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INDUSTRIAL DEVELOPMENT
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ENVIRONMENTALLY SOUND MANAGEMENT AND FINAL DISPOSAL OF PCBs

INDIA

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STEEL AUTHORITY OF INDIA LIMITED

RAMKY GROUP
Towards sustainable growth

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2. Introduction

A polychlorinated biphenyl (PCB) is an organic chlorine compound with the formula $C_{12}H_{10-x}Cl_x$, where x ranges from 1 to 10. Polychlorinated biphenyls (PCBs) were commercially manufactured to use in numerous industrial and consumer applications, most notably as insulation fluids in electrical transformers and generators but also in products including fluorescent lamp ballasts, caulk, and carbonless copy paper.

The International Agency for Research on Cancer and the Environmental Protection Agency classify PCBs as a probable human carcinogen. In 1995, the **Governing Council of the United Nations Environment Program (UNEP)** called for global action to be taken on POPs, which it defined as "chemical substances that persist in the environment, bio-accumulate through the food web, and pose a risk of causing adverse effects to human health and the environment". Following this, the Intergovernmental Forum on Chemical Safety (IFCS) and the International Program on Chemical Safety (IPCS) prepared an assessment of the 12 worst offenders, known as **the dirty dozen**. The INC met five times between June 1998 and December 2000 to elaborate the convention, and delegates adopted the **Stockholm Convention** on POPs at the Conference of the Plenipotentiaries convened from **22-23 May 2001 in Stockholm, Sweden**. The Convention entered into force on **17th May 2004**.

The Stockholm Convention is a global treaty to protect human health and the environment from persistent organic pollutants (POPs). The Stockholm Convention focuses on eliminating or reducing releases of POPs. It sets up a system for tackling additional chemicals identified as unacceptably hazardous. Ultimately, the Convention points the way to a future free of dangerous POPs and promises to reshape our economy's reliance on toxic chemicals. The Stockholm Convention (SC) on persistent organic pollutants (POPs) recognizes that POPs including polychlorinated biphenyls (PCBs) "possess toxic properties, resist degradation, accumulate and are transported through air, water and migratory species, across international boundaries and deposited far from their places, where they accumulate in terrestrial and aquatic ecosystems". Exposure to PCBs is of a major public health concern, in particular impacts upon women and, through them, upon future generations.

The Environmental Protection Agency of United States issued final regulations banning the manufacture of polychlorinated biphenyls (PCBs) on 19th Aril, 1979. The Republic of India signed the Stockholm Convention on POPs on **14th May 2002** and ratified it on **13th January 2006**. The Global Environment Facility (GEF)-funded project entitled "Environmentally Sound Management

& Final Disposal of Polychlorinated Biphenyls (PCB) in India" was approved on 14th June 2007. By the Government of India's notification, the Ministry of Environment and Forests (MOEF) was assigned as the National Focal Point (NFP) for the Stockholm Convention on POPs. The GEF Operational Focal Point in India signed the project document on **8th November 2007** and the Inception Workshop for the development of this project was held on 6th May 2008

3. Objective

The overall objective of this project is to reduce and eliminate the use and releases of PCBs to the environment through promotion of measures to minimize exposures and risks by introducing disposal of PCBs, PCB containing equipment and PCB-containing mineral oils. India is required to end the use of PCBs and complete the project "Environmentally sound disposal of PCBs" in the country by 31st December, 2025 and by 31st December, 2028 respectively.

The Principal objectives of the project are:

- Strengthen the legal and regulatory framework for environmentally sound management and disposal of PCBs, PCB-containing equipment and PCB-containing mineral oils and wastes.
- Improve institutional capacity at all levels of PCBs disposal management; Removal of PCB-containing mineral oils, PCB-containing equipment and wastes from targeted sites and transport them to disposal unit.
- Disposal of PCB-containing mineral oils, PCB-containing equipment and wastes in an environmentally sound manner.

The Ministry of Environment, Forests and Climate Chance (MOEF & CC) is the national executing partner for the project. **Bhilai Steel Plant (BSP)**, a unit of Steel Authority of India (SAIL), is the lead beneficiary of this project. SAIL/BSP is organizing the project implementation site at Bhilai, Chhattisgarh, with a co-financing support in the form of infrastructure cost, land cost, utilities, operating expenses and others for this disposal unit.

United Nations Industrial Development Organization (UNIDO) acts as the GEF Implementing Agency for the project implementation, supervision & monitoring of project management. UNIDO to supervise the project implementation works at BSP by **Ramky Enviro Engineers Ltd (REEL)**. REEL has been awarded of procuring the technologies, international expertise and equipment needed to install the facility.

4. Physical Properties of PCBs and POPs

S. No.	POP Name	Mol wt.	Chemical formula	M.P ^{o}C	B.P ^{o}C	Sp. Gravity
1	Dieldriin	381	$C_{12}H_8Cl_6O$	176 -177	385	1.75
2	Aldrin	365	$C_{12}H_8Cl_6$	104	145 at 2mm Hg	1.70
3	Chlordane	410	$C_{10}H_6Cl_8$	106 – 107	175	1.60
4	DDT	354.4	$C_{14}H_9Cl_5$	108 – 109	260	1.56
5	Endrin	381	$C_{12}H_8Cl_6O$	200 (Decompose)	-	1.70
6	Heptachlor	373.5	$C_{10}H_5Cl_7$	95 – 96	Dec.	1.58
7	Hexachlorobenzene	285	C_6Cl_6	227 – 229	323 – 326	-
8	Mirex	546	$C_{10}Cl_{12}$	485	485 (dec.)	-
9	Toxaphene	414	$C_{10}H_{10}Cl_8$	65 -90	Dec.	1.63

A laboratory will be used to analyze PCBs using Gas chromatography (GC) to examine the PCB contaminated mineral oil. The plant laboratory chemists and technologist will be trained on the methods used to measure the PCB in the different matrices. The stack and air monitoring samples will be measured in an external laboratory for volatile organics, PCB and Per-chloroethylene. The plant operations laboratory will be able to perform PCB analysis only. Based on the concentration of polychlorinated biphenyl (PCB), the received mineral oil will be separated in three parts:

I. Low Level PCB Oil – PCB concentration is range between > 2 to ≤ 6700 mg/ Kg of Mineral oil.

II. High Level PCB Oil - PCB concentration is range between > 6700 to ≤ 50000 mg/ Kg of Mineral oil.

III. Pure PCB Oil - PCB concentration is > 50000 mg/ Kg of Mineral oil.

5. Different Parts of the Project

Based on different process the project is divided by two parts:

I. **Destruction of pure PCB liquid waste (Part A).**

II. **De-Chlorination of high level / low level PCB liquid waste (Part B).**

6. Summary of Destruction Process (Part A)

The proposed facility is setting up for the destruction of pure PCB liquid waste as well as decontamination of porous material contaminated with pure PCBs in Transformer Oil. This facility (Part A) consist of two different systems.

