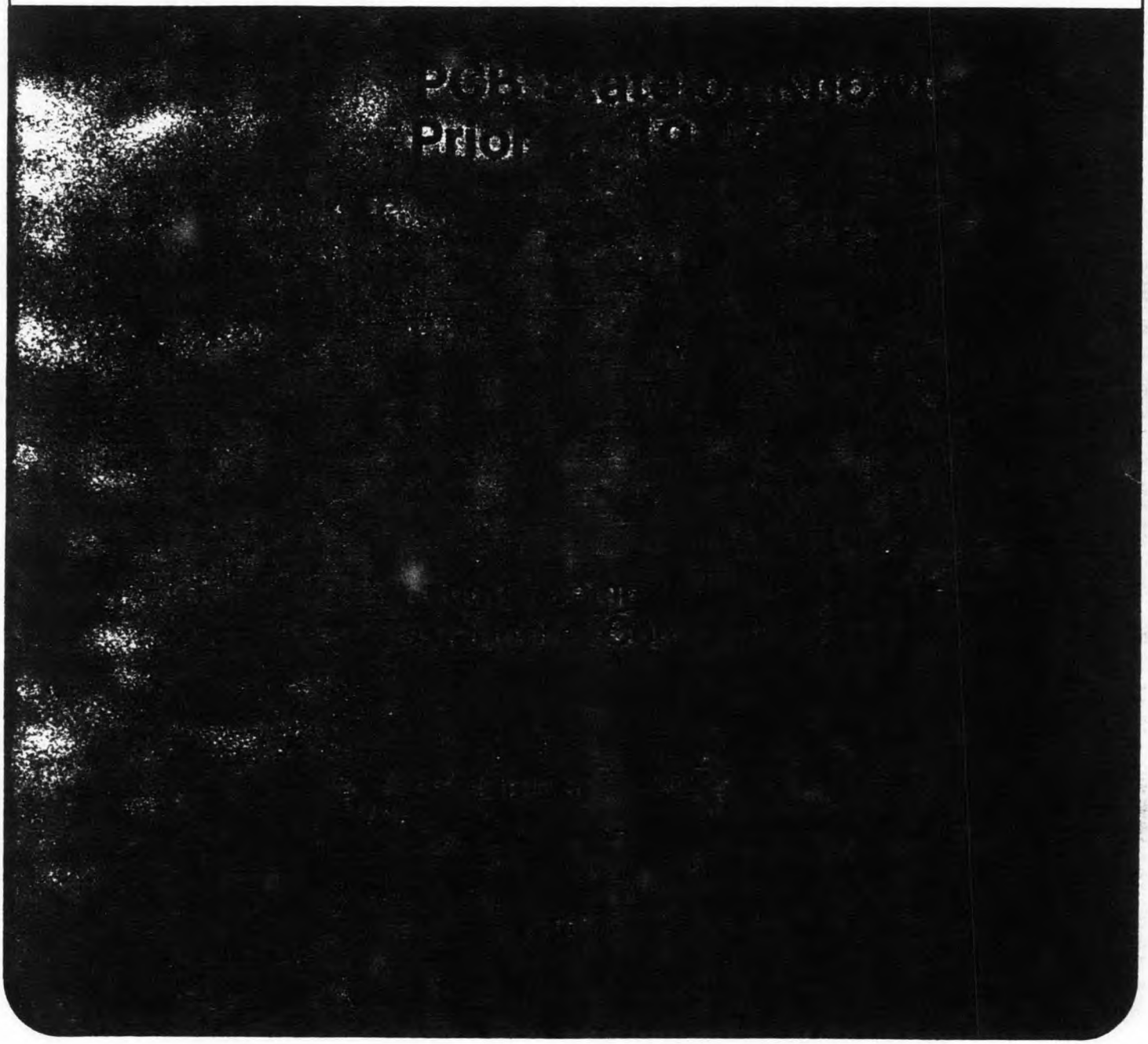
Report



INTRODUCTION

The purpose of this study was to review the general state of knowledge regarding polychlorinated biphenyls (PCBs) commonly held by the metal products manufacturing industry prior to 1977. The procedure utilized was to conduct a comprehensive computer-assisted literature search and analyze the extent and content of literature containing the following types of information relative to PCBs which may have been available prior to 1977:

1. Information in the technical and scientific literature regarding concerns over PCBs in relation to public health or the environment.
2. information in trade literature regarding concerns over PCBs in relation to public health or the environment.
3. information available through general news sources, newspapers and news magazines.

