WHAT MONSANTO CHEMICALS COMPANY KNEW ABOUT THE HAZARDS AND EFFECTS OF POLYCHLORINATED BIPHENYLS

By

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ABSTRACT

The purpose of this study is two-fold: to determine what and when Monsanto Chemicals Company knew about the hazards and detrimental effects of producing polychlorinated biphenyls (known as PCBs). This research addresses Monsanto's PCB production history, and Monsanto's knowledge and understanding of the toxic and hazardous effects of PCBs.

Background information discusses properties, benefits, and the history of PCBs, as well as the foundation for the current environmental, health, and public concerns. This thesis is compiled in a chronological format based on internal Monsanto documentation and extensive external research. The summary of research, results and conclusions, and recommendations are predicated on background information as presented within the study.

Research findings conclude that the questions about PCB toxicity and effects are inconclusive. Public understanding is limited through the 1970's and research studies are not definitive regarding key issues. However, Monsanto records suggest early indications of problems generated by the manufacture and release of Aroclor. Unfortunately, the demand for PCB-laden products by business and consumer encouraged PCB-laden production. Substitutes for PCB are nonexistent.

Internal documentation provides instances of spills, leaks, and careless manufacturing policies. Outside research and requests sent to Monsanto over the forty years of production point to potential problems with health effects, safe product disposal, and environmental pitfalls. Conclusive data is unattainable regarding the daily operations on Monsanto, while future study is imperative to determine the long-term effects of PCBs. Additional research opportunities yield greater health and environmental findings and enhance understanding of PCBs.

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I. INTRODUCTION

The purpose of this study is to explore Monsanto Chemicals Company's knowledge about the hazards and detrimental effects of producing polychlorinated biphenyls (known as PCBs). The foundation for this study is litigation against Monsanto (now known as Solutia) and the Anniston, Alabama manufacturing facility. Litigious Anniston residents charge Monsanto with health and environmental concerns from prolonged exposure to PCBs generated from years of Monsanto's questionable production processes.

PCBs can be found with various forms and are practically insoluble in water. PCBs are flame retardant and, therefore, were in high demand for electrical equipment and other industrial applications in the period 1930-1975. PCBs have been known to cause a number of health problems affecting the immune, reproductive, nervous, and endocrine systems. These industrial chemicals also are believed to be carcinogens and have been proven to cause cancer as shown in animal testing (Shifrin and Toole, 1998). A great deal of research and study was underway in 1998-2000 to determine the exact toxicity and potential health threats generated by PCBs. However, part of the difficulty in analyzing these chemicals is that PCBs are not a single compound, but actually various mixtures, or congeners, of individual PCB compounds.

Monsanto's PCB production process began in 1929 and continued through the early 1970's before the 1976 ban on PCB production in the United States. Monsanto Industrial Chemical Company was the sole producer of PCBs in the United States under the Aroclor® family name. Several major companies, including GE and Westinghouse, purchased Monsanto's Aroclor and used it to generate hydraulic fluids, PCB derivatives, and other chemicals. Aroclor was especially popular in electric capacitors and transformers because of property characteristics and could be found in use at almost any major urban electric facility.

Although most original documentation and general history from the 1930's, 40's, and early 50's is no longer available, numerous internal and court documents dated from as early as 1954 are preserved. Subjects covered in this work are based on this preserved documentation which includes Monsanto's knowledge and actions, neighbor and employee concerns raised to Monsanto, outside party research and communications expressed to Monsanto, and public reactions to various activities occurring throughout the PCB plant life-cycle (Shifrin, 1998).

In 2000, over 6,500 publications existed regarding PCBs. Accordingly, a significant percentage of PCB-related material focuses on the health concerns and environmental effects associated with PCB exposure in the workplace and in the environment. A number of studies and medical examinations have been completed on animals in laboratory settings to evaluate the toxicity and potential for cancer and other disorders. Adversely, limited human research has been completed in Japan and around the globe; thus inadequate literature and findings are currently available. Few publications or studies address the in-depth history of Monsanto's PCB production process and their knowledge of PCB-related problems.

The goal of this study is to elaborate relevant PCB background information, and to describe Monsanto's knowledge and production history of PCBs. Following the procedure described in the next chapter, this work includes background research, a summary of findings and results, and ultimately, conclusions and recommendations.

II. PROCEDURE

This thesis focuses on the development of a sequential history and general timeline of Monsanto's knowledge and insight on PCB risks and adverse health and environmental effects. The aforementioned timeline is generated to understand and evaluate the situation via the information obtained from attorneys, the Alabama cou system, and academic consultants.

To accomplish this goal, extensive background material and research is need elaborate on the history, characteristics, benefits, and effects of PCBs and PCB production. Therefore, the first step in the process is to establish the foundation by completing extensive external research on PCBs, their production, and related health findings.

Available sources for research completion include the Internet, journals, newspaper articles, and published studies. Similar sources supply the history of Monsanto Industrial Chemicals Company, their U.S. PCB plants, and the available Monsanto publications. Finding is this study are assessed, summarized, and compilec the Background Research and Information section.

Additional data and information regarding Monsanto's knowledge and insigh been gathered from materials furnished by prosecuting attorneys in the case. After developing the foundation and basis for the case and subject in the Background Rese and Information section, this material needs to be categorized by importance and relevance. Extensive correspondence with legal representatives deliberated the best approach to evaluate the Monsanto material at hand.

Research material includes several hundred documents encompassing numerous three-inch binders that have been studied and summarized by document, date, and title. Upon summary completion of the above information, the research data is formulated to support thesis exploration. A chronological synopsis of Monsanto involvement is offered.

The culmination of this research provides the Results and Conclusions section. A list of Recommendations for further investigation is generated. The completed work is then reformatted and modified under guidance from Thesis Directors and outside sources.

III. BACKGROUND RESEARCH AND INFORMATION

A. PCB Characteristics and Manufacturing History

PCBs, polychlorinated biphenyls, were discovered over 100 years ago and are a group of distinct chemical compounds consisting of two benzene rings and one to ten chlorine atoms. Benzene rings are the foundation of numerous fuels including gasoline and petroleum. While these substances are extremely flammable, the substitution of chlorine molecules for hydrogen atoms results in a flame-resistant substance. As shown in Table 1 in Appendix I, molecules with more than one chlorine atom are known as PCBs. PCB's exist to some extent in the natural environment, although there are no known natural sources of PCBs. In total, it is believed that there could theoretically be 209 possible PCB isomers.

PCBs can be found in various appearances ranging from mobile, oily liquids to white, crystalline solids to hard, noncrystalline resins. PCBs are practically insoluble in water, but soluble in oils and organic solvents. They are resistant to oxidation, acids, bases, and other chemical agents, and boast good dielectric properties. PCBs are thermally stable and are colorless crystals in their pure structure. Their color ranges from colorless to light yellow, and they have no known smell or taste. When heated to decomposition, PCBs generally emit toxic fumes of hydrochloric acid and other chlorinated compounds (Shifrin and Toole, 1998).

Commercial-grade products are liquids because the melting point is depressed when the PCBs are mixed. Technical-grades of PCBs have different proportions of the various chlorobenzene isomers with small amounts of polychlorinated dibenzofurans and polychlorinated naphthalenes as contaminants. Technical-grade PCBs were used in capacitors, transformers, hydraulic fluids, newsprint, vacuum pump fluids, lubricants, carbonless copy paper, inks, plasticizers, fillers in investment casting waxes, pesticide extenders, surface coatings and sealants, and flame retardants.

PCBs were developed in 1929 and first produced by Swann Chemical Company in that year. PCBs were developed originally for primary use as heat transfer fluids and dielectrics. Monsanto Industrial Chemical Company purchased Swann Chemical Company in 1935. During the 1930s and 1940s, PCBs often were combined with chlorinated napthalenes manufactured by the Halowax Company. Monsanto Chemical Company produced PCBs at plants in Sauget, Illinois and Anniston, Alabama until 1978 (Commoner, 1994).

Monsanto sold PCBs under several trade names, including Aroclor®, and several customers denoted their Monsanto-produced product under separate trade names, including Askarel®. Major categories of products containing Aroclor are old fluorescent lighting fixtures, electrical appliances containing PCB capacitors, caulking compounds for skyscraper windows, air conditioners, typewriters, power saws, old microscope oil, and hydraulic fluids. Monsanto's Aroclor was manufactured with various chlorine concentrations, but the two key products included Aroclor 1254 and 1260, which are biphenyls containing 54% and 60% chlorine respectively and function in the range of 250-360°C. Eight mixtures of PCBs were sold in the United States under the Aroclor trade name (see Table 1 in Appendix I). Aroclor generally contained between 27 and 77 congeners in proportions that probably varied by manufacturing batch, as well as by design. To add to the varied manufacturing complications, once Aroclor is released into the environment, physical, chemical, and biological processes work differently to degrade each congener further into different chemical formations making Aroclor even more dangerous and difficult to control (Thoman, 1989).

Monsanto's plant in Anniston, Alabama, was their largest producer of Aroclor. Anniston, Alabama, situated approximately 60 miles east of Birmingham and 90 miles west of Atlanta, has approximately 12,100 families, and a population of 26,623. Of this population, 5,926 people are estimated to live within one mile of the plant. The city has 52.321 square kilometers of land, and no bodies of water. Monsanto's plant in Anniston is situated on 570 acres, with 70 acres developed as the plant site. Highways, railroads, and utilities separate the Monsanto site (www.solutia.com, February 6, 2000).

Monsanto's landfills are south of the main facility, as shown in Appendix I, Figure 2. According to court documents, Monsanto buried more than five-and-a-half million pounds of PCBs in these landfills. The area north of the Monsanto facility has residential and industrial neighbors. The west and east are bordered completely by residential neighborhoods. The facility sits in a valley bordered by ridges and mountains. The major waterways near the plant are Snow Creek, Choccolocco Creek, and the Coosa River.

The plant began in 1915 when Theodore Swann became interested in the manufacture of six-inch explosive shell cases for the U.S. Army. In 1917, the Southern Manganese Corporation began operations at the present site manufacturing ferromanganese and other steel-making chemicals. In 1927, the Anniston plant entered the field of organic chemicals with the production of biphenyl, which remains a major product of the plant. The plant has manufactured phosphates, calcium carbide, chlorine, insecticides, and fire-resistant industrial and electrical fluids. Solutia Inc. currently operates the plant manufacturing heat transfer fluids (Therminol), Paranitrophenol, plasticizers, and polyphenyls.

The industrial importance of PCBs was based on their flame-resistant characteristics. Electrical product manufacturers found that PCBs worked perfectly in their products since they did not burn, break down, or react with other chemicals. Other chemical alternatives to PCB usage in electrical equipment include silicone fluids, fluorocarbons, high molecular weight hydrocarbons, low molecular weight chlorinated hydrocarbons, and high boiling oils and esters. Derating of a transformer might be needed when using an alternative, though, which would change the power load and end up reducing transformer efficiency, increasing operating costs, and increasing fire and safety liability. (*Federal Register*, 1985).

PCBs are no longer produced in the United States, except for some restricted research and development applications. The import and export of PCB compounds has not been permitted since 1979. It has been estimated that between 1929 and 1977, about 1.1 billion pounds of PCBs were produced in the United States. Monsanto was the sole U.S. producer of PCBs and their domestic production reached a peak volume of 86 million pounds in 1970.

B. Effects of PCBs on Health and the Environment

Concern about the presence of PCBs in the environment began around 1966 when research in Sweden revealed the presence of PCBs in soil and water samples being screened for DDT. Additional research validated suspicions that biodegradation of PCBs was extremely slow (Jensen, 1966).

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In 1968, Western Japan faced a widespread human poisoning episode, called "Yusho," due to PCB contamination of rice bran oil. "Yusho" involved over 1,300 people who became ill from consuming rice bran oil with over 2,000 parts per million (ppm) of a PCB heat-transfer fluid. This epidemic generated a great deal of concern an fear worldwide about the safety and effects of PCBs. This concern was magnified even greater when another poisoning episode involving rice bran oil and PCB contamination, called "Yu-Cheng," evolved in 1978.

In an article concerning the Housatonic River and the GE plant in Pittsfield, Massachusetts, which used PCBs to manufacture capacitors and transformers, David Schalk, an Indiana researcher, remarked: "Regulatory authorities appeared to have paid little attention to PCBs prior to the late 1960's. Only then did the U.S. Food and Drug Administration (FDA) begin the regulatory process by setting internal 'action levels' (www.housatonic-river.com, January 23, 2000)." In 1970, the FDA announced component concentration guidelines for fish and milk, and in 1972 they published proposed tolerances in the Federal Register. Nearly all FDA activity regarding PCBs during the 1970-2000 period has focused upon fish and shellfish. The Federal Insecticide, Fungicide, and Rodenticide Act canceled the registration of all pesticides th contained PCBs either as an active ingredient or as an extender to retard evaporation, effective November 29, 1970. As Schalk commented,

> The U.S. EPA gathered information during the early 1970s, but did little to regulate PCBs before they were forced to administer the PCB phase-out mandated by Section 6(e) of the Toxic Substances Control Act of 1976 (TSCA). EPA currently regulates PCBs which are still in service in electrical equipment or which are distributed in commerce for special uses. They also regulate PCB discharges into the environment and the disposal or destruction of discarded PCBs (www.housatonic-river.com, January 23, 2000).

Monsanto Chemical Company voluntarily restricted the types of Aroclor products produced to contain less than 60% chlorine. A 1974 government ruling restricted the use of PCBs to closed systems only. This action and a series of other U.S. government decisions generated the regulation of PCBs under the Toxic Substances Control Act (TSCA) in 1976.

TSCA banned the manufacture, processing, distribution, and use of PCBs in all products that were not totally enclosed. PCBs are currently the only chemical family fully regulated under any government act (Flynn and Kleiman, 1997). The government decision to ban all commercial production of PCBs was reached in 1976 although production didn't cease until 1979. As in the U.S., there is no longer commercial production of PCBs in Europe.

Thus, research confirmed that PCBs were released into the world and exposed to the public through sewers, burning PCB-containing products, smokestacks, usage of PCB-containing materials, leakage of old equipment, and leaching from landfills. Therefore, the primary routes of potential human exposure to polychlorinated biphenyls are inhalation, ingestion, and dermal contact.

A major source of exposure to PCBs is through the human diet. Major U.S. commodities, including fish, cheese, eggs, and contaminated animal feed, have been found to contain PCBs. From prior releases of PCBs in industrial uses and the perseverance of the compounds in the environment, widespread contamination of water and soil has resulted in the potential exposure of the general population. At least ten hazardous wastes sites designated in the National Contingency Plan have listed PCBs as contaminants. NIOSH estimated in 1977 that 12,000 workers had potentially been exposed to PCBs in the work environment (U.S. EPA, 1990).

PCBs remain in the air for approximately 10 days and may be carried long distances. In water, most PCBs stick to organic particles and sediments. Their solubility in fat and ultimate storage in body fat causes these chemicals to bioaccumulate in the food chain.

Findings of health effects are traditionally classified as acute or chronic. PCBs have been shown to cause a number of problems affecting the immune system, reproductive system, nervous system, and endocrine system. Acute effects are generally considered to be physiologic responses that occur shortly after exposure. People exposed to PCBs in the air for a long time have experienced irritation of the nose, lungs, and skin (including rashes, fatigue, nausea, liver disorders, and severe acne). Chloracne and peripheral neuropathy have also been associated with acute PCB exposure (Kimbroughm, 1987).

Chronic effects include endocrine disruption, reproductive problems, skin disorders, and various forms of cancer. It is not known whether long-term exposure to PCBs causes birth defects or reproductive problems in people. In addition, evidence is still inconclusive about the ability of PCBs to cause cancer in humans. The weight of the experimental evidence supports the conclusion that PCBs can cause cancer in animals (IARC, 1987). The U.S. EPA has even determined that sufficient evidence exists to consider PCBs to be animal carcinogens (EPA, 1996).

C. Disposal and Destruction of PCBs

Disposal and remediation of PCBs has slowly evolved over the years. All of the variability in manufacturing and the physical, chemical, and biological effects causing varied PCB congeners creates an analytical challenge to resolving Aroclor questions and studies. Although a great deal of research and development has been underway, a technically and economically feasible alternative for solving the environmental problems generated by PCBs has not yet been found. Solution techniques have been difficult to develop since slightly chlorinated PCBs decompose faster than highly chlorinated PCBs and methodology for water treatment will not be as effective for treating soil or air. To further complicate matters, detection mechanisms for locating and evaluating PCB mixtures also pick up other halogenated organic compounds present in the environment, like dioxin or DDT. This interferes with and complicates the testing process and procedures for PCB mixtures. According to the *Federal Register* (1985), PCB monitoring, testing, and disposal has cost over $970 million.

With the cessation of production and decrease in PCBs in existing products, PCB levels in the environment are decreasing slowly. In addition, the PCB levels in foods, waters, and blood are subsiding as exposure levels are reduced. Therefore, because of the decreasing of PCBs in existence, previous and current remediation efforts, and the restriction of importing PCBs to the U.S., the general population exposure risk has been significantly curtailed.

IV. SUMMARY OF RESEARCH

Prosecuting attorneys presented a plethora of legal documentation, often referred to as internal documentation, relating to Monsanto liability. This information and material has been prioritized and sorted into chronological order, as summarized in Appendix I, Figure 3. Limited information appears prior to 1933. The bulk of internal documentation spans the period from April 1955 until 1998. The remainder of this research section pursues a chronological synopsis of Monsanto internal documentation beginning with the year 1947. Appendix I, Table 2 gives a complete alphabetical list of characters mentioned throughout text.

A. 1947

At this time, Monsanto employees and others believed that PCBs and related mixtures were potential health hazards and, therefore, it was essential that both consequences and recommendations for proper handling be addressed accordingly in the plants. Mr. Barbre of the Krummrich plant in Sauget, Illinois, commented on the information explaining Krummrich's findings with chloracne:

> During the 11 years of production here only one man evidenced dermatitis. He had also shown similar symptoms in several other departments. When making Aroclor #1270 which is flaked, a noticeable amount of fine fume solidifies in the air. If men are exposed to it during hot humid weather, the skin is irritated, but we do not have any difficulty in curing cases or dermatitis from it (Barbre, 27 Oct 1947).

B. 1950

At the Anniston plant, no special protecting clothing was provided for Aroclor operators. As A.C.W. Pennington of Newport commented;

A daily change of clothing was provided in the past, but this practice ceased before the war. Gauntlet leather gloves and face shields are, of course, available as required on the plant. Tins of cold cream ointment, theatrical quality, are too in the building, but the application of the cream is left up to the operator's decision of the job in question. The men are expected to take a bath, in their own time, at the end of the shift. A good quality soap, and alcohol for rubbing down purposes, are provided. The operators are sufficiently trained in the need for personal cleanliness that a record of bath taking is not warranted. Emergency showers are provided on each floor of the Diphenyl building and safety notices are widely used (Pennington, December 29, 1950).

This was different from the St. Louis plant where the Aroclor area was rated a toxic department. Each operator was provided with a complete set of clothing including a safety hat, coat, pants, undergarments, socks, and rubber shoes. A clean change of clothing, except shoes, was kept in each operator's locker in time for next shift. Men working extra shifts were even given a clean set of clothing. Canvas gloves and goggles were provided and hand barrier cream was available for use when necessary.

St. Louis also offered twenty minutes paid time to bathe at the end of the shift, but no records were kept showing that these baths were taken. Theoretically, food was not allowed to be eaten within the building and instructions were issued that hands and face should be washed well before eating. Employees in toxic departments were given an annual medical examination and a lung X-ray every three years (Pennington, December 29, 1950).

In April 1950, Monsanto expressed an interest in determining the amounts of Aroclor released into the air. The company had sent correspondences to an outside company who manufactured the "Halidometer," which claimed to determine trace amounts of PCBs in air (Rapps, April 20, 1950). Research was actually completed by the Kettering Laboratories Medical Department in Cincinnati to determine the safe concentration of Aroclor in air. Monsanto was also beginning to study Aroclor's effects on animals and establish a safe level of PCB exposure to animals and vegetation (Ellenburg, March 15, 1954).

Questions were also raised concerning the effects of Aroclor-containing paints in greenhouses on plants. Monsanto determined that most paints were somewhat harmful, and there was no evidence that Aroclor made them worse. Company officials contended Aroclors were used as rabbit repellants without doing any actual harm to vegetation. Obviously, the converse would be true for rabbits.

