## ASKAREL: REQUIEM FOR AN OLD RELIABLE

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### Abstract

For several decades, askarel containing polychlorinated biphenyls (PCB's) was considered an excellent insulating fluid. In the span of a few short years, it has come under attack as a pernicious and ubiquitous environmental contaminant. Regulations concerning this material are evolving rapidly, and a total ban is ultimately expected. Spill prevention, control and disposal are required to preclude high economic loss as well as adverse publicity. Alternates to the use of askarel include new fluids that must also be reviewed for environmental acceptability.

### Introduction

Until rather recently, our society used many chemicals with seemingly few environmental problems. In a short span of time, several factors contributed to a substantial change in the environment. A rapidly expanding population, enjoying the fruits of the most advanced technology and greatest affluence in the history of mankind, created a demand for more goods, often based on a host of new chemicals and materials. Consequently, genuine and serious environmental problems were becoming common.

In the latter part of the 1960's, there was a new mood of social awareness and activism. Concurrently, the rapid advances in technology also included significant improvements in the means of detecting and measuring contaminants at remarkably low levels. The stage was set for the sudden change in the status of askarel, an old reliable.

### PCB's - The Problem

Polychlorinated biphenyls are produced by substituting one to ten chlorine atoms for hydrogen atoms on the biphenyl structure shown in Figure 1. There are 209 possible combinations or isomers; for example, there are twenty-four different possible arrangements for the molecule containing three chlorine atoms. One of these trichlorobiphenyls is illustrated by Figure 2.

The manufacturing process results in a loosely controlled mixture of various amounts of many of the isomers; hence the characteristics of a particular batch is the sum of the several individual components. Some general conclusions about these compounds are:

1. They cause abnormalities in cells, organs and glands of many animals. This occurs at rather low levels of the chemical.

2. The material is quite stable and barely reacts, degrades, or decomposes under normal circumstances; it is quite insoluble in water.

3. It is heavier than water and is ingested by bottom-feeding animals. Animals tend to bioaccumulate the chemical, i.e., it is absorbed readily and excreted slowly, with a resultant high level becoming stored in tissues.

4. Traces of two very similar chemicals (see Figure 3), polychlorinated dibenzofuran and polychlorinated dibenzodioxin, have been found in the tissues of animals which have absorbed PCB's. The materials may be present in the original PCB or may be metabolized from PCB by the animal. These compounds are known to be highly toxic.

5. PCB's are ubiquitous and are apparently mobile in the atmosphere. They have even been found in snow at the Antarctic.

6. They are being found at significant levels in human tissues and in mother's milk.

About ten years ago, PCB's were first isolated and identified as a possible contaminant contributing to problems in animals. At that time, this chemical was in wide use. About half was utilized as the primary constituent of askarel in electrical equipment (askarel also contains trichlorobenzene as a solvent). The remainder of the PCB was used in plastics, paints, carbonless paper, and many other products and processes. Since few problems had ever been noted with the material, any scrap or waste was indiscriminately sewered or placed in dumps, as most chemicals had been handled for quite some time.

One of the characteristics that made PCB's or askarel attractive was its stability; but this very permanency also meant that the material remained virtually intact for decades. It is generally conceded today that this residual of PCB's will be present as a contaminant for decades, regardless of a complete elimination from the market place.

### Initial Control Efforts

PCB's because of their excellent stability and thermal properties, have been used as a heat-transfer fluid in several industries. In Japan during 1968, a food product was contaminated with PCB's from a heat-exchange operation and more than 1200 people were afflicted, some rather severely, with what was called "Yusho" disease. This outbreak, plus other incidents, and a rapidly expanding research effort identifying PCB's as a potential detriment, led the sole U.S. producer (Monsanto Industrial Chemicals Company) to voluntarily restrict sales to closed electrical systems.

This step removed about half the PCB's from the market, and began the elimination of the most common uses whereby PCB's were being introduced to the environment, such as through carbonless office papers. Of course, outdated capacitors and the like continued to be thrown on the junk pile.