An evaluation also was made as to the circulation of the above information (ie. the likelihood that Singer staff would have come in contact with these sources of information), as well as the applicability of the information to Singer's situation. The following assumptions were made as a basis for delineating the scope of this evaluation:

1. Singer phased out its die casting operation at the facility in question in 1972. Monsanto reportedly has no records of Pydraul sales to this facility after 1972.
2. Monsanto's records reportedly show that only Pydraul A-200 and Pydraul 312 were sold to this Singer facility. There reportedly no records indicating Pydraul F-9 sales.
3. Singer's facility was sold in March 1977.

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BACKGROUND

Polychlorinated biphenyls (PCBs) refer to a class of complex mixtures of chlorine-substituted biphenyl compounds ($C_{12}H_xCl_{10-x}$). PCBs are among the most stable organic compounds known, exhibiting certain chemical and physical properties which make them extremely advantageous to industry. These properties include: low solubility in water, low vapor pressure, low flammability, high heat capacity and low electrical conductivity (1). Due to these favorable properties, and also because PCBs exhibit little acute toxicity, these compounds have been used extensively in many industrial applications; primarily in "closed" or "semi-closed" systems such as electrical transformers and capacitors, heat transfer systems and hydraulic systems. The inertness and chemical stability of PCBs are also responsible for the concern over their presence in the environment; PCBs are persistent and not readily broken down in nature, either chemically or biologically (1).

In the mid-1960s, growing awareness in the technical research community over the consequences of environmental pollution identified PCBs as a potential environmental pollutant. Studies were undertaken to determine the fate of PCBs in the environment and the possible link of PCB contamination to various environmental interferences with photosynthesis, reproduction, biological accumulation in the food chain and other natural processes; human health concerns were also being raised (2).

PCBs had been recognized by individuals in the health field as a health hazard in the workplace as early as 1933, shortly after the initiation of widespread commercial production, and in 1943 the Director of the Division of Industrial Hygiene of the New York Department of

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Labor stated that worker exposure to PCBs should be controlled insofar as humanly possible. These early notices addressed direct worker contact with PCBs, and did not indicate concerns over residuals in the environment, nor issues relating to incidental use. PCBs as a work-place hazard were given little public, scientific or regulatory attention until after they were identified as a potential environmental problem (3). An acute PCB poisoning outbreak in Japan (1968) manifested itself in a variety of deleterious human effects (4). Although later attributed to the probable affect of other substances, this incident served as the spark for increased attention to PCBs. Since PCBs are so persistent in the environment, potential chronic effects were considered to pose a more serious issue than acute effects. In 1975, environmental officials believed that people who ingested high levels of PCBs were at a greater risk of stillbirths, miscarriages and dermatological problems (5); the Mobil Corporation announced a possible link between PCBs and cancer in humans for the first time in 1976 (6). However, it was very difficult to document toxic effects and attribute them solely to a single chemical or family of chemicals. The possibility of synergistic effects or predisposing factors that can cause any aspect of the environment to be sensitive to the presence of PCBs could not be ruled out. Even with present day knowledge and technology, positively linking specific chemicals to definitive effects is a complex task and remains a questionable issue. In addition, when the level of interest in PCBs was raised in the period of the late 1960s to early 1970s, the ability of researchers to reach verifiable conclusions was hampered by an inadequacy of the available data base.

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An estimated 1.25 billion pounds of PCBs have been sold in the United States since 1930. The Monsanto Industrial Chemical Company, the sole domestic producer of PCBs, saw a rise in the use of PCBs in hydraulic and heat transfer systems during the 1950s and 1960s. PCBs were widely used in heat transfer and hydraulic fluids because of their fire resistant properties (1). As a company manufacturing small electrical appliances, the Singer Company was an incidental user of hydraulic systems; hydraulic fluids necessary for systems operation were allegedly purchased directly from the Monsanto Company. The Singer Company's main purpose was materials production and PCBs were not a significant focus. Handling and use of PCB-containing materials resulted only from the fact that some hydraulic machinery was incorporated into its electrical appliance manufacturing process.

Marketing its mixtures under the trade name "Arocior", Monsanto produced the majority of the PCBs used in United States industry prior to 1971. In 1971, the company voluntarily limited sales of PCBs and PCB-containing products in response to growing concern over their potential for causing detrimental effects to human health and when released into the environment. Monsanto restricted sales of PCBs to closed systems only and developed PCB-free substitutes for many of its products (7).