C. 1951

Monsanto determined that care was needed in laboratories, etc. where Aroclors were used in heating baths and that appropriate ventilation was needed. Vapors of hot Aroclors were distinctly irritating to the eyes and the nose above a concentration of about 3 milligrams per cubic meter in air. In December 1951, the Newport plant report recorded burns by hot Aroclor including a case of a splash into a man's eye without serious damage.

Several sources, therefore, gave appropriate warnings including Monsanto's Bulletin P-115 (new edition, 1951), which mentioned limits of 0.5 to 1.0 milligram per cubic meter in air as the highest allowable concentration and 10 mg for more highly-chlorinated Aroclors. H.B. Edkins "Chemistry of Industrial Toxicology," gave 0.5 to 1.0 mg as the allowable limit in working rooms. Packages of Aroclors leaving the Krummrich and Newport plants, therefore, had a label calling attention to possible toxic effects.

D. 1955

In the 1950s, Monsanto saw many references to harmful effects including chloracne resulting from exposure to PCBs, especially in cases where people working with small electrical components were exposed to the fumes of hot, highly chlorinated Aroclors. Chloracne was sometimes accompanied by gastric and liver problems. Some health problems were recorded among the production workers at Anniston in the early days of the development of Aroclors. At that time, highly chlorinated Aroclors were being made from diphenyl, which had come from low-grade benzene. Since Monsanto switched to a better grade of benzene and used a closed system, the same Aroclors had been made without trouble. In March 1955, it was reported that the Anniston diphenyl and Aroclor plants had gone 12 years without lost time manufacturing accident.

From the start of Aroclor manufacture at the Krummrich plant, the operators had been supplied a clean change of clothes everyday, and time had been allowed at the end of the shift for bathing. Operators were advised to wash their hands and face before eating. The Anniston operators did not have the same opportunities to change clothes and bathe. This issue grew even more intense after Monsanto's main office in St. Louis received an article from the *Chemist Analyst* addressing the safety and health concerns of PCB exposure.

An article published in 1946 (Martin, 1946) and distributed internally at Monsanto in 1955 commented on the toxicity of Aroclor compounds both from the standpoints of their absorption from inhaled air, as well as from their effects in producing skin disorders when workers were chronically exposed. Since these effects were repeatedly observed, industrial hygienists saw to it that proper controls were established wherever these products were used. For example, the maximum allowable concentration of chlorinated diphenyls for an 8-hour working day was 1 milligram per cubic meter of air.

The effects and consequences of acute exposure to PCBs depend on the size of the melting-point bath, the caution used, and the final heating temperature. Careless handling of PCBs could have resulted in contamination of the skin, clothing, towels, working environments, etc., greatly enhancing the potential for dermatitis or chloracne. Therefore, scrupulous cleanliness was insisted upon whenever PCBs were handled (Mather, April 1955).

Questions arose in 1955 concerning the difference in toxicity between the various Monsanto PCBs Aroclors 1242, 1254, and 1268. Monsanto had found in earlier research that toxicity increased with chlorination, although there was not too great of a difference between similar mixtures. The biggest concerns to Monsanto, at this point, were the cases of inhalation, absorption, or ingestion. The maximum allowable concentration set for Aroclor 1254 was 0.1 mg/cubic meter and as high as 10.0 mg/cubic meter for Aroclor 1268. As Dr. Emmett Kelly of Monsanto pointed out: "I think the former is too low and the latter is too high. In this country they do not use the MACs (Maximum Allowable Concentration) very routinely, but certainly in England I think it would be all right to consider 0.2 mg/cubic meter as perfectly safe" (Kelly, September 20, 1955). Dr. Kelly was trying to convince Monsanto to determine what the actual concentrations of Aroclor were in the various operations and applications and not waste any more time on researching the maximum MACs. Monsanto spent over $15,000 in laboratory testing by Kettering Laboratory to determine these levels.

As a result of the Kettering testing, Monsanto reasoned that MACs would not impact juries in litigation. Therefore, Monsanto dismissed the relevance of the findings. Dr. Kelly concluded with the following observation:

> We, therefore, review every new Aroclor use from this point of view. If it is an industrial application where we can get air concentrations and have some reasonable expectation that the air concentrations will stay the same, we are much more liberal in the use of Aroclor. If, however, it is distributed to householders where it can be used in almost any shape and form and we are never able to know how much of the concentration they are exposed to, we are much more strict. No amount of toxicity testing will alleviate this last dilemma and therefore I do not believe any more testing would be justified (Kelly, September 20, 1955).

E. 1957

Toxicity remained a constant question throughout the next few years. Records indicated that another memo in 1957 again generated questions about the toxicity of Montars at the Anniston plant. Of course, no laboratory data existed to elaborate, or even to determine if a risk existed, but Dr. Kelly believed that these chemicals would have caused chloracne similar to the conditions generated by chlorinated napthalenes and diphenyls. He further explained that liver trouble could have become a threat if the fumes were inhaled at elevated temperatures. This prompted Monsanto to recommend that the maximum allowable fume concentration be set at 0.5 milligrams per cubic meter of air for exposure data information to customers.

Mr. Edelblut, a Monsanto employee, explained in a 1957 internal memo that the draining process of Montars at Anniston caused some fumes to escape into the air due to inadequacies in their blowers and the constantly changing wind currents. Therefore, Edelblut had requested data be taken to determine if, in fact, safety from Montar fumes was in doubt (Edelblut, September 30, 1957).

F. 1958

Questions were generated in 1958 concerning safety labeling due to changes in several states' labeling laws. This was especially a concern for a Pydraul customer. Socony Mobil. who requested that a caution stamp be affixed to all Pydraul purchased from Monsanto for resale. Of course. Monsanto's major concern was competition and that wording of the label could have been used as a major advantage to competitors if not done correctly. Socony Mobil had recommended the following label:

> CAUTION Contains Chlorinated Hydrocarbons. Avoid prolonged breathing of vapors or mists. Avoid contact with eyes or prolonged contact with skin. If skin contact is had. remove by washing with soap and water. For eyes. flush with water. If clothing becomes soaked with fluid. remove promptly. and launder before wearing again.

Given the inherent safety and health fears generated by this label. Monsanto preferred the customer to use something similar to their label for Aroclor. which read (see Figures 4 through 12 in Appendix I): "CAUTION Avoid prolonged and repeated contact with skin. Avoid prolonged breathing of vapors and dust." Monsanto's brief label indicated their position on safety to customers and the public. As Mr. Smith had stated in his memo in 1958: "It is our desire to comply with the necessary regulations. but to comply with the minimum and not to give any unnecessary information which could very well damage our sales position in the synthetic hydraulic fluid field" (Smith. December 5. 1958).

G. 1960

In 1960. Chicago Pneumatic Tool wrote a letter to Monsanto concerning accidental leakage of Pydrauls in normal operations and its effect on aquatic life. Jack Garrett of Monsanto replied with the explanation that Pydraul fluids are insoluble in water and heavier and will, therefore, sink to the bottom and not appear like oil spills. He openly admitted that if Pydrauls were discharged in large quantities they could adversely affect the organisms in the bottom of the receiving stream. It was believed by Monsanto that large concentrations of these materials could probably be removed by emulsion breaking and settling, although Monsanto has had no real experience with this process. This could have been accomplished by gravity separation if the emulsions could be readily broken.

Garrett further explained that Monsanto had no experience with any regulatory agency concerning the discharge of these materials and he imagined that agencies would "frown" on the discharge of large quantities of any type of hydraulic fluid. Considering the minimal laboratory animal testing Monsanto had contracted to date, Garrett expected little toxicity effects on aquatic life based on minimal discharges. Of course, to date, Monsanto had completed no tests on aquatic animals. Monsanto, however, believe that large releases of PCBs could generate some "readily identifiable damage" (Garrett, August 29, 1960).

H. 1965

Five years later in 1965, discussions at a private Dow meeting provided Dr. Kelly with information involving 2,4,5-T acid and its dioxane contents indicating personnel findings that dioxane was a contaminant and a chloracne-causing agent. Dow implied that dioxane might be a potential carcinogen. Dr. Kelly agreed with Dow's findings and thus felt as if it was mandatory for Monsanto to devise analytical methods to determine the presence of dioxane and other contaminants within the PCB process and develop ways to minimize the effects of this known chloracne-causing agent (Kelly, June 24, 1965).

In September 1965, Monsanto received feedback from one of their customers, a Mr. Haredos, who was concerned and worried about the potential toxic hazards of using Aroclor 1242 at toxic temperatures discussed in an August 27th letter he had received from Monsanto. The customer's major concern was Monsanto's comment that at temperatures greater than 150°, mechanical exhaust ventilation should be utilized to remove Aroclor 1242 vapors. This was somewhat contradictory to the information originally furnished by Monsanto. Mr. Haredos utilized Aroclor in a plant and in mining equipment and, therefore, the ventilation provided in mines would not be sufficient to keep Aroclor at the threshold limit value of 1.0 mg/cubic meter of air. Complaints had already been raised about irritation and odor. Monsanto's Medical Department was skeptical about his uses since no data were available to prove the safety of Aroclor usage in mining applications.

In response to Mr. Haredo's comment that hot Aroclor spills on the floor of his plant were common and that his own employees had complained of health discomfort, Mr. Wheeler said: "...this had to stop before he killed somebody with liver or kidney damage—not because of a single exposure necessarily but only to emphasize that 8-hour daily exposure of this type would be completely unsafe" (Wheeler, September 3,1965).

I. 1966

In December 1966, Monsanto explored opportunities to expand their Aroclor product into Sweden, a highly industrial market, over the next five years. Outside sources questioned Monsanto's position and Monsanto was determining if data and knowledge of safety factors, etc. should be published in Sweden or not. The other concern was the disposal of Aroclor waste. Questions had been raised concerning the safety and effectiveness of sealed drum disposal since leakage was always possible (Wood, December 1, 1966).

J. 1968

Questions continued regarding Sweden through 1968 when some publicity regarding a study at the Institution of Analytical Chemistry at the Stockholm University concerning the collection of PCBs in the organs of animals occurred. Studies indicated that PCBs could have been connected to DDT and were just as dangerous. Researchers found the PCBs in fish, eagles that fed on those fish, on fir tree needles, and in the hair of a five-month-old baby.

Scientists working with biocides had also determined that PCBs had been causing peaks in their gas chromatographs for a long time. PCBs were believed to break down slower than DDT and found to cause harm to the skin and liver. Research assistant Soren Jensen tested fish and birds and air samples and had found that PCBs were found as often in the environment as chlorinated hydrocarbons (types: DDT, DDE, Lindane). He did not find PCBs in animals with a purely vegetarian diet. PCBs were most often found in water species. He also found PCBs in the hair of his whole family, including his baby daughter, who may have gotten it through the milk of her mother. Testing on sea eagles from a state museum that were collected from1880-present showed that PCBs could be found in birds since 1944. Jensen found that PCBs are just as damaging whether they are inhaled, eaten in food, or absorbed through the skin (Rising and Strand, November 28, 1968).

Public awareness was heightened in December 1968 when wildlife advocates drew attention to DDT. The advocates 'intent to ban DDT in Wisconsin and, if successful, in other states, alerted Monsanto since DDT had been linked to Aroclor. Monsanto initiated steps of defense. A study of chickens fed Aroclor to determine the damaging effects of PCBs versus DDT was conducted. Monsanto continued testing to establish safe levels of Aroclor. If safe levels could be determined, Calandra's lab (Industrial Bio-Test) would complete a two-year experiment on animals to study the effects on the following generations.

Monsanto, however, did not believe that the wildlife advocates would find this information sufficient. Monsanto sought to use Aroclor only when they could control the process and reduce pollution. Monsanto executives wanted to ensure that Aroclor plants had minimal amounts of air or water contamination. There appeared to be concern with the levels of environmental exposure at the Anniston and Krummrich plants. Monsanto hoped to show that Aroclor could become disposable through incineration. Representatives geared to assist consumers in the disposal of either off-grade or non-reworkable Aroclor by using incineration or a toxic dump. As Mr. Richard stated, the wildlife advocates were dedicated to the demise of DDT and Monsanto's problem:

> ...Aroclor has been "identified" along with DDT residues and hence we are almost certain of being drawn into the court records and may also be one of the scapegoats of the DDT defense. The wildlife people have accused Aroclor of doing all the bad things of DDT... We (Monsanto) probably have 6 months to 1 year while they fight out the DDT case. I want to use this time to minimize our exposure. We will need your help in setting TSD targets (Richard, December 30, 1968).

K. 1969

Aroclors in plant effluents became a major concern in 1969 when focus on Aroclor pollution shifted specifically to waterways and thus generated concern about sewering practices in plant outfalls. Unfortunately, techniques were not in place to analyze water for Aroclors in low concentrations. Clean-up methods needed to be established for the plant water being sent into Snow Creek and the outlet of the Village waste treatment plant at Krummrich. Data collecting also was planned on the locations and amounts of Aroclor discharges sent to the sewers and methods were under development to dispose of chemicals in ways other than sewering.

Monsanto hoped that this would allow them to act quickly in response to a possible crisis if one developed. The head office instructed all project information to be compiled in a report prior to June 1 and then a decision would be made with a low-cost alternative to eliminate the need for sewering. At Anniston, they were drumming and hauling the spent Aroclor to a dump, so due to problems at Krummrich, head office suggested asking Anniston about their practices and using a similar set-up if it was economical and practical (Hodges, January 23, 1969).

Mr. Roush of Monsanto expressed some concern generated from The Vapor Generator Company in February 1969 due to both medical and application data, which was compiled and sent to Monsanto's Japanese counterparts as arguments for the safe use of PCBs as heat-transfer fluids. Roush explained the results of vapors: "Essentially, we said that there are certain toxic and systemic effects that can be brought about by the vapors of chlorinated biphenyls." Roush believed that it only seemed a matter of time until the regulatory agencies would be breathing down Monsanto's neck regarding the use of this material. Roush also mentioned the feeding studies that were in process to give more exact data than was available in the past and the importance of those results (Roush, February 14, 1969).

Sediment and water samples taken in September 1968 from Snow Creek were obtained for determining the Aroclor concentration levels. Results indicated that Aroclor 1242 was present (water extracted appeared to contain only the lighter chlorinated species), but more quantitative results would have to await the development of more specific measuring techniques. Mr. Tucker believed that should these results turn out to be indicative of what exists in the environment, and given the current government interest, additional studies and samples should be taken further down Snow and Choccolocco Creeks and even the Coosa River, if needed. Tucker indicated that Anniston had the necessary testing equipment to complete this task and should start as soon as possible (Tucker, February, 25, 1969).

In March 1969, outside consultants summarized and completed three studies to investigate Choccolocco Creek. The first study was conducted between late 1966 and August/September 1967. It was used to develop a defense to be used in the environmental lawsuit in which Monsanto was currently involved. The second study was conducted in May 1968 and the third was in January of 1969. Both studies were to decide if effluents from Monsanto were causing any negative effects on the Watershed. All reports mentioned that there were not fish or other aquatic life in Snow Creek, the recipient of the wastewater and sewered acid from the Aroclor process. There were other industries near Monsanto's Anniston plant that could be affecting this too, but it was of interest because of Monsanto's dump in Snow Creek. Monsanto also decided to hire a marine biologist to study the effects of the Aroclor on the water and the species living in it (Wright, March 25, 1969).

A meeting was held later that month with the Industrial Bio-Test Laboratories, Inc. (IBT) to discuss test result status on Aroclor 1242 including a rat tissue residue study, chicken tissue residue study, fish toxicity, chicken toxicity, duck toxicity, etc. Monsanto reconfirmed their belief that Aroclor was not intended to be spread around, but that use in closed systems and recycled streams would offer limited exposure. Joe Calandra of IBT again mentioned the need for soil and bug experiments so that PCBs could be shown to degrade. (Notes on 3/6/69 meeting with IBT, March 10, 1969). W.R. Richard and E. Wheeler reviewed the background on Aroclor properties, recent analytical results by Scott Tucker, and the history of Aroclor application uses. Wheeler was planning to report on the toxicity studies completed to date including the chicken, fish, duck, rat tissue, and other works in progress. Wheeler believed that the logistics of Aroclor exposure and likelihood of contamination were not discussed enough (Richard, March 10, 1969).

Anniston summarized their plans in May 1969 for PCB determinations in liquid waste streams including sources, quantities and recommended actions. Anniston did not plan to look for atmospheric losses based on their mutual feeling that losses to the atmosphere were negligible. This proposed plan involved sampling Snow Creek (started 5/1/69, completed by 7/1/69), analyzing PCB-laden mud and water samples from Snow Creek (target completion was 8/1/69), sampling Choccolocco Creek (target completion was 8/1/69), to complete Anniston's in-plant survey to identify and quantify sources of PCB processing and potential losses, to establish continuous monitoring systems, and to investigate Aroclor scrap disposal methods (begun in 1970-1971). The Anniston plant also planned to proceed with projects to reduce the Aroclor found in the HCl recovery stream. The only departments who were using or processing Aroclors at the Anniston plant was P_2S_5 – a Therminol system and the Aroclor processing set-up (Taffee, May 12 1969).

Actions, plans, and problems at Anniston and Krummrich were summarized in May 1969 to avoid sewering Aroclors into natural waters. Monsanto had generally taken the position that before any expensive projects were undertaken to halt sewering of Aroclors, knowledge should first be gathered about what levels existed in the receiving waters. Problems resulting from the loss of Aroclors in the plant effluents needed to be defined. Techniques had been developed and a lot of Anniston samples had been analyzed; their transmission was expected during mid-May. Manpower and equipment priority was a problem at Anniston, as Hodges explained:

> As soon as the laboratory techniques are received and studied by the plants, we need to determine priority of the Aroclors testing program in relation to other work and to move to obtain the necessary manpower and equipment. The electron capture equipment exists at Anniston, but it has never been used – considerable development work is therefore necessary.

Suggested work to minimize losses at Anniston was addressed including possibilities to reduce sewering. Hodges elaborated that Monsanto did not know what problems actually existed at Choccolocco Creek and the Coosa River. Additional funding and a chemist were needed to complete this work at an estimated cost of $100,000 to Monsanto. Monsanto continued to work on their sewering problem and to address losses in the Aroclor production department (Hodges, May 12, 1969).

Additional external questions about PCBs arose in May 1969 from the National Air Pollution Control Administration's Cincinnati Laboratories on the effectiveness and quality of incinerating chlorinated biphenyls. Along with the incineration inquiries. questions came up at a Federal Water Pollution Control Administration Laboratory meeting in Georgia about how Monsanto's Anniston plant controlled the escape of PCBs out of the plant. Monsanto anticipated that the Federal regulators could be looking at the creek. river, or lake water and mud samples below Anniston for PCBs (Wheeler. May 26. 1969).

In September 1969, the Aroclor "Ad Hoc" Committee met to address objectives and goals. The committee agreed that their objectives were to continue to sell and profit from Aroclors and Terphenyls and find further uses for them while protecting the company image. The committee agreed that Aroclor 1254 and 1260 should be the study focus. However, Aroclor 1242 was not yet implicated because the uses of 1242 actually reduce environmental contamination and may degrade biologically. Unless very careful. 1242 could be destroyed during analysis due to oxidation.

Later that same year, studies concluded that PCBs were linked to DDT in a ratio of about 40-50:1. There was also a possibility that PCBs may increase or add to the effects of other "chlorinated aromatics." By substantiating the testing of samples taken by other researchers, Monsanto learned about the problem and showed their interest. but testing was very expensive and could have helped build legal cases against them. This concerned Monsanto because testing ruled out the chances that Aroclors are not involved.

Aroclors were believed to be safe for humans in "reasonable" levels. Monsanto coordinated testing on rats and dogs by giving them 100 parts per million. Testing was founded on the idea that 1/100 of the level of toxicity will be safe and that 1 parts per million in a diet would be the maximum. A test conducted in Pensacola showed 5 par per billion were toxic to shrimp within 18 days.

Monsanto, therefore, needed to determine what the safe level of PCB was for various species. Monsanto decided to keep in touch with the labs doing research on Aroclors. They received interest from labs wanting Aroclor samples: 2/3 of the interes came from state labs, which would share information, and 1/3 came from universities, who may not share information.

Monsanto reviewed the problems persisting at the Escambia River in Pensacola and discovered that even though they only released 1-3 gallons per day into a large riv they found 42 parts per billion PCBs in the water and 476 parts per million in the mud downstream. Although usage there stopped, many felt that the contamination of the water would not end due to the contamination of the mud persisting. As of September 1969, no samples had been taken from downstream to see if the contamination had decreased.