1. Plascon Destruction System.
2. Indirect Thermal Desorption (ITD) System.

6.1 Plascon Destruction System

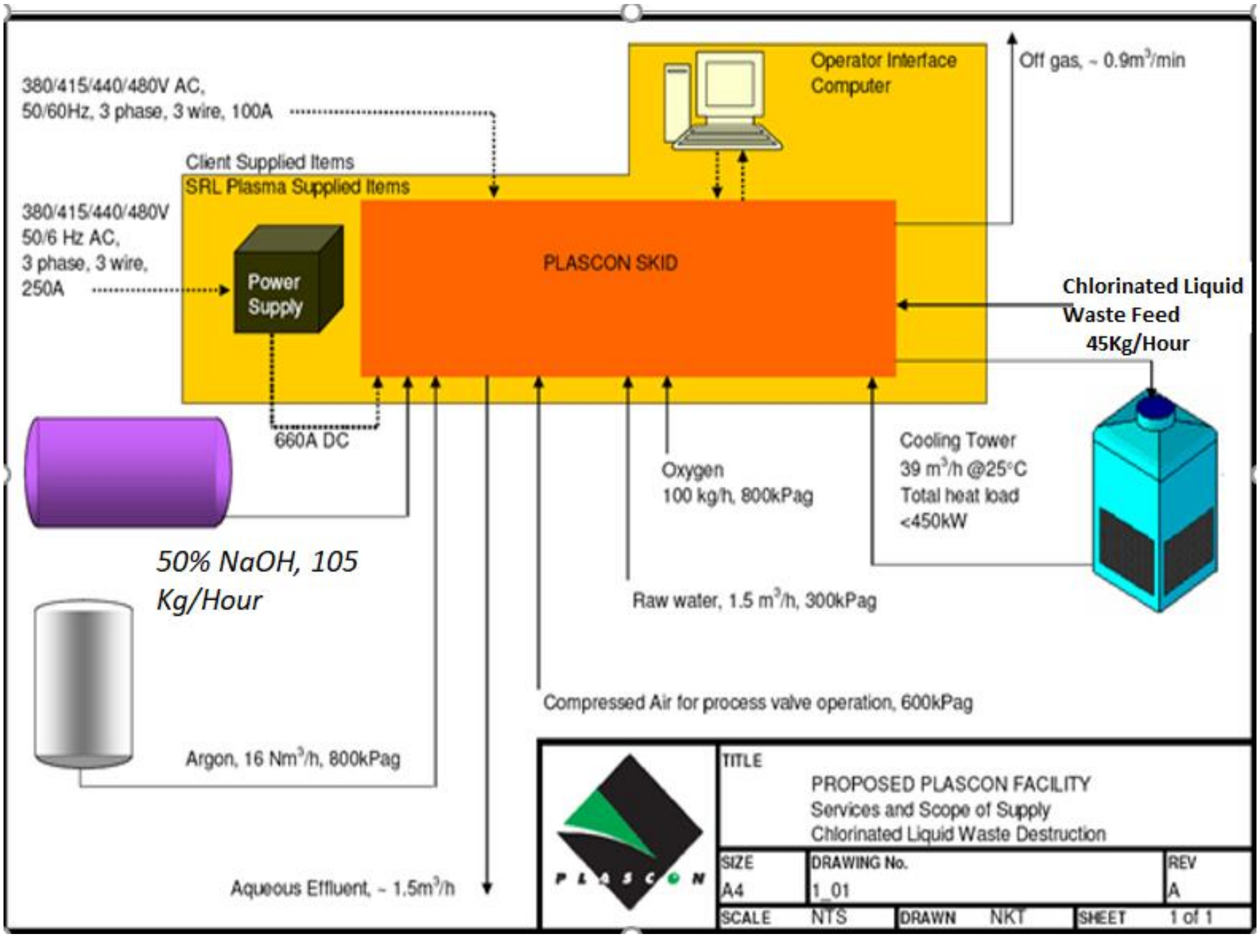
The system will destruct at least 330 Tons of pure PCBs per year. The Plascon process produces a high temperature (10,000°C) plasma arc by ionizing argon gas in a 150 kW DC discharge between a separate cathode and anode. The liquids or gasses to be destroyed are injected into the plasma at a specially designed Injection Manifold (IM). An average mixing temperature at the injection manifold of approximately 3,000°C degrades the molecules upon entry into this region, converting them into atoms and ions. This process is known as pyrolysis (degradation by heat).

Oxygen is also injected at the IM. These molecules are also split into their component atoms by pyrolysis. As the ionized gas cools downstream from the injection manifold, oxygen combines with carbon to form CO. The hot gas continues to cool to approximately 1,500°C in a water jacketed reaction chamber called the Flight Tube and is then rapidly cooled in the Quench with a direct spray of cool, alkaline liquor. At this point the hydrogen and chlorine atoms will have combined to form HCl and some of the CO will have reacted with excess O_2 to form CO_2.

Below the Quench in the Spray Scrubber the gas is fully neutralized by further sprays of recirculating alkaline liquor. From the Spray Scrubber the gas passes through a packed column and demister to remove any remaining acid gases.

The pH of the recirculating liquor is maintained by the controlled addition of caustic solution (NaOH). Liquor at a pH of approximately 8 and containing NaCl at a concentration of up to 20% bleeds from the system via a liquid sealed overflow in the Spray Scrubber.

6.1.1 Flow Diagram of Plascon System



6.1.2 List of Equipment for Plascon System

- Plasma Torch and liquid waste injection system
- Gas scrubber vessel and scrubber liquid re-circulation system
- Packed column scrubber
- Di-ionized water coolant system
- DC Arc power supply
- Control system and required instrumentation
- PLC system
- Heat Exchanger
- Cooling Tower System
- Plasma coolant system
- Caustic storage tank

6.1.3 List of Auxiliary facilities for Plascon System

- Cooling tower with circulating pumps
- Air compressor
- Multiple effective evaporators (MEE) including boiler.
- Water softener
- Bulk argon storage.
- Bulk oxygen storage
- Nitrogen cylinders with manifold
- Bulk diesel storage
- Solid waste holding facility

6.1.4 Utilities / Services Required for Plascon System

The consumption of the raw materials in the pure PCB destruction process is based on the destruction of pure PCB. The following chemicals, consumables and fuel are expressed in ton per ton of pure PCB destroyed.

S. No.	Utility Name	Unit	Cons. Norm
1	Electricity	KWH/Ton	4000
2	Argon	Ton/ Ton	0.76
3	Oxygen	Ton/ Ton	2.22
4	NaOH 50% w/w	Ton/ Ton	2.35
5	Process water	Ton/ Ton	5.8
6	Compressed Air	Ton/ Ton	0.1
7	Fuel (HSD)	Ton/ Ton	0.20

6.2 Indirect Thermal Desorption (ITD) System

The Thermal Desorber is a batch process, that will decontaminate at least 330 tons/year of porous materials contaminated with pure PCBs in transformer oil. The indirect thermal desorption unit used as a means of removing organic contaminant constituents from solid contaminated wastes. The basic premise of operation is that any compound with a boiling point less than 450^0 C will be removed from a solid contaminated media and collected as a separate liquid condensate. The residual solid media is analyzed for conformance with the landfill guidelines and the condensate is further pre-treated and treated through suitable media to destroy the target contaminant of concern (COC). ITD is designed for decontamination of equipment such as capacitors, small transformer cores and absorbent materials. Following treatment in the ITD, the waste is “PCB Free” and the copper and steel can be recycled. Other materials can be disposed of as inert waste following treatment through the ITD. The ITD is designed with a HSD burner as its heat source.