In late 1975, the U.S. Environmental Protection Agency sponsored a PCB conference which was both technical and political. The technical program was enlightening; there was little doubt that hard scientific evidence identifying PCB's as a major concern was developing quickly. The political aspect of the conference came from two sources. First, the

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public sector was allowed to make presentations, the majority of which predictably were emotional and often based on misinformation. The second political aspect arose as representatives from various governmental agencies - FDA, Interior, NIOSH, Commerce, etc. - made statements to explain past indifference and to scourge the plague of the 70's, PCB's. There was little doubt that the bureaucracy felt safe in taking a stand, and that regulation or restriction was imminent. There is strong public support for control since the mass of the populace is technically naive and thoroughly frightened by the constant disclosure that everything from licorice to marachino cherries may be mutagenic, teratogenic, or carcinogenic.

In this context, and knowing that there were some substitute materials forthcoming, the equipment manufacturers began phasing out of askarel and into new fluids. Naturally, the fluid supplier (Monsanto) recognized that the market was disappearing and made the decision to terminate all production of the chemical later this year. Thus today, there are three questions to be answered:

1. What should be expected concerning the askarel-filled equipment now in service?

2. Exactly what is available in the future?

3. What assurance is there that the course taken now is correct; can this happen again with a substitute material?

## Anticipated Pressure

In these times of OSHA, IRS, FDA, EPA, Consumer Protection Agencies and the like, it is apparent that users of equipment containing askarel can expect the following:

1. Specific regulations will be published for askarel handling, protection, disposal, etc. For example, one state is in the process of promulgating a regulation that includes mandatory labeling of equipment containing more than two pounds of PCB.

2. Users will be asked to inventory askarel on the plant premises and to indicate the location of equipment in reference to waterways.

3. Monitoring of effluents will be required; this is already being specified in NPDES permits in some locales.

4. Protective measures, such as dikes, will be made mandatory.

5. It may be required to include askarel in the spill plans which most plants already have.

6. Any accidental spill will have to be reported, even if it was apparently completely controlled on the plant site. If the spill should involve more than a certain quantity, a regulatory agency may visit the site.

7. If a spill should escape to a waterway, recovery of the lost askarel will be required. There have been some specific (and very expensive) instances where this has been done in the past.

8. There will be a ban on new installations of askarel-filled equipment, which will be rather meaningless since industry is already voluntarily abandoning the market. But there will ultimately also be a ban forbidding the continued use of existing equipment. This too may prove to be meaningless because the unavailability of askarel for topping out or retrofilling transformers may result in early retirement of most askarel-filled equipment. There are substitutes available for topping out, but there is a limit to their use.

## Loss Prevention and Control

Until quite recently, askarel spills were virtually ignored. As attention focused on the problem, many incidents came to light. Spills or losses are known to have occurred under these circumstances:

1. As a consequence of moving or handling.

2. Overloaded or faulty capacitor.

3. Overloaded and overheated transformer which loses fluid through the relief valve.

4. Changing out carbonized askarel from a shorted transformer.

5. Leaks from valves on the transformer casing.

6. Loss when sampled for dielectric or moisture test.

7. Improper disposal of sample.

8. Misuse - mistaken for another chemical. This has occurred when waste askarel was placed in a used drum without relabeling.

9. Damage to drums or equipment by other equipment such as forklifts.

10. Freak incidents, such as an icicle piercing a transformer cooling fin, or a capacitor skewered by the arrow of a frustrated bow hunter.

Two actions should be taken immediately to preclude such occurrences. A rather detailed inventory should be taken of every askarel transformer and capacitor as shown in Figure 4. While most plants have some form of inventory for electrical purposes, they do not include information which will allow an evaluation of the environmental risk. It is suggested that oil transformers be included in the inventory since even these present potential environmental costs. Inactive units or stored fluids should also be noted

The second most immediate action is to inform or educate the plant staff. There are two objectives - (1) to prevent or control spills, and (2) to ensure that personnel are not confused or frightened by inadequate knowledge of a potential problem.

It is suggested that an appropriate label - large and bright - be placed on askarel equipment. It is also necessary to ensure that contract personnel are informed to look for these labels, and it may be advisable to specify in writing the responsibility for spills caused by a contractor.

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After making an inventory of askarel equipment, decisions must be made whether to invest in protection or spill control for a particular item. This matter is arbitrary, but it is suggested that the items be rated by vulnerability to damage, quantity of askarel, and proximity to a waterway. Thus the larger transformer located by a road with an adjacent running ditch going toward the river warrants more consideration than the smaller unit inside a building away from any traffic.