While Monsanto voluntarily reduced sales of PCBs because of increasing environmental and health concerns, no data base available at the time was adequate to define or quantify suspected effects. Although PCB-related studies were emerging in the 1970s (2), highly sensitive and sophisticated analytical and sampling techniques for PCBs

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were not yet developed; most of these studies were reported in specialized journals or government documents (2).

More easily accessible information was not well coordinated and scattered among various popular literature sources. During the period 1971-1977, PCB-related articles were found in The Wall Street Journal (8-22); The New York Times (23-28) and in a variety of popular magazines (3, 5, 6, 29-39). This existing database, prior to 1977, lacked strongly supported and well documented, widely available findings and was, therefore, insufficient to adequately verify PCB concerns; it may have led, at best, to estimations of potential environmental impacts. As a result, it was difficult to judge the extent to which PCB environmental concerns were commonly recognized by management in industries which were incidental users of PCB-containing materials, especially prior to the enactment of federal regulations and bans, without an extensive review of the type, contents and sources of literature available to that period.

REGULATORY HISTORY

Serious attempts to control toxic substances began in the 1970s in response to an environmental movement which had exposed several serious chemical hazards that could not be addressed under existing laws (40). These publicized events which intensified interest and concern included widespread contamination of food, water, and soil by highly toxic compounds of organic mercury discovered in the late 1960s; the World Health Organization's estimation (mid-1970s) that between sixty to ninety percent of all cancers were attributable to environmental factors; early 1970s findings that PCBs were suspected carcinogens;

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and a positive link made between vinyl chloride and cancer of the liver in 1975 (41). Charges brought against the General Electric Company in the mid-1970s over PCB pollution of the Hudson River and the subsequent court battle was a well publicized event which was also a motivating factor toward more stringent national controls (35). Amidst the limitations of technological and economic assessment and uncertainty regarding health and environmental risks, legislative action began on the Toxic Substances Control Act (TSCA) in 1971 and debate continued for nearly six more years (42, 43).

The act was drafted as a regulatory vehicle to control risks from exposure and use of raw industrial chemicals that fell outside the jurisdiction of existing environmental regulations, which included polychlorinated biphenyls. Before the passage of TSCA, PCBs were only regulated if they appeared in drinking water; however, being highly stable, PCBs would most often be particulate-associated and contaminate sediment rather than drinking waters. As potential adverse effects from PCBs increased, Congress specifically included a ban on the manufacture of PCBs and a phasing-out of existing use within the TSCA legislation. TSCA was passed by Congress on September 28, 1976, signed into law by the President on October 12, 1976, and became effective on January 1, 1977; PCB regulations under TSCA were not drafted until after promulgation of the statute in early 1977; did not become effective until 1979; and included exemptions for PCBs used in totally enclosed systems and the use of PCBs in concentrations less than fifty parts per million. These exemptions, which allowed for the continued use of 99.3% of all PCBs in use overall, were overturned by a federal court in 1980. An interim PCB inspection and maintenance

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program was put into effect shortly after the court ruling and more stringent regulations were promulgated in 1982 and 1984; these rules still permitted use of PCBs in non-food electrical equipment until October 1, 1988 (40). Issues regarding acceptable levels of PCBs in the environment have been sufficiently difficult to reconcile that a quantitative PCB Spill Cleanup Policy was not adopted by the USEPA until April 2, 1987 (52 FR 10688-10709). Therefore, in the content of issues relating to the Singer facility, the following conclusions can be stated regarding the evolving regulatory framework for PCBs:

1. regulatory activity did not occur until four to five years after Singer's die casting operations had been discontinued.
2. the passage of TSCA occurred in late 1976, with an effective date of January 1, 1977 and the promulgation of regulations effective in 1979. This compares to a sale of the facility in March 1977, well before the details of the regulations were available as an indication of the specific concerns relating to PCBs.
3. when the regulations were promulgated, they emphasized control, but permitted continued direct use, of PCBs. This kind of mixed regulatory message would have not evinced concern on the part of incidental users of PCBs, such as Singer.

At the present time, ongoing research continues to explore and reveal potential dangers associated with PCB compounds. However, such specific and in-depth knowledge has only been developing over recent years. During the early stages of recognition and concern regarding PCB dangers to human health and the environment, expertise

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and easily accessible literature in this area appear to have been limited. The following description of the literature review conducted for this study identifies the major documents and publications which were available prior to 1977 regarding PCBs, and addresses the likelihood that Singer staff, otherwise undisposed to research the subject, would have had contact with this literature.