As of this time, Monsanto stopped the sewering of Aroclor waste and returned the process of sending waste to the landfills. Officials hoped that plant effluent levels would fall below solubility ranges, although they were not yet sure how far the levels needed to be reduced or the costs involved. Monsanto believed that until contaminatio of the environment by their customers ended, it was not worth the expense to take extreme measures to limit what is being dispersed from the plants.

There had been delays in getting results of the samples taken, so any programs reduce this waste had been difficult to develop. Monsanto facilities had yet to develop pollution reduction programs except trying to prevent contamination from the products while loading tank cars and drums. In 1-2 years, Monsanto planned to lower product contamination and air emissions when loading cars, but the expense of comprehensive air sampling was not yet justified. Contamination caused by customers was a greater problem than that of the plants (for example- highway paints.) Biodegradation of PCBs occurred at a very low rate, so they were concerned that other decomposition had to occur so that there was no build-up (Minutes of Aroclor "Ad Hoc Committee, September 5, 1969).

A month later, Monsanto faced additional external inquiries regarding PCBs. Monsanto's goal was to make the government and universities prove their case while avoiding confrontation with them, if possible. It became Monsanto's goal to follow any regulations and meet or exceed the requirements because they wanted to avoid bad publicity and competition. Monsanto wanted to keep record of how much contamination was present and where it was coming from. Representatives were informed of any experiments with evidence developed against Aroclors. Company officials hoped to determine safe exposure levels and show that there were also other toxic chemicals affecting the shrimp tested, some of which may be worse than Aroclor, in usage and existence.

Monsanto also knew that Aroclor would harm some insects and animals, but they hoped to build a defense by showing that the contamination was acceptable at a low concentration. The degradation would be slow, thus, Monsanto needed to start restricting environmental exposure and cleaning up. The focus would be to clean up the Aroclors and to develop substitute products when needed before the publicity and competition got out of hand.

The first big problem recognized in the United States was with water pollution. The Aroclor settled on solids like river bottoms and was long-lasting. Florida and the Gulf Coast had seen Aroclor 1254 and 1260 in concentrations of 40-200 parts per billion, which was causing problems with the plant effluent and shrimp. San Francisco had seen Aroclor 1254 and 1260 contamination in thin bird eggshells. Aroclor 1254 and possibly 1242 were found in the Great Lakes. In addition, the company believed that the shrimp experiment would become public, causing bad press and increasing competition.

Monsanto viewed air pollution as a lesser problem than water pollution. Hydraulic leakage and air compressor fluids are problematic to the customer because clean up often required replacement of equipment with less-sensitive components. Monsanto intended to clean up these issues to reduce air and water pollution.

Direct contact with the product was not an issue except in food heat transfer. There could have been some leakage in heat transfer, so Monsanto representatives offered to work with customers to encourage clean up through better plant and dumping procedures. Monsanto would also create a substitute product. When they began looking at capacitor fluids, they determined that if poor material or plant producers were used, 5% of the production could have been lost, causing pollution. Monsanto planned to work with customers to clean up their plants and prevent the use of poor quality materials. Obviously Monsanto wished to keep the product, but realized a replacement product was needed soon.

Monsanto wanted to retain product offering to customers in the transformer industry by increasing customer awareness and education on PCB issues. The main concern was the possible water contamination that could occur. The off-grade Aroclors could be recycled and transformers could be reworked, but dumping of the old fluid could not occur.

Government officials could have decided to observe the Monsanto plants' outfall and cause the shutdown of the plants. Monsanto believed that this would shut them down depending on what plants or animals the government chose to find harmed. Therefore, Monsanto felt the need to take precautions to stop Aroclor from infiltrating the water. Some Monsanto personnel suggested that samples of water and mud be taken for analysis before and after clean up. Personnel considered using incinerators to get rid of Aroclor and pentachlorophenol wastes.

At this point, Monsanto suggested establishing limits of toxicity for Aroclor 1242, 1254, and 1260. The purpose of the limitations was to observe whether or not the concentrations were declining and if there was any further evidence of contamination. Company officials wanted the studies to concentrate on the species most sensitive to the contamination to confirm or deny the negative results (Richard, September 9, 1969).

PCB contamination was believed to extend beyond the United States into Canada, parts of Europe (especially the UK and Sweden), Asia, and Latin America. Monsanto confirmed that PCBs were present in mid-1969 and that as many studies were showing, PCBs were an ecological problem across the globe. Aroclor 1254 and 1260 had been found in the environment, but Aroclor 1242, or at least part of it, degraded biologically. As of that point, there had not been any confirmed reports of Aroclor 1242 in the environment with the exception of in-plant effluent, streams, and the mud below the plants.

PCBs could be found concentrated in the fatty tissue of marine or aquatic life. more sensitive species, like shrimp, it was toxic in quantities as low as 5 parts per billi Species of birds that fed on aquatic life may also have encountered harm from PCBs. Birds were affected because PCBs influenced their calcium metabolism causing eggsh flaws, which stopped the proper hatching of their young. Monsanto confirmed the eggshell problem through their testing. The testing, however, did not suggest harmful effects to man or other mammals even though there were many investigations pending a various places.

Monsanto also believed that PCBs had been incorrectly connected to DDT. This was mainly because PCBs had been present in the analysis of DDT. They were also connected to the other chlorinated hydrocarbon pesticides. This was a problem because nearly every type of food in the U.S. was being checked for these materials.

Monsanto planned several actions to improve their image and protect their products. One action included developing a task force, which consisted of representatives from medical, legal, research, marketing, and public relations. The task force was assigned the responsibility of determining the "timing and content" of public notification about PCB dangers. In the interim period, Monsanto hoped to prove testing results regarding Aroclor 1254 and 1260 presence in the environment inaccurate and notify the public of their findings. Officials wanted to guard the other PCBs and chlorinated terphenyls from public scrutiny, and declare their strategy to reformulate some Therminols and Pydraul that had been difficult to control. Representatives hoped to focus on better control over Aroclor 1254 and 1260 uses and increase customer education. Within the plasticizer industry, representatives planned to explain the different uses of fluids and plasticizers and highlight potential hazards. Monsanto hoped to develop Aroclor 1254 and 1260 substitutes and alternative products to offer customers.

Monsanto aggressively designed short-term and long-term plans for study and testing. For the short-term (within a 12 month period), researchers developed a program to deal with this problem. Officials hoped to conduct studies that would provide results regarding biodegradation and toxicity. Representatives monitored publicity. Marketing actions included reduction or replacement of Aroclor 1254 and 1260 in which the Aroclor was mobile. Monsanto mobilized to help customers clean up their plants and track companies that failed to clean up their plants. Monsanto planned to retrieve and dispose of the fluids properly. The marketing group considered developing new names for products that did not contain PCBs. The production division cleaned up the plants and ended the contamination. The legal team would then determine Monsanto's official position on the issue and suggest courses of action that would not adversely affect the market, but would also decrease the chances for legal ramifications. Finally, the public relations team promoted public actions that would look appropriate.

The long-term (from 1-3 years) plan was tentative and would be reviewed quarterly by Organic Management. In the research and medical area, management planned to continue biodegradation, toxicity, and metabolism studies. In the manufacturing field, officials hoped to use R&D to identify typical Aroclor isomers. determine "control for effluent composition, test substitute formulas, and develop new processes" (PCB Environmental Pollution Abatement Plan, November 10,1969).

Mandates were ordered to clean up the plants. The engineering group set up plant incineration arrangements and developed processing equipment if necessary. The marketing department played the role of the liaison with the consumer, checked into problems with the association of the Monsanto name denuding negative attitudes or publicity. Marketing allocated the means for the retrieval and disposal of fluids. Finally, an inexpensive disposal system needed to be created for the customers.

Total costs of the program had not been fully determined, but they anticipated $220,000 for only the toxicology work. The cost of the whole program could have been as high as $2-2.5 million. (PCB Environmental Pollution Abatement Plan, November 10, 1969)

Monsanto learned in December 1969 that they had an impending need to provide an incinerator to dispose of scrap Aroclor. Until this point in time, about 300,000 pounds needed to be incinerated and they hoped the remainder could be returned to Monsanto's plants and distilled. Exact arrangements for distillation, however, remained unclear. If the material could not be distilled, then much more than 300,000 pounds would have to be incinerated. At that time, Monsanto's only means for disposal was landfilling, which was not an acceptable alternative (Benigus, December 5, 1969).

L. 1970

January 1970 raised questions and skepticism from Monsanto's largest and oldest PCB customer – General Electric Company. GE was disturbed about the results of the laboratory research. GE purported that the testing was not conclusive and findings to date were not totally clear. Monsanto presented GE a booklet containing most of the pertinent publications to date, and indicated that additional articles would appear shortly.

GE found the reports by Mr. Wheeler on chronic animal toxicity tests and animal reproducibility studies more unfavorable than anticipated. Particularly alarming to General Electric was evidence of the effect on hatchability and production of thin eggshells in white leghorn chickens from studies involving Aroclor 1242, 1254, and 1260. Monsanto maintained that some of the studies would be repeated to arrive at better conclusions.

GE stressed the demand for the Aroclor compounds for their Askarel transformers, which operated many major city power plants. These transformers would fail without the Aroclor transformer fluid. GE Representatives noted that lights, motors in air conditioners, and many other industrial applications would not run. Mr. Wheeler further confirmed Monsanto's findings by explaining that lower-chlorinated biphenyls were not observed in aquatic environments. These inconclusive studies did not allow GE to draw conclusions. The literature indicated that trichlorobenzene and tetrachlorobenzene were not susceptible to biodegradation, therefore, GE was intrigued with the absence of reports about finding these materials in the environment.

Wheeler offered the following observation: "the obvious implication is that since these materials are used with the higher chlorinated PCBs found – the source of the latter is not from dielectric fluids." However, it was reasoned that chlorobenzenes may not remain due to their relatively higher vapor pressure or may not have been found at that date because they had not yet been zeroed in to the analytical spectrum. Therefore, the GE representatives believed that the benefits of Aroclors in transformers far outweighed the questionable threat to the environment. It appeared that in those situations where control was practical, such as transformer usage, Monsanto could possibly continue to supply Aroclor 1254 and 1260 (Minutes of St. Louis Meeting with GE, January 21 and 22, 1970).

Status updates also arrived around January 1970, which summarized the pertin findings by outside studies coordinated by IBT. These data were given to the U.S. FDA and one or two other state agencies. Mr. Wheeler believed that this information could possibly be released with discretion in Britain or Europe. Several Monsanto employees' interpretation of the findings was that the PCBs were exhibiting a greater degree of toxicity in chronic studies than originally anticipated. Secondly, although there were variations depending on species of animals, the PCBs' toxicity was found to be about the same as that of DDT in mammals. Wheeler presented additional interim data, which would perhaps have been more discouraging. Monsanto planned to repeat some of the experiments to confirm or deny the earlier findings (Wheeler, January 29, 1970).

In mid-February, Mr. Johnson of Monsanto sent out a letter to various company officials and sales people addressing the importance of properly handling questions and materials related to Aroclors and their sales. Johnson instructed sales agents to give verbal answers only – all written correspondence was to come from the corporate office. The corporate office planned that Aroclor 1254 and 1260 would no longer be sold to their customers and substitution to Pydraul products without Aroclor had to be made. Monsanto and its customers were not interested in using a product that presented a problem to the environment. Monsanto certainly had no reason to be defensive or apologize about making this change. Monsanto claimed to be making these changes to benefit the customer, aid the environment, and enhance safety. This modification cost Monsanto significantly in research money and time. As Johnson explained to the corporation:

> I doubt if our competitors know whether their product could present a problem to our environment. You might ask your customer if he has ever asked Houghton or Scauffer, Carbine, etc about the effects of their products. ... We should also recognize (point this out to your customer) we must clean up. The Chemical Week article gives him an idea of the laws in effect in his state. ... We can't afford to lose one dollar of business.

Monsanto had no replacement products for Aroclor 1254 and Aroclor 1260 and, therefore, would continue to make these products; however, customers would have to use their own judgment on continued usage (Johnson, February 16, 1970).

March 1970 brought about the generation of the Aroclor Environmental Program, which addressed waste handling at the U.S. plants, the future of several Aroclor products, biodegradability, incineration, and toxicity. While both U.S. plants realized that their effluents could contain virtually no Aroclor, they chose 10 parts per billion as their targeted amount. The plants were observing their streams to find the PCB concentration present at that time while also instituting plans to minimize leakage, spills, and intentional dumping. The Anniston plant hoped to capture the Aroclors using a sump that they intended to purchase for their sewer system. At that time, Monsanto was still disposing of all their waste containing PCBs in the same dumps used for other plant waste.

Possibly due to its low solubility inhibiting its passage through the environment, Aroclor 5460 was not found in water and wildlife samples. However, there was apprehension about the effectiveness of current technology to identify the substance in the environment.

Due to the concern surrounding PCBs, Monsanto was searching for an alternative for Aroclor 1242 in NCR paper used in the United States and the United Kingdom. The typical incineration process dissipated the Aroclor into the environment and made the final resting place of Aroclor hard to manage.

Monsanto conducted studies to evaluate Aroclor toxicity and biodegradability. Tests conducted indicated that 1221 was biodegradable and 1242 showed limited biodegradability. Each of the other Aroclors proved to be defiant to degradation in the environment. It was thought that their isomer structure established this amount of degradation. Toxicity testing still left a lot of questions, including why Aroclors were not found downstream of the plant in Anniston after 40 years of manufacturing. However. Aroclors were detected in Snow Creek, located near the plant. and life had been gone from this creek for several years. It had been believed that other plant waste was to blame, but Aroclors were possibly implicated at this point.

Monsanto investigated claims by Bayer and Prodelec in Europe and Rollins-Purle in New Jersey that they had the ability to incinerate PCBs. They hoped to receive data from Europe concerning the gases formed during this process. Studies were also underway to evaluate alternative Aroclor removal processes (Papageorge, March 6. 1970).

The Ohio State Board of Health in March 1970 found PCB (especially Aroclor 1254) in milk from 3 herds of cattle. It was believed that the contamination originated from 3 concrete silos. The inside of the silos were painted in 1967 with paint including Aroclor 1254. Kelly recommended telling customers not to use Aroclor if it was to be involved with food or water for both animals and people (Kelly, March 30, 1970).

In March 1970. Monsanto had problems with water leakage from the PCB dump and the lack of security throughout the dumpsite. Monsanto found dumping to be expensive and, therefore, created a task force to evaluate the situation and develop solutions. Immediate actions included converting the dump into a landfill and fencing the area (Mullally, March 31, 1970).

Data completed by Monsanto in April 1970 encompassed 167 various samples ranging from water and sediment to fish to human fat to milk. The water, sediment, and air samples contain PCBs typical of Aroclor 1242, 1248, 1254, and/or 1260. The milk, human fat, and fish samples contain PCBs most typical of Aroclor 1254 (Keller, April 17, 1970).

In May 1970, Monsanto met with AWIC (Alabama Water Improvement Commission) to let them know the situation. AWIC was unaware of the dangers associated with Aroclors and did not show a high level of concern. AWIC planned to assist Monsanto with research and testing (Miller, May 7, 1970).

The Anniston plant technical services department progress report, compiled in July 1970, summarized progress to date on Aroclor clean-up efforts at Anniston and available data regarding the plant's Aroclor losses. Aroclor losses for 3 months averaged 16 pounds per day, which is a considerable improvement over losses of over 250 pounds per day in 1969. This improvement could be attributed to an education effort and better operating procedures. Additional projects were planned to further reduce environmental losses (Progress Report, Technical Services Department, Anniston, Alabama Plant, July, 21, 1970).

Monsanto was working in July 1970 to develop pyrolysis and incineration techniques to dispose of Askarel. Although the facility scope was underway, the feasibility of shipping Askarel waste from customers to the facility for disposal seemed low. Until the factory was in operation, the only realistic alternative was landfilling the waste. Landfilling of hazardous waste had a number of issues that might have presented difficulties including monitoring, location, design, and operation. As Papageorge explained: "The disposal of solid material contaminated with Askarel is a technological and economic challenge" (Papageorge, July 27, 1970).

Disposal issues continued into October 1970 when Monsanto received repeated requests from Westinghouse to secure a landfill in Pennsylvania for PCB wastes. These disposal issues arose after word spread throughout the company detailing the results of migration studies. In 1938, Monsanto completed a study in Gainesville, Florida, which placed almost 4 ounces of Aroclor 1242 in soil holes (2200 parts per million total). In 1969, Monsanto went back to the holes to determine location of the Aroclor sprayed over 31 years ago, and found concentrations to be relatively the same. This data indicated that Aroclor concentrations in the soil did not migrate to any significant degree over 30 plus years.

Monsanto held their performance review in late 1970, which discussed and addressed the PCB environmental problem and actions in further detail. Their objective here was to minimize and control the PCB effluent from their plants to 10 parts per billion by September 1971. Newport, Anniston, and Sauget plants were still not on track to meet the target due to high contamination and improper maintenance of Therminol substances. Monsanto planned to continue informing customers of the PCB problem and to emphasize the importance of proper handling and disposal. This was followed by a plan to notify distributors that they were not selling Aroclor products after August 1970. Monsanto had discontinued the sale of PCB-laden materials for cutting oils, pesticides, medical, dental, and cosmetic use by June 1970.

In contrast, the plant continued to develop reliable and accurate analytical methods to determine PCB content and evaluate options for biodegradation, incineration, and PCB waste removal tactics. Monsanto's secondary goal was to work on a positive public image by establishing and maintaining favorable relationships with all external parties (Papageorge, October 1, 1970).

August 1970 brought about questions regarding Choccolocco and Snow Creeks' safety and toxicity. The FDA found high levels of PCB concentrations in fish. Monsanto had been emitting about 16 pounds per day of PCBs and they were working to further improve that number. During this time, Monsanto had no real indication as to what the government and control agencies would expect or want. They did, however, understand that if this issue reached the press, the AWIC would be forced to close those areas to fishing unless the areas reached the 5 parts per million guidelines set by the FDA (Monsanto Medical Department, August 17, 1970).

1970 brought about a few changes regarding PCBs in the industry. Monsanto's marketing division pulled out of the plasticizer PCB market. The Norwegian government instituted laws requiring users of PCBs to be registered. (Papageorge, September 8, 1970)

Additional air sampling programs began in September 1970, when Monsanto realized that specific goals were not being reached. These programs were in addition to the total Aroclor sampling program began in August (Foresman, September 23, 1970).

Water studies increased in October and November of 1970. The AWIC had become more involved by requesting routine status reports, but, overall, AWIC was satisfied with the progress Monsanto had made. PCB emissions to Snow Creek rose to 32 pounds per day. These emissions were attributed to additional contaminants within the Aroclor process. Air sampling indicated that PCB concentrations during this time were improving within desired limits. AWIC was willing to keep the findings to themselves unless Monsanto wanted the information released (Jessee, October 26, 1970).

Questions arose in December 1970, concerning the costs involved in the toxicological studies and projects underway, especially since goals might fail to be reached. As Savage explained, Monsanto "simply cannot afford it. Project Development work, in particular is unrealistic" (Savage, December 24, 1970).

M. 1971

Waste expenditures and alternative products were reviewed again in January 1971. Further projects were going to be dependent on the level of PCB leakage, the effectiveness of existing projects in process, and the attitude of the AWIC (Landwehr, January 20, 1971). Discussions about alternative products generated the option and suggestion that Monsanto begin producing Aroclor 1272. A letter from R. Williams greatly summed up some of the thoughts and concerns generated by this idea:

> I have been told that in about 1930 Aroclor 1270 or 1272 was produced in Anniston. The people who were directly involved in the production of this product began to break out in a rash after some period of time. Later, sores began to show up on the face, neck, arms, and body of these people. Medication did not seem to have much effect on these sores. This operation apparently did not last too long and these people were transferred to other pdts, however, their condition did not seem to show much improvement even with the medical treatment prescribed. After possibly 3 or 4 yrs. several of these people sued the company and they were given several thousand

> dollars each. I believe $5,000 was the most any one received. I remember four of the people filing suit. I knew nothing of this operation, but I suspect that very little or no consideration was given to the fume and dust hazard. (Williams, January 20, 1971)

Memos circulated Monsanto indicating questions regarding the reduction of PCBs in the plants. Due to the amount of PCBs in the soil and sewer systems, the high levels of PCBs persisted even as the plants gained better control of their pollution source. This led them to believe that clean up would have been too expensive. In addition, projects were beginning to indicate the complexity of the clean-up processes and the techniques involved (Papageorge, January 29, 1971).

