

Development of comprehensive Polychlorinated Biphenyls (PCBs) Inventories for National Implementation Plan

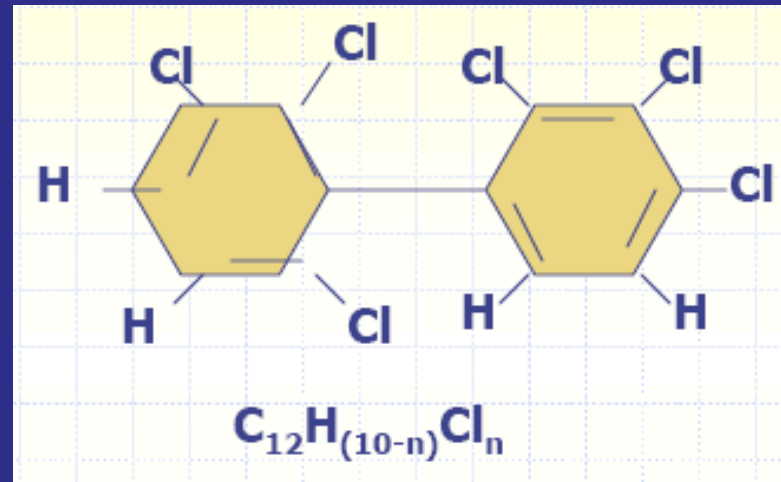
Dr. P. Thomas

Additional Director (rtd)

Central Power Research Institute

pthomas64@gmail.com

PCB an overview



- PCBs are a group of man-made organic chemicals consisting of carbon, hydrogen and chlorine atoms. PCBs have no taste or smell.
- They are mixtures of up to 209 Individual chlorinated compounds known as congeners / around 130 congeners found in commercial.
- The number of chlorine atoms and their location in a PCB molecule determine many of its physical and chemical properties (1242, 1254, and 1260).

Table of PCB Species by Congener Number

Descriptor*	CASRN	Congener Number	IUPAC Name	Type
	1336-36-3		Polychlorinated biphenyl (PCB)	Category
CP1_---_---_	2051-60-7	1	2-Chlorobiphenyl	Congener
CP0_---_---_	2051-61-8	2	3-Chlorobiphenyl	Congener
CP0_---_---_	2051-62-9	3	4-Chlorobiphenyl	Congener
---_---_---_	13029-08-8	4	2,2'-Dichlorobiphenyl	Congener
CP1_---_---_	16605-91-7	5	2,3-Dichlorobiphenyl	Congener
CP1_---_---_	25569-80-6	6	2,3'-Dichlorobiphenyl	Congener
CP1_---_---_	33284-50-3	7	2,4-Dichlorobiphenyl	Congener
CP1_---_---_	34883-43-7	8	2,4'-Dichlorobiphenyl	Congener
CP1_---_---_	34883-39-1	9	2,5-Dichlorobiphenyl	Congener
---_---_---_	33146-45-1	10	2,6-Dichlorobiphenyl	Congener
CP0_---_---_2M	2050-67-1	11	3,3'-Dichlorobiphenyl	Congener
CP0_---_---_	2974-92-7	12	3,4-Dichlorobiphenyl	Congener
CP0_---_---_	2974-90-5	13	3,4'-Dichlorobiphenyl	Congener
CP0_---_---_2M	34883-41-5	14	3,5-Dichlorobiphenyl	Congener
CP0_---_PP_	2050-68-2	15	4,4'-Dichlorobiphenyl	Congener
---_---_---_	38444-78-9	16	2,2',3-Trichlorobiphenyl	Congener
---_---_---_	37680-66-3	17	2,2',4-Trichlorobiphenyl	Congener
---_---_---_	37680-65-2	18	2,2',5-Trichlorobiphenyl	Congener
---_---_---_	38444-73-4	19	2,2',6-Trichlorobiphenyl	Congener
CP1_---_---_2M	38444-84-7	20	2,3,3'-Trichlorobiphenyl	Congener
CP1_---_---_	55702-46-0	21	2,3,4-Trichlorobiphenyl	Congener
CP1_---_---_	38444-85-8	22	2,3,4'-Trichlorobiphenyl	Congener
CP1_---_---_2M	55720-44-0	23	2,3,5-Trichlorobiphenyl	Congener
---_---_---_	55702-45-9	24	2,3,6-Trichlorobiphenyl	Congener
CP1_---_---_	55712-37-3	25	2,3',4-Trichlorobiphenyl	Congener
CP1_---_---_2M	38444-81-4	26	2,3',5-Trichlorobiphenyl	Congener
---_---_---_	38444-76-7	27	2,3',6-Trichlorobiphenyl	Congener
CP1_---_PP_	7012-37-5	28	2,4,4'-Trichlorobiphenyl	Congener

