Rectifier, 274/28 1967			50	

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
STATIC			30 X 13 X 10	400	PFCU
STC	25 PV 500				
STC	57, 25QA	0.5	7.6 x 5.3 x 1.3		
STC	59, 1, QA, 2	0.5 + 0.5	8.1 x 4.1 x 2.5		
STC	60, 13, QA, 14	0.5 + 0.5	8.1 x 4.1 x 2.5		
STC	64, 17, QA, 18	0.5 + 0.5	7.6 x 5.3 x 1.8		
STC	53	1			
STC	60	1	1.3 x 4.1 x 8.1		
STC	60	1	8.1 x 4.1 x 1.5		
STC	56	1 + 1	8.1 x 4.1 x 2.5		
STC	56, C3	1 + 1	8.1 x 4.1 x 2.5		
STC	57, C1	1 + 1	8.1 x 4.1 x 2.5		
STC	57, D, C1	1 + 1	8.1 x 4.1 x 2.5		
STC	58, C3	1 + 1	8.1 x 4.1 x 2.5		
STC	59, C2	1 + 1	8.1 x 4.1 x 2.5		
STC	60 (FS1, K4)	1 + 1	8.1 x 4.1 x 2.5		
STC	61	1 + 1	8.1 x 4.1 x 2.5		
STC	56, QA	2	8.2 x 4.1 x 2.4		
STC	57, C2	2	2.5 x 4.1 x 8.1		
STC	60	2			

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
STC	61	2	2.5 x 4.1 x 8.1		
STEDEPOWER	SP 21	4			
SUDD	PTB Nr.IIIB E	4.5			
T.M.C.	08038 MFD				
T.M.C.	508221				
T.M.C.	51644P	2	8.0 x 4.1 x 2.5		
T.M.C.	S16414.P	2	2.5 x 4.1 x 8.8		
TCC			12 x 9.5 x 7.5	230/400	PFCU
TCC	T 10987/2		16 x 14 x 10	415	PFCU
TCC	T 10988/11		16.5 x 15 x 10.5	415	PFCU
TCC	T 11868/54		23.3 x 15.3 x 10.3	415	PFCU
TCC	121 B	? +/-15%	12.3 x 7.8 x 3.4	1200/1500	Fluo. Lamp Capacitor
TCC	Y30, Group 2, S.5965/2	0.05		50	
TCC	L 681705-A	0.5	5.0 x 2.5	400	Fluo. Lamp Capacitor
TCC	DMZ M.K2. 2831-627	3.2 +/-5%	12.2 x 10.2 x 5.2	600	Fluo. Lamp Capacior A Plessey Product
TCC	5910-99-011-2883	4 +/-20%	6.3 x 5.2 x 3.0	100/200	Fluo. Lamp Capacitor
TCC	92	4	11.6 x 5.2 x 5.2	600/750	Fluo. Lamp Capacitor
TCC	TCB/YE/A2	6 +/-10%	5.8 x 6.5	350	

Make	Type	Capacitance (µF)	Dimensions (cm)	Power (V)	Remarks
TCC	KP 5465.522/1/14104/ 000	10 +/-15%	16.2 x 7.7 x 5.2	500	Fluo. Lamp Capacitor A Plessey Product
TCC	TCB/TH/O	10	12 x 7.8 x 7.8	440	PFCU
TCC	TCB/UK/O	10	12 x 7.8 x 7.8	440	PFCU
TCC	TCB/UM/O	10	12 x 7.8 x 7.8	440	PFCU
TCC	21118	10 +7% +10%	10 x 8 x 5	360	Fluo. Lamp Capacitor
TEAPOL		250			
THE CAPACITRON CO. THE CAPACITRON CO.	A1300-68SP KS2035C	3.5 3.5	10.5 x 5.5 x 2.5 10.5 x 5 x 2.5	236 220	Fluo. Lamp Capacitor Underwriters Lab listed. Fluo. Lamp Capacitor
THE TELEGRAPHIC	FR Type		12 x 12 x 8.4	230/400	Underwriters Lab listed. PFCU
CONDENSOR CO.					
TMC	S114498	3.25 Min	7.8 x 3.8	275	Fluo. Lamp Capacitor
TMC	S112387	4.5 Min	10 x 5 x 3.3	275	Fluo. Lamp Capacitor
TMC	S118208R XA. C2166	5.5 +/-10%	13 x 3.8	250	Fluo. Lamp Capacitor
TOC	TCB V ?A	3			
UCC	EKA 150				
UCC	IC10, IC20				
UCC	CP5700	0.05	13 x 4.0	6000	Cathodray ‘Visconol’
UCC	56, No. 18	0.5			
UCC	18 54	0.5 + 0.5			
UCC	18 56	0.5 + 0.5			

Make	Type	Capacitance	Dimensions (cm)	Power (V)	Remarks
		(µF)			
UCC	55 No. 18, 1, 2	0.5 + 0.5	7.5 x 5.3 x 1.2		
UCC	56 No. 18	0.5 + 0.5			
UCC	16 54	1 + 1			
UCC	16 55	1 + 1			
UCC	55, No. 16, C3	1.0 + 1.0	8.1 x 4.1 x 2.5		
UCC	56, No. 16, C1	1.0 + 1.0	8.1 x 4.1 x 2.5		
UCC	56, No. 16, C3	1.0 + 1.0	8.1 x 4.1 x 2.5		
UCC	57, No. 16, C3	1.0 + 1.0	8.1 x 4.1 x 2.5		
UCC	4 54	2			
UCC	4 C8772 62	2			
UCC	55 No. 4, QB	2.0	2.5 x 4.1 x 8.1		
UCC	C5651 50	2			
UCC	BCE 6325 BX	3.25 +/-10%		250 VAC	Paper Capacitor
UCC	Fluoropack PBB 105	3.25			
UCC	BS2818-1961	3.5			
UCC	PFE 635	3.5			
UCC	FLUURSEAL PFS	5.5			
UCC	PFS	5.5			
UCC	PFS	6			
UCC	FLUURSEAL PFS	7			