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Hazardous Waste Engineering
Research Laboratory
Cincinnati OH 45268

Research and Development

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Project Summary

Assessment of PCDDs and PCDFs from PCB Transformer and Capacitor Fires

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The U.S. Environmental Protection Agency (EPA), under the Toxic Substances Control Act (TSCA), has been mandated to develop appropriate regulations for the control of exposure to polychlorinated biphenyls (PCBs). In light of this responsibility the EPA Office of Toxic Substances recently issued an Advance Notice of Proposed Rulemaking (ANPR) intended to define the problem of releases of PCBs and other toxic compounds during fires involving transformers and capacitors containing PCBs. The ANPR is intended to cover the following areas:

- Risks associated with PCB transformer and capacitor fires
- Number and distribution of PCB transformers and capacitors
- Location of equipment
- Frequency of fires
- Furan/dioxin formation
- Regulatory options

The EPA Office of Research and Development (ORD) has also been mandated under EPA's recently released *Dioxin Strategy* document to evaluate fire accidents involving PCB transformers and capacitors as potential new sources of polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in the environment. To develop the information to support the two mandated programs, the EPA/ORD undertook this study to assess the problems associated with fires involving askarels, to catalog the contamination experiences, and to review potential decontamination methods as well as disposal of contaminated material. The study recognized the limitation of available data. It has drawn upon the body of scientific knowledge available on thermodynamic equilibria of chlorinated substances and the more common experiences gained from decontamination and detoxification of PCBs in non-fire accident situations. This study assesses the chemistry of PCBs under thermal conditions and evaluates the generation of PCDDs and PCDFs. It reviews technologies for destruction and disposal of PCBs and their toxic contaminants. Methodologies to assess potential hazards and reduce exposure are also discussed.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Polychlorinated biphenyls are a class of compounds that have various combinations of chlorine atoms attached to the biphenyl molecule. Since commercial introduction in the late 1920's, over 1.25 billion pounds of PCBs have been manufactured and used in the United States primarily in mixtures with chlorobenzenes known as askarels, which are used as dielectric fluids for electrical transformers and capacitors, heat transfer systems, and hydraulic systems.

Federal regulation of PCBs took several years to develop. Beginning in the late 1960's, scientific evidence began to accumulate on PCBs' various toxic effects and concentration in many biological species. Because of these concerns, in 1971, the Monsanto Industrial Chemical Co., the sole United States producer, terminated sales of PCBs for all but closed electrical systems uses. In 1976, Congress enacted the Toxic Substances Control Act and included special provisions for the regulation of PCBs. Accordingly, in 1979, EPA banned all production and sales of PCBs. Additional regulations enacted under TSCA now govern the disposal of PCBs and equipment containing PCBs. A large amount of the PCBs sold in the United States prior to the ban is still in use as dielectric fluid in transformers and capacitors.

Recently, there have been additional concerns brought on by the finding of toxic contaminants in PCBs and askarel fluids including PCDFs, chlorinated benzenes and other chlorinated substances. PCDFs and other chlorinated substances are formed as contaminants in the manufacturing and formulation processes for PCBs and askarel fluids. PCDDs can be formed from the reaction of chlorinated benzenes when askarel fluids are heated to high temperatures. The finding of PCDFs and the potential generation of PCDDs under thermal conditions has major implications for the recently-adopted EPA strategy for mitigating and controlling chlorinated dioxins in the nation's environment. Findings of such toxic chemicals will also complicate emergency response and clean-up procedures for fires involving transformers and capacitors containing PCBs.

Several such fires have been reported. The most famous fire involved a transformer and occurred in an 18-story office building in Binghamton, New York on February 5, 1981. Similar cases have been reported in other parts of the country and in foreign countries such as Sweden and Finland. These accidents have led to the need for assessing potential environmental loading of PCDDs and PCDFs and human exposure risk from this new source category. Additionally, because such fire accidents have occurred randomly in office buildings, schools, etc., and not only in industrial plants, there is a high public awareness of this issue. Thus, there is a genuine public concern over potential exposure to highly toxic substances (i.e., dioxins and furans) from such fire accidents.

Fire fighters, electric utility companies and insurance companies are particularly concerned that fire emergency procedures and fire site clean-up protocols may not be adequate in light of these new findings. Present fire fighting methods were developed when the hazards of exposure to highly toxic chemicals were not as well understood. In an already dangerous profession, fire fighting personnel must now recognize the danger of exposure to hazardous chemicals with potential long-term health implications.

Conclusions

Approximately 130,000 transformers and 2.8 million capacitors currently in service contain PCBs or mixtures of PCBs and trichlorobenzenes which are also called askarels. Approximately 2 million mineral oil transformers have fluid contaminated with PCBs in concentrations of 500 parts per million or greater.