Revised as of November 2003

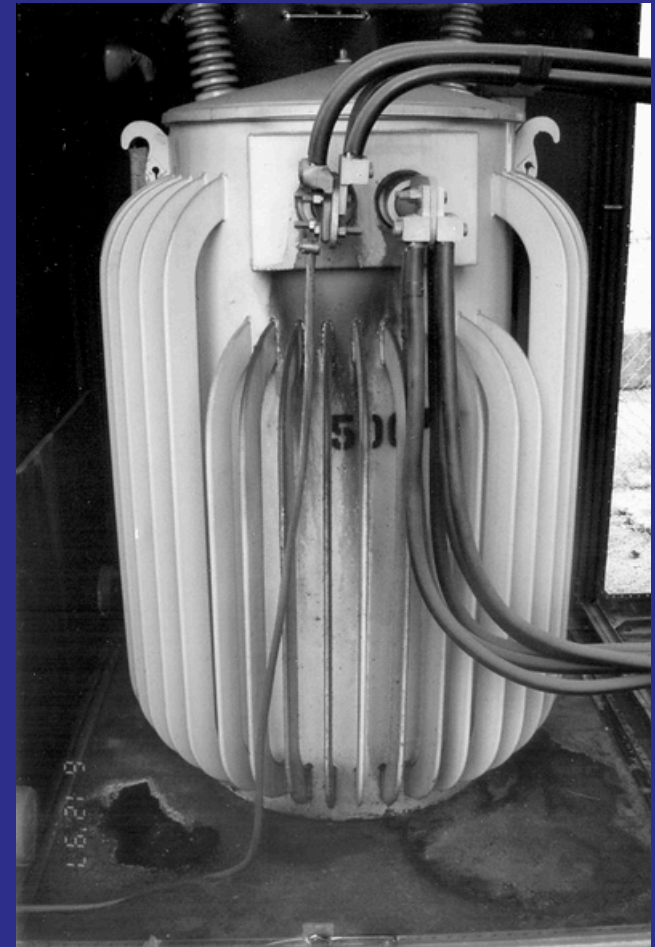
Descriptor*	CASRN	Congener Number	IUPAC Name	Type
---_4CL_PP_2M	35694-08-7	194	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	Congener
---_4CL_PP_2M	52663-78-2	195	2,2',3,3',4,4',5,6-Octachlorobiphenyl	Congener
---_4CL_PP_2M	42740-50-1	196	2,2',3,3',4,4',5,6'-Octachlorobiphenyl	Congener
---_4CL_PP_2M	33091-17-7	197	2,2',3,3',4,4',6,6'-Octachlorobiphenyl	Congener
---_4CL_--_2M	68194-17-2	198	2,2',3,3',4,5,5',6-Octachlorobiphenyl	Congener
---_4CL_--_2M	52663-75-9	199	2,2',3,3',4,5,5',6'-Octachlorobiphenyl	Congener
---_4CL_--_2M	52663-73-7	200	2,2',3,3',4,5,6,6'-Octachlorobiphenyl	Congener
---_4CL_--_2M	40186-71-8	201	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	Congener
---_4CL_--_2M	2136-99-4	202	2,2',3,3',5,5',6,6'-Octachlorobiphenyl	Congener
---_4CL_PP_2M	52663-76-0	203	2,2',3,4,4',5,5',6-Octachlorobiphenyl	Congener
---_4CL_PP_2M	74472-52-9	204	2,2',3,4,4',5,6,6'-Octachlorobiphenyl	Congener
---_4CL_PP_2M	74472-53-0	205	2,3,3',4,4',5,5',6-Octachlorobiphenyl	Congener
---_4CL_PP_2M	40186-72-9	206	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	Congener
---_4CL_PP_2M	52663-79-3	207	2,2',3,3',4,4',5,6,6'-Nonachlorobiphenyl	Congener
---_4CL_--_2M	52663-77-1	208	2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl	Congener
---_---_---_--	2051-24-3	209	Decachlorobiphenyl	Congener