Incineration was discussed in July 1971 since Monsanto and several customers were still incinerating some Aroclor. Changes were made to the Askarel Inspection and Maintenance Guide indicating that proper incineration had been determined to be at 2,000°F and that hydrogen chloride gas needed to be neutralized. Scrap may have also been sent to the Krummrich Plant in Sauget, Illinois (Benignus, July 22, 1971).

In August 1971, Biological Consultants wrote Monsanto an interim report due to a great deal of unfavorable publicity Monsanto received as a result of the congressional sub-committee report. Their analysis up to that point showed that results from their studies in fish PCB levels and toxicity were not improving and therefore "detrimental to Monsanto" (Suttkus and Gunning, August 15, 1971).

Monsanto encountered further problems when the Federal Department of Justice recommended that suit be initiated against the Anniston plant for PCB emission under the Federal Refuse Act in November 1971. Monsanto met with the Southeast Regional Office to discuss these effluents and the options available for clean up. Production of PCBs was greatly reduced in January 1971. PCB effluents were still posing a production problem and were mainly attributed to Monsanto's inability to completely separate biphenyl from other polyphenyls during manufacture (Meeting at Southwest Regional Office of EPA, November 11, 1971).

N. 1972

During the initiation of meetings with the EPA, IBT was wrapping up some of their testing on toxicity in animals. In a handwritten letter from Otis, of IBT, some of the questions regarding the validity of their testing can be summed up by his comments:

> I am ashamed to publish the work done in these studies. (egg quality testing) One must report the data but interpretation is without conviction of reality. This is perhaps the most significant of the Aroclor studies and some of my conclusions are not in agreement with these of the reports (which I signed without detailed analysis) or with statements which have been made in discussions with FDA and environmental groups. There is nothing like writing of publication to disclose defects (Otis, January 14, 1972).

Questions regarding the safety and toxicity of PCB-laden materials generated a number of concerns regarding the risks involved. In January 1972, Monsanto insisted that their largest purchaser of PCBs, GE, sign a waiver passing risk and responsibility onto GE (Schlotter, January 21, 1972). GE then began asking for information to present to the public and authorities when questions arose regarding PCBs. Monsanto's responses addressed PCBs and the origination of their environmental problems, toxicity, and some other generic information. Papageorge explained that PCBs might be toxic and that they are definitely persistent in the environment (Papageorge, February 2, 1972).

Biological Consultants finalized their work and submitted it to Monsanto in June 1972. Data indicated that fish below the Monsanto outfall had high PCB concentrations. Their research continued to find deformed, sick, and lethargic fish during collections and, thus, they recommended continuing to monitor and study the situation (Suttkus and Gunning, June 9, 1972).

Monsanto was asked to cease the submission of data on a regular basis to the AWIC in July 1972. They felt this was especially justified since they stopped PCB-related manufacturing operations on May 1, 1972 (Jessee, July 13, 1972).

O. 1974

At a meeting of the AOAC in October 1974, a report was made indicating that contaminants in the PCB process were potentially more toxic than the chlorinated biphenyls. It found chlorinated dibenzofurans in Aroclor mixtures as relevant contaminants that should be reviewed and evaluated. The report ultimately implied that PCBs were not widespread in the environment. (AOAC Meeting Presentation, October 1974). Several notes made by Monsanto representatives at the meeting asked if the levels were harmful to humans, if the medical department knew about and were comfortable with this, if furans were a possibility, and what was being done to evaluate the AOAC statements.

P. 1975

Almost a year later, in August 1975, a plan was developed to learn more about chlorinated dibenzofurans in Aroclor. Monsanto wanted to know if Bayer or others had carried out any of this research. A publication entitled "Identification of Chlorinated Dibenzofurans in American Polychlorinated Biphenyls" by R. W. Risebrough et al. of the University of California appeared earlier showing the identification of chlorinated dibenzofurans in all Aroclor products except Aroclor 1016. This really pushed Monsanto to want to collect their data and to determine if the literature was accurate (Keller, August 15, 1975).

Communications increased from March to August 1975 between Monsanto and IBT when results for the testing were completed and the reports were prepared. Some discrepancies arose between the testing done by IBT and the studies done elsewhere by Drs. Squire (of the National Cancer Institute) and Kimbrough (Calandra, March 24, 1975). Original reports indicated that Aroclor 1260 was "slightly tumorigenic" at chronic levels of 100 parts per million or greater. IBT's findings indicated that Aroclor was not a cancer-causing agent and they offered to assist Monsanto in any way possible, in or out of court (Calandra, April 18, 1975). Monsanto wasn't pleased with the wording of IBT's reports and Levinskas was able to get IBT to change the Aroclor 1242, 1254, and 1260 reports from "slightly carcinogenic" to "does not appear to be carcinogenic" (Calandra, August 4, 1975).

Additional communications began to arrive from the U.S. EPA to Monsanto. In October 1975, a letter indicated that the presence of PCBs and comparable chemicals was found in several regions within the U.S. The EPA, therefore, asked Monsanto for a lot of historical information including production and manufacturing practices, dates, distribution and discharge information by Monsanto and customers, and known health information and effects, etc. The health information desired was a description of "any adverse health or environmental effects which you know or believe to have resulted from the introduction of PCB compounds or mixtures into the environment" (Legro, October 17, 1975). In an internal response between Wood at the head office and Papageorge, Wood indicates that the environmental questions asked were risky: "none? Yusho? Chloracne years ago – dangerous question" (Wood, October 30, 1975).

Monsanto compiled their status and situation in what was labeled a PCB position paper in November 1975, which gave some background, financial and customer impacts, and decision alternatives. Records indicated that Monsanto sales peaked at over 90 million pounds in 1970, but were roughly half of that amount in 1972. Chlorinated homologs, which biodegrade faster and an incineration service for liquid PCB wastes was introduced. With the push from the EPA, several states, and the public, PCBs had become a visible problem. Several indications suggested that the EPA might have been attempting to generate public support for a toxic substances act using the PCB issues.

Monsanto's decision could have several impacts on both the company and its customers. The decision could have easily hurt their reputation as a responsible member of society. However, termination of PCB sales across the globe would have resulted in losses of approximately $18 million in annual sales and $6 million in annual gross profit. Phase-out and write-off costs were estimated to be $2.6 million. Losses to other Monsanto biphenyl-related products could have been another $15 million in lost annual sales and $5-6 million in lost annual gross profit.

Standing relationships with customers might also have been severely strained if PCB production was ceased. Capacitor customers had non-PCB options available to them. These non-flame retardant options including phthalate esters, mineral base oils, and Monsanto's developmental product MCS 1238. The transition from PCBs to another chemical would probably have meant additional investment in tooling and plant set-up. Transformer customers could have substituted mineral oil or high flash point silicones instead of PCB's, but these are not flame retardant and would require investment in tooling and redesign. As Monsanto claimed:

> Known alternate products sacrifice fire resistance and thus would likely require changes in not only our customers' processes but force negotiations with insurance underwriters, possible changes in building codes, an interim disruption in power distribution, and delayed new construction (Monsanto PCB Position Paper, 1975).

Monsanto, therefore, had three options: continue selling PCBs until forced to stop, cease production on their own, or work out a compromise which would have developed a replacement that retained most of Monsanto's customer and eliminated the use of PCBs. Continuing PCB production would have been viewed poorly by the public. Early shutdown would have seriously offended and aggravated current customers, hurting Monsanto's credibility and resulting in a number of problems to customers and the public. Therefore, the only reasonable alternative, Monsanto felt, was to develop a replacement and slowly reduce sales.

Monsanto began a number of tasks to accomplish this goal. One of the key steps was the visitation paid to various interested federal agencies by Monsanto and Calandra of IBT to discuss and review the non-carcinogenic conclusions reached by IBT. Replacement programs were also underway. The immediate solution was PCBs with a reduced chlorine amount, such as Aroclor 1016, which was more readily biodegradable. Testing was underway for two non-PCB replacement capacitor products, MCS-1238 and MCS-1588, whose properties posed no acute health concerns. Those mixtures were just the beginning of the testing process for toxicity effects to animals. Transformer replacement mixtures, such as MCS-1838 and 1839, were still under development (Monsanto PCB Position Paper, November 13, 1975).

Papageorge sent a response to the EPA in December 1975, which stated that Monsanto was not aware of any health or environmental effects resulting from PCBs that had not already been reported or known to the EPA. However, the Anniston plant was believed to have a total of 5,576,000 pounds of PCBs disposed within their landfill (Papageorge, December 11, 1975).

Q. 1976

Almost a year later, in September 1976, Monsanto began final preparations to stop manufacturing; they finally ceased all U.S. production of PCBs on October 31, 1977. Plans to shut down the Newport facility were also in the works with the government in the United Kingdom. Monsanto, therefore, prepared questions and answers for an announcement in the UK. These questions addressed several key issues including Monsanto's feeling that highly chlorinated biphenyls do not biodegrade and thus should not be produced. Carcinogenicity was also addressed. As quoted by George Roush, M.D., Director of Monsanto's Medical and Environmental Health Dept: "We have seen nothing in our preliminary health studies with our PCB workers or in our extensive long-term feeding studies with animals that would indicate that PCBs are carcinogenic" (Bishop, September 29, 1976).

R. 1979

PCB disposal remained an issue as questions arose in late 1979 regarding incineration, storage, and landfill options. None of the Monsanto plants wanted to house the excess Aroclor awaiting incineration and landfilling was becoming a problem as the Anniston plant was labeled a hazardous waste disposal site.

S. 1980

In 1980, the United States District Court determined that all data and reports generated by IBT were not accurate. This insinuated that IBT falsified the toxicology reports and lied outright. In addition, the 1972 Section Head for rat toxicology at IBC became the Manager for Toxicology for the Department of Medicine and Environmental Health at Monsanto (U.S. District Court v Calandra, et al., 1980).

T. 1981

A Monsanto hazardous waste guideline was generated in November 1981 addressing various key issues associated with hazardous wastes, which would have included Aroclor and PCB-related wastes. They hoped to establish monitored and/or controlled disposition of all solid wastes by Monsanto, and to reduce reliance on deep-well injection of wastes. The preferred order of treatment methods given by Monsanto was: "biological, chemical, or physical treatment of the waste to convert it to usable or innocuous material; thermal destruction or separation; deep-well disposal; ocean disposal; and land disposal" ("Worldwide Environmental Protection Guideline Number 2," November 10, 1981).

U. 1983

In March 1983, plans were underway to dredge a portion of Choccolocco Creek in Anniston to help clean-up PCB-laden materials found in the water, soil, sediment, etc. Monsanto plant officials were working with government agencies to develop a technical plan to properly handle creek cleaning. Realizing that it was known at this time that PCBs were found commonly in small amounts in many waterways, Monsanto and officials felt it was unproductive to try and determine the source of PCBs in the Choccolocco Creek area since it accepted water from several sources ("Preparedness Statement, Anniston Plant PCB Incident," March 16, 1983).

V. 1985

Communication between Monsanto Agricultural Chemical's new plant manager, E. J. Jurevic, and the EPA in May 1985 discussed the status and operations of Monsanto's 7 inactive or closed Anniston landfill cells and one active non-hazardous solid waste site. The inactive cells closed on or before the mid-70s and had no records or logs kept describing its contents. Some contents were, however, believed to be hazardous. Monsanto projected that the amount of material disposed of in landfills was approximately 300 tons per year (Jurevic, May 21, 1985).

W. 1986

In May 1986, it was proposed that three parts of Snow Creek and the drainage ditch should have sediment removed. Officials planned to do this by dredging them and getting rid of the bottom sediment. Monsanto believed that these actions would both deepen and improve the channel of the drainage ditch. Officials also hoped to install a culvert. Monsanto would pay for the work with the exception of any analysis done by regulatory groups.

Monsanto decided to take the material that was dredged and put it onto the bank of the creek for dewatering so that they could take it to a secure Monsanto landfill for sampling and analysis to determine the amount of PCBs present. After the sampling was completed, officials planned to send material to Monsanto to corroborate the results from the dredging. The results would then have been submitted to the Alabama Department of Environmental Management and the Alabama Attorney General's office. If the results indicated that there was less than 50 parts per million PCBs, then the dredging would have been considered successful and complete. Everyone in contact with the sediment was to wear protective clothing and take any other precautions necessary (Brown, May 15, 1986).

X. 1987

Control of the Anniston plant was expected to move from Monsanto Agricultural to Monsanto Chemical Company in February 1987, so it was necessary for any information regarding the environmental issues Monsanto faced to be communicated to the new management. Monsanto believed that they were acting appropriately considering their knowledge of the issues involved and that it was important to sustain a cooperative attitude with regulators and members of the community to avoid further problems. Fulfilling environmental obligations was expected to cost Monsanto about $400,000 per year (Redington and Pierle, February 26, 1987).

Y. 1989

PCBs were also a concern for Tull Chemical Company, which was located near Snow Creek and had been in operation since 1955, the year they bought their equipment from Monsanto. A report issued in October 1989 showed that they produced sodium monofluoroacetate, which was a highly toxic animal poison. Before 1984, Aroclor was used in their heat transfer system. Sediment samples showed PCB concentrations of 82ug/g in 1984, which is significantly higher the PCB concentrations observed in Snow Creek above Tull Chemical. The Alabama Department of Environmental Management believed that this PCB contamination is the result of a spill on-site (Alabama Department of Environmental Management, October 27, 1989).

Z. 1990

In keeping with Monsanto's efforts to maintain a positive relationship with the community and the government, Richard J. Mahoney developed "The Monsanto Pledge" in January 1990. The pledge covered a number of key toxicity and environmental issues and reads as follows:

> "The Monsanto Pledge: It is our pledge to:
> -reduce all toxic and hazardous releases and emissions, working toward an ultimate goal of zero effect;
> -ensure no Monsanto operation poses any undue risk to our employees and our communities;
> -work to achieve sustainable agriculture through new technology and practices;
> -ensure groundwater safety;
> -keep our plants open to our communities and involve the community in plant operations;
> -manage all corporate real estate, including plant sites, to benefit nature; and
> -search worldwide for technology to reduce and eliminate waste from our operations, with the top priority being not making it in the first place" (Mahoney, January 1990).

AA. 1993

In December 1993, more fish sampling was suggested on part of Choccolocco Creek to determine the amount of coverage necessary in the fish consumption advisory that was in effect at that time. Based upon the evaluation conducted by Superfund, this area was likely to be placed on the National Priority list (Cooner, December 15, 1993).

BB. 1995

Contamination became enough of a concern that in October 1995, Monsanto planned to offer to buy the homes of residents affected by these environmental problems. They intended to use this acquired property to construct a facility to collect runoff water coming from their landfills. They estimated that there were about 25 homes and 50 people living in the contaminated location (Hughes, 1995).

In fact, in November 1995, the Alabama Department of Public Health asked ADEM to institute emergency sampling because of their concern about the safety of residents in light of exposure to PCBs. Some of the homes in Anniston were located in places that had PCB levels in the soil over the benchmark (Warr, November 1, 1995).

Actions taken at Superfund sites should have met the mandates of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) as it was stated in the National Contingency Plan (NCP). This stated that it was necessary for actions be taken that would protect the health of both humans and the environment. They must also have complied with or waived all requirements, be cost-effective as well as use permanent solutions and treatment and recovery technologies as much as possible.

In order to identify what actions should be taken, preliminary cleanup objectives were determined. In soil, this level would have been 1 parts per million for sites in residential areas. Levels of 10-25 parts per million were suggested if the site was not residential. Surface water could be either drinking water or water that has an effect on the food chain and aquatic life.

It is expected that principal threats should be treated, when possible, and that they consider material that contains less of a threat. Principle threats are those that have material with PCB levels above 100 parts per million in sites in residential areas and 500 parts per million in industrial locations if the concentrations are greater than 1-2 orders of magnitude above the preliminary remediation goals.

Alternatives for treatment must have met each of the five following criteria: long-term effectiveness and permanence, toxicity reduction, mobility or volume through treatment, short-term effectiveness, ability to implement, and cost. The final decision should have shown the treatment used and the action levels needed, along with the amount of time necessary for implementation (Guidance on Remedial Actions for Superfund Sites with PCB Contamination, December 5, 1995).

ADPH sent a letter to property owners in the Anniston area in December 1995. The letter to the owners gave the result from the ADPH collection on the owner's property. The levels of PCBs that were typically seen in soils in the Anniston area were 0.18 parts per million. The letter indicated that samples taken from the recipient's property were higher than recommended levels (Daniell, December 21, 1995).

CC. 1996

In January 1996, ADPH decided to look into possible PCB exposures in Cobbtown and Sweet Valley, located near Monsanto in Anniston, through the use of dust and blood samples as well as questionnaires. The soil in these residential areas had PCB levels ranging from 0.51 to 496 parts per million. The results indicated that a great number of people in the area have high levels of PCB in their system. The affected population believed that the contaminated soil and sediment somehow worked its way into local neighborhoods; therefore, Dr. Williamson was interested in learning about data that indicated their level of exposure to the PCBs (Williamson, January 22, 1996). On the other hand, in February 1996, the Department of Public Health stated that due to a lack of connection between PCB soil levels at the homes and their PCB blood level, no further soil sampling was necessary (Warr, February, 7, 1996).

In February 1996, ADEM decided that PCBs were being released from the Monsanto facility. At the same time, Monsanto admitted that the West-End landfill, which was sold to the Alabama Power Company in about 1960, had PCBs being released because construction caused a disruption of the cap. Monsanto voluntarily made attempts to re-purchase the West End landfill and they were working to recap it. There was a voluntary buy-out of property and relocation efforts made around the East Drainage Ditch (EDD) after the results of sampling in these areas. Monsanto has shown ADEM their willingness to take action to correctly and to quickly address the health and environmental concerns associated with PCBs (Memo regarding Monsanto's Anniston facility from ADEM, February 29, 1996).

The EPA and the Emergency Response and Removal Branch (ERRB) looked at the Anniston, Alabama site to decide if it was eligible for removal action under the National Contingency Plan (NCP). If Monsanto did not take action on requirements in the order signed with the ADEM, the ERRB was going to step in to take action to protect the health of the people and the environment (Lair, March 1996).

On March 8, 1996, a consent order was written indicating that an analysis of soil at Monsanto's facility shows there are PCBs on and off-site including the West End Landfill, East Drainage Ditch, and Northern Drainage Ditch. Monsanto neither admitted nor denied the findings in the consent order, but they did consent to the terms of the order. Monsanto would relocate necessary citizens, clean-up 2 local church sites, and take regular samples. The EPA's Emergency Response and Removal Branch (ERRB) reviewed the available information for the Monsanto site to determine its eligibility for a potential removal action under the National Contingency Plan (NCP) (Lair, March 19, 1996).

Monsanto also decided to conduct further testing in August 1996. They tested 19 workers from their Anniston plant for PCBs and then asked each of them to complete a questionnaire. The majority of employees tested were over the age of 55. The workers showing over 20 parts per billion had worked for over 6 years in the PCB manufacturing department, but 4 or 5 employees who had worked for that department for more than 6 years showed less than 20 parts per billion in their blood. The workers that stated they had consumed fish from Choccolocco Creek or Lake Logan Martin showed no current exposures to PCBs. None of the workers lived near the plant (Daniell, August 2, 1996).

After further information was gathered by April 1996, Monsanto determined that 125 people, 35 homes, and 4 businesses were in the exposed area. The state wanted to determine if there had been any recent exposure, to provide information to stop or lower exposure, and to alleviate any health problems related to PCBs (Significant Findings at Anniston, April, 27, 1996).

PCBs are suspected carcinogens and teratogens to humans. PCBs can cause liver damage, a skin rash called chloracne, and damage to the nervous system if they are encountered at high concentrations.

OSHA says that legal airborne permissible exposure limits (PEL) is 1 milligram per cubic meter averaged over an 8-hour shift. NIOSH says 1 microgram per cubic meter over a 10-hour shift is acceptable. Exposure to PCBs can occur through the skin, inhalation of contaminated dust, or ingestion if people eat and/or smoke with contaminated hands. PCB concentration in the sediment is 4.8 parts per million at the work site (Cook, December 4, 1996).

V. RESULTS AND CONCLUSIONS

Despite evidence of dangers, the manufacture of PCBs grew to gigantic proportions with over 1.1 billion pounds of PCBs produced in the United States between 1929 and 1977. While PCBs were developed originally for power transformers and electric capacitors, its flame retardant capabilities and other positive properties quickly expanded usage to other markets and projects. PCBs were utilized in many other products including fluorescent lights, caulking compounds for skyscraper windows, air conditioners, typewriters, power saws, and hydraulic fluids. The mass production of Aroclor by Monsanto helped to replace existing products, like carbon paper, in the marketplace.