METHODOLOGY

In addressing this study's concerns, an extensive literature search was conducted to reveal available PCB information prior to 1977. The wide range of sources reviewed includes:

- Monsanto product information which Monsanto claims it supplied to Singer as a user of PCB-containing materials;
- Customer letters allegedly received by Singer from Monsanto between February 1970 and August 1973 regarding materials reformulations to remove PCBs; and
- Dialog Databases: Dialog is a computer-based information source which periodically - monthly, semi-monthly or weekly - updates available databases. This system facilitates research of a large information base both quickly and efficiently; Dialog's range of databases contains more than 50 million references and abstracts of published information and statistics from thousands of trade and professional journals, newspapers, magazines and government reports (44).

For the purpose of this study, the following databases within the Dialog system were utilized:

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1. National Technical Information Service (NTIS) - a central source for the dissemination of United States government-sponsored documents.
2. Compendex - includes significant engineering and technological literature.
3. Information Service in Mechanical Engineering (ISMEC) - provides in-depth coverage of technical literature in mechanical engineering, production engineering and engineering management.
4. Scisearch - an international, interdisciplinary index to science, technology, biomedicine and related literature.
5. Enviroline - provides coverage of the scientific, technical and socio-economic aspects of major environmental and resource literature.
6. Pollution Abstracts - a resource for references to environmentally related technical literature on pollution, including sources and control.
7. Magazine Index - an indexing of over 435 popular American and Canadian magazines.
8. Environmental Bibliography - provides access to periodicals dealing with the environment.
9. Management Contents - provides comprehensive current and retrospective information on all aspects of business and management.
10. Congressional Information Service (CIS) - a master guide and index to the publications of nearly 300 United States House, Senate and Joint committees and subcommittees.

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11. National Newspaper Index - provides indexing of the Christian Science Monitor, the Los Angeles Times, The New York Times, The Wall Street Journal and The Washington Post.
12. Trade and Industry Index - a comprehensive indexing of more than 300 business, trade and industry journals along with nearly 1,200 additional publications.
13. Occupational Safety and Health - a bibliographic database produced by the National Institute for Occupational Safety and Health.
14. Chemical Regulations and Guidelines System (CRGS) - an authoritative index to United States federal regulatory material relating to the control of chemical substances, covering federal statutes, promulgated regulations and available federal guidelines, standards and support documents.

As illustrated, the literature search is representative of a wide-ranging scope covering engineering and technical literature, government documents and testimony, popular public media literature and specific trade and industry journals. All sources were queried for PCBs, hydraulic fluids and systems, the metal products manufacturing industry and/or other relevant topics. Significant sources were researched at length while abstracts or synopses were sufficient for less relevant information resources.

[redacted]

RESULTS

Monsanto Product Information

Handling and storage guidelines for hydraulic fluids, allegedly provided to Singer by Monsanto, indicated that products may be used

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safely if reasonable precautions are taken (45-50). Product literature advised against repeated or prolonged skin contact with the fluids. In the event of accidental contact with the eyes, Monsanto advised thorough flushing with plain water. At room temperature, it was stated there was usually no vapor inhalation hazard. It was recommended that respiratory protection or mechanical exhaust ventilation should be provided in the event of volatilization or possible decomposition of the fluid (51-57). Several versions of the handling instructions were provided; dates of issue could not be determined for many of these documents so that a sequence of changes in handling instructions could not be formulated.

Product labels contained only a warning against skin and eye contact and avoiding prolonged breathing of vapors and mists. It was also recommended that clothing soaked with fluid be laundered before wearing again (58-63). It was noted on labels that the products contained "chlorinated hydrocarbons", a caution no more noteworthy than that found on a number of common degreasing solvents used in industrial settings.

These precautions, supplied directly from Monsanto, addresses employee direct contact health concerns only, similar to those for other common industrial lubricants and solvents, and lacks any notifications regarding concern over environmental effects of PCBs or PCB-containing materials. Further, PCBs were not even noted so that customers might infer a need for precautions, if any.

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Monsanto's Customer Correspondence

The following is a summary of customer correspondence from Monsanto to users of certain PCB-containing fluids, dated from February 1970 through August 1973. It is not known whether these records include all correspondence from Monsanto to its customers, but is intended as representing the level of information and concern allegedly transmitted by Monsanto to Singer. It is important to note that all of the following customer correspondence had been directed by Monsanto to the Purchasing Department at Singer. A general awareness of the handling and management of toxic or hazardous materials for the purpose of environmental control was not present in industry, or represented by regulatory activity, at this time. Therefore, it is unlikely that procedures were in effect for efficiently transmitting such information from purchasing to an environmental coordinator, a position which Singer reportedly did not establish until 1979 on the corporate level.