The porous materials shall be decontaminated in In-direct Thermal desorption system by heating the contaminated components to around 450^0 C in a closed chamber by burning HSD in the outer shell of the heating chamber. The pure PCBs shall be distilled and absorbed in the circulating oil, which shall be sent to Part-B system for destruction of low level PCBs and recovery of oil for recycle& reuse.

Inert and traces of non-condensed gases pass through a carbon adsorption bed and finally exhausted to atmosphere through the boiler chimney. The fuel combustion gases mostly containing CO_2 from the jacket side of ITD are also sent to boiler chimney. The residual PCB content in the porous material after decontamination in the ITD shall be < 50ppm.

The ITD is fully automated, so once loaded with the contaminated equipment, it will operate unattended until it is time to unload the desorbed materials.

6.2.1 Waste suitable for ITD System

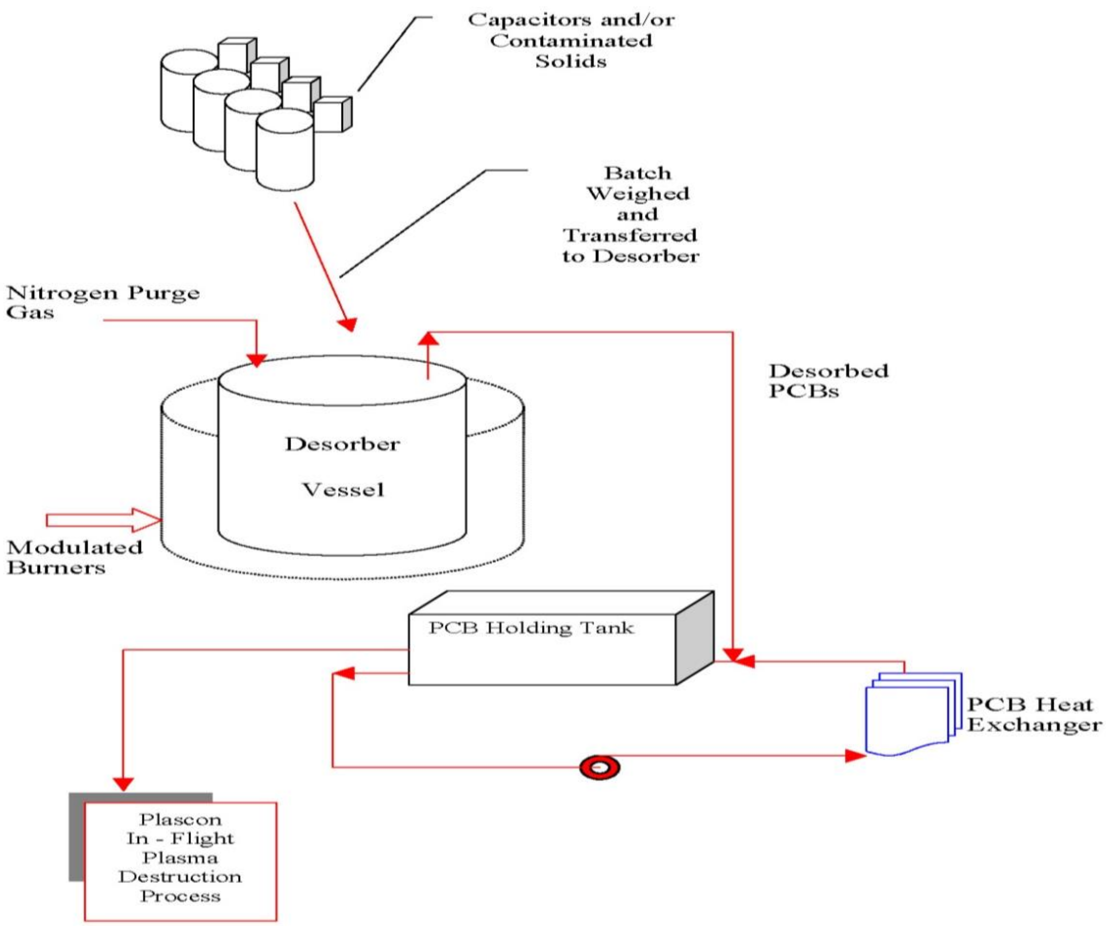
The system is designed primarily to remove polychlorinated biphenyls (PCB) from contaminated electrical equipment. The unit is however capable of effectively treating a range of solids contaminated with organic compounds including the following waste streams provided suitable pre-treatment and process cycle parameters are utilized.

- **PCB contaminated Capacitors**
  - Typically, PCB capacitor cans and/or PCB light fitting capacitors contaminated with high PCB concentrations.
  - Capacitor Cans: 5-50kg steel boxes with porous internal aluminium and paper components. Approximately 50% (normally near pure) PCB oil by mass.
  - Light Fitting Capacitors: Small sealed metal tubes containing PCB as an oil or as a wax as roughly 15% concentration by mass.
- **PCB contaminated Transformers**
  - Transformers: Large pieces of electrical equipment contaminated with low to high concentrations of PCB oil. Normally contain a complex core consisting of copper or aluminium wound over silicon steel.
- **Contaminated soils**
  - PCB
  - Pesticides (organochlorine, organo phosphorous, other)
  - Chlorinated Organic compounds
  - Organic compounds (PAH, BTEX, TPH etc.)

- **Contaminated Packaging**
  - Steel containers containing organic residues (normally shredded)
  - Plastic containers containing organic residues (normally shredded, small quantities only)

- **Pesticide Solids**
  - Solid concentrated or blended pesticide powders. (Note: Concentrated (<50% COC content solids must only be processed in quantities of 200kg or less per batch).
  - Some pesticide sludge (dependent on residual liquid content).
- **Spill Clean-Up Material**
  - Diatomaceous earth (kitty litter).
  - Vermiculite
- **Other Contaminated Solid Media**
  - Activated carbon.

6.2.2 Flow Diagram of ITD System



6.2.3 List of Equipment for ITD System

- **Heating Pot** – This consists of an internal vessel into which the objects to be decontaminated are placed, and an external refractory lined vessel. A gas burner heats the space between the two vessels which in turn heats the contents of the internal vessel. The internal vessel has an insulated lid which is removed for the loading and unloading of items to be decontaminated.
- **Receiver Vessel** – This vessel contains a volume of liquid into which vapors driven off from the Heating Pot are absorbed. Once this liquid has absorbed a quantity of Heating Pot vapors it is replaced with fresh liquid.
- **Bag Filters** – These remove any large particulates that may form in the absorption liquid.
- **Ejector** – This ensures intimate contact between the vapors emanating from the Heating Pot and the absorption liquid.
- **Carbon Filter** – this ensures that the air discharge to atmosphere through vent pipe is free from any contamination.

6.2.4 List of Auxiliary Facilities for ITD System

- Cooling Tower System
- Air Compressor
- Bulk Diesel Storage
- Bulk Argon Storage
- Nitrogen Cylinders with Manifold
- Solid Waste Holding Facility

6.2.5 Utilities / Services Required for ITD System

The consumption of the raw materials in the decontamination process is based on the decontamination of Porous materials. The following chemicals, consumables and fuel are expressed in ton per ton of Porous materials decontaminated.

