Laboratory Study of Polychlorinated Biphenyl (PCB) Contamination in Buildings
Evaluation of the Encapsulation Method

Problem:
Polychlorinated biphenyls (PCBs) are a class of organic chemicals, known as congeners, that have been used in a variety of commercial products. PCBs were used in caulking, electronics, fluorescent light ballasts and other building materials from the 1950s to the late 1970s. Buildings built or renovated during that time may contain PCBs in caulking and other materials.

In 1979, the U.S. Environmental Protection Agency (EPA) banned the commercial production of PCBs, citing health and environmental concerns. Health concerns related to PCB exposure include, but are not limited to, cancer, reproductive effects and neurological effects.

PCBs are regulated by the Toxic Substance Control Act (TSCA) Title 40, Part 761 (enacted in 1976). Unless specifically authorized, current regulations require the removal of materials using PCBs if their content are over 50 parts per million (ppm). However, there is no federal requirement for testing of materials so the amount of PCBs in materials and PCB emissions are often unknown.

In response to concerns raised by the public about PCBs in schools, EPA announced in the fall of 2009 a series of steps that building owners and school administrators should take to reduce exposure to PCBs that may be found in caulk and other materials in buildings constructed during this timeframe. In addition, EPA scientists began conducting research in the following areas:

- Characterization of potential sources of PCB exposures in schools (caulk and other materials).
- Investigation of the relationship of these PCB sources to PCB concentrations in air, dust, and soil.
- Evaluation of mitigation methods to reduce exposures to PCBs in caulk and other sources.

This fact sheet summarizes EPA's results from its laboratory research and mathematical modeling on encapsulation, a commonly used abatement technique that reduces contamination in buildings. Encapsulation is accomplished by painting a contaminated surface(s) with a coating material that serves as a barrier to prevent the release of a contaminant from a source.

Action: EPA conducted research on 10 coatings, including epoxy and polyurethane coatings, latex paint and petroleum-based paint, to better understand how encapsulation may reduce PCB concentrations in indoor air and contaminated materials. To achieve its objectives, EPA used a combination of laboratory testing and mathematical modeling. EPA conducted sink tests to determine whether the encapsulants absorb PCBs from the source, and then ranked the encapsulants. EPA also used wipe sampling to evaluate the performance of the encapsulants under both natural and accelerated aging conditions in laboratory chambers. The barrier model was used to evaluate the relative performances of encapsulants in this study.

Results: This study demonstrates that encapsulation can be used as a solution to mitigating PCB contamination in buildings. Selecting effective encapsulants can reduce PCB concentrations in the encapsulant layer at the exposed surfaces and eventually in indoor air, but there are limitations. Study results showed that the performances of the ten coating materials were significantly different. Overall, the three epoxy coatings performed better than the other types of coating materials

because they were more effective in reducing the PCB surface concentrations. However, further study is needed on additional coating types to determine which ones provide optimal performance. Generally, coating materials that are better at resisting the migration of PCBs from the source (*e.g.,* those that have smaller material/air partition coefficients and smaller diffusion coefficients for PCBs) perform better at reducing the concentrations of PCBs at the exposed surface and in indoor
air. Resistance to PCB migration is key in selecting the most effective encapsulants for PCB sources.

Even if high-performance coating materials are used, encapsulation is suitable only for low PCB content sources, and not for higher-content sources. To estimate the upper limit of the PCB concentration in the source for successful encapsulation, several factors must be considered, including selection of performance criteria, properties of the encapsulant (*e.g.,* resistance to PCB sorption and thickness of the coating), properties of the source (*e.g.,* source area), and environmental conditions (*e.g.,* ventilation rate). Depending on the mitigation goals, the performance criteria may include:

- PCB concentration in wipe samples
- Average PCB concentration in the layer of the encapsulant
- PCB concentration at the exposed, encapsulated surface
- Contribution to the PCB concentration in room air.

Among these criteria, wipe sampling is the easiest to implement. Post-encapsulation monitoring by either wipe or air sampling is essential.

None of the tested coatings are truly impenetrable to PCB molecules, so encapsulation alone may not be effective in meeting mitigation goals. However, it is theoretically feasible to encapsulate a PCB source with a barrier material that is impenetrable to PCB molecules. Flexible metallic tapes that can adhere to the surface of the source are candidates for such barrier materials, although these were not tested. Further research is needed to identify or develop the most effective barrier materials and to develop procedures for encapsulating PCB sources with such materials.

Impact: Although this study was limited to laboratory testing and in scope, the results provide useful information on ranking encapsulants by their resistance to PCB migration from the source and estimating partition and diffusion coefficients. They also advance our understanding of the encapsulated sources and factors that may affect encapsulation performance. The results should be useful to mitigation engineers, building owners and managers, decision-makers, researchers, and the public.