Chemical Treatment of PCB Containing Mineral Oil and Oil-Filled Transformers

Glenn Maling
ENSR Operations
1700 Gateway Blvd. S.E.
Canton, Ohio, USA 44703
(216) 452-0837

Chemical treatment of PCB containing mineral oil is a proven viable alternative to retrofilling and/or incineration. It achieves superior PCB removal, reduces the operational risk to transformers, and eliminates oil handling and transportation.

INTRODUCTION

Due to cross-contamination, many mineral oil filled transformers are now contaminated with low levels of PCB. Although oil units represent less PCB in pounds than the askarel unit population, they comprise the largest volume of contaminated material. As such, oil can typically pose greater environmental risk and clean up cost potential due to outdoor locations, larger volumes, and easy access to surface waterways.

Retrofilling, the common drain-flush-refill transformer procedure, has been used for decades to replace deteriorated oil with clean oil. It has also been used for the removal of PCBs. However, retrofilling presents difficulties in some cases regarding achieving the lowest possible PCB level, preserving transformer integrity, and generating large volumes of oil which must be handled by workers, transported and disposed. Chemical PCB destruction was developed to resolve these concerns.

DESIGN OBJECTIVES

In 1976, Sun Company (Radnor, PA) and Ohio Transformer Corporation (Louisville, OH) formed a partnership to develop a PCB destruction system. The resulting company, Sunohio, became established as a field service firm for electric power systems while research and development commenced.

The objectives of the R & D program were to develop a method which would destroy PCB to non-detectable levels (<2 ppm); which would preserve the treated fluid for continued service; and which was mobile, such that the service could be performed at the transformer or bulk storage location.

The resultant process was named PCBX^{SM}, and became the first mobile system to receive USEPA approval. The first commercial contract to be performed in the United States occurred in 1981, and the first Canadian contract occurred in 1984. Currently, four systems service North America.

PROCESS OVERVIEW

The system is a dechlorination process which is applicable to mineral oil dielectric fluid containing PCBs. The process is housed in two tractor trailers which travel to the location of the transformer or storage tank. Upon arrival, the system is set up and attached to the transformer's top and bottom valves. (See Diagram in Appendix A). Oil quality and PCB level is confirmed on-site in the accompanying mobile laboratory.

The oil is pumped from the transformer into the processing unit where it is heated to reaction temperature. Simultaneously, oil is pumped from the processing unit's 400 gallon on-board storage system into the

transformer, forming a continuous, closed loop circulation that maintains transformer oil level.

BASIS OF CHEMISTRY

Once heated, the oil is injected with a proprietary metallic sodium based reagent which dechlorinates the PCB (Na+Cl=NaCl(Salt)+Polyphenyl Polymer). The timed reaction is quenched with water (NaCl+Polymer+NaOH+H). The reaction by-products are removed from the oil stream by centrifuge (NaCl, Polymer and NaOH) and degassing columns (H).

OIL RESTORATION

The detoxified oil is then restored using conventional reclamation techniques. The filtration/oil polishing process includes Fullers Earth and cartridge filters, vacuum degassing and dehydration and a submicron final filter. The fully restored oil has excellent dielectric properties before being returned to the transformer at the top valve.

PROCESSING RESULTS

A number of circulation passes are performed (based on oil quality and PCB level) until oil is detoxified to <2 ppm and acceptable dielectrics are achieved. Processing results are measured in terms of both (1) dielectric quality and (2) PCB removal.

1. Dielectric Properties

Resulting oil quality is a guaranteed aspect of the detoxification system. Oil qualities are monitored throughout the process in the mobile laboratory. The chart below illustrates the guaranteed minimum standards, the standards to which ENSR's technicians operate in the field, and the typical results achieved as monitored through post-contract analysis.

Test	Minimum	Field	Typical Results
PCB	<2 ppm	<2 ppm	<2 ppm
Dielectric	30	37	40-50
IFT	33	37	40-45
Acid	.04	.03	.015
Power Factor 100°C	.6	.5	.3-.5
Water	20	15	<5

In addition to achieving oil quality that meets or exceeds new oil standards, the process provides long-term transformer care benefits such as life extension and increased efficiency. This is due to the thorough cleansing of transformer internals that occurs by the continuous, hot-oil circulation nature of the processing.

2. PCB Removal

The PCBX system has been determined by USEPA to have an equivalent destruction efficiency to

incineration. When performed on bulk quantities of oil, PCB destruction is complete; achieving removal to undetectable (<2 ppm).

When performed on transformers, oil is detoxified to undetectable (<2 ppm) and leachback (from windings into clean oil) averages only 1% - 3% of initial PCB level. This very low leachback is achieved due to the continuous hot-oil circulation through transformer windings.

Historical reclassification results, described below, demonstrate that 93% of units (>1000 gallons, <500 ppm) processed have been recertified to below 20 ppm/PCB.

PCB/ppm	Percentage of Units Serviced (see notes)			
Reclass Range	A	B	C	D
<10	67	17	60	49
11-20	26	41	33	35
21-30	4 (97)	28 (86)	5 (98)	11 (95)
31-49	3	14	1	5

(A) Total units (all volumes) serviced with initial PCB <500 ppm.

(B) Total units (all volumes) serviced with initial PCB <1000 ppm.

(C) Units serviced >1000 gallons, with initial PCB <500 ppm.

(D) Units serviced >1000 gallons, with initial PCB 50-2250 ppm.

PCB removal is also long-term in transformers. Studies conducted on processed transformers indicate that post-processing levels do not increase after the 90 day reclassification period or even after a period of 12 months, demonstrating reclassification permancy.

SYSTEM FLEXIBILITY

The detoxification system can be applied directly to transformers, and will process energized transformers up to 69 Kv. The system is also applied to bulk quantities of oil in storage tanks or tankers. The systems have been used as an integral part of small-unit retrofill projects, to detoxify larger units as well as treat bulked retrofill oil for immediate reuse in the retrofill program.

The system may also be applied to other contaminated streams such as hydraulic fluids. This system was utilized, with some pre-processing treatment, for 820,000 gallons of contaminated Bunker C oil in 1987.

PRICING

Many job-specific variables affect service contract cost, including total project volume, volume per transformer, PCB levels, initial oil quality, number of set-ups required, energized vs. deenergized servicing and final PCB level to be guaranteed. Examples of current pricing (U.S. locations and dollars) are:

1. 50,000 gallons bulk oil, 50-500 ppm: $2.75-4.00/gallon
2. (4) 8,500 gallon units, one set up, deenergized: $4.75-6.00/gallon
3. (20) 200 gallon units, 15 set ups, 50-1000 ppm/PCB, energized: $45.00/gallon.

CONCLUSION

The PCBX system has detoxified over 8,000 transformers and 20 million gallons of mineral oil in

the U.S. and Canada since 1981. This proven technology is cost-effective while eliminating the risks of oil handling and transportation required by retrofilling. The process also achieves superior PCB removal compared to retrofilling, and provides significant transformer care advantages over the alternate procedure.