S. No.	Utility Name	Unit	Cons. Norm
1	Electricity	KWH/Ton	600
2	Fuel	Ton/ Ton	0.150
3	Activated carbon	Ton/ Ton	0.001
4	Nitrogen	Ton/ Ton	0.1

6.3 Waste Management

There are no major streams and rivers, which can get effected by the proposed decontamination facility. Hence there will be no major effect on the surface water environment. The domestic wastewater from proposed facility shall be send to septic tank followed by soak pit.

In Plascon destruction process, approximately **9KL** of liquid waste will be generated in a day. The effluent shall be treated in the **Multiple Effective Evaporator (MEE)** followed by **Agitated Thin Film Drier (ATFD)** system, where the recovered water is subsequently recycled/reused in the scrubbing system of Plascon unit and the salts thus generated in the ATFD shall be sent to approved TSDF/ landfill facility. **No liquid effluent will be generated in ITD system.**

6.3.1 MEE & ATFD System for Treatment of Liquid Waste

- **Multiple Effect Evaporator (MEE) System**

MEE system works on evaporation system. Evaporation falls into the concentration stage of downstream processing and is widely used to concentrate foods, chemicals, and salvage solvents. The goal of evaporation is to vaporize most of the water from a solution containing a desired product, or in the case of drinking water from seawater, an undesired product. After initial pre-treatment and separation, a solution often contains over 85% water. This is not suitable for industry usage because of the cost associated with processing such a large quantity of solution, such as the need for larger equipment. If a single evaporator is used for the concentration of any solution, it is called a single effect evaporator system and if more than one evaporator is used in series for the concentration of any solution, it is called a multiple effect evaporator system.

Evaporators are integral part of a number of process industries namely Pulp and Paper, Sugar, pharmaceuticals, Desalination, Dairy and Food processing, etc. The goal of evaporation is to concentrate a target liquid, and this needs to be achieved for many different targets today.

In this project liquid waste generated in Plascon destruction system will be treated in MEE to get a concentrated effluent which will be dried by ATFD system and generate salts.

- **Agitated Thin Film Drier (ATFD) System**

ATFD stands for evaporation of liquid/ solvents to make concentrated liquid to dry powder, flakes or salts. It is the ideal apparatus for continuous processing of concentrated material to dry solids. ATFD consist of cylindrical, vertical body with heating jacket and a rotor inside of the shell which is equipped with rows blades all over the length of the dryer. The hinged blades spread the wet feed product in a thin film over the heated wall.

The turbulence increases as the product passes through the clearance before entering calming zone situated behind the blades as the heat will transfer from jacket to main shell under the smooth agitation. Liquid will evaporate and convert to slurry to cake or to dry powder, flex or salts.

The vapors produced rise upward, counter-currently to the liquid and pass through cyclone separator mounted of vapor outlet of ATFD. Further this vapor will be condensed in condenser and recovered as condensate. System will be operated under vacuum for temperature sensitive products and atmospheric condition for normal drying.

Concentrated effluent from MEE will be transferred to ATFD to generate dried salts and the same will be transferred to approved TSDF/ landfill for disposal facility.

6.3.2 Solid wastes

Solid waste source	Case	Flow per day	Mass per year	Temperature
PLASCON	Solids from ATFD shall be sent to approved landfill	~ 2 T per day	660 Tons per year	Ambient to 40^{O}C
ITD	Shall be sent to approved TSDF / landfill	~ 7 kg/ day	2.3 T per year	Ambient to 40^{O}C

Non-hazardous salts generated from MEE and ITD shall be collected in special containers and disposed in facilities authorized by Indian ministry of environment for handling this type of wastes.

6.3.3 Waste Gases

Waste gases source	Case	Flow per day	Flow / year	Temperature
PLASCON	Sent to atmosphere through APC	~ 67.0 m^3/day	22110 m^3/ year	Ambient to 40^oC
ITD	Sent to atmosphere through APC	~ 7.0 m^3/day	2310 m^3/ year	Ambient to 40^oC

7. Summary of De-Chlorination Process (Part B)

De-chlorination process is setting up to extract the chlorine atoms from high level & low level PCB contaminated mineral oil. The process operates at ambient temperature and does not use flammable solvents. This process extracts chlorine atoms by chemical reaction using sodium dispersion solution. Solution is air and water sensitive and during reduction the process must be blanketed with nitrogen. When introduced to the reaction tank, solution reacts immediately with the PCBs and chlorinated hydrocarbons to form sodium chloride.

This process consists several parts. As a pre-treatment process oil to be filtered by oil de-gasifier unit to eliminate the impurities and contaminated oil with water is reduced to acceptable levels. After pre-treatment the oil is decontaminated then sodium reagent will be added directly to the oil after the application of a nitrogen blanket. The amount of solution added is determined before the cleanup to determine the PCB, chlorinated hydrocarbon, other impurity levels. As the PCBs react to the sodium they are monitored on site with a gas chromatograph (GC). After de-chlorination the oil will be cleaned of salts and solids through oil regeneration & filtration unit. The solids, salts and small amounts of water solution of sodium hydroxide are removes at this stage. All wastes removed at this stage and the mineral oil transformed into non PCB oil. This de-chlorination facility is designed for the treatment of almost **907 tons/year** of high level/low level PCB contaminated mineral oil. Principles of all processes related to this facility will be discussed below.

7.1 Preparation of Sodium Dispersion

Batches of sodium dispersion will be prepared during every operating shift at the plant. The amount of sodium dispersion prepared in every batch would be equivalent to the amount of reagent necessary to carry out the three planned PCB/POP destruction runs in every shift. Each high level PCB destruction batch uses about 120 kg of sodium dispersion. The manufacturing process is designed to prepare 450 kg of sodium dispersion (40/60 ww) in an 8-hour shift. The mass of oil is 270 Kg (315 L) and the mass of sodium used is 180 Kg.

Sodium dispersion manufacturing calculations are as follows:

$$Oil_m = Oil_\rho \text{ X } Oil_v$$

Where, Oil_m = Mass of mineral oil.

Oil_ρ = Density of mineral oil = 0.856 Kg/L

Oil_v = Volume of mineral oil.