*Key to Table Columns

Descriptors	
CP0 / CP1	These 68 co-planar congeners include 20 with chlorine substitution at none (CP0, non-ortho) and 48 with chlorine substitution at only one (CP1, mono-ortho) of the 2, 2', 6, or 6' positions.
4CL	These 169 congeners have a total of four or more chlorine substituents (regardless of position).
PP	These 54 congeners have both para positions (4 and 4') chlorinated.
2M	These 140 congeners have two or more of the meta positions (3, 3', 5, and 5') chlorinated.
NOTE: The 12 "Dioxin-like" congeners are those that display all four of the above Descriptors.	
CASRN	
Chemical Abstracts Service (CAS) Registry Number.	
Congener Number	
The numbering presented in the table is identical to that published by Ballschmiter et al., 1992.	
IUPAC Name	

History

- Discovered in the 19th century
- Began manufacture in 1929
- Excellent properties for many applications
 - Non-flammable
 - Does not easily degrade



Leaking PCB Transformer

Use

- Used extensively from 1929 to 1978
 - Dielectric fluids - transformers and capacitors
 - Industrial fluids - hydraulics, gas turbines
 - Adhesives, textiles, printing, sealants, etc.

- Manufactured in at least:

Austria, China, Czechoslovakia, France, Germany, Italy, Japan, Russia, Spain, U.K., U.S.

- National PCB phase outs took place
 - Late 1970s: Canada, Japan, Sweden, U.S.
 - Early 1980s: France, Germany, Spain, U.K.

Principal Uses of PCBs

- Dielectric fluids 60%
(transformers and capacitors)
- Industrial fluids 15%
(hydraulics, gas turbines)
- Adhesives, textiles, 25%
printing, sealants, etc.

Human health impacts of PCBs

Human exposure

- Ingestion : fish, plants, animals
- Dermal Routes : lipophilic nature- people working in and around PCB site, thro contacts.
- Inhalation exposure : inhaling vapors

Distribution of PCBs in Human Body

Liver muscle, kidney, and brain, and then redistributed to other tissues with high lipid and fat content

Metabolism and Excretion

Metabolism of PCB congeners first occurs in the liver
PCB metabolites are retained for a long time in the body parts such as lung, liver, and kidney tissues.

Toxicological effects

- **Skin Diseases** : acne-like rash called chloracne
- **Enzyme induction** : cytochrome P-450 enzyme (O/R)
- **Liver toxicity** : Enzyme induction, resulting in increase liver size and alteration in liver function
- **Vitamin A deficiency** : liver 90% of Vitamin A
- **Endocrine effects** : alters hormonal systems in thyroid and sex steroids.
- **Immune system effects**: decreases the production of antibodies (monocyte and granulocyte counts)
- **Brain dopamine levels deficiency**: PCBs affect central nerves system – decreases dopamine levels in brain.
- **Genotoxicity** : binds DNA and cause genotoxicity

Where PCBs are found

Applications

Closed

- Transformers
- Capacitors
- Lighting ballasts
- Motors
- Magnets

Partially Closed

Heat transfer fluids
Hydraulic fluids
Vacuum pumps
Switches
Circuit breakers
Voltage regulators
Liquid-filled electrical cables
Liquid-filled circuit breakers

Open

Plasticizers
Sealants
Adhesives
Paints
Surface coatings
Carbonless paper
Inks
Lubricants

Closed Applications

- A Closed PCB Application is one in which the PCBs are held completely within the equipment.
- Under ordinary circumstances, no PCBs would be available for exposure to the user or the environment.
- However, PCB emissions may occur during equipment servicing / repairing and decommissioning, or as a result of damaged equipment.
- The two most significant examples of closed PCB-applications are capacitors and transformers.

Partially closed applications

- Partially closed PCB applications are those in which the PCB oil is not exposed to the environment, but may become so periodically during typical use.
- These types of uses may also lead to PCB emissions, through air or water discharge.
- Examples of partially closed systems include heat transfer and hydraulic systems, and vacuum pumps.