The transformer involved in a fire in Binghamton, New York contained a mixture of 65% Aroclor 1254 and 35% chlorinated benzenes together with some other additives. Analyses of soot samples taken from the building showed high levels of PCBs, and the presence of 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD) and 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF). The estimated cleanup cost for the building is $24 million and almost $1 billion in liability claims are pending against the state in law suits filed primarily by the fire fighters.

Laboratory combustion studies on PCBs and askarels have identified a variety of other chlorinated products such as polychlorinated naphthalenes, pyrenes, biphenylenes and chrysenes. The types of chlorinated products that are formed depend on the composition of the fluid in the transformer or capacitor. In the Binghamton incident, both PCDDs and PCDFs were identified whereas after the San Francisco fire, only PCDFs were found. The Binghamton transformer contained a mixture of PCBs and trichlorobenzenes and the San Francisco transformer contained only PCBs. The finding of PCDDs in the Binghamton incident is attributed to chemical reactions involving trichlorobenzenes present in the transformer fluid.

The presence of highly toxic substances such as PCDFs and PCDDs in PCBs fire incidents has increased concerns for the safety of emergency response personnel and has complicated cleanup and remedial measures. There is a need for development of a generally accepted protocol for fighting and extinguishing fires involving PCB electrical equipment.

Electrical utilities can assist local fire fighting departments with better information on the problems associated with PCB fires. Fire departments should know the number and location of PCB transformers and capacitors within their jurisdictions. Highly visible labels or signs should be placed on all PCBs-containing electrical equipment and in other nearby areas to indicate the presence of these devices. Electrical utilities, owners and/or operators of the equipment should retrofit the equipment to assure that electrical power could be rapidly disconnected in the event the transformer enters a failure mode. The primary load breaker air switch on the high-voltage side of the transformer should be located outside the equipment vault to allow rapid disconnect without entering a vault potentially containing high concentrations of PCBs and associated pyrolysis products.

Response operations during the initial phase of a fire incident involving transformers and capacitors containing PCBs requires familiarity with response organization and management, the uses and limits of equipment and apparatus, site entry, control, and decontamination procedures. In order to control PCB fire situations, adequate protective clothing, equipment and fire extinguishing chemicals are necessary to ensure personnel safety.

PCB transformer/capacitor fires are unique because of the toxic residues generated and the resultant long-lasting contamination. Every effort should be made to put out the fire as quickly as possible in order to minimize the production of highly toxic pyrolysis products. After the fire, access to areas possibly contaminated by the fire must be limited until the extent of contamination can be determined. Wipe and bulk soot sampling are used to identify areas contaminated with PCBs and to delineate the extent of both vertical and horizontal contamination.

There are no Federal guidelines to define acceptable cleanup levels for PCBs releases due to fires. NIOSH has found background levels up to 0.5 mcg PCBs per 100 cm^2 of surface area in urban areas. In the absence of certain PCDF and PCDD isomers, the mitigation effort could be directed at cleanup of the PCBs contamination to 0.5 mcg/100 cm^2 of affected area. In terms of airborne exposure, the NIOSH recommended guideline for the workplace is 1.0 mcg PCBs per cubic meter of air.

The presence of PCDF and PCDD isomers will affect surface and air cleanup guidelines according to the biological and toxicological activity of the specific isomers. Reoccupancy criteria have been established by the State of New York and the State of California following the Binghamton and the San Francisco fires. The State of New York proposed an allowable daily intake of 2 pg/kg/d for 2,3,7,8-TCDD, resulting in an air/inhalation exposure limit of 10 pg/m^3 for 2,3,7,8-TCDD. A limit of 39 pg/m^3 for 2,3,7,8-TCDF was proposed. The State of California proposed air exposure guidelines of 10 pg/m^3 for 2,3,7,8-PCDDs/PCDFs and 1.0 mcg/m^3 for PCBs. The criteria for surface exposure are 3 ng/m^2 for 2,3,7,8-PCDDs/PCDFs and 100 mcg/m^2 for PCBs. In addition to these values for decontaminated areas outside of the transformer vault, the State of California proposed reentry guidelines for the area inside the vault. These consist of an air exposure of 80 pg/m^3 for 2,3,7,8-PCDDs/PCDFs and 1.0 mcg/m^3 for PCBs and a surface exposure of 24 ng/m^2 for 2,3,7,8-PCDDs/PCDFs and 1.0 mg/m^2 for PCBs. Sweden and Finland have also established reoccupancy criteria after the occurrence of PCBs fire incidents.

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The complete report, entitled "Assessment of PCDDs and PCDFs from PCB Transformer and Capacitor Fires," (Order No. PB 85-188 837/AS; Cost: $14.50, subject to change) will be available only from:
National Technical Information Service
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