Understanding PCB toxicity in the environment is complicated even further by the variations in polymer formulations within the Aroclor mixtures. By 2000, over 6500 articles and scientific documents have been written concerning PCB toxicity, which indicates the difficulty in understanding and interpreting the effects of PCBs in the environment. In addition to the congener complication, other contaminants in the environment have helped to defer obtaining reliable field data on PCBs. Even in late 1971, a senior FDA official was quoted in Newsweek saying "PCBs are everywhere. And we don't know if we should or should not be alarmed." (*Newsweek*, October 11, 1971). The FDA further reinforced the concern for lack of knowledge when the report to Congress stated that their "knowledge of the toxicological effects of PCBs is limited at this time" (*Federal Register*, 1972).

Western Japan was the first location of public exposure to PCBs in early 1968 when PCB contamination was found in rice bran oil, called "Yusho." "Yusho" involved over 1,300 people who were affected with health problems ranging from chloracne to swelling of the skin. This epidemic generated a concern and fear worldwide about the safety and effects of PCBs. This concern intensified when another poisoning episode involving rice bran oil and PCB contamination, called "Yu-Cheng," occurred in 1978.

Unfortunately, the same types of problems were seen in the industry over 35 years prior to "Yusho." Within a year after the Anniston plant began to manufacture Aroclor, most of the workers had developed chloracne and a wide range of other symptoms. Twenty-three of the workers were seriously ill with chloracne within two years of plant operation. Dr. Barry Commoner (Commoner, 1994) said that Monsanto knew by 1933 "from the effects on their own workers that they were dealing with a very serious substance." This was greatly influenced by the 1933 reports of skin diseases, including chloracne, appearing among most of the workers in the PCB plant in Anniston. As a result of the continued report of skin diseases by workers, Monsanto immediately launched a medical investigation which resulted in steps to change to a closed manufacturing process in which all chemical reactions would occur in a closed system. As Commoner commented, "The appearance of chloracne, which is a painful but curable skin disease, did not lead Monsanto at that time to suspect that PCBs were a 'very dangerous substance'" (Commoner, 1994).

In 1936, two Atlanta physicians published a case history (Archives, 1936) about one of the Monsanto workers described as, "O.D., a negro aged 26 [who] began work with polychlorinated biphenyl in April 1930." The physicians reported that the patient had a severe case of chloracne and observed that the patient, even in December 1933, "... complained of lassitude, loss of appetite and loss of libido." This was followed by an article written by Louis Schwartz, M.D., Senior Surgeon, U.S. Public Health Service, New York, N.Y. (Schwarz, 1936) which elaborated on similar effects from PCBs:

> In addition to these skin lesions, symptoms of systemic poisoning have occurred among workers inhaling these fumes. Those working with the chloro-diphenyls (PCBs) have complained of digestive disturbances, burning of the eyes, impotence and hematuria.

The appearance of chloracne did not indicate to Monsanto that PCBs were, in fact, dangerous. From this point, the early indications of potential health threats convinced Monsanto that a sealed system and extra care was needed. Not ten years after these reports, Monsanto was told by a health agency to avoid human contact with PCB materials for safety reasons. The Monsanto company has tried to improve their manufacturing processes over the years and has consistently appeared to endorse reasonable regulations involving the chemicals.

Monsanto has employed over 800 managers, scientists, and technicians who were working exclusively on environmental, product, and worker safety and health. Records further indicate that Monsanto spent over $150 million on projects and research involving safety and health. Internal documentation has shown that necessary actions and "reasonable" remediation and manufacturing changes have been made to the process over the years to reduce some risk.

Unfortunately, Monsanto's process of manufacturing PCBs in Anniston failed in reducing significant risk and allowed enormous discharges of PCBs and PCB-related materials into the environment, either through losses in the production processes.

chemical releases, or accidents. Several Anniston Plant Technical Services Department Reports readily indicate the vast amounts of PCBs discharged into the air, water, and soil.

Although the numbers steadily declined, original amounts lost prior to the reduction techniques and the amounts discharged during the improvement phase cannot be eliminated. With decomposition of PCBs into a number of different congeners and the slow biodegradation in the environment, it is almost impossible to quickly and easily eliminate the huge amounts of PCBs discharged by Monsanto.

The discovery of PCBs in the environment by sources other than Monsanto really did not come until the 1960s due to a number of reasons. These reasons included the fact that PCBs generally were not intentionally distributed throughout the environment (unlike chemicals such as DDT, etc.), and that analysis of PCBs and PCB-related materials by gas chromatography gave overlapping signals, making it difficult to distinguish PCBs from other chlorinated materials. Since the acute health effects and toxicity of PCB exposure is relatively low, there appeared to be no immediate "visible" need to look for PCBs in the environment until the "Yusho" incident. Public knowledge took a major turn when the research of Swedish scientist, Soren Jensen, discovered unexpectedly high PCB levels in fish, human hairs, and the feathers of eagles in museums.

While the public was slowly learning, Monsanto strove to keep any knowledge or understanding of the effects of PCBs internal. A letter written by Dr. Kelly of Monsanto in September 1955 about Aroclor toxicity helps to summarize the situation prior to public knowledge (Kelly, 1955):

> Monsanto's position can be summarized in this fashion. We know Aroclors are toxic but the actual limit has not been precisely defined. It does not make too much

> difference, it seems to me, because our main worry is what will happen if an individual develops any type of liver disease and gives a history of Aroclor exposure. I am sure the juries would not pay a great deal of attention to MACs (MAC is the maximum allowable concentration).

Dr. Kelly's comment is indicative of Monsanto's stance found in internal documentation that indicates Monsanto had a greater understanding of the potential effects and hazards of PCBs. Records suggest that numerous meetings and conferences were held throughout the years between first production in 1930 and the ceasing of production in the late 1970's which discussed Monsanto's knowledge and position on PCB toxicity. The determination of the numerous staff meetings and discussions appears to be Monsanto's goal: continue to sell and profit from Aroclors and find further uses for them while protecting the company image.

Monsanto was advised of data and laboratory results indicating that PCBs were in fact hazardous to fish, rats, and other animals. PCBs can be and have been found in fish, oysters, shrimp, birds, and on the coast of industrialized nations worldwide. These findings should have indicated that additional in-depth research and study on the toxic effects of PCBs should be considered and implemented.

Although data relating to the carcinogenicity of PCBs was insufficient to determine whether PCBs are carcinogenic to humans, the indications presented to Monsanto painted warning signs that health threats were of concern. Monsanto's handling of the toxicology testing was questioned when the accuracy and accountability of the work performed by Industrial Bio-Test Labs were discounted as worthless after litigation appeared against the four key people assisting Monsanto at IBT. Written information linked Monsanto and IBT and implicated that Monsanto was running IBT's research. Evidence shows that test conclusions were changed by IBT at Monsanto's request. Monsanto's involvement generates serious questions about the validity of the work, as well as perception of liability.

Finally, in mid-1969, Monsanto confirmed that PCBs were present in the environment and that as many studies were showing, PCBs were an environmental concern across the globe. By this time, Aroclor 1254 and 1260 had been found (and confirmed) in the environment. Monsanto agreed that the concern and problem is more widespread than the United States, and entails parts of Canada, Europe, Asia, and Latin America. This confirmation was enforced in a statement Monsanto sent to Dr. Mark Thoman in 1979 (Thoman, 1979):

> Monsanto acknowledges that there are problems associated with chemicals – either through their misuse or through some earlier industry practices which today's technology has shown to be inadequate. Monsanto agrees these problems exist, and we have repeatedly spoken out for a cooperative effort by industry, government, academia, and other groups to address the problems in a cooperative fashion. Those who simply shout from the sidelines add nothing to solving the problems that exist, and indeed are counter-productive.

From the initial production of Aroclor in 1930, Monsanto's knowledge and expertise on PCB toxicology and environmental effects expanded. Internal documentation implicates a number of questions and fears were raised from the mid 1950s on. In the late 1960's and early 1970's, Monsanto customers began to question the safety of PCBs. Monsanto's largest, oldest, and most valued customer, General Electric, met with Monsanto in January 1970, to discuss impending PCB-related fears and concerns.

Predicated on the probes and inquiries relating to PCBs' safety, Monsanto appeared to wrestle with the proper course of action throughout PCB history to handle the potential problems. Obviously, a definitive plan of action impacted Monsanto monetarily. Total worldwide profits at stake were between $8 to $11 million dollars gross profit annually within the fluids and plasticizers segment.

Ultimately, Monsanto's course of action impacted the company bank account and permeated to the customer and to the consumer. Because PCBs are fire-resistant, the decision evolved into the double-edged choice: risk human life to fires; or risk the animal extinction and minor toxic effects in prolonged exposure. Given the above dilemma, officials believed that PCBs would probably be accepted as a necessary pollutant and tolerated under these conditions. The electric industry used Aroclor in transformers and capacitors because it was both inexpensive and successful as a dielectric fluid. The hot metal working industries used it because they needed fire resistive fluids to protect their employees. Consequently, various industries were dependent on Monsanto's Aroclor products to operate safely and efficiently.

Customers contacted Monsanto and requested the continuing production of Aroclors regardless of available information. Although concerned about PCB effects, General Electric, a vital customer, signed an agreement with Monsanto releasing Monsanto from liability in order to purchase Aroclor mixtures. Without these mixtures, GE power generation systems would not function and were not interchangeable with any other fluid. GE continued to pressure Monsanto by explaining that major U.S. cities, like New York, would literally shut down without this mixture. This pressure enforced Monsanto's position to continue selling product (or at least until another alternative chemical was developed).

Ultimately, the raised issues left Monsanto with three major options in 1969. First, Monsanto could elect to do nothing about the findings of PCBs in the environment.

The company could not, however, deny the results of investigating agencies, since they would face serious lawsuits and be forced out of business if they did. Secondly, Monsanto could choose to discontinue the manufacture of PCBs, which would cause great financial loss, increase competition, and conceivably, would admit guilt. However, manufacture shutdown would not eliminate the known contamination in existence, and could theoretically generate continual problems with major customers. Thirdly, Monsanto could respond responsibly and admit to the evidence of contamination and correct the problem as new data is collected. This choice would reduce the use of higher chlorinated biphenyls and publicize the situation, thus restoring the company with a better image. Responsible actions with the third option would grant Monsanto more time for additional product development and alternative chemicals and formats designs (Fluids, 1969).

Research indicates that Monsanto chose the third option during the 1970s. Officials of the company continued to monitor PCB discharge into the air and water, and worked to reduce the levels of discharge allowed out of the plant through increased production accuracy, manufacturing process design modifications, discharge improvement projects, and "PCB-catching" implementations which helped to catch PCBs prior to their release into local creeks and tributaries. Monsanto committed to seal off their toxic and hazardous landfills and to begin to appropriately handle the public situations as they arose (see Figure 13 in Appendix I for Probability of Success graph).

Conclusively, documentation and research indicate that Monsanto knew prior to 1969 about the health and environmental effects and concerns generated by the production of PCBs. The absence of public knowledge and prior experience with the issue compounded and deferred attention from elimination of the problem. Inadequate manufacturing techniques and processes further inflated the environmental and safety issue over the years as spills in the plant, and "accidental discharges" continued to occur fairly often.

Monsanto voluntarily began a program to terminate the sale of PCBs in 1970 to open applications. Monsanto limited the supply of PCBs to the electric industry. In addition, the company generated preventive steps to improve the manufacturing and transport of PCBs. Better labels were also a key improvement to indicate the safety and environmental concerns of PCBs. (See Appendix I). Monsanto's voluntary program was reviewed and endorsed by a Federal Interdepartmental Task Force. In fact, the then-EPA Administrator, Russell Train, said that he would not ask Monsanto to stop the production of PCBs in 1975 because of its effects of the electrical power industry and railroads.

Although Monsanto was the only domestic U.S. producer of PCBs, five additional manufacturers of PCBs are recognized and other producers who remained unrecognized. Internal documentation indicates that major competitors in the industry did not seem too concerned or worried about the PCB problems and safety concerns growing worldwide. At one point, Monsanto made reference to the fact that Monsanto appeared to be the only manufacturer truly concerned about the future in the industry, and that if any changes were to be made, leadership would come from Monsanto to organize group effort.

The findings of this research suggest that Monsanto's PCB problem is one of inadequate knowledge and expertise of PCBs. Documentation provides sketchy accounts of product uncertainty and public confusion did not encourage major remediations. Like any other for-profit organization, Monsanto's goal is to make money. As the only U.S.

producer of PCBs, there was little contest. At the same time, Monsanto realized that in order to continue making money long term, a positive reputation and favorable customer relations are necessary. Once safety and environmental concerns became public fears. Monsanto strove to do their part as a corporate citizen by working to minimize effects of PCBs on the public while retaining a profit.

Neither Science nor research could predict the abilities or the problems relating to PCBs' usage. Future projections were not warranted when PCBs were introduced. Generating chemicals came with a price. Monsanto finally realized that price after thirty plus years of reaping money from PCBs. Eventually, Monsanto opted to reduce and ultimately cease the production of Aroclor before it was too late. Unfortunately, Monsanto's manufacturing processes and operating habits in Anniston and Sauget were not "clean" enough to spare the company from facing repercussions financially and repercussions from the public viewpoint

. All worldwide users and producers of PCBs felt the pain generated by the toxic effects and hazards found to be true of PCBs. Monsanto's largest customer. GE, continues to experience the pain as clean-up efforts of the Housatonic River persist. Seventy years later in 2000, the GE Board of Directors generates reports explaining the updated costs and effects of their PCB clean-up efforts. Solutia continues to work to clean up the waterways around the Anniston area and to settle legal battles with neighboring churches, civilians, and other organizations.

The major questions may remain clouded. Accountability may be perceived as transitory. Could the expenses and negative effects associated with PCBs have been avoided if Monsanto had ceased production earlier? Did Monsanto know enough to know better? Documentation proves questionable, but inherent warning signs surfaced. Evidence seems not to condemn or condone, nor answer if another company could have more effectively solved the PCB problem.

VI. RECOMMENDATIONS

As indicated in the findings of this research, there are varied complications associated with determining Monsanto's knowledge of PCBs. In summation, the complications include a deficient information trail of internal documentation, as well as external knowledge and insight about PCBs within the framework of Monsanto production and an evaluation of future effects of PCB usage. For Anniston, the major issues, concerns and legal battles generated by the manufacture of PCBs have been litigated. Monsanto (now Solutia) has settled to pay a substantial sum of money toward the clean-up and further rectification of PCB situations.

This research encourages continued study and testing. The limited knowledge of the past obscures current understanding. Additional research and study is necessary to ascertain health and environmental risks generated by PCBs.

Determination of Monsanto's stance in the issues is blighted by insufficient data relating to daily operations and the actions Monsanto selected throughout PCB production history. Discussions with retirees, ex-employees, and interviews with participants with sponsored letters, reports, or memorandums would certainly generate a greater awareness of Monsanto's accountability.

A conclusive investigation is recommended to measure the effects caused by the situation of PCBs on the environment progressively. In other words, what is occurring today? Tomorrow? Next month? Some studies seem to indicate that the effects of PCBs are decreasing with time; however, existing and future observations and investigations are necessary to evaluate the long- term impact of polychlorinated biphenyls.

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APPENDIX I: TABLES AND FIGURES

TABLE 1: Monsanto Product Line Structure and Material Nature

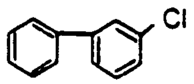
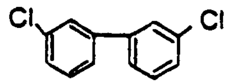
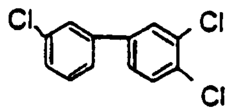
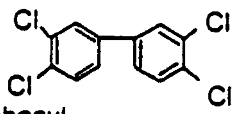
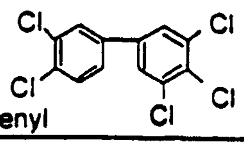
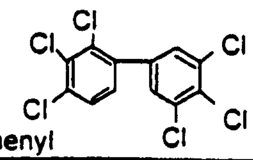
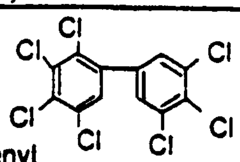
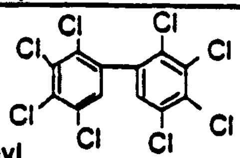
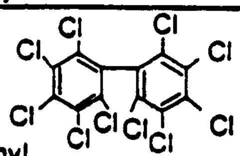
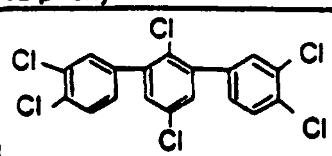
Chemical	Monsanto Product Line	Nature of Material at Ambient
 Monochlorobiphenyl	Aroclor 1221	thin liquid (oil)
 Dichlorobiphenyl	Aroclor 1232	thin flush water
 Trichlorobiphenyl	Aroclor 1242	Oily type fluid material
 Quarterchlorobiphenyl	Aroclor 1248	Thicker - transmission oil
 Pentachlorobiphenyl	Aroclor 1254	Heavy - molasses
 Hexachlorobiphenyl	Aroclor 1260	Thick - tar
 Heptachlorobiphenyl	Aroclor 1262	Very thick - liquid
 Octachlorobiphenyl	Aroclor 1268	Solid
 Decachlorobiphenyl	Aroclor 1271	Solid
 Terphenyl	Aroclor 5460	Solid

TABLE 2: Cast of Characters

People Listed Alphabetically			
Name	Title / Job Code	Company	Section First Found
Barbre	Krummrick Plant Employee, Sauget, Illinois	Monsanto	IV. Summary of Research; A. 1947
Calandra, Dr. Joseph C.	Researcher and Laboratory President	Industrial Bio-Test Laboratories	IV. Summary of Research; J. 1968
Commoner, Dr. Barry	Researcher and PCB Activist	Independent	V. Results and Conclusions
Edelblut, C.M.	Employee, Anniston Plant, Anniston, Alabama	Monsanto	IV. Summary of Research; E. 1957
Edkins, H.B.	Chemist and Author	Independent	IV. Summary of Research; C. 1951
Garrett, Jack	Employee, Medical Department	Monsanto	IV. Summary of Research; G. 1960
Haredos	Monsanto Customer	Unlisted	IV. Summary of Research; H. 1965
Hodges, Paul B.	Employee in General Offices	Monsanto	IV. Summary of Research; K. 1969
Jensen, Soren	Swedish Scientist and Researcher	Independent	IV. Summary of Research; J. 1968
Johnson, N.T.	Sales and Marketing Official in Head Office	Monsanto	IV. Summary of Research; L. 1970
Jurevic, E.J.	Anniston Plant Manager	Monsanto	IV. Summary of Research; V. 1985
Kelly, Dr. Emmett	Toxicologist and Medical Department Head	Monsanto	IV. Summary of Research; D 1955
Kimbrough, Dr.	Researcher	Independent	IV. Summary of Research; P. 1975
Levinskas, Dr. George	Manager, Environmental Assessment and Toxicology	Monsanto	IV. Summary of Research; P. 1975
Mahoney, Richard J.	Chairman and CEO	Monsanto	IV. Summary of Research; Z. 1990
. O.D.	Aroclor Worker	Monsanto	V. Results and Conclusions
"Otis" Fancher, PhD	Vice President, Chemist and Drug Researcher	Industrial Bio-Test Laboratories	IV. Summary of Research; N. 1972
Papageorge, William B.	Employee in Head Offices, PCB Leader/Spokesperson	Monsanto	IV. Summary of Research; L. 1970
Pennington, C.W.	Employee	Monsanto	IV. Summary of Research; B. 1950

