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D R A F T

CASE STUDY

POLYCHLORINATED BIPHENYLS

STUDY OF PRINCIPLES OF DECISION MAKING FOR CHEMICALS IN THE ENVIRONMENT

NATIONAL ACADEMY OF SCIENCE

Nature of Decision

Beginning in early 1970 Monsanto Company management decided to terminate the sale of commercial mixtures of polychlorinated biphenyls for all applications except for use in closed systems as a dielectric fluid in capacitors and transformers for which no acceptable fire resistant alternative materials exist. This decision was made voluntarily and is not based on any state or federal legislation.

Chronology

During the period 1968 - 1969 several laboratories throughout the world were developing analytical methodology for identifying and quantifying polychlorinated biphenyls. This activity followed a report in which Doctors S. Jensen and G. Widmark of the University of Stockholm had claimed that unknown peaks observed in chromatographs developed during pesticide analyses were due to the presence of polychlorinated biphenyls. Reports from these laboratories established that polychlorinated biphenyls were present in the environment.

The mixtures being discovered were reported as more closely resembling the commercial material sold by Monsanto as Aroclor 1254. Also, at that time, some investigators attributed the inability of some species of wild birds to properly reproduce because of poor egg shell formation to the presence of polychlorinated biphenyls, a premise, incidentally, that has not been supported by subsequent studies.

By late 1969 and early 1970 preliminary reports of Monsanto sponsored studies underway at Industrial Bio-Test Laboratories, Northbrook, Illinois, indicated that at the higher dosage levels the higher chlorinated polychlorinated biphenyls resulted in loss in weight gain and enlarged livers in rats and dogs. Feeding of the lower chlorinated polychlorinated biphenyls to leghorn chickens resulted in a reduction in egg hatchability.

With the presence of polychlorinated biphenyls in the environment fairly well established and with the preliminary test results indicating possible adverse effects to mammals and birds, the first phase of the sales termination program was initiated. Sales of polychlorinated biphenyls to "open type" uses were discontinued on August 30, 1970. "Open type" uses were defined as those which offered minimum opportunity for control and would result in relatively easy entry into the environment. These applications included coatings, sealants, waxes, plasticizers, pesticide extenders, adhesives and inks.

Alternative fluids were developed to replace the polychlorinated biphenyls in fire resistant industrial hydraulic fluids and in carbonless copy paper coating systems. Conversions in these two applications began in September, 1970, and were fully implemented by April, 1971.

In early 1970 incidents were reported of the presence of polychlorinated biphenyls in milk from cows fed sileage from concrete silos which had been coated with a mixture containing polychlorinated biphenyls. Also, in early 1970, incomplete reports from Japan indicated that widespread illness had occurred because of the presence of polychlorinated biphenyls in cooking oil extracted from rice bran. The polychlorinated biphenyls were reported to have leaked from the processing equipment in which they were used as a heat transfer medium.

These reports of human food contamination emphasized the need for controls to protect the human food supply. The termination of sales to the previously described "open type" uses was considered adequate for preventing cases similar to the silo coating incidences. In September, 1970, sales of polychlorinated biphenyls to heat transfer systems used in processing human food were terminated.

In April, 1971, as a result of Monsanto's sales termination program, polychlorinated biphenyls were sold only as fire resistant fluids for use in closed systems. These were

(a) dielectric fluids in capacitors and transformers and (b) heat transfer fluids in systems not related to food processing.

In addition to the withdrawal of polychlorinated biphenyls from the many uses described, steps were taken to replace the higher chlorinated mixtures with the less persistent lower chlorinated mixtures. Aroclor 1248 and Aroclor 1254 were no longer sold to the heat transfer applications. Aroclor 1260 was replaced by Aroclor 1254 in transformer fluids. Aroclor 1016 was developed to replace Aroclor 1242 as the preferred capacitor fluid.

During early summer, 1971, poultry flocks in the southeastern United States were contaminated with polychlorinated biphenyls. The source of contamination was identified as a pasteurizing unit processing fish meal used as a poultry feed ingredient. Polychlorinated biphenyls, used as a heat transfer fluid, leaked into the fish meal which was being heated to control salmonella content.

Heat transfer systems, when properly designed, maintained and operated, can be considered closed systems which can be operated with no significant environmental or food contamination problems. However, the incident involving the contaminated fish meal highlighted the magnitude of the effort required to assure that all units are acceptable. Lacking

the necessary resources to assure adequate control, Monsanto management in December, 1971, decided to terminate sales of polychlorinated biphenyls to any heat transfer applications. This action represents the final step taken to control sales. Currently polychlorinated biphenyls are sold only to manufacturers of capacitors and transformers.