Although it could not be verified through Singer records that all Monsanto correspondence noted here actually was received by Singer, for the purpose of evaluating the possible response of Singer to the information contained in the following letters, it has been assumed that all letters were received by Singer.

February 9, 1970 - Points out that recent newspaper and magazine articles indicate that PCBs have been discovered in certain natural environments. Alerts the customer to the potential problem of environmental contamination and announces the development of new formulations to replace products presently containing PCBs with greater than 54% chlorine by weight. Also indicates "...that all possible care should be taken in the application, processing and effluent disposal of these products to prevent them becoming environmental contaminants." An

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undated letter of correspondence from Monsanto to the Singer Company conveys a similar message (64,65). However, the February 9 letter makes specific note of two "additional facts" which likely led Singer to believe that these issues had no relevance to the products which it was using:

"1. Products such as Pydraul^{R} 90, 135, 230, 312, A-200, F-9, 150 and 60, Turbinol^{R} 153 and Therminol^{R} FR-1 and FR-2 are not formulated with Aroclor^{R} 1254 or 1260.

"2. PCBs with a chlorine content of less than 54% have not been found in the environment and appear to present no potential problem to the environment."

These two statements by Monsanto categorically excluded the Pydraul A-200 and 312 products used by Singer from its announcements. Although later announcements by Monsanto would announce the reformulation of these two products to remove chlorinated organics, statement (2) preceding would make this measure appear to be precautionary. The tone and wording of subsequent correspondence did nothing to alter this impression.

August 27, 1970 - Announces the reformulation of Pydraul F-9 to eliminate PCBs since it had been reported "... (PCBs) had been discovered at some points in marine, aquatic and wildlife environments". The one page letter does not indicate any specific environmental on public health concerns over PCBs, nor does it emphasize any immediate concerns over continued use. Rather "...as inventory is depleted in warehouses around the country the new formulations will be shipped to fill your orders". (66) It should be noted that there reportedly are

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not records at either Monsanto nor Singer which indicate that Singer ever received Pydraul F-9.

February 1, 1971 - Announces the reformulation of Pydraul 312, 135, 230, 540-A and 200, all of which had contained PCBs. The new products would be shipped after inventories of old stock were depleted. (67) This letter is almost identical in tone to that of August 27, 1970, in that it contains no wording representing significant concern connected with use or continued use of the products.

January 31, 1972 - Informs companies that effective June 30, 1972, old formulations will have been phased out and all Pydraul products will be new formulations containing no chlorinated components. (68) Again, this letter does not mention any concerns relating to the previous Pydraul formulations, ie. "we have decided to stop using polychlorinated terphenyls as a component in our fluids." To non-technical staff, the use of the word terphenyls may have caused confusion, since biphenyls had previously been mentioned.

February 28, 1972 - Renotification of the phasing in of new products with compatibility claims; "...no draining, cleaning or changing of seals in your system is necessary. You need only to add the new products as make up to your present system." (69) No warning tone nor cautionary statements were made in this letter.

March 1972 - Announces the eventual world-wide discontinuation of all PCB-containing Therminol products. Suggests that "...remaining

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systems be drained completely, flushed to remove PCB, and refilled with non-PCB fluids." Also asks that all PCB materials be returned to Monsanto for disposal. Attached to the March letter of correspondence is a Therminol Conversion Bulletin which points out that, "Most recently, PCB has been identified as a potential hazard to the environment. Monsanto has accordingly elected to discontinue sale and manufacture of Therminol FR fluids..." Similar information is included in an additional, undated letter of correspondence from the Monsanto Company to Singer (70,71). However, since Singer reportedly did not use any of Monsanto's Therminol products, this correspondence may have been discarded as not applicable to Singer.

August 1973 - Announces the Food and Drug Administration rule of July 6, 1973 (72), regarding PCB contamination of animal feeds, food and food-packaging materials; advises customers to review operations and assure compliance. Includes announcement of the availability of high temperature incineration at Monsanto's Illinois plant for the proper disposal of chlorinated materials; related shipping and price information is included with the letter dated August, 1973 (73).

While these notices do represent Monsanto's modifications of the gradual removal of PCBs from use, these notices did not indicate that these activities were necessitated by a significant concern over the potential impacts of PCBs or contamination by PCBs. The items of potential contaminant concern were food (ingestion) related; the letter did not addressed incidental, non-food chain uses, nor issues related to residuals from spills.