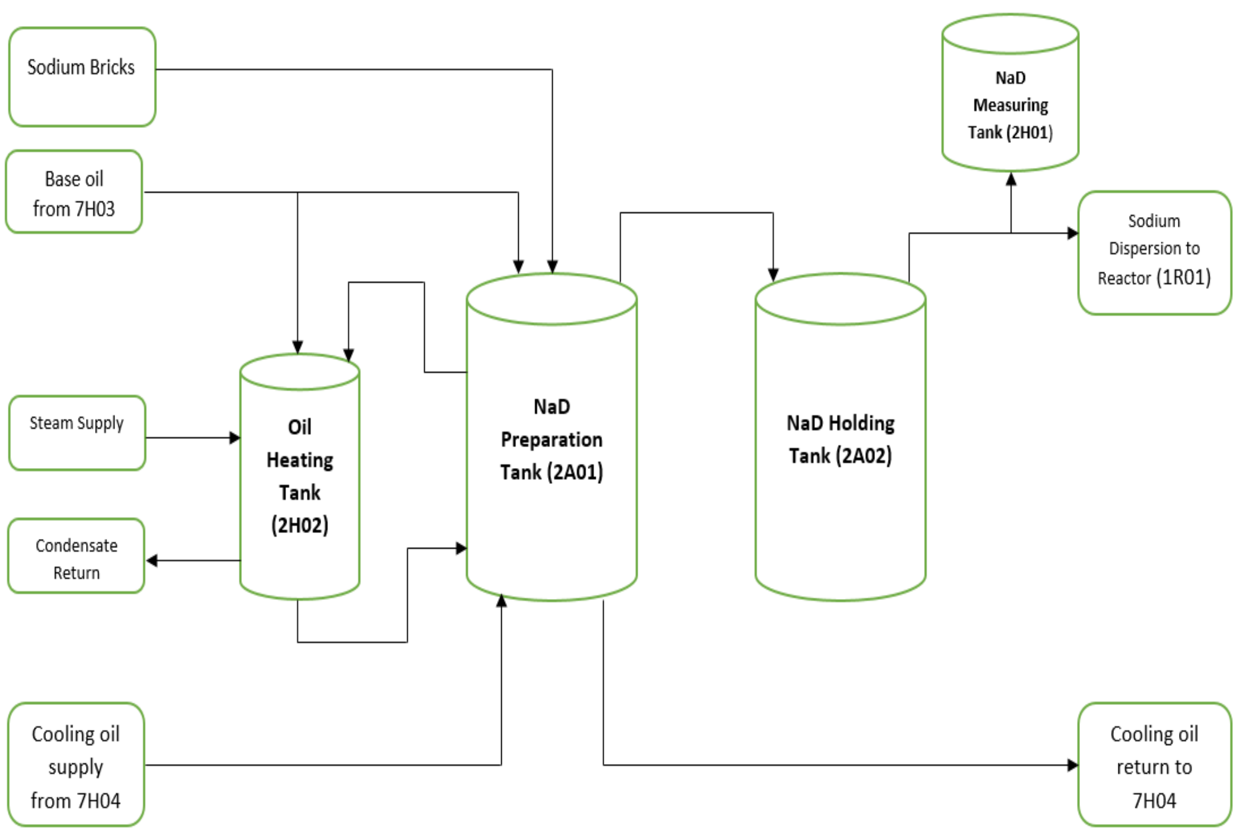
40% Na/Oil - The following formula is used to calculate the mass of sodium metal to be added to a known mass of mineral oil.

$Na_m = 0.666667 \times Oil_m$

Where, Na_m = Mass of sodium metal

Oil_m = Mass of mineral oil.

7.1.1 Process Flow Diagram of Sodium Dispersion System



7.2 Mineral Oil Storage and Handling Process

This system provides liquid storage for the plant operations. The storage tanks system provides the following functions for the plant operations:

7.2.1 Oil Storage Facilities

- High level PCB Oil Storage Tank (7H01)
  - Receiving High level PCB >6,700 to < 50,000 mg/kg PCB oil
  - Shipping High level PCB for incineration > 50,000 mg/kg PCB

- Low level PCB Oil Storage Tank (7H02)
  - Receiving Low level PCB > 2 to < 6,700 mg/kg PCB oil

- Recovered Mineral Oil Storage Tank (7H03)
  - Receiving non-PCB mineral oil
  - Supply clean mineral oil rinsing
  - Supply clean oil to drums for storage
  - Supply clean oil to decontaminate drums

- Regenerated Mineral Oil Storage Tank (7H04)
  - Supply regenerated mineral oil for retro-filling transformer
  - Drumming regenerated mineral oil

7.2.2 Oil De-Gasifier Unit (7Z01)

De-gasifier unit is used to degasify and transfer PCB contaminated mineral oil. The de-gasifier removes water dissolved in mineral oil. The target for degasification is <100 ppm water. Before transferring low level PCB to low level PCB oil storage tank (7H02) it should be run through a de-gasifier to remove dissolved water from the oil.
De-gasifier (7Z01) is also used to transfer the PCB contaminated mineral from 7H02 to the process reactor (1R01), this further reduces the dissolved water content prior to the de-chlorination of the PCBs using sodium dispersion.

Principle of operation:

The throughput capacity of de-gasifier is dependent on the concentration of the water in the oil. Water can occur in three phases within an oil system, depending on the chemistry of the oil. In general, oils dissolve some water. However, mineral oil has a specific water-saturation point beyond which excess water becomes either emulsified or free. Therefore, oil may have dissolved or, emulsified and/or free water.
Below table shows the water solubility in mineral oil as a function of temperature.

Water in Oil Solubility as a Function of Temperature.

Oil Temperature (^0C)	Water Content in Oil (mg/kg)
0	22
10	36
20	55
30	83
40	121
50	173
60	242
70	331
80	446
90	592
100	772

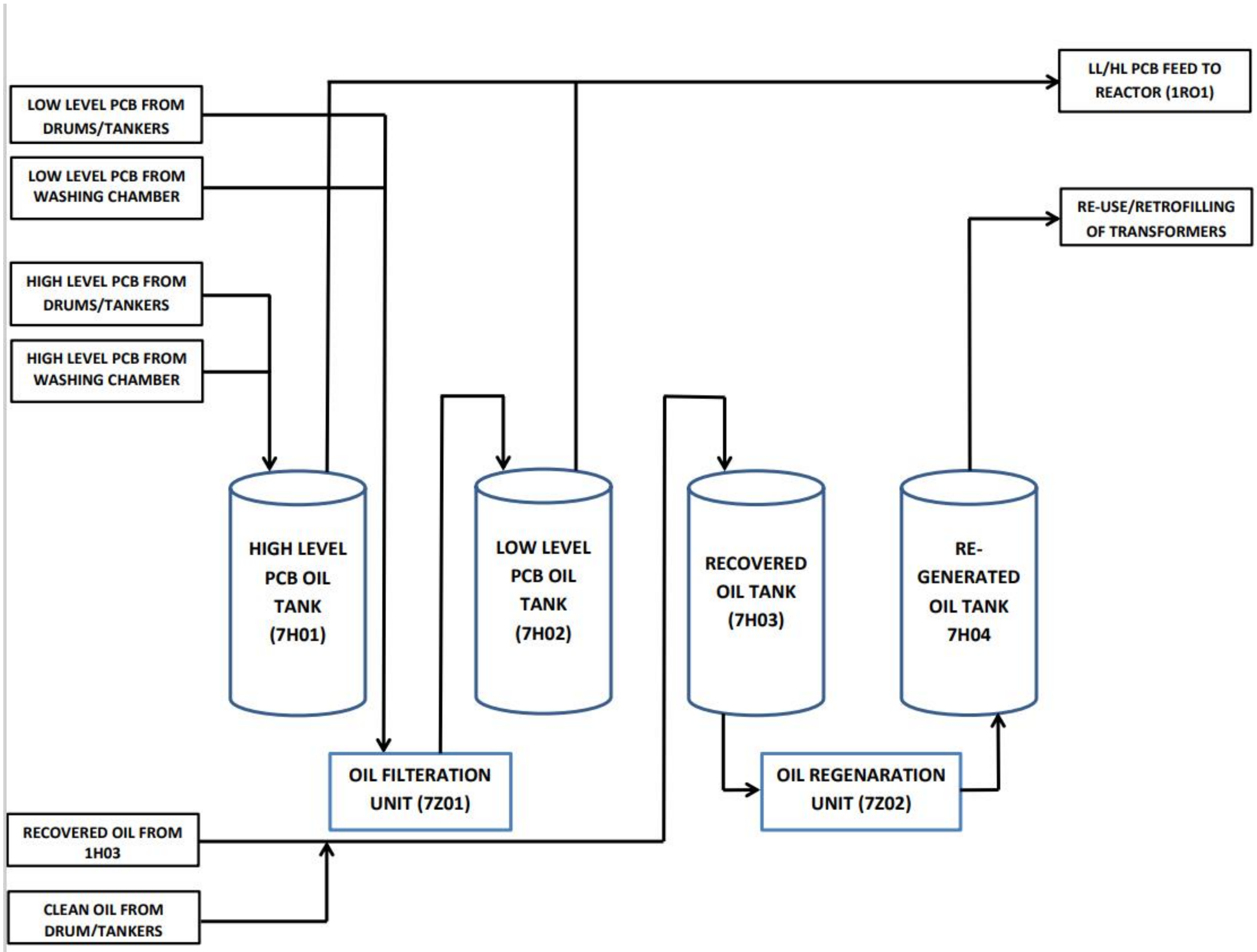
7.2.3 Oil Regeneration & Filtration Unit (7Z02)