TABLE 2: Cast of Characters

People Listed Alphabetically			
Name	**Title / Job Code**	**Company**	**Section First Found**
Richard, W.R.	Researcher	Monsanto	IV. Summary of Research; J. 1968
Risebrough, R.W.	Researcher	University of California	IV. Summary of Research; P. 1975
Roush, Dr. George	Director of Medical and Environmental Department	Monsanto	IV. Summary of Research; K. 1969
Savage, J.	Employee in General Offices	Monsanto	IV. Summary of Research; L. 1970
Schalk, David	Researcher and PCB Activist	Independent	III. Background Research and Information; B. Effects of PCBs on Health and the Environment
Schwartz, Dr. Louis	Senior Surgeon	U.S. Public Health Service	V. Results and Conclusions
Smith, D. F.	Employee	Monsanto	IV. Summary of Research; F. 1958
Squire, Dr.	Researcher	National Cancer Institute	IV. Summary of Research; P. 1975
Swann, Theodore	Founder	Swann Chemical Company	III. Background Research and Information; A. PCB Characteristics and Manufacturing History
Thoman, Dr. Mark	AACTion Editor and Associate Editor	American Academy of Clinical Toxicology (AACT)	V. Results and Conclusions
Train, Russell	Administration	Environmental Protection Agency (EPA)	V. Results and Conclusions
Tucker, E. Scott	Laboratory Chemist	Monsanto	IV. Summary of Research, K. 1969
Wheeler, Elmer P.	Health Effects Department	Monsanto	IV. Summary of Research, H 1965
Williams, R.	Employee	Monsanto	IV. Summary of Research; M. 1971
Williamson, Dr. Donald	State Health Officer	Alabama Department of Public Health (ADPH)	IV. Summary of Research; CC. 1996

TABLE 2: Cast of Characters

People Listed Alphabetically			
Name	Title / Job Code	Company	Section First Found
Wood, David	Employee in Head Offices	Monsanto	IV. Summary of Research; P. 1975
Wright, Eugene G.	Pollution Control Engineer	Monsanto	IV. Summary of Research; K. 1969

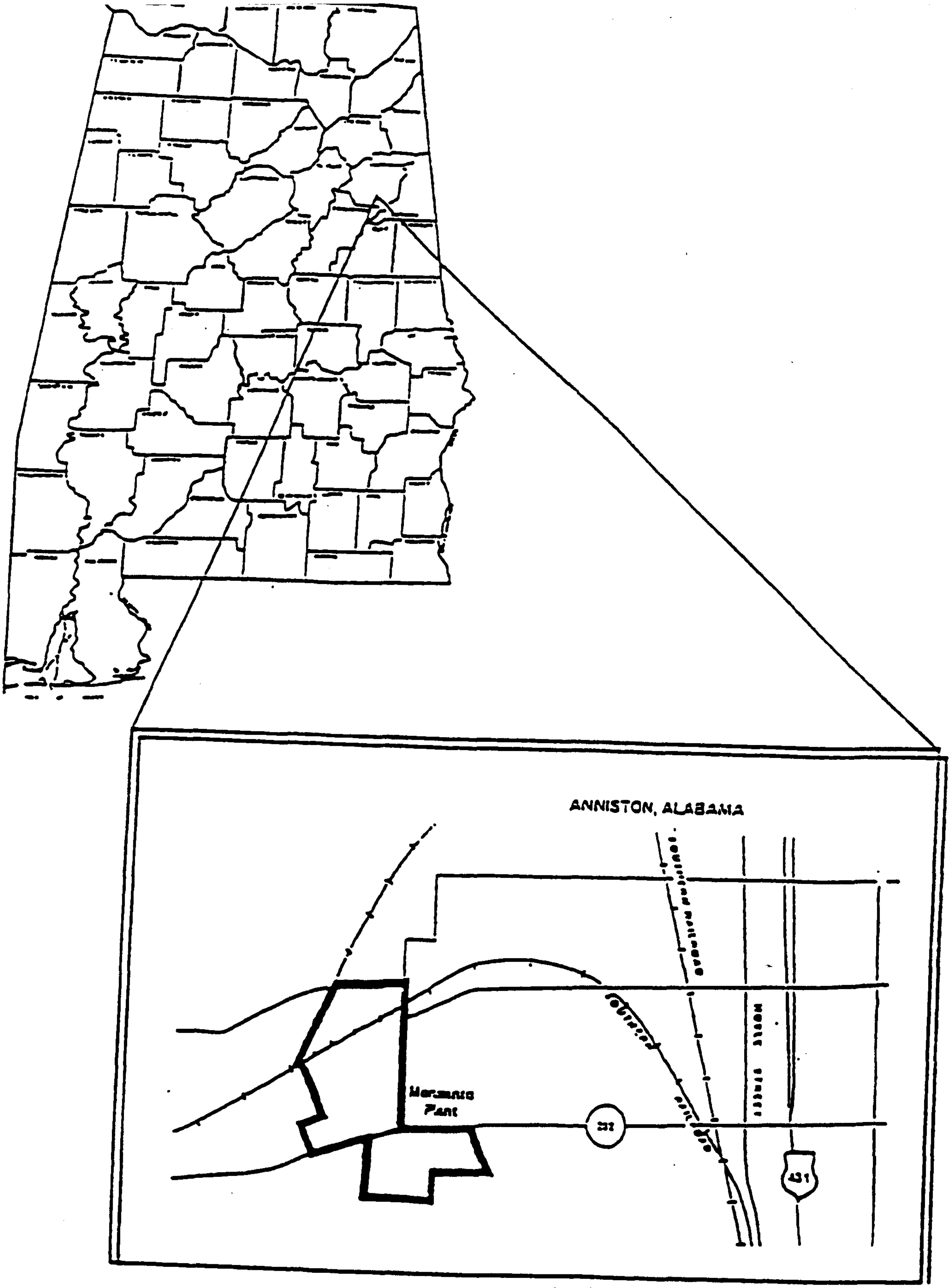


FIGURE 1: Regional Location Map for the Monsanto Company Site

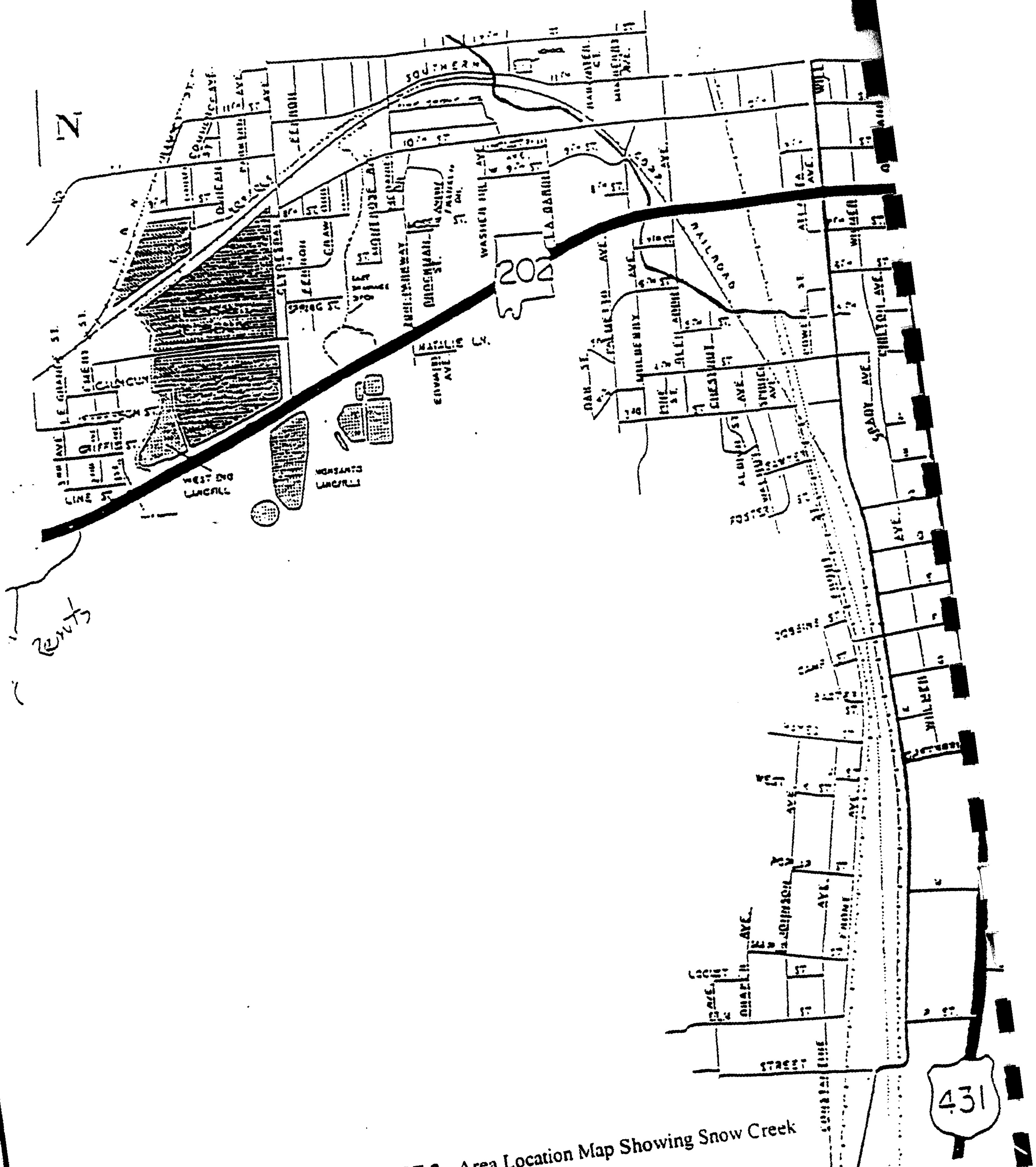


FIGURE 2: Area Location Map Showing Snow Creek

1935 - 1959

What Monsanto Knew About PCBs	What Monsanto Told Customers	What Monsanto Told Regulators	What Monsanto Told Neighbors
• PCBs can cause eye, nose, & throat irritation, interfere with skin function and physiological disturbances • PCBs are toxic, concern for liver disease • PCBs can contaminate hands and foods • PCBs persist in soil • External literature suggests PCBs are quite toxic by inhalation, ingestion, or prolonged skin exposure • Highly chlorinated compounds are particularly toxic	• Good substitute for waxes • Use in paint • Enhances pesticides • Minimum disclosure on cautionary labels	• Nothing	• Nothing

FIGURE 3: Knowledge Timeline – 1935-1985

1960 - 1969

What Monsanto Knew About PCBs	What Monsanto Told Customers	What Monsanto Told Regulators	What Monsanto Told Neighbors
• PCBs were found in Snow Creek near the Anniston Plant • No water life in Snow Creek • External literature suggests that PCBs cause skin, liver, and stomach trouble • Cleanup before eating after exposure; practice "cleanliness" • Toxicity has been repeatedly showed • Annual medical exam for workers	• Avoid contact with skin • Avoid breathing vapors and dust • A great deal of PCBs might result in readily identifiable damage • Spills could cause lethal liver or kidney damage • Chloroacne and liver trouble can result from large doses	• Earlier problems resulted from contaminants • Could cause liver problems with inhalation	• Nothing

FIGURE 3: Knowledge Timeline – 1935-1985 (continued)

1970 - 1979

What Monsanto Knew About PCBs	What Monsanto Told Customers	What Monsanto Told Regulators	What Monsanto Told Neighbors
• Releasing hundreds of pounds per day • High levels of PCBs in Choccolocco Creek fish and water • PCBs are toxic to animals • PCBs cause tumors in rats • Anniston is at risk to PCBs • Alarming effect on environment requires immediate corrective action • Landfill disposal no longer acceptable • PCBs were leaking at the dump sites causing problems • PCBs were seen in Snow Creek	• PCB landfills contaminate creeks and must be monitored • Take "extreme" care to prevent any release to the environment • Prevent leaks and spills • Eliminate air contamination • Need to incinerate • Must indemnify Monsanto to buy PCBs • PCBs persist in soil after thirty years	• Intend to define the environmental effects • Keep it quiet • Releasing one to five pounds per day • Not a carcinogen	• This is a new problem • "We" are solving it • No cause for alarm

FIGURE 3: Knowledge Timeline – 1935-1985 (continued)

1980 - 1985

What Monsanto Knew About PCBs	What Monsanto Told Customers	What Monsanto Told Regulators	What Monsanto Told Neighbors
• Spend money to become rid of PCBs • Need to review plants to see if pollutants have escaped •	• PCBs are hazardous substances • PCBs cause cancer in rats • PCBs leach from landfills • PCBs are "bad"	• Will cleanup Snow Creek	• "We" are the best around

FIGURE 3: Knowledge Timeline – 1935-1985 (continued)

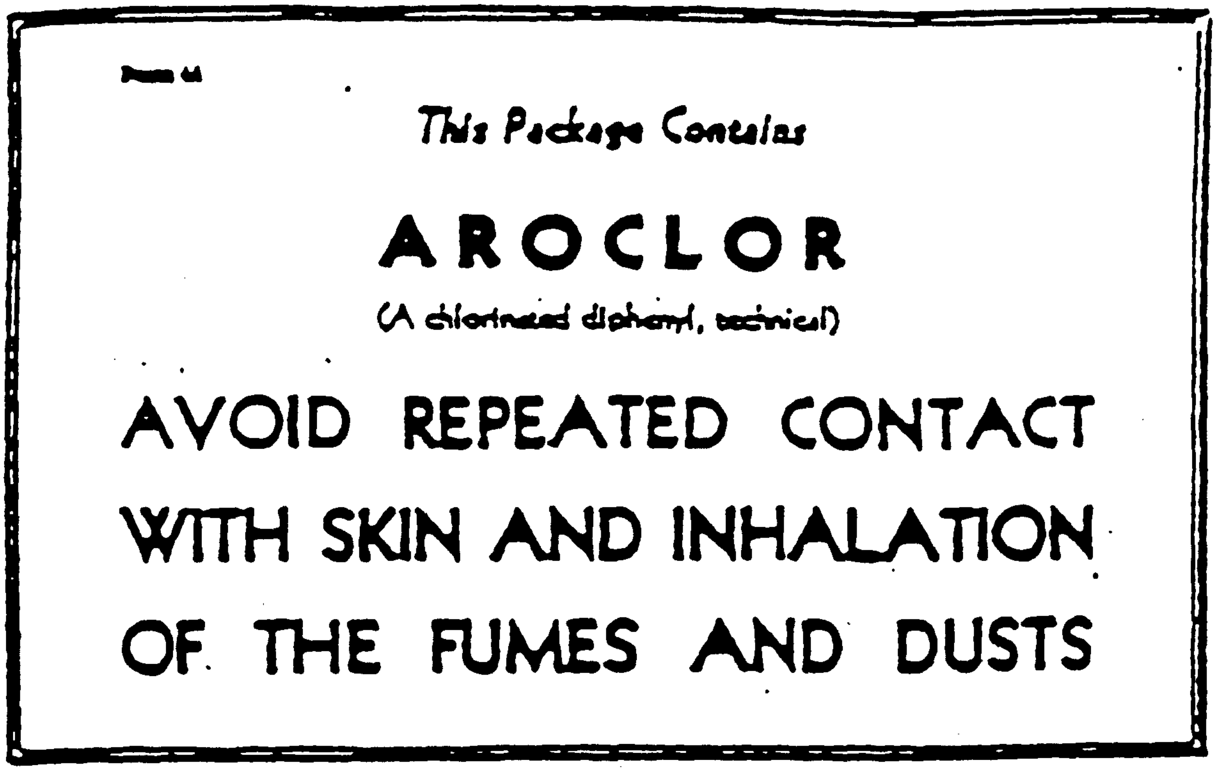


FIGURE 4: Original Aroclor Warning Label

WASTE DISPOSAL

Used polychlorinated biphenyl fluids may be returned freight prepaid for proper incineration at 3¢ per pound.