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Dialog Database Literature Search (44).

- Technical and Scientific Literature

  Dated 1964 through 1969, close to 300 references were found concerning PCBs in the environment, the majority of which are reports on scientific studies. Many additional articles were found dated 1970 through 1977. Again, most were toxicological or other scientific study reports; a limited number of citations directly addressed PCB environmental impacts or effects. Most articles are located within specialized publications in the chemical, biological, biochemical toxicological or medical sciences, and not in popular reading or trade literature.

- News and Business Periodicals; Popular Press

  These resources offered a relatively small number of references relevant to the study's scope:

  1971 - Time Magazine (29)

  1971 - Newsweek (30)

  1972 - Science News (31)

  1972 - Nature (32)

  1973 - Science (33)

  1973 - Environment (3)

  1973 - Environment (34)

  1975 - Nature (35)

  1975 - Business Week (5)

  1975 - Sports Illustrated (36)

  1976 - Business Week (37)

  1976 - Environment (38)

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1976 - Environment (39)

1976 - Business Week (6)

In general, these sources addressed concerns regarding PCB-related health and environmental effects; a growing number of fish and other wildlife studies were implicating PCBs in a variety of detrimental effects. As reported, products containing PCBs were widely used throughout industry, especially in insulating fluids, prior to Monsanto's voluntary sales and production restrictions. While magazines such as Time, Newsweek, Sports Illustrated and Business Week are read by the general lay public and are high visibility publications, they represent six articles over a six year period, or one a year. Magazines such as Science News, Nature, Science and Environment reach a more general science audience but represent only an additional article per year on PCBs, even if it is assumed that the reader was a subscriber to all of these magazines over this period.

- Newspapers

Approximately 21 references to PCBs were available in The New York Times and The Wall Street Journal between 1973 and 1977 (8-28). The full text of these articles has been reviewed and the major topics include:

-Actions of the Federal Environmental Protection Agency

-The Toxic Substances Control Act (TSCA)

-PCBs in the Hudson River; other contaminated areas

-Activities by Monsanto (reformulations, price increases,

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restrictions)

-FDA regulations regarding food and food packaging materials

-Persistence of PCBs in the environment; health concerns

-Activities of the General Electric Company

These articles were available from popular newspapers that were easily accessible sources of information. However, of the 21 newspaper articles, only one was published prior to 1975 (8) regarding a 1973 FDA curb on PCBs in food packaging, an order which was rescinded in 1975 (9). The remaining 20 articles (9-28) were published from 1975-1976 as the issue of PCBs in the environment was first being brought to public awareness. Since Singer ceased die casting operations in 1972 and, therefore, use of Monsanto hydraulic fluids, it is likely that Singer staff would have been even less attentive to these few articles. Further, these articles did not address the implications of incidental uses such as that by Singer.

Government Documents

Prior to the passage and implementation of TSCA, testimony was given by major users of PCBs in electrical equipment and by Monsanto, the sole manufacturer of PCBs in the United States. Public Hearing transcripts were reviewed and no hydraulic fluid customers, such as Singer, were found to have attended or given testimony on any aspect of TSCA or its subsequent regulations (74-79).

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This is an indication that incidental users such as Singer were not at the time considered to be an issue relative to PCB control.

DISCUSSION

In 1976, the United States Environmental Protection Agency reported that inadequate regulating forces were not preventing PCBs from entering the environment. It concluded that the PCB regulatory strength was insufficient; the Toxic Substances Control Act came into effect in 1977. Prior to the proposal and promulgation of TSCA, the PCB issue was surrounded by a weak regulatory structure; Monsanto's industry-imposed restrictions were voluntary, with no legal basis (1). Under these circumstances, incidental users of PCB-containing materials were most likely far removed from regulatory concerns.

Maximum losses of PCBs to the environment from all uses are thought to have occurred prior to 1970 (7). Even with no legal basis for any regulatory compliance, the majority of these losses seem to have been unintentional. The need for a comprehensive manual describing methodology for controlling the release of PCBs to the environment was recognized by the government (7); however, federal regulations and limits were not proposed until TSCA in 1976. Again, most losses of PCBs to the environment occurred before precautions against contamination due to uncontrolled releases were put into law (7).