Regeneration unit is used to filter the impurities and removes dissolved water from the recovered mineral oil. Before transferring recovered oil from recovered mineral oil tank (7H03) to regenerated mineral oil storage tank (7H04) it should be pass through the regeneration & filtration unit to remove impurities from the oil. Regenerated mineral oil will be used for retro-filling of transformer.

7.2.4 Summary of Oil Storage & Handling Process

- Receiving low level PCB oil waste streams.
- Receiving high level PCB oil waste streams.
- Shipping high level PCB oil for incineration.
- Receiving clean non-PCB oil for the PCB de-chlorination system and mineral oil decontamination system.
- Shipping excess recovered clean mineral oil for disposal or upgrading and transformer rinsing.
- Shipping excess regenerated clean mineral oil for sale and for retro-filling transformers for reclassification.

7.2.5 Process Diagram of Mineral Oil Storage Facility



7.3 De-Chlorination Process

The Low Level **(>2 mg/kg to ≤ 6,700 mg/kg)** or High Level **(>6,700 mg/kg to ≤ 50,000 mg/kg)** PCB de-chlorination process loop is also defined by the chlorine content. This process loop is used to determine the destruction efficiency of the sodium based system by the destruction of PCB contaminated mineral oils.

For Low Level PCB contaminated mineral oil the PCB waste stream chlorine concentration should be <0.03% (512 kg of Chlorine per 2900 kg batch (54200 mg/kg Chlorine). In this process configuration the low level PCB contaminated mineral oil is pumped directly into the reactor and heated to 100°C and then treated with a measured amount of sodium dispersion. The reaction is allowed to run for 30 minutes and then the reaction mixture is analyzed for PCB using GC-ECD.

The High Level PCB processing loop can treat 2% Chlorine per 2900 kg batch (61 kg of chlorine). Each batch will use approximately 150 kg of metallic sodium dispersion. The reaction is controlled by the injection rate of the PCB waste stream, a cooling oil jacket on the reactor and injecting cooling oil. The reaction is allowed to run for 60 minutes and then the reaction mixture is analyzed for PCB using GC-ECD.

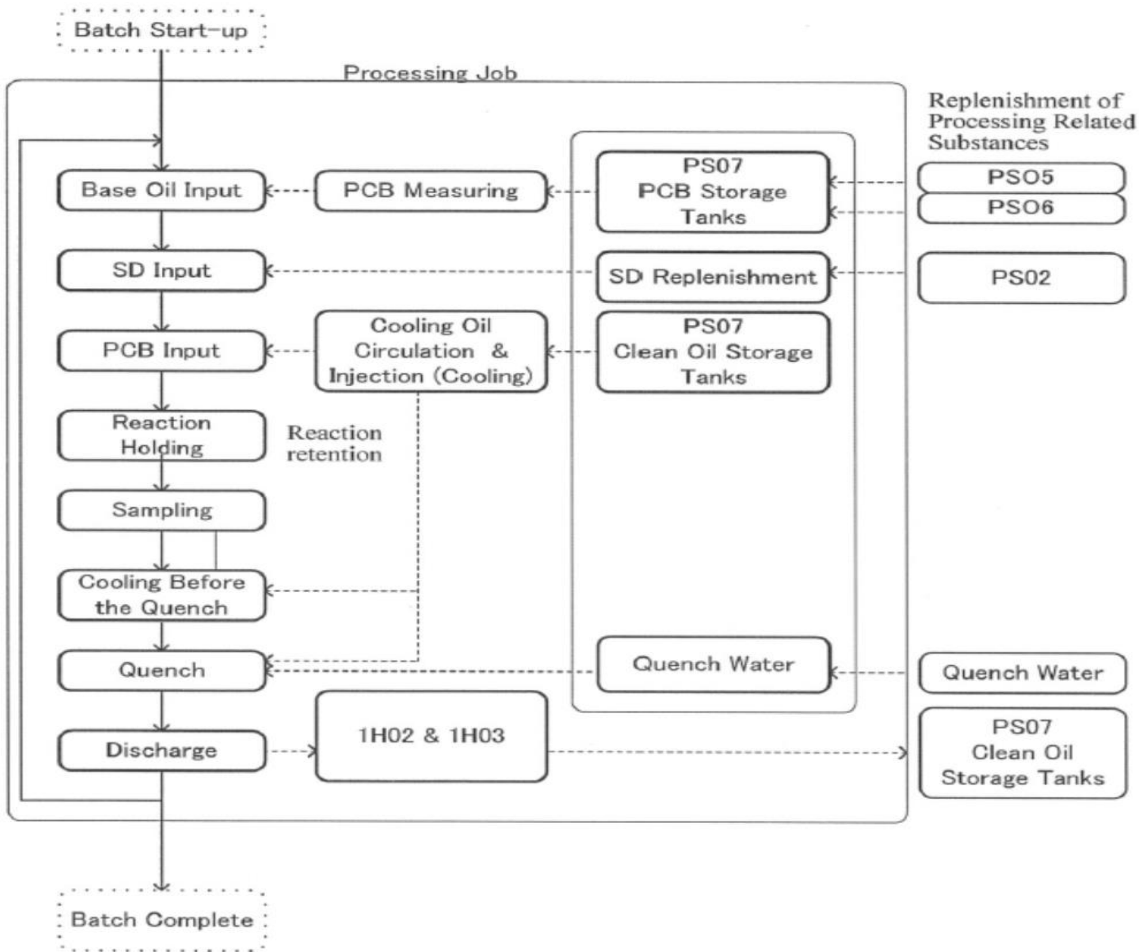
The mineral oil from the completed reaction is <2 mg/kg PCB and is recovered from the sludge and used in other plant processes. The recovered mineral oil will be regenerated for retro-filling reusable transformers.

The sludge by-product of the reaction can be recycled or disposed of following Indian regulations.