Open applications

- **Lubricants :**
 - Cuttings oils
 - Lubricating oils
- **Surface Coatings :**
 - Paints - Paint on the undersides of ships
 - Flame Retardants : ceilings tiles, furniture and walls
- **Adhesives :**
 - Special adhesives, Adhesives for waterproof wall coatings
- **Plasticizers :**
 - Gasket, Rubber seals, Printing Inks & Dyes
- **Other Uses :**
 - Insulating materials & Pesticides

PCBs Inventory

Objectives

- To compile an accurate list of all equipment and material containing PCBs
- To ensure PCB-containing equipment and material are properly managed
- To develop and implement a strategy to dispose of all PCB-containing equipment and material

Inventory Process Steps

- Planning
 - Pre-inventory preparation
 - Communication program
 - Site selection
- Conducting the Inventory
 - Data collection: Direct or indirect
 - Safety issues
- Data Management
 - Type and level of PCBs
 - Equipment, location and size
 - In-service equipment, surplus, waste

Planning

- Pre-Inventory preparation
 - Establishing the program
 - Form preparation
 - Self Reporting or/and physical inventory
 - Identification of PCB equipment
 - Identification of analytical support
 - Scheduling
- Communication program
- Promoting the program
- Communication with the facility managers
- Communication with Senior Management
- Site selection
 - Identifying the sites to be inventoried
 - Site coordination

Inventory Form Preparation

- Facility Information
 - Facility name, owner, address, telephone, e-mail
 - Facility point of contact

- Equipment Information
 - Type, volume of fluid
 - PCB type and concentration
 - “Nameplate” information (manufacturer, age etc.)

- Equipment condition
 - In-use?, surplus?

Notification

- Announce the program
- Identify participating organizations
 - Utilities, heavy industry, mining, large commercial entities
 - Trade associations, professionals
- Identify and engage contact persons within those organizations
- Send forms and instructions to contact persons
- Establish Help Line

Education

- Prepare simple brochures
- Prepare web page with information
- Organize meetings, workshops, seminars

Identification of PCB Equipment

- Most Manufacturers of transformers and capacitors identified their equipment as containing PCBs.
- Check the nameplate of the original equipment. Transformers' nameplate may still be readable.
- Most of the utilities when installing transformer stations installed capacitor banks with several capacitors manufactured in same lot. The identification of 1 capacitor may provide information for a bank of 50 or more capacitors.

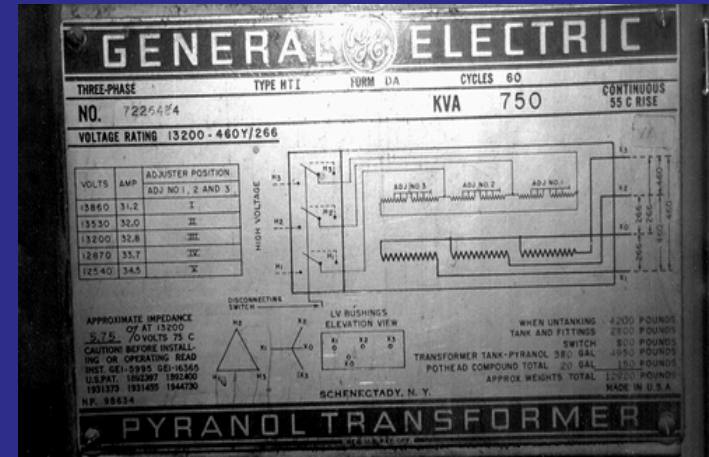
Inventorying PCB-Containing Equipment

- Inspect both the equipment and corresponding records
- Record information on the inventory form
- Check and confirm information with facility escort



Determining if the equipment contains PCBs

- Look for manufacturer's nameplate
- Apply assumption rules





Improper identification



PCB Filled
Transformers
identification



Assumption Rules

<u>Situation</u>	<u>Assumption</u>
•Transformers/Capacitors with no information	Assume PCBs
•Transformers with mineral oil contaminated dielectric fluid and no other information	Assume PCB
•Switches, voltage regulators, contaminated fluorescent light ballasts with no information	Assume PCB

Equipment Information

- Equipment type
- Location
- Size (kW)
- Manufacturer
- Serial number
- Years in service
- Total weight of equipment
- Weight (volume) of dielectric fluid
- Date of manufacture
- Trade name of dielectric
- Brand