PCB-containing materials were used widely throughout industry because of their non-flammability and other thermal stability properties. The extent to which PCBs were present in the world environment was not known until 1966, when a Swedish scientist used a gas

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chromatograph and first identified PCBs in tissue samples of fish and birds and in human hair (30,36). When potential detrimental effects to the environment and human health were suspected in the late nineteen sixties, Monsanto, the only manufacturer of PCBs in the United States, responded with a gradual phasing out of PCB-containing products. The transition initially involved the depletion of remaining stock followed by the introduction of reformulated replacement products. The change-over process was carried out in a non-emergency manner and correspondence from Monsanto on this matter, aforementioned and summarized, did not convey an alarming overtone (64-73). In fact, initial correspondence forwarded by Monsanto to purchasers (64) specifically exempted the products used by Singer from PCB-related issues, while later correspondence (68) may have confused the issue by addressing terphenyls rather than biphenyls. As an incidental user of Monsanto's PCB-containing hydraulic fluids, this review assumes that Singer conformed to the company's requests and complied with product changes.

In developing Singer's "PCB state of knowledge" prior to 1977, an extensive literature search was conducted to reveal available sources of information at that time. A list of scientific and technical journals routinely read by Singer personnel was not available during the study; this could provide additional insight into the evaluation of PCB knowledge within plant management and other personnel. Knowing the actual sources frequently utilized by certain individuals of Singer's personnel may have resulted in more specific findings regarding the company's awareness of PCBs. Notwithstanding this limitation, a wide range of literature sources which are presumed to have been available and read

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by Singer personnel was researched. In general, most PCB references were found in government documents and highly specialized or otherwise obscure journals, sources unlikely to be easily or commonly accessed by Singer's management and labor personnel. However, although a limited number of articles cited earlier in this report, which addressed PCB and environmental concerns, appeared in popular magazines and newspapers prior to 1977, they do not appear to represent a long-term information source or definitive body of knowledge, and did not address issues relating to incidental users such as Singer. Indeed, the topics discussed may have served to confuse the issues even as they stood at that time (8,9).

Areas of concern addressed in scientific and technical literature, as well as many government-sponsored documents, included: the determination of PCB concentrations and distribution in various environmental media; evaluation of effects and significance of the presence of PCBs in the atmosphere, soil, aquatic and other biological systems; potential health risk and environmental impact studies; detection, sampling and other analytical techniques and; disposal and destruction alternatives. The majority of this emerging knowledge was published in government reports or specialized journals such as the Journal of the National Cancer Institute and Pesticides Monitoring Journal, and was not readily available in the popular media (2).

As concern over PCBs increased, related articles appeared in popular newspapers and magazines. Several articles in The Wall Street Journal and The New York Times between 1973 and 1977 revealed concern over the use of PCBs and their potential as an environmental pollutant. The Wall Street Journal published one article in 1973; no

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PCB articles were reported in 1974; three articles were available in 1975; a string of ten articles were published in 1976 and; one article appeared in 1977. Similarly, The New York Times did not report on PCBs until the late 1970s; one article appeared in 1976 followed by five articles that were not printed until 1977. The majority of these articles were limited in text, often consisting of only a few short paragraphs, and only two were reported as front page news (10,13). These articles related exclusively to manufacturers or direct users of PCB oils, rather than incidental users such as Singer. No articles were found to have appeared in 1971 and 1972, preceding the 1972 cessation of die casting activities at the Singer facility. Articles appearing after that time may not have been considered applicable to continuing activities at the facility, even if the topics covered were appropriate to incidental users of PCBs, which they were not. Therefore, there may have been no reason for Singer to deduce from these articles, even if available to Singer staff, that its level of use, relative to that in transformers, for example, was of environmental concern.

PCB-related articles also appeared sporadically in popular magazines. Two stories were published both in 1971 and 1972 prior to the cessation of die casting and the use of hydraulic fluids at the facility; three appeared in 1973 and 1975 respectively and four articles were reported in 1976. However, these articles appeared after hydraulic fluid use had ceased at the facility in 1972, and Singer staff may not have been attuned to these issues. None of the magazines, which included Time, Newsweek, Science, Nature, Science News, Environment, Business Week and Sports Illustrated, reported PCB-related articles in successive issues; only Environment, Business Week and Nature

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published more than one PCB article prior to 1977 in their respective magazines. The general public clearly was not inundated with PCB information through popular media channels; available information was sparse or generally infrequent.

While it is reasonable to assume that Singer's management and labor personnel had read or were likely to be familiar with some of the articles appearing in the popular literature, the sporadic nature of the appearance of the articles and the number of different sources they appeared in made it improbable that any one person read or was aware of every published account. Each article did convey concern or raise questions as to the health and environmental effects of PCBs, including reporting of fish and wildlife studies; industrial use of PCBs and PCB substitutes; worker exposure and risk; government regulations; fines and penalties levied on PCB polluters and; Monsanto's PCB manufacturing and restrictions. No articles addressed the issue of PCBs in hydraulic die casting or electrical motors; the electrical equipment industry was the most widely covered, dealing mainly with the use of PCBs in the cooling systems of large electrical distribution transformers and industrial capacitors. The popular media did not address the concerns of incidental users of PCBs and, without any state or federal regulations, interpretation of existing information was left to individual companies.

CONCLUSION

Based upon this study's findings, it appears that concern over PCBs and their potentially dangerous effects on the environment began in the mid-1960s and has continued growing to today's present efforts.

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Early information on PCBs, prior to 1977, consisted mainly of scientific research studies and reports, without a comprehensive environmental data base having yet been accumulated. In assessing a general PCB state of knowledge, it may be assumed that most of this literature remained in the scientific and other specialized fields. A metal products manufacturing company such as Singer, or any other incidental user of PCB-containing hydraulic fluids, was limited primarily to popular media and supplier contact as channels of information. These sources of information did not address the issues of incidental use, but only the concerns raised in high use situations.

PCB concerns were raised in popular reading literature which was readily available and it is reasonable to assume that some of this information had been read by Singer personnel; however, the overall number of relevant articles from all sources is relatively small (44), even if considered in total, and from widely disparate sources. While newspapers and magazines did carry some articles concerning health and environmental effects, Business Week (1975) reported industry claims that further restrictions on PCBs would trade a dubious health-hazard for almost certain safety and economic problems (5); Business Week (1976) also reported that PCB users remained skeptical of PCB substitutes (37). In the mid-1970s, it still seemed as though financial and safety concerns within industry outweighed suspected risks from PCBs.

Customer correspondence alleged sent from Monsanto to the Singer Company purchasing staff did inform Singer of a growing concern over the potential presence of PCBs in the environmental, no note of environmental nor public health concern was made. While it is assumed that Singer responded by complying with the suggested changes, it is

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the conclusion of this review that a sense of urgency or undue concern was not conveyed to the customer by the wording nor tone of Monsanto's mailings (64-73). Further:

1. Monsanto's initial mailing in 1970 exempted the Monsanto products used by Singer from those containing the Aroclors found in the environment. Therefore, Singer would have concluded that Pydraul A-200 and 312 were not at issue.
2. Later Monsanto correspondence addressed polychlorinated terphenyls rather than biphenyls, causing potential confusion in customers receiving the notice. This item points out the lack of familiarity with even the appropriate at this period in time.
3. At no time did the Monsanto correspondence clearly indicate "concerns", "risks" or "problems" associated with continued use. Rather than recalls of existing stocks, which would have implicitly indicated a level of significant concern, the MOnsanto correspondence announced the phase-in of reformulations over periods of 60 to 90 days, a clear indication of a lack of concern over continued use of the products.

Coupled with the other information available from popular reading sources, it is reasonable to assume that Singer had been cognizant of emerging PCB concern over potential health and environmental effects; however, the interpretation and extent to which the available information conveyed any further depth of concern over using PCB-containing fluids is uncertain. Additional research into environmental practices at Singer's plant, input from corporate environmental personnel and review of plant records (for example, Occupational Safety and Health

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Administration inspections, employee complaints, material spills and/or leakages) may provide other, relevant information into the Company's knowledge regarding PCBs.

The Singer Company could only have been expected to follow the recommendations of Monsanto, involving the gradual phasing out of PCB-containing fluid and conversion to PCB-free products; any further level of response did not seem warranted at the time. Singer's PCB state of knowledge prior to 1977 could be described at most as one of general awareness regarding the potential for health and environmental problems, but also as one which was limited by a sporadic supply of public information that was often unverified and did not reflect Singer's operations as an incidental user of PCBs. In addition, Singer's use of PCB fluids ceased in 1972 when its die casting operation was shut down. At that time, information regarding PCBs was largely limited to technical literature and some articles relating the results of environmental monitoring. Available PCB information, along with a lack of federal PCB regulations or restrictions, provided a climate prior to 1977 in which PCB fluid users such as the Singer Company most likely did not recognize that significant environmental health risks were associated with their past purchase and use of these products; changes in the use of PCB-containing fluids were primarily a result of the supplier's product reformulations.

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