Ship to: Supervisor Dept. A-246
MONSANTO COMPANY
SAUGET, ILLINOIS 62201

1149/53

FIGURE 5: PCB Waste Disposal Label

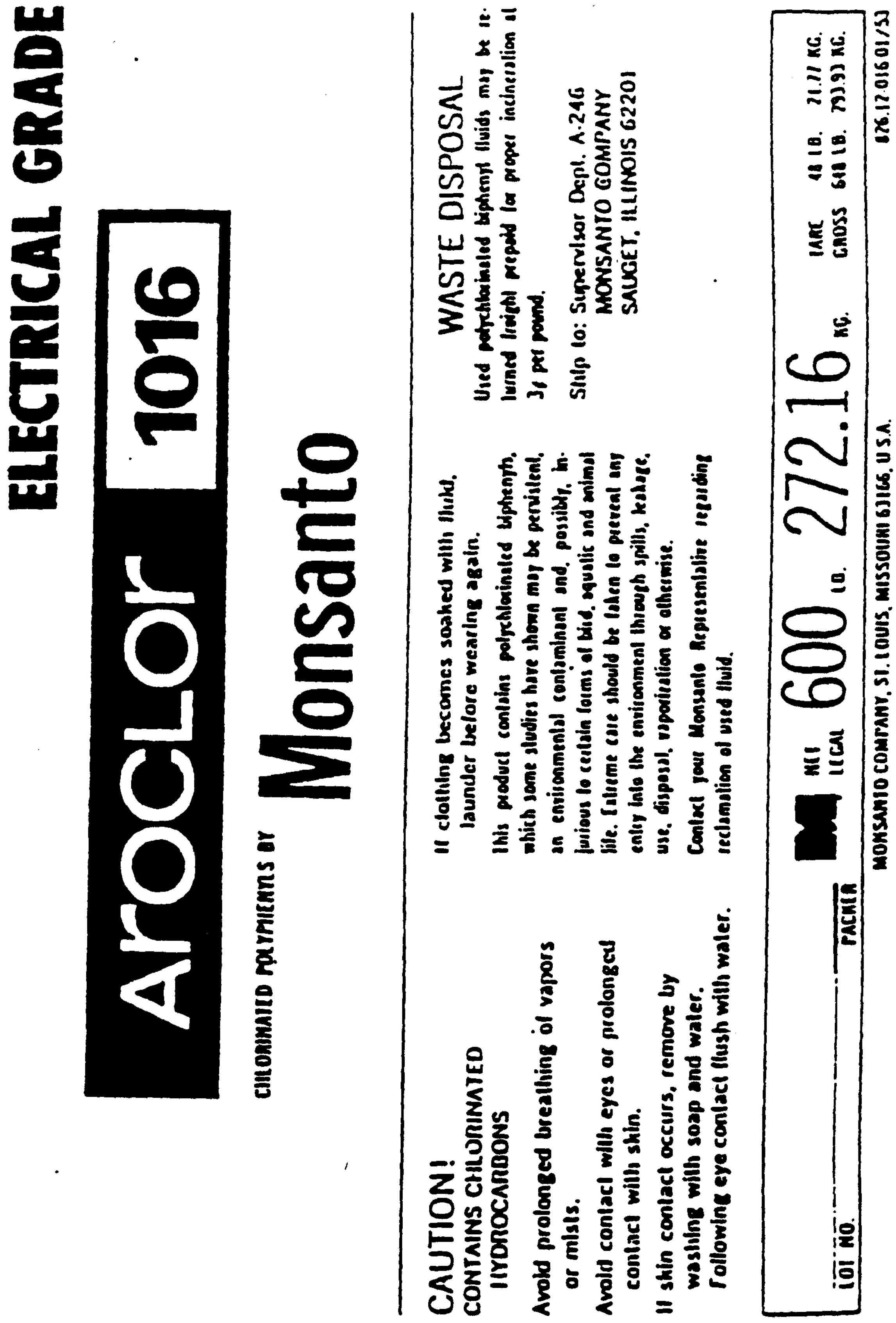


FIGURE 6: Aroclor 1016 Label

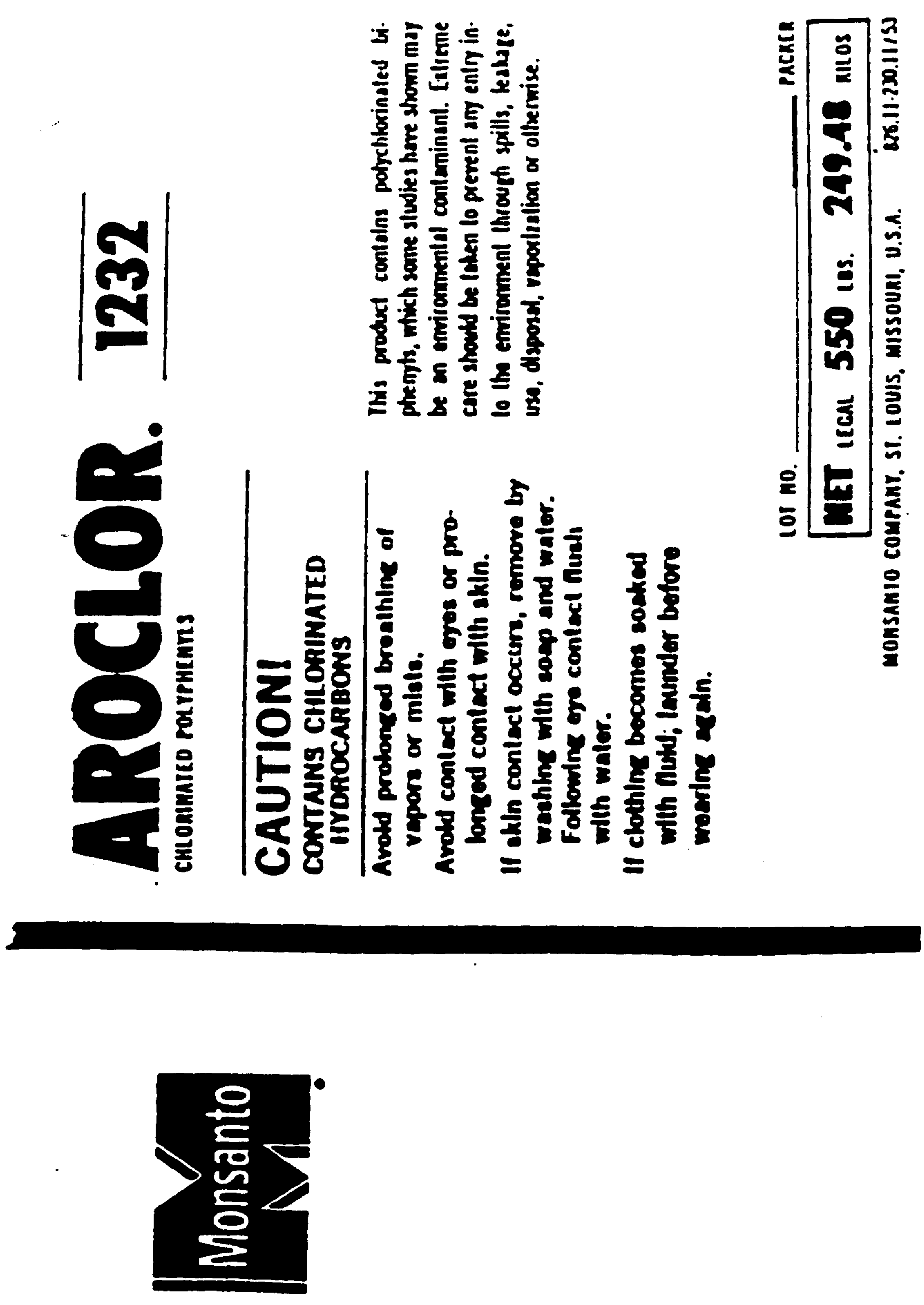
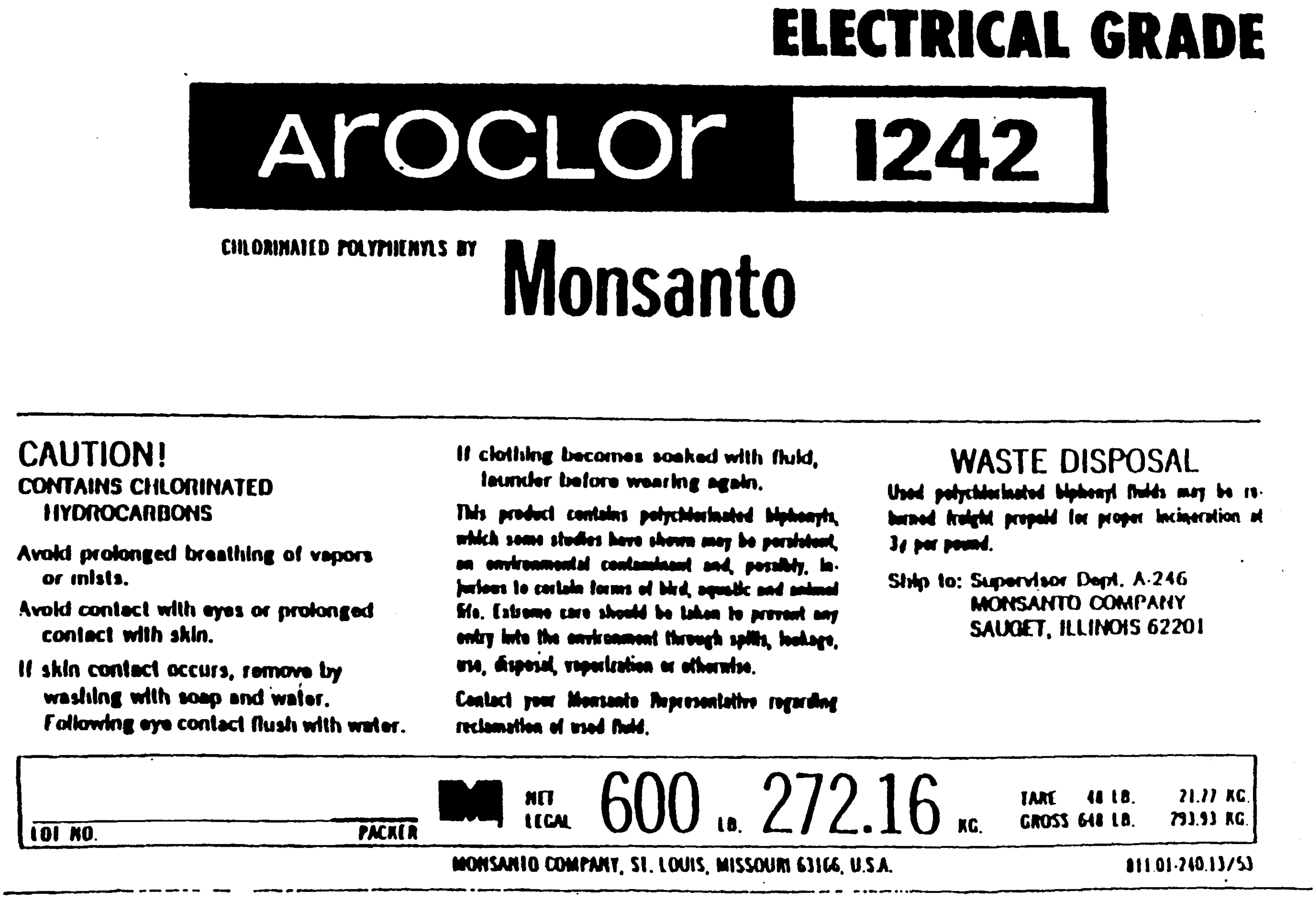