The potential for a costly spill can be reduced by preventive measures. For example, place fences or posts around exposed equipment; a light roof may be added to prevent damage from ice or dropped tools. Relocation of the equipment is an alternate. A plug should be threaded into the drain valve of a transformer. Finally, many spills could be prevented by operating equipment at the design rating instead of 110% plus.

Inevitably, equipment will fail or freak accidents will occur; several steps may be taken to contain spilled askarel. Dikes can be installed around equipment preferably with a capacity slightly greater than the largest volume of askarel in one unit. If the location is outdoors in a wet climate, a device known as an imbiber valve, which contains molecular sieves that pass water but retain PCB's, can be installed when the dike is constructed. Plastic shields can be placed around pole-mounted capacitors to restrict a spill to a lesser area.

All drain holes in vaults should be plugged, and ramped sills placed at doors. All joints should be sealed with a silicone putty, and concrete block walls should be sealed with silicone paint or an equivalent coating.

Should askarel be spilled, the precise amount of cleanup or reclamation is arbitrary - there are no standards yet. At the time of the spill in the Duwamish Waterway (Seattle) in 1974, the EPA terminated the operation when the PCB content was reduced to 77 parts per trillion; this should indicate that a thorough collection is expected.

Collection of visible or standing askarel can be initiated with an absorbent compound. Rags with solvent such as trichlorobenzene should be used to wipe down equipment, poles, etc. Soil should be removed to a depth exceeding the obvious level to which the fluid soaked, and radially beyond the last visible signs of fluid. Boards or the like should be replaced. All solid wastes - rags, gloves, soil, shovels, etc. as well as liquids should be set aside for proper disposal.

Should a spill enter an internal sewer, the water flow should be terminated and askarel collected from the low spots. If the sewer discharges into a sewage plant, most of the PCB that is carried in the water will attach to suspended matter in the treatment plant and settle. Of course, these settled materials usually end up in a landfill eventually, but at least most of the PCB apparently remains immobilized.

The worst situation, of course, is if a spill enters a waterway intact. Noone has an answer for the situation where the contaminant enters a fast stream and disperses widely. For lakes or rather static waters, the bottom is dredged. The material first passes through a settling chamber, then through a sand filter, and finally through an activated carbon column. All of the wet solids require disposal. Obviously, every effort should be made to avoid a spill of this nature; the cost is horrendous. The final bill for cleaning the spill of 265 gallons into the Duwamish Waterway was $500,000.

Proper disposal of waste askarel, scrap equipment, or solids wastes is rather well defined. Askarel may be transported as a liquid or gelled with molecular sieves. About twenty facilities are available for burning or landfill. Burning requires quite high temperatures to ensure complete destruction, and the exhaust gases must be scrubbed with caustic to remove the hydrochloric acid that is emitted. Landfill can only be in certain approved sites. Transportation of PCB's to a disposal site requires special preparation and handling. In one incident involving a spill from a 1500 kVA transformer, transportation and incineration cost $2,200. In another incident involving the rupture of a pole-mounted capacitor, transportation and burial cost $150.

Environmental Acceptability of Alternate Compounds

Several alternate fluids are now available in new transformers and capacitors.

Silicone-based fluids are offered for liquid-filled transformers. All evidence thus far indicates that the material is quite innocuous. It should be noted that unlike askarel, the silicone fluid has a specific gravity less than one, and any spill would have to be treated as an ordinary oil spill.

Obtaining detailed environmental information from the vendors on their new capacitor fluids has been difficult, and much of it is not comparable. For example, one vendor will report on the toxic effects on a certain fish species on the basis of a 16 day test, while another uses a 96 hour test. All the new materials offer definite improvements over PCB's however. On the basis of all the data-toxicity, biodegradability, solubility, etc. - which this writer has been able to obtain, the three available fluids should be environmentally ranked:

| | |
|---|---|
| Most acceptable | - isopropyl biphenyl |
| Second | - butylated chlorodiphenyl oxide |
| Third | - di - 2 - ethylhexylphthalate (a phthalate ester) |

One suggested alternative to the replacement of askarel transformers has been to retrofill with the silicone-based fluids. This procedure involves draining out all possible askarel, followed by flushing with trichlorobenzene. A certain amount of askarel will be retained in pockets, insulation, etc.; the residual PCB content is estimated to be 1-3%, and will be very dependent upon the amount of care taken and number of flushings performed. It should be noted that all flushing fluids will require disposal by methods approved for PCB's.

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## Conclusions and Recommendations

In this age of environmental awareness and social activism, many chemical substances will be scrutinized intently. Regardless of its relative impact, PCB is currently being cited as the leading hazardous chemical which warrants control. Industry faces a new round of regulations, reports, and costs. As with any such issue, the cost can be best controlled by gathering information, making unemotional judgments, and planning to take the appropriate action before the citations are issued.

Specifically, these steps are recommended:

1. Define the problem in the plant. Locate each item and assess the probability of damage or loss. Estimate the cost of equipment protection and spill control.

2. Get information from the vendors on their new equipment, including very specific data to back any claims of environmental properties.

3. For transformers, determine the efficacy of retrofilling and the probable availability of topping fluid.

4. Proceed with protection, retrofilling, or replacement on a scheduled basis. In many instances, the choice will not be obvious, and it is suggested that it is better to err on the side of greater environmental protection.

5. In some instances where only a few pieces of equipment are involved, consider that total elimination of askarel may cost less than the hidden costs of continually reporting, inspecting, etc.

Noone can be completely sure that the steps taken will preclude a costly spill of this hazardous chemical. Should one occur, however, the plant that has evinced awareness and effort will fare better with the regulatory agencies and the public than a plant which ignored the problem of PCB's.

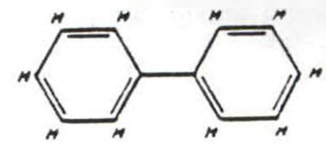


*Figure 1 - Biphenyl Molecule*

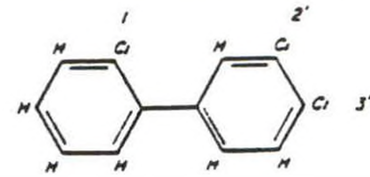
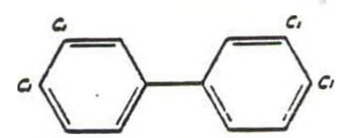
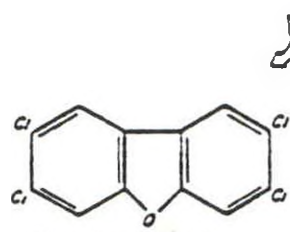


*Figure 2*

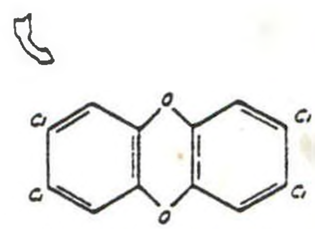
*Figure 2 - 1-2',3' Trichlorobiphenyl*



*Tetrachloro Biphenyl*



*Tetrachloro Dibenzofuran*



*Tetrachloro Dibenzodioxin*

*Figure 3 - Possible PCB Metabolites*

| Transformers No. | Location | Mfr. | Capacity kVA | Insulating Fluid | Gal. | Risk of Potential Damage or Spill | Degree of Environmental Sensitivity |
|---|---|---|---|---|---|---|---|
| 1 | East Side Ply. Plant | West | 1500 | Inerteen | 382 | High. Outside bldg., asphalt drive 2 sides, forklift area | Medium. Concrete pad, no curb, 100 ft. from drainage |
| 2<br>3<br>4 | Sawmill | West | 250 ea. | Oil | 100 ea. | Low. Outside bldg., fenced, no traffic | Medium. Concrete pad, no curb, 50 ft. from drainage |
| 5 | Machine Shop | GE | 1000 | Pyranol | 210 | Medium. Work area. Equipment fabrication. Snow plow area | High. 20 ft. from drainage ditch. No Platform |
| etc. | | | | | | | |

| Capacitors No. | Location | Mfr. | Rating KVAR | Insulating Fluid-Gal. | Risk of Potential Damage or Spill | Degree of Environmental Sensitivity |
|---|---|---|---|---|---|---|
| 1 | MCC Shop | McGraw - Edison | 15 | | Low. Inside Control Room. | Low. Room closed, with door curb. |
| 2-25 | Coal Yard | Sprague | 4800 (24 x 200) | | Medium. Pole-mounted Low traffic. Multiple Units | High. Coarse gravel underneath. 75' from river. |
| etc. | | | | | | |

Figure 4. Suggested Inventory Sheets

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