7.3.1 PCB De-Chlorination Process Loop

- Transfer PCB oil from Low level PCB storage tank (7H02) or high level PCB storage tank (7H02) to Reactor (1R01)
- Inject sodium dispersion to Reactor (1R01) from NaD Holding tank (2A02)
- Obtain treated oil for PCB analysis
- Confirm results
- Quench excess sodium dispersion
- Discharge Reactor (1R01) to Buffer Tank (1H02)
- Transfer from Buffer Tank (1H02) to Settling Tank (1H03)
- Remove sludge from Settling Tank (1H03)

7.3.2 Flow Diagram of De-Chlorination Process



7.4 Metal Equipment Dismantling & Rinsing Process

The transformers will be drained and dismantled for processing through the oil extraction system. The dismantling process is done under a slightly negative pressure to limit the exposure to PCB vapor. Daily, during the daily operation transformers will be rinsed and drained prior to dismantling for processing through the mineral oil wash process.

To reduce the exposure to PCB vapors transformers are rinsed using mineral oil prior to dismantling the equipment. The amount of oil used in each rinse and the PCB concentration of the oil removed from the transformer determines the amount of rinsing require.

Large transformers casings and drums can be decontaminated by rinsing the casing/drum or metal using mineral. This reduces the exposure to PCBs during the dismantling process.

7.4.1 Rinsing Process Using Mineral Oil

Contaminated PCB casings are placed in the decontamination tank. Use 2000 L of mineral oil to wash the outside surface of the transformer and using the same mineral oil wash the inside of the transformer, this procedure will take 30 minutes. Mineral oil samples are collected during the wash cycles to determine the PCB extraction efficiency during each wash cycle. Once the first wash cycle is complete the contaminated mineral oil is drained to the appropriate PCB oil storage tank for processing through non-combustion PCB destruction process. Repeat the wash cycles at least four more times. Once wash is complete and the metal is drained, obtain swipe samples from the metal pieces and log pertinent data as previously stated.

If the swipe samples are less than 10 µg/100 cm2 then the metal can be released for disposal or recycling. If the swipe samples exceed the 10 µg/100 cm2 then the metal has to be washed again.

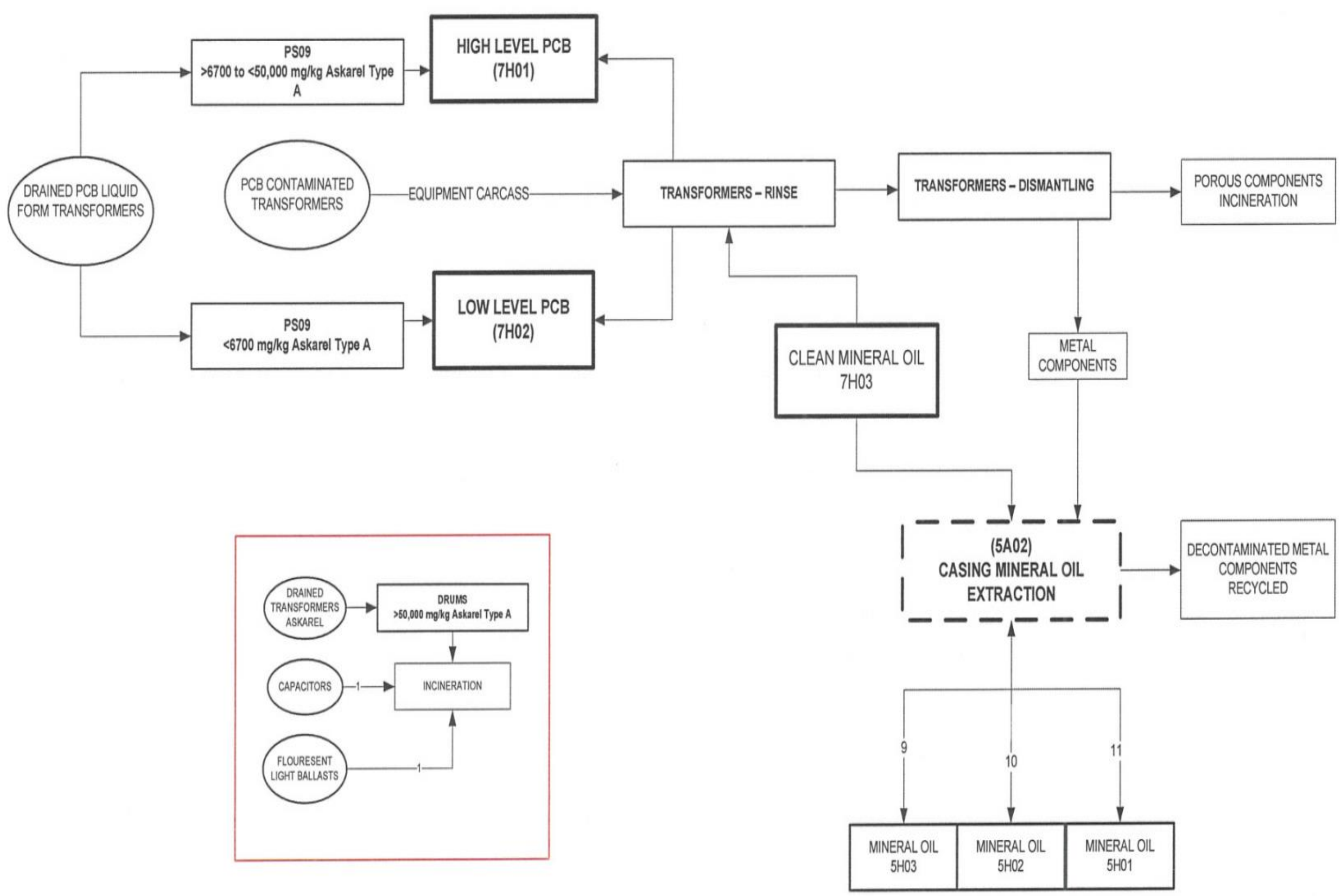
7.4.2 Dismantling & Rinsing Process Loop

- Casing wash tank (5A02)
- Clean Mineral oil used - 2000L per wash cycle (this can vary depending on the initial concentration of PCBs to be decontaminated).
- Time of decontamination operation - approximately 2.5 hours
- Closed loop system Tanks (5H01, 2 and 3) are oil supply tanks with low PCB levels, the oil from these tanks are used for the first 3 wash cycles. Contaminated oil from (5H03), (5H02) and (5H01) wash cycles are discharged to the PCB storage tanks depending on the PCB level. The fourth wash cycle from (7H03) is discharged to (5H03). Wash cycle number 5 is discharged back to (5H02) and wash cycle 6 is discharged to (5H01).
- Remove the washed metal pieces and store in a secure PCB free location for removal as scrap metal.

- Obtain three swipe samples from 100 cm2 areas of each piece of metal and mark the location of the sample on each part and identify the sample with the batch number, metal piece number and location.
- Analyze the swipe samples to determine the PCB level.
- Store the samples for quality control.
- Swipe samples are <10 µg/100 cm2 dispose of the metal
- Swipe samples are >10 µg/100 cm2 then rewash the contaminated parts.
- Mineral oil samples from analysis are to be returned to LL PCB oil tank (7H02) or HL PCB oil tank (7H01).
- Casing wash tank must be vapor tight.

This process removes PCBs from the metals. The mineral oil wash cycles are transferred to 7H01 or 7H02 for decontamination using the de-chlorination process and the recovered oil is reused in the decontamination process.

7.4.3 Flow Diagram of Dismantling & Rinsing Process



7.5 Waste Management

The facility is designed as a Zero Liquid Discharge (ZLD) plant, hence there will be no major effect on the surface water environment. The domestic wastewater from proposed facility shall be send to septic tank followed by soak pit. The expected hazardous waste generation from Part-B of the facility will be collected in containers & sent to secured land fill. Entire flooring is done in concrete with HDPE lining below flooring for an adequate facility for handling, collection, storage, transportation and disposal of hazardous wastes including PCB contaminated oil.