FIGURE 7: Aroclor 1232 Label



CDS 00020

FIGURE 8: Aroclor 1242 Label

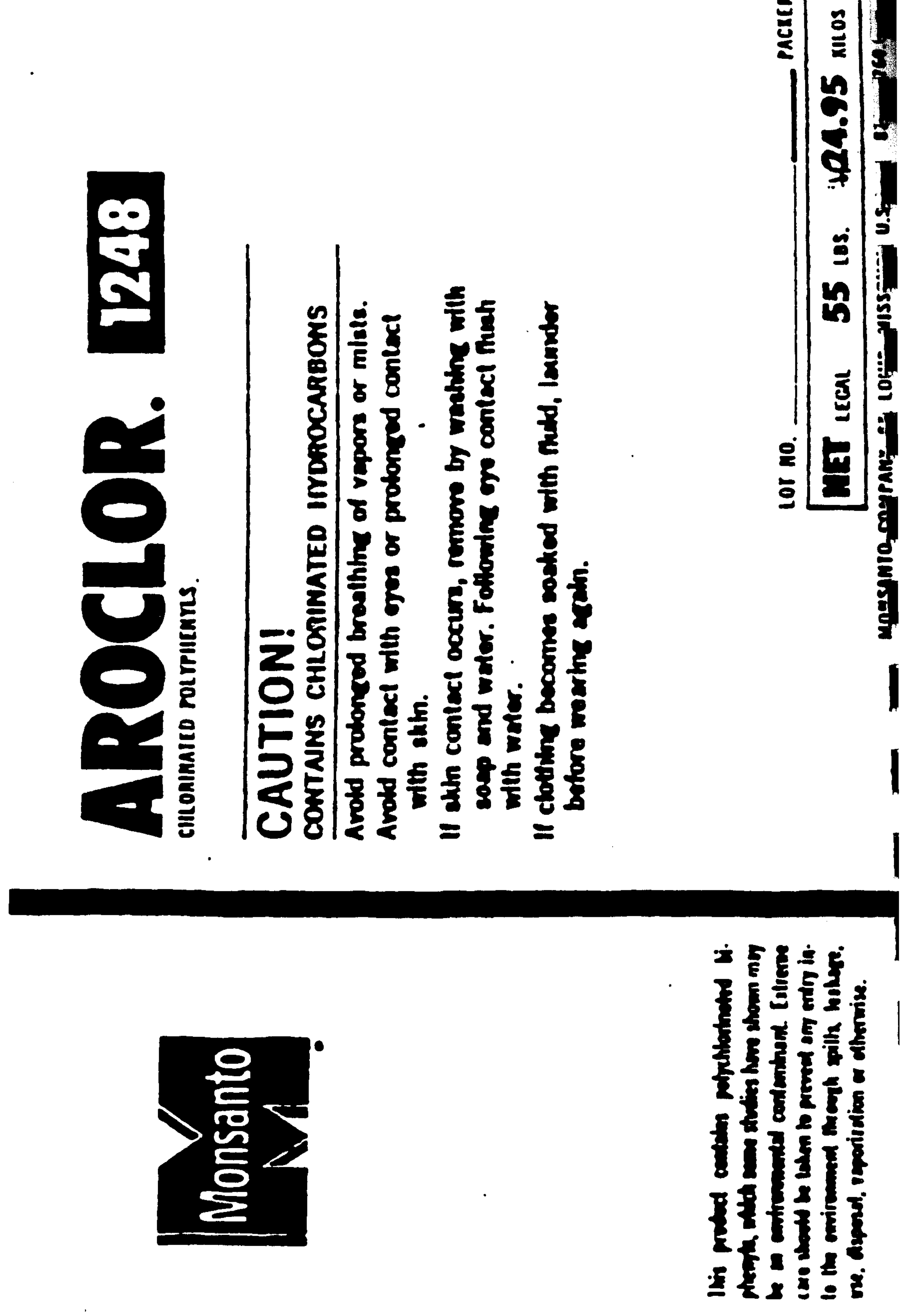


FIGURE 9: Aroclor 1248 Label

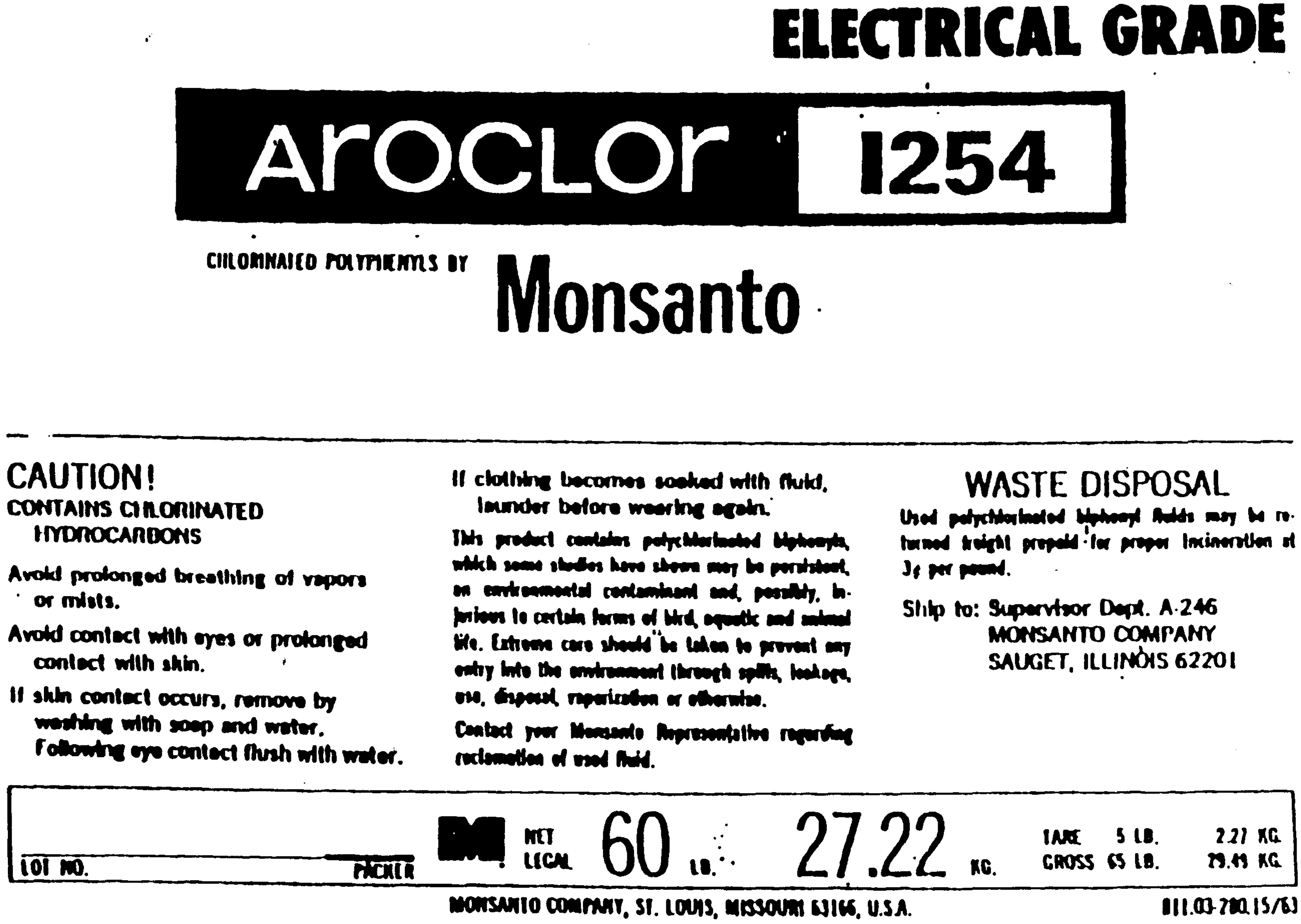


FIGURE 10: Aroclor 1254 Label

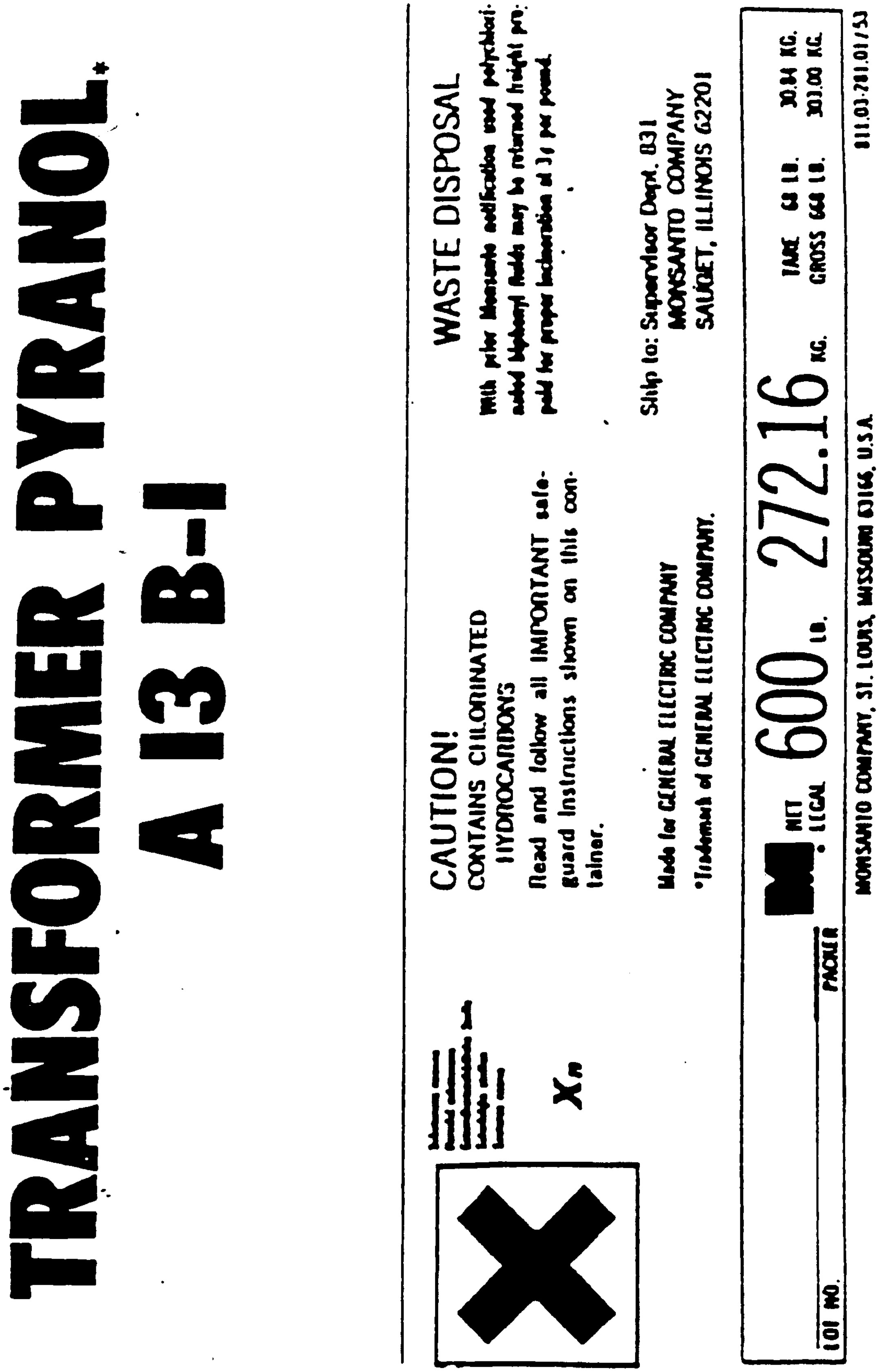


FIGURE 11: Transformer Pyranol Label

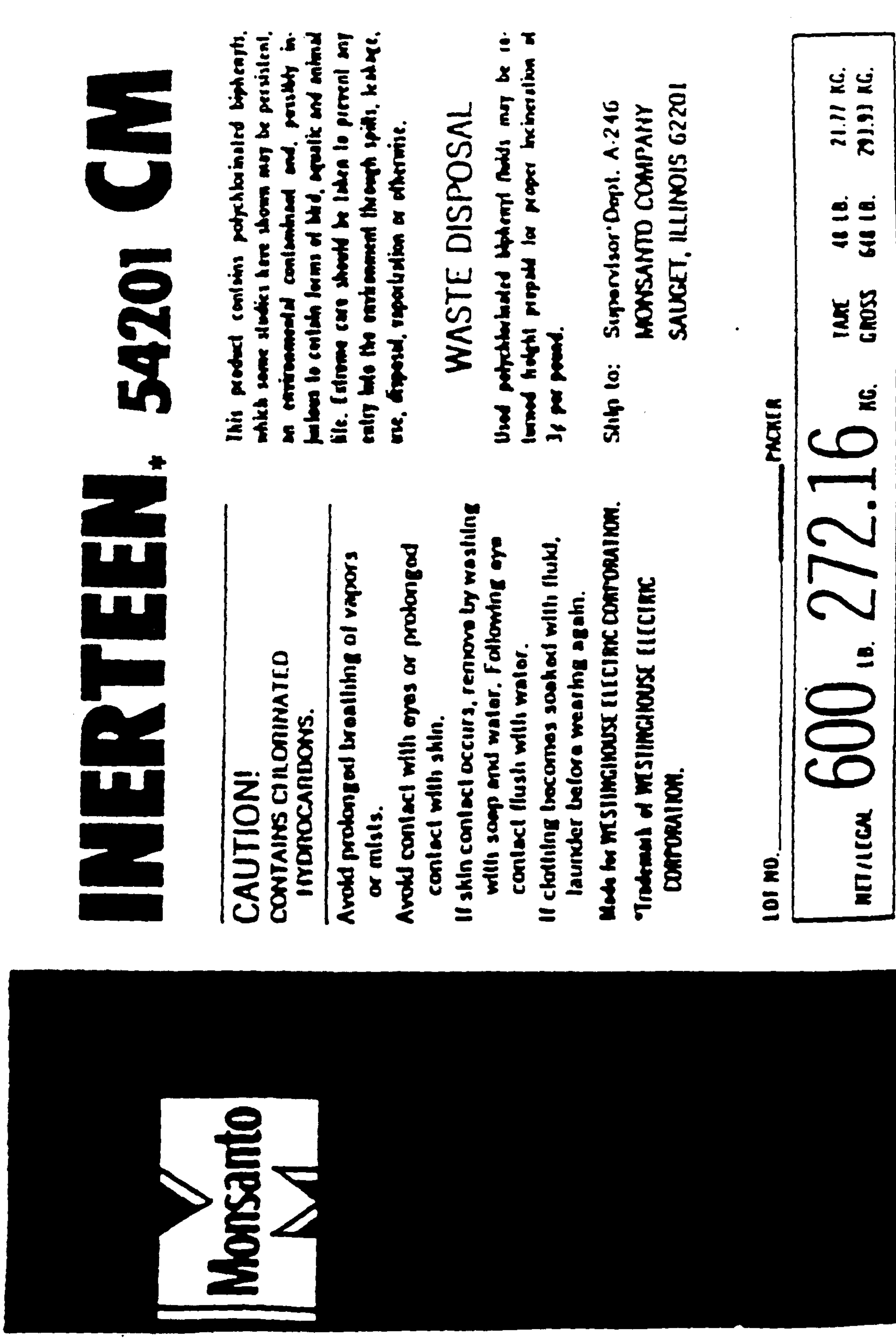


FIGURE 12: INERTEEN Label

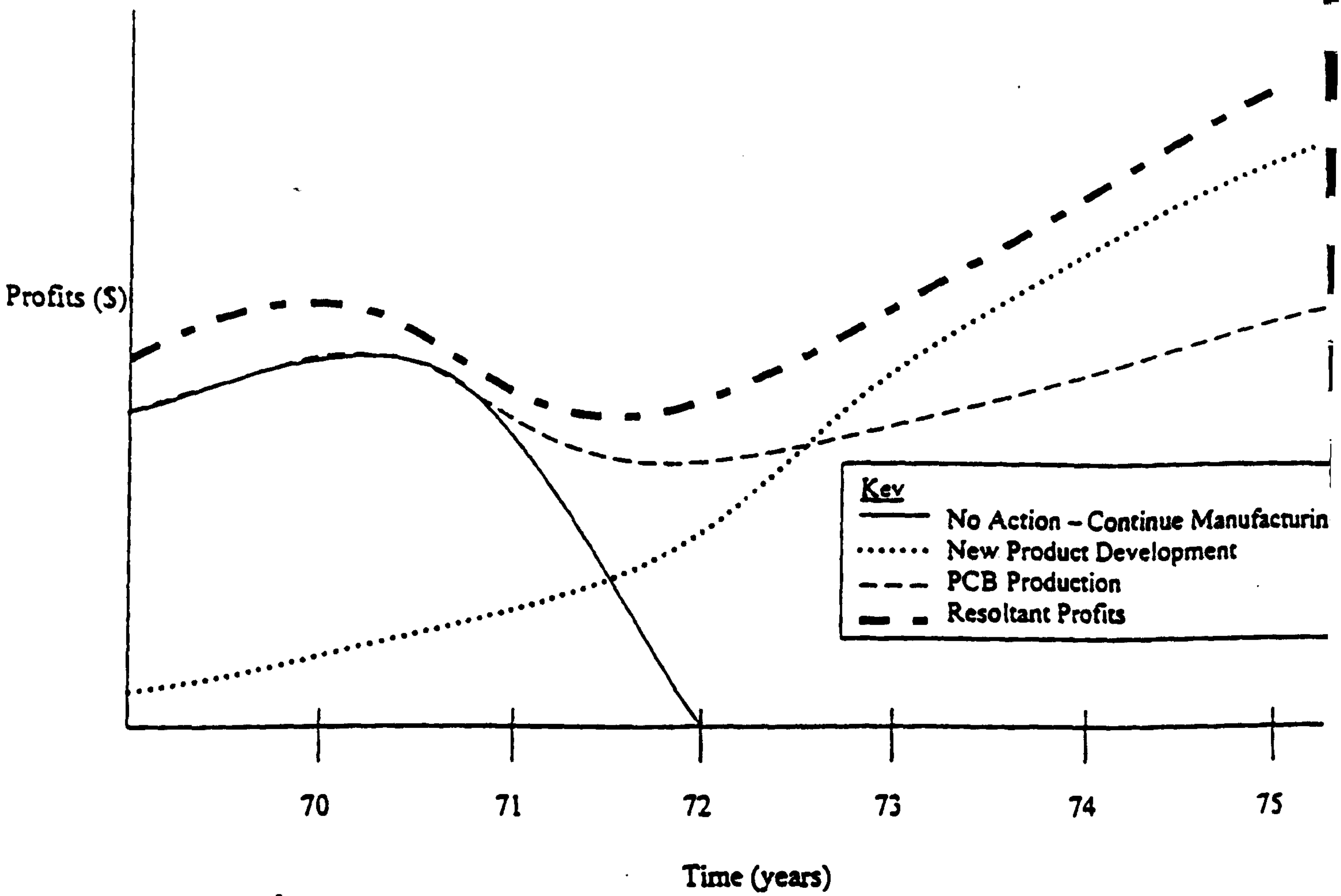


FIGURE 13: 1969 Perceived Probability of Success

APPENDIX II: MONSANTO MSDS SHEETS

MONSANTO PRODUCT NAME

Polychlorinated Biphenyls (PCBs)

MONSANTO COMPANY
800 N. LINDBERGH BLVD.
ST. LOUIS, MO 63167

Emergency Phone No.
(Call Collect)
314-694-1000

Date: 10/88

PRODUCT IDENTIFICATION

Synonyms:
PCBs
Chlorodiphenyl (__% Cl)
Chlorinated biphenyl
Polychlorinated biphenyl
Chlorinated biphenyls
(approx. __% Cl)

Trade Names/ Common Names:
Aroclor*1 Series 1016, 1221, 1232, 1242, 1248, 1254, 1260
Therminol*1 FR Series

PYRANOL*2 and INERTEEN*3 are trademarks for commonly used dielectric fluids that may have contained varying amounts of PCBs as well as other components including chlorinated benzenes.

ASKAREL - Generic name for a broad class of fire-resistant synthetic chlorinated hydrocarbons and mixtures used as dielectric fluids that commonly contained about 30-70% PCBs. Some ASKAREL fluids contained 99% or greater PCBs and some contained no PCBs.

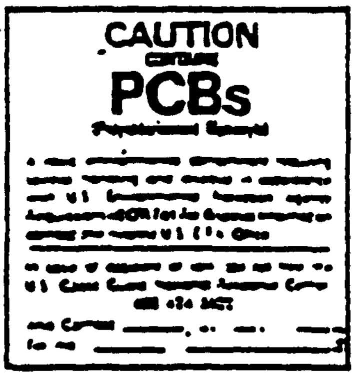
This list of trade names is representative of several commonly used Monsanto products (or products formulated with Monsanto products). Other trademarked PCB products were marketed by Monsanto and other manufacturers. PCBs were also manufactured and sold by several European and Japanese companies. Contact the manufacturer of the trademarked product, if not in this listing, to determine if the formulation contained PCBs.

*1 Registered trademark of Monsanto Company
*2 Registered trademark of General Electric Company
*3 Registered trademark of Westinghouse Electric Corporation

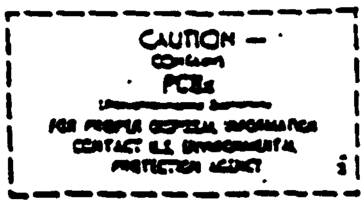
CAS No.'s: 001336363, 053469219, 021672296, 01109769, 011096825 and others

WARNING STATEMENTS

Federal regulations under the Toxic Substances Control Act require PCBs, PCB items, storage areas, transformer vaults, and transport vehicles to be marked. (check regulations, 40 CFR 761, for details)



OSW 022821



PRECAUTIONARY MEASURES

Care should be taken to prevent entry into the environment through spills, leakage, use, vaporization, or disposal of liquid or containers. Avoid prolonged breathing of vapors or mists. Avoid contact with eyes or prolonged contact with skin. If skin contact occurs, remove by washing with soap and water. Following eye contact, flush with water. In case of spillage onto clothing, the clothing should be removed as soon as practical, skin washed, and clothing laundered. Comply with all federal, state, and local regulations.

EMERGENCY AND FIRST AID PROCEDURES

Ingestion: Consult a physician. Do not induce vomiting or give any oily laxatives. NOTE TO PHYSICIAN—If large amounts are ingested, gastric lavage is suggested.

Skin: If liquid or solid PCBs are splashed or spilled on skin, contaminated clothing should be removed and the skin washed thoroughly with soap and water. NOTE TO PHYSICIAN—Hot PCBs may cause thermal burns.

Eyes: Eyes should be irrigated immediately with copious quantities of running water for at least 15 minutes if liquid or solid PCBs get into them. A petrolatum-based opthalmic ointment may be applied to the eye to relieve the irritating effects of PCBs.

Inhalation: Remove to fresh air. If skin rash or respiratory irritation persists, consult a physician. NOTE TO PHYSICIAN—If electrical equipment arcs over, PCBs or other chlorinated hydrocarbon dielectric fluids may decompose to produce HCl, hydrochloric acid, a respiratory irritant.

OCCUPATIONAL CONTROL PROCEDURES

Eye Protection: Wear chemical splash goggles and have eye baths available where there is significant potential for eye contact.

Skin Protection: Wear appropriate protective clothing and chemical resistant gloves to prevent skin contact. Consult glove manufacturer to determine appropriate type glove for given application. Wear chemical goggles, face shield, and chemical resistant clothing such as a rubber apron when splashing is likely. Wash immediately if skin is contaminated. Remove contaminated clothing promptly and launder before reuse. Clean protective equipment before reuse. Provide a safety shower at any location where skin contact can occur. Wash thoroughly after handling.

ATTENTION! Repeated or prolonged contact may cause chloracne in some people.

Respiratory Protection: Avoid breathing vapor or mist. Use NIOSH/MSHA approved equipment when airborne exposure limits are exceeded. Full facepiece equipment is recommended and, if used, replaces need for face shield and/or chemical splash goggles. Consult respirator manufacturer to determine the type of equipment for a given application. The respirator use limitations specified by NIOSH/MSHA or the manufacturer must be observed. High airborne concentrations may require use of self-contained breathing apparatus or supplied air respirator. Respiratory protection programs must be in compliance with 29 CFR Part 1910.134.

Ventilation: Provide natural or mechanical ventilation to control exposure levels below airborne exposure limits (see below). If practical, use local mechanical exhaust ventilation at sources of air contamination such as open process equipment.

Airborne Exposure Limits: Chlorinated biphenyl (approximately 42% chlorine)

OSHA PEL: 1 mg/m³ 8-hour time-weighted average - Skin*

ACGIH TLV: 1 mg/m³ 8-hour time-weighted average - Skin*

2 mg/m³ short-term exposure limit - Skin*

**Skin notation means that skin absorption of this material may add to the overall exposure. Avoid skin contact.*

(OCCUPATIONAL CONTROL PROCEDURES continued on page 3)

OCCUPATIONAL CONTROL PROCEDURES *(continued)*

Airborne Exposure Limits (Continued): Chlorinated biphenyl (approximately 54% chlorine)

OSHA PEL: 0.5 mg/m³ 8-hour time-weighted average - Skin*

ACGIH TLV: 0.5 mg/m³ 8-hour time-weighted average - Skin*

1 mg/m³ short-term exposure limit - Skin*

*Skin notation means that skin absorption of this material may add to the overall exposure. Avoid skin contact.

FIRE PROTECTION INFORMATION

Fire and Explosion: PCBs are fire-resistant compounds. They may decompose to form CO, CO_2, HCl, phenolics, aldehydes and other toxic combustion products under severe conditions such as exposure to flame or hot surfaces.

At temperatures in the range of 600-650°C in the presence of excess of oxygen PCBs may form polychlorinated dibenzofurans (PCDFs). Laboratory studies under similar conditions have demonstrated that PCBs do not produce polychlorinated dibenzo-p-dioxins (PCDDs).

PCBs in electrical equipment have been reported to produce both chlorinated dioxins (PCDDs) and furans (PCDFs) during fire situations. These combustion products may result all, or in part, from non-PCB components of the dielectric fluids or other combusted materials. Consult the equipment manufacturer for information regarding composition of the dielectric fluids in electrical apparatus.

Standard fire fighting wearing apparel and self-contained breathing apparatus should be worn when fighting fires that involve possible exposure to chemical combustion products. Fire fighting equipment should be thoroughly cleaned and decontaminated after use.

Federal regulations require all PCB transformers to be registered with fire response personnel.

If a PCB transformer is involved in a fire-related incident, the owner of the transformer may be required to report the incident. Consult and follow appropriate federal, state, and local regulations.

REACTIVITY DATA

PCBs are very stable, fire-resistant compounds.

DSW 022823

HEALTH EFFECTS SUMMARY

Skin Contact: PCBs can be absorbed through intact skin. Local action on skin is similar to that of common organic solvents where contact leads to removal of natural fats and oils with subsequent drying and cracking of the skin. A potential exists for contracting chloracne.

Eye Contact: The liquid products and their vapors are moderately irritating to eye tissues.

Ingestion: The acute oral toxicities of the undiluted compounds are: LD_{50} rats—3.55 gm/kg for 42% chlorinated, and 11.9 gm/kg for 54% chlorinated—"slightly toxic."

Inhalation: Animal experiments of varying duration and at different air concentrations show that for similar exposure conditions, the 54% chlorinated material produces more liver injury than the 42% chlorinated material.

(HEALTH EFFECTS SUMMARY continued on page 4)

HEALTH EFFECTS SUMMARY (continued)

Other:

There are literature reports that PCBs can impair reproductive functions in monkeys. The National Cancer Institute performed a study in 1977 using Aroclor 1254 with both sexes of rats. NCI stated that the PCB, Aroclor 1254, was not carcinogenic under the conditions of their bioassay. There is sufficient evidence in the scientific literature to conclude that Aroclor 1260 can cause liver cancer when fed to rodents at high doses. Similar experiments with less chlorinated PCB products have produced negative or equivocal results.

The consistent finding in animal studies is that PCBs produce liver injury following prolonged and repeated exposure by any route, if the exposure is of sufficient degree and duration. Liver injury is produced first, and by exposures that are less than those reported to cause cancer in rodents. Therefore, exposure by all routes should be kept sufficiently low to prevent liver injury.

Numerous epidemiological studies of humans, both occupationally exposed and non-worker environmentally exposed populations, have not demonstrated any causal relationship between PCB exposures and chronic human illnesses such as cancer or neurological or cardiovascular effects. PCBs can cause dermatological symptoms; however, these are reversible upon removal of exposure source.

PCBs are identified as hazardous chemicals under criteria of the OSHA Hazard Communication Standard (29 CFR Part 1910.1200). PCBs have been listed in the International Agency for Research on Cancer (IARC) Monographs (1987)-Group 2A and in the National Toxicology Program (NTP) Annual Report on Carcinogens (Fourth).

PHYSICAL DATA

PROPERTIES OF SELECTED AROCLORS[3]

PROPERTY	1016	1221	1232	1242	1248	1254	1260
Color (APHA)	40	100	100	100	100	100	150
Physical state	mobile oil	mobile oil	mobile oil	mobile oil	mobile oil	viscous liquid	sticky resin
Stability	inert	inert	inert	inert	inert	inert	inert
Density (lb/gal 25°C)	11.40	9.35	10.55	11.50	12.04	12.82	13.50
Specific gravity x/15.5°C	1.36-1.37 x-25°	1.18-1.19 x-25°	1.27-1.28 x-25°	1.30-1.39 x-25°	1.40-1.41 x-65°	1.49-1.50 x-65°	1.55-1.56 x-90°
Distillation range (°C)	323-356	275-320	290-325	325-366	340-375	365-390	385-420
Acidity mg KOH/g, maximum	.010	.014	.014	.015	.010	.010	.014
Fire point (°C)	none to boiling point	176	238	none to boiling point	none to boiling point	none to boiling point	none to boiling point
Flash point (°C)	170	141-150	152-154	176-180	193-196	none	none
Vapor pressure (mm Hg @ 100°F)	NA	NA	0.005	0.001	0.00037	0.00006	NA
Viscosity (Saybolt Univ. Sec. @ 100°F) (centistokes)	71-81 13-16	38-41 3.6-4.6	44-51 5.5-7.7	82-92 16-19	185-240 42-52	1800-2500 390-540	— —

OSW 022824

NA—Not Available

SPILL, LEAK & DISPOSAL INFORMATION

Cleanup and disposal of liquid PCBs and other PCB items are strictly regulated by the federal government. The regulations are found at 40 CFR Part 761. Consult these regulations as well as applicable state and local regulations prior to any disposal of PCBs, PCB items, or PCB-contaminated items.

If PCBs leak or are spilled, the following steps should be taken immediately:

All non-essential personnel should leave the leak or spill area.

The area should be adequately ventilated to prevent the accumulation of vapors.

The spill/leak should be contained. Loss to sewer systems, navigable waterways and streams should be prevented. Spills/leaks should be removed promptly by means of absorptive material, such as sawdust, vermiculite, dry sand, clay, dirt or other similar materials, or trapped and removed by pumping or other suitable means (traps, drip-pans, trays, etc.).

Personnel entering the spill or leak area should be furnished with appropriate personal protective equipment and clothing as needed. See Occupational Control Procedures section of this MSDS.

Personnel trained in the emergency procedures and protected against the attendant hazards should shut off sources of PCBs, clean up spills, control and repair leaks and fight fires in PCB areas.

All wastes and residues containing PCBs (e.g., wiping cloths, absorbent material, used disposable protective gloves, clothing, etc.) should be collected, placed in proper containers, marked and disposed of in the manner prescribed by EPA regulations (40 CFR Part 761) and applicable state and local regulations.

Various federal, state and local regulations may require immediate reporting of PCB spills and may also define spill clean-up levels. Consult your attorney or appropriate regulatory officials for information relating to spill reporting and spill clean-up.

ENVIRONMENTAL INFORMATION

Care should be taken to prevent entry of PCBs into the environment through spills, leakage, use, vaporization or disposal of liquids or solids. PCBs can accumulate in the environment and can adversely affect some animals and aquatic life. In general, PCBs have low solubility in water, are strongly bound to soils and sediments, and are slowly degraded by natural processes in the environment.

ADDITIONAL COMMENTS

OSW 022825

Polychlorinated Biphenyls

For regulatory purposes, under the Toxic Substances Control Act the term "PCBs" refers to a chemical substance limited to the biphenyl molecule that has been chlorinated to varying degrees or any combination of substances which contain such substance (40 CFR Part 761).

Chemically, commercial PCBs are defined as a series of technical mixtures, consisting of many isomers and compounds that vary from mobile oily liquids to white crystalline solids and hard non-crystalline resins. Technical products vary in composition, in the degree of chlorination and possibly according to batch.

The mixtures generally used contain an average of 3 atoms of chlorine per molecule (42% chlorine) to 5 atoms of chlorine per molecule (54% chlorine). They are used as components of dielectric fluids in transformers and capacitors. Prior to 1972, PCB applications included heat transfer media, hydraulic and other industrial fluids, plasticizers, carbonless paper, paints, inks and adhesives.

In 1972 Monsanto restricted sales of PCBs to applications involving only closed electrical systems (transformers and capacitors). In 1977 all manufacturing and sales were voluntarily terminated. In 1979 EPA restricted the manufacture, processing, use, and distribution of PCBs to specifically exempted and authorized activities.

FOR ADDITIONAL NON-EMERGENCY INFORMATION, CONTACT:

John H. Craddock
Product & Environmental Safety Director [illegible]

Paul R. Michael
Product & Environmental Safety Manager

Environmental Policy Staff
Monsanto Company
800 North Lindbergh Boulevard
St. Louis, Missouri 63167
(314) 694-4764

DSW 022826

VITA

Robert B. Cissell, son of Robert J. and Judy L. Cissell, is a native of Louisville, Kentucky. Raised in Louisville, Robert graduated from Saint Xavier High School in 1995 while taking courses at Bellarmine College and then began undergraduate studies at Speed Scientific School, the engineering school within the University of Louisville. He graduated with honors from the University of Louisville with a Bachelor of Science in Chemical Engineering in 1999. He graduates with his Master of Engineering in Chemical Engineering and his Master of Business Administration in May 2000. He is currently employed part-time as an Engineer at General Electric Appliances in Louisville, Kentucky and will transition to a full-time role upon graduation. Studies of particular interest include operations, global, and entrepreneurial management, water and gas treatment, environmental engineering and related issues, and Spanish. When not immersed in work or studies, Robert enjoys racquetball, rollerblading, and real estate.