Objectives

The objectives of Monsanto Company's management in arriving at the polychlorinated biphenyl marketing policy were and continue to be as follows:

1. Minimize the potential for the entry of polychlorinated biphenyls into the environment and human food.
2. Retain those applications of polychlorinated biphenyls which involve closed systems offering opportunity for control and in which the fire resistant properties of polychlorinated biphenyls are highly desirable.
3. Avoid major disruptions in commerce and industry resulting in unwarranted adverse consequences to society in general.

Information

Early reports available to Monsanto Company repeatedly referred to the detection in environmental samples of the presence of the higher chlorinated polychlorinated biphenyl

mixtures, most often identified as being similar to Monsanto's Aroclor 1254 material. The absence of the lower chlorinated mixtures, which were used in greater quantities, led to some early misunderstandings relating to the polychlorinated biphenyl types and their applications which were sources of environmental contamination.

Also, early reports of effects on wildlife were speculative in relating presence of polychlorinated biphenyls to noted harm; e.g. soft egg shells, dead sea birds and baby seals. Subsequent analyses of the data have not supported the early conclusions. The only observable effects to wildlife, fish and birds, have resulted from research studies conducted at exposure levels not found in the environment. The only exception reported was the sensitivity of juvenile shrimp to extremely low concentrations of polychlorinated biphenyls.

Monsanto sponsored studies on laboratory test animals, rats, dogs and chickens, also indicated observable effects at levels not found in the environment. Harm to domestic animals, poultry and ranch mink, has occurred and in each case attributed to the unintended presence of high levels of polychlorinated biphenyls in their diet.

From the available information the following impressions were derived:

1. Polychlorinated biphenyls of higher chlorine content were present in the environment.

2. No known harm to wildlife has been conclusively documented but the potential for harm at high concentrations of polychlorinated biphenyls did exist.
3. Domestic animals can be adversely affected by the presence of polychlorinated biphenyls in their diet.

Information relating to human effects consists of the results of tests to establish skin tolerance data and the effects observed on the Japanese rice oil victims. Polychlorinated biphenyls have been reported present at low levels in samples of human adipose tissue and in human milk.

Information on what the unavailability of polychlorinated biphenyls has cost the ultimate user is not available. Conversion costs to alternate materials has in some cases been considerable, e.g. heat exchange applications have required extensive equipment modifications to permit use of flammable alternate fluids. Some applications, although small in volume, still lack a satisfactory alternative material, e.g. immersion fluid for optical microscopy, ingredient in investment casting wax formulations, component in military systems.

The decision to restrict the sales of polychlorinated biphenyls has resulted in a decrease in the amount of material manufactured by approximately 50 per cent. One Monsanto production unit has been dismantled and about 75 jobs (production, maintenance, administrative, engineering, shipping) have been eliminated. The cost of controlling effluent losses at the

remaining production unit, installation of facilities to produce a less persistent mixture for capacitor application and the installation of an incinerator to destroy scrap polychlorinated biphenyls has exceeded $2,000,000.00. The cost of controlling effluent losses at the capacitor and transformer plants using polychlorinated biphenyls is not available.

One of the key considerations in arriving at the decision to continue to supply polychlorinated biphenyls as dielectric fluids in capacitors and transformers was the fact that in these applications the fluids are hermetically sealed in metal containers permitting a high degree of control of escape into the environment. Another major consideration was the important role these capacitors and transformers have in the efficient generation transmission and distribution of power without risk of fire and explosion and in compliance with specific laws, codes and insurance restrictions mandating non-flammable liquid content.

Implementation

Implementation of the restricted sales policy did create some localized hardships for the many users of polychlorinated biphenyls. The costs involved in developing alternative materials or in sacrificing performance in their applications would be impossible to quantify.

There have been reports of fires in heat transfer systems which were converted to alternative flammable fluids. The number of fires and extent of damage is unknown. The risk of fires still exists and is exemplified dramatically by the potential hazards that are associated with installations such as off-shore gas and oil producing platforms.

During 1974 investigators with the EPA laboratory in Duluth, Minnesota, reported that the concentrations of polychlorinated biphenyls in the Milwaukee River are decreasing. Also in 1974 studies by Woods Hole Institute of Oceanography personnel indicate that the amount of polychlorinated biphenyls in the Atlantic Ocean is decreasing.

Observations, Comments, Recommendations

The lack of reliable data relating to the fate and effect of the many isomers of chlorinated biphenyl in the environment continually frustrated the decision making process. Unproven claims of total nondegradability, carcinogenicity, teratogenicity, mutagencity and extremely high toxicity created emotional unwarranted concerns.

The availability of more information could perhaps have helped define which commercial mixtures and which applications were undesirable. Lacking this data the termination of sales was made on a broad rather nondiscriminatory basis. For example,

it can be seriously challenged whether the use of polychlorinated biphenyls in immersion optical microscopy results in environmental problems. Also, the use of these materials in selected heat transfer systems, properly maintained and operated, could in all probability be justified based on the highly desirable fire resistant property of the fluids.