7.5.1 Waste Water

- **Domestic Waste Water –** Approximately 1.5 KL/ Day of waste water from domestic purpose will be send to septic tank followed by soak pit.
- **Industrial Waste Water –** No industrial effluent will be generated. The facility is designed as a Zero Liquid Discharge plant.

Garland drain and collection pit provided to prevent the flow of raw materials, products, fuel, wastes etc. with rain water. The same will be recycled as process water and gardening purpose.

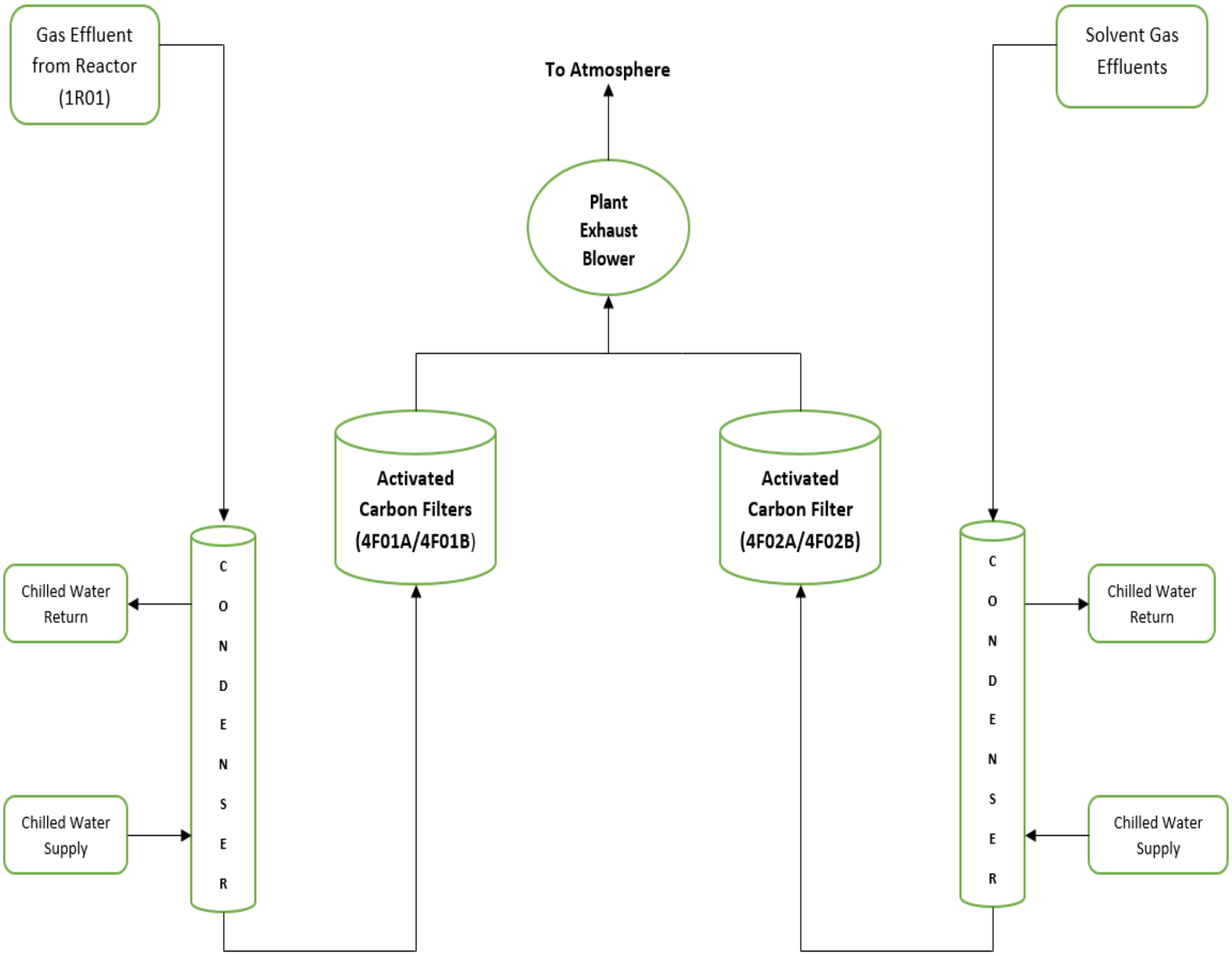
7.5.2 Solid Waste Management

After de-chlorination process **100 Kg/Day** of sludge containing mainly sodium chloride will be produced. Wastes shall be collected in special containers and transferred to TSDF for further treatment and disposed in facilities authorized by Indian ministry of environment for handling this type of wastes.

7.5.3 Waste Gases

The facility operates as essentially closed system based on the ALARA (As Low as Reasonably Achievable) principle wherein any releases to the environment are controlled and in the event of exposure, this is or should be lower than permissible regulated limits. Activated charcoal is used in the stack for trapping the volatile organic carbons during handling of PCBs. Proper ventilation arrangements with exhaust fans are also being installed for ensuring safe/healthy working environment. Emissions from the plant pass through gas condensers followed by activated charcoal filters (4 units) prior to release to the atmosphere.

7.5.3.1 Process Diagram for the Treatment of Waste Gases



7.6 Monthly Production Details of De-Chlorination Process

<u>MATERIAL BALANCE FOR ONE MONTH</u>

<table>
<tr><th colspan="2">Material In</th><th colspan="2">Material Out</th></tr>
<tr><th>Components</th><th>Mass (kg)</th><th>Components</th><th>Mass (kg)</th></tr>
<tr><td rowspan="2">PCBs (Aroclor 1260)
Moles of PCBs (360 g/mole)
- Chlorine 1.00
- Hydrogen 0.01
- Carbon 0.68</td><td rowspan="2">170</td><td>Mineral Oil</td><td>1,73,630</td></tr>
<tr><td>Sludge
- Sodium Chloride 410
- Sodium Hydroxide 2820
- Polyphenyl 60</td><td>3,290</td></tr>
<tr><td>Mineral oil</td><td>1,69,830</td><td rowspan="4">Gases
- Nitrogen 300
- Hydrogen 100</td><td rowspan="4">400</td></tr>
<tr><td>Nitrogen</td><td>300</td></tr>
<tr><td>Sodium Dispersion (40% Na)
- Sodium 2000
- Mineral oil 3000</td><td>5,000</td></tr>
<tr><td>Flushing oil (mineral oil)</td><td>2,000</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>Total Material In</td><td>1,77,300</td><td>Total Material Out</td><td>1,77,300</td></tr>
</table>

7.7 List of Auxiliary Facilities for De-Chlorination Process

- Cooling Tower System
- Boiler Unit with Water Softener Facility
- Chiller Unit
- Air Compressor Unit
- Oil De-Gasifier Unit
- Oil Filtration & Regeneration Unit
- Nitrogen Cylinders with Manifold
- Bulk Diesel Storage Facility
- Bulk Sodium Metal Storage Facility
- Solid Waste Holding Facility

8. Overall Water Flow Chart

Flow chart of water requirement for the entire project (including Part A & Part B) are given Below: