

Development of a Simple PCB Removal Method for Contaminated Transformers and Rapid PCB Measurement Method

Background and Objective

In 2003 it was reported that PCBs might be still be present as a contaminant in insulating oil in a large number of transformers. Cost effective procedures for PCB measurement and removal are therefore highly desirable. The first object of this project is to develop a rapid, cheap screening method using a PCB biosensor along with an accurate, quantitative PCB measurement method using gas chromatography. Both methods are specially designed for detecting for PCBs in insulating oil. The second object is to develop a simple process for removing PCBs from the core and coil assembly of contaminated transformers using flushing or energizing with circulation of heated PCB-free insulating oil after draining of original contaminated oil.

Main results

1. Improvement in PCB biosensor

PCB biosensor previously developed by us have been further improved [V08053]. Rapidness and measurement accuracy were improved by employing negative pressure concentration for separation of PCBs from oil and a more sensitive detection cell to visualize reaction of antibody to PCBs as a red color (Fig. 1). The detection limit and coefficient of variation of the improved biosensor satisfied the requirements for a screening method established by the Japanese Ministry of Environment.

2. Establishment of rapid measurement using gas chromatography instrument

The separation of PCBs from oil matrices on the basis of molecular size using gel permeation column chromatography followed by a two-layer silica gel column was established. The purified PCBs were accurately quantified by gas chromatography with electron capture detection. Excellent correlation between the new method and the current official method for PCBs in oil has been established. In addition, the detection limit and coefficient of variation of the new method satisfy requirements for use as a quantitative method established by the ministry of environment in the Japanese government (Fig. 2) [V09023].

3. Empirical experiment for PCB removal from contaminated transformer by flushing or energizing

Circulative flushing is a treatment process for used and stored transformer. Energizing is a treatment process in service transformers. Contaminated transformers (50-200kVA, 88-250L, 37-73mg-PCB/kg-oil) were used for PCB removal experiments after replacement of original contaminated oil by PCB-free insulating oil. In the flushing treatment, heated PCB-free oil was circulated by pumping to leach PCBs from the core assemblies for 72-132 hours. In the energizing treatment, PCB-free oil placed in the transformer which was then energized and loaded (simulating normal in service conditions) for less than 190 days. Energizing the transformers resulted in heating and convective circulation of the oil. PCB analysis of the core assemblies of treated transformer after flushing or energizing showed less than regulatory criteria as PCB status. These results proved that low level PCB contaminated transformers could be classified to non-PCB status, resulting PCB removal by circulative flushing or energizing processes (Fig. 3).

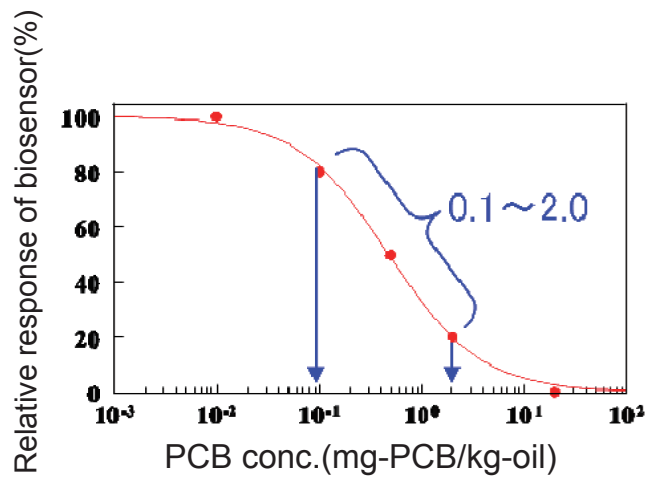
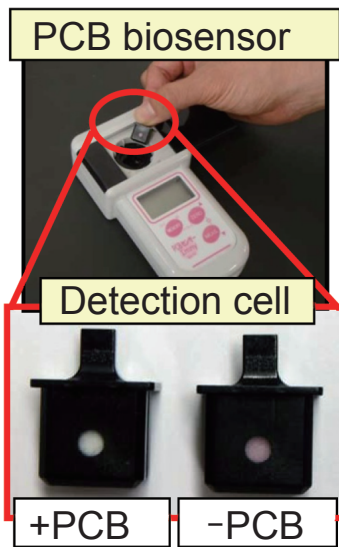


Fig.1 Improvement of PCB biosensor

Density of red color of improved detection cell changed depending upon PCB concentrations. The detection limit of the improved biosensor was 0.1mg-PCB/kg-oil with less than 30% coefficient of variation.

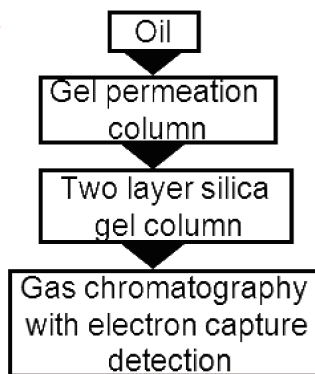
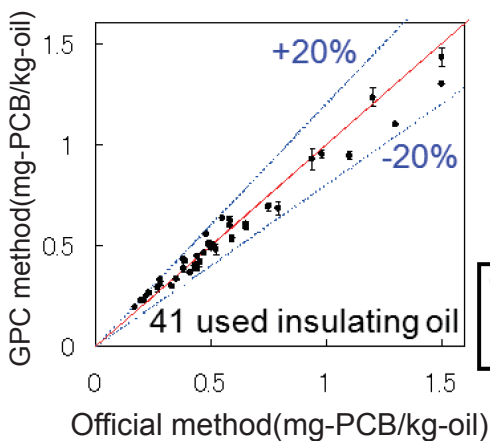


Fig.2 PCB separation from oil matrix by gel permeation chromatography

PCBs were separated, depending upon molecular size by gel permeation effect. The detection limit of developed method was 0.05mg-PCB/kg-oil with less than 3.7% coefficient of variation. The measurement error against official method for PCBs in oil was within plus and minus 20%.

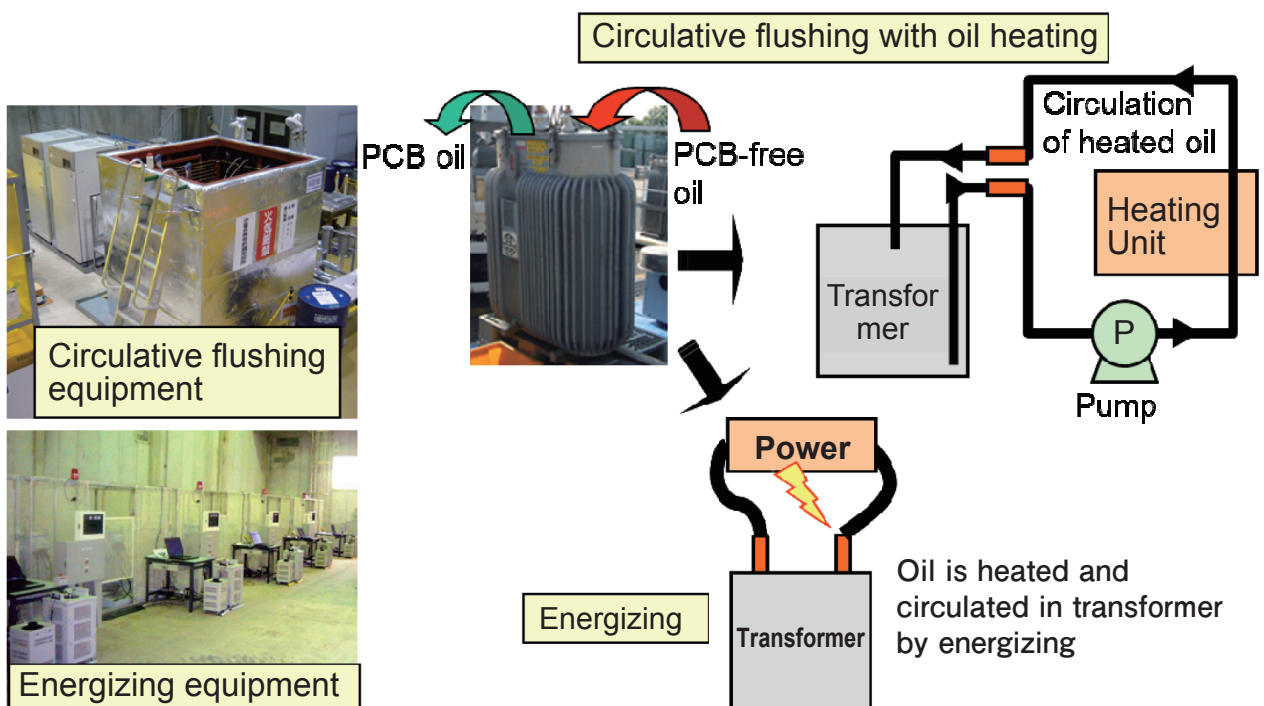


Fig. 3 Flushing or energizing procedure for transformer washing