Aceclor	Chlorinated diphenyl	Dyknol	Kenneclor	Polychlorodiphenyl
Adkarel	Chlorinol	Educarel	Leromoll	Prodelec
Aceclor	Chlorobiphenyl	EEC-18	Magvar	Pydraul
Adkarel	Chlorodiphenyl	Elaol	MCS 1489	Pyraclor
ALC	Chlorofen	Electrophenyl	Montar	Pyralene
Apirolio	Chlorphen	Elemex	Nepolin	Pyranol
Apirorio	Chorextol	Elinol	Niren	Pyroclor
Areclor	Chorinol	Eucarel	No-Flamol	Pyronol
Arochlor	Chorinol	Fenchlor	NoFlamol	Saf-T-Kuhl
Arochlors	Clophen	Fenclor	Non-Flamol	Saf-T-Kohl
Aroclor	Clophenharz	Fenocloro	Olex-sf-d	Santosol
Aroclors	Cloresil	Gilotherm	Orophene	Santotherm
Arubren	Clorinal	Hexol	PCB	Santothern
Asbestol	Clorphen	Hivar	PCB's	Santovac
ASK	Delor	Hydelor	PCBs	Siclonyl
Askael	Delotherm	Hydol	Pheneclor	Solvol
Askarel	Delorene	Hydrol	Phenochlor	Sorol
Auxol	Diaclor	Hyrol	Phenoclor	Soval
Bakola	Dialor	Hyvol	Plastivar	Sovol
Biclор	Dicolor	Inclor	Polychlorinated biphenyl	Sovtol
Biphenyl, chlorinated	Diconal	Inerteen	Polychlorinated biphenyls	Tarnol
Chlophen	Diphenyl, chlorinated	Inertenn	Polychlorinated diphenyl	Terphenychlore
Chloretol	DK	Kanechlor	Polychlorinated diphenyls	Therminal
Chlorextol	Duconal	Kaneclor	Polychlorobiphenyl	Therminol 88
Chlorinated biphenyl	Dykanol	Keneclor	Pydraul	Turbinol

Safety Considerations

- Must be aware and comply with basic safety Requirements
- Must bring own basic personal protective Equipment
- Must be aware of emergency response plan

Inspect Equipment Service Records

- Determine whether the equipment has been retrofilled
 - If yes, where is the waste fluid?
- If equipment has been retrofilled, ask for service records, tests performed
 - Dielectric fluid tests for PCBs should be done after 3 months of normal operation
 - Determine if PCB concentrations are still below
 - 50 ppm or specified concentration

Inventory of PCBs oil

S.No	PCB Concentration	Total Tonnes
1	Pure PCBs (100%)	3000.03
2	Contaminated PCBs Above 500ppm	6717.632
3	Stockpiles	120.00
	Total	9837.662



PCBs GUIDELINES

1. PCBs identification, tracking and record keeping
2. PCBs, PCB containing equipment, packaging and transportation
3. PCBs, PCB containing equipment and PCBs waste interim storage
4. PCBs, PCB containing equipment and PCBs waste disposal

1. PCBs identification, tracking and record keeping

The purpose of placing a label to facilitate the identification of PCBs containing Equipment. To ensure that the operators and general public are informed the existence of PCBs containing equipment in their factory, so that they can adopt suitable management measures as required. Labels must include information about the contact reference , ie., person in- charge of emergency response and handling, transporting and disposing PCB waste.

2. PCBs, PCB containing equipment, packaging and transportation

FOLLOW THE LEGISLATIONS

MOTOR VEHICLE ACTS : Hazardous waste rule.

PACKAGING OF PCBs : Marking and labelling etc.,

TRANSPORTATION OF PCBs : Vehicle and Driver requirement

TRAINING : Handling and transportation of PCBs

3. PCBs, PCB containing equipment and PCBs waste interim storage

Larger the size of PCBs storage, greater is the risk associated with the infrastructure.

Setting up multiple temporary storage facilities close to the site would be good option.

Storage capacity depends on the amount of PCBs which may be disposed over a certain period of time.

Avoid storage : Fire, Flood, Earthquake & Leakage

4. PCBs, PCB containing equipment and PCBs waste disposal

Complete destruction of the PCBs

Commercially available and proven track record

Prevent the formation of dioxins, furans and other by-product POPs.

Not generate any waste with POPs characteristics.



Thank you



CENTRAL POWER RESEARCH INSTITUTE

