K-49

C O N F I D E N T I A L

The Toxicity of a Mist Generated by the Aspiration of Pydraul

K-49

by

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EXHIBIT K-24

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Sequence of Tables

1. The Mortality, Length of Survival, and Changes in Weight of Animals Exposed to the Mist of Pydraul in Air (Experiment No. 1).

2. The Mortality, Length of Survival, and Changes in Weight of Animals Exposed to the Mist of Pydraul in Air (Experiment No. 3).

3. The Mortality, Length of Survival, and Changes in Weight of Animals Exposed to the Mist of Pydraul in Air (Experiment No. 5).

4. The Mortality, Length of Survival, and Changes in Weight of Animals Exposed to the Mist of Pydraul in Air (Experiment No. 4).

5. The Mortality, Length of Survival, and Changes in Weight of Animals Exposed to the Mist of Pydraul in Air (Experiment No. 2).

6. Conditions of Formation of Mist of Pydraul, and Summary of the Data as to the Fate of Animals Exposed to the Mist.

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C O N F I D E N T I A L

The Toxicity of a Mist Generated by the Aspiration of Pydraul

Scope

The purpose of this work was to learn whether the replacement of Houghto-Safe 271 by another nonflammable liquid, Pydraul, in the catapult system of an aircraft carrier would give rise to a toxic hazard. The responses of animals to the saturated vapor of Pydraul and to the fog formed by dropping it upon the surface of a heated Inconel were described in a report (Project 49) dated March 11, 1953. The effects of Pydraul when maintained in contact with the skin of rabbits according to the 24-hour sleeve method of Draize, Woodard and Calvery were included in the early report.

Summary

1. Groups of animals, each consisting of 1 cat, 2 guinea pigs, 2 rabbits and 4 rats, survived throughout and after periods of 0.5, 1.0 or 3.25 hours of exposure to the mist of Pydraul in the concentration of 0.21 or 0.26 mg per liter, and when killed for examination, were found to have suffered no gross or microscopic damage to their tissues.

2. Fatalities, preceded by evidences of labored breathing, occurred among guinea pigs, following 2.0 or 4.0 hours of exposure to air bearing the mist of Pydraul in the concentration of 0.45 mg

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per liter. The guinea pigs that died had diffuse toxic lesions in their brain, liver and kidneys, but no alterations of the lungs.

Cats, rabbits and rats survived under the severe conditions which induced some fatalities among guinea pigs, and developed no signs of intoxication (there was an excess of salivation on the part of the cats). When these animals were killed for examination, the livers and kidneys of the cats and rabbits exhibited degenerative changes, but no visceral abnormalities were found in the rats.

Equipment and Experimental Methods

Aspiration of the Material at Room Temperature. The mist was generated by use of a modified atomizer, which was originally designed in the Army Chemical Center, Medical Laboratories. A photograph of the atomizer is shown in Figure 1. A stream of compressed air at a pressure of 24 to 29 pounds per square inch (Table 6) passed from the gauge of a compressor through a drying tower of silica gel before entering the atomizer containing the Pydraul.

The functional portion of the atomizer was composed of two parts each fabricated from stainless steel (Carpenter #303) tubing or rod. The center tubing (20 gauge), which was 10 inches in length and 0.25 inch in outside diameter, had a wall thickness of 0.036 inch. The lower end of this tubing was closed with a stainless steel plate. One inch above the lower end, 4 apertures, each 1/32" in diameter, were drilled horizontally through the tubing at

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points in its circumference which were situated at 90° from each other. A stainless steel collar (1 inch in length and 7/16" in outside diameter), which was fabricated from a rod, fitted over the lower portion of the tubing. The collar contained 4 tubes each 1/32" in diameter and located 90° apart; holes were drilled vertically along the length of the collar.

Because of the viscosity of the Pydraul it was necessary that the vertical and horizontal apertures be placed precisely opposite each other. Immersion of the apertures below the liquid level resulted in a more consistent mist of Pydraul than when the apertures were above the liquid level.

The larger particles of mist were removed by impingement on a glass mantle and returned to the 500 ml glass reservoir below. In the first 3 experiments, air bearing a mist of the Pydraul entered the upper rear of a 223-liter cylindrical steel chamber, described in the earlier report (March 11, 1953), at the rate of 30.9 liters per minute, and at room conditions of temperature and pressure. In 2 later experiments the air-borne mist entered the chamber at the rate of either 45 or 46.5 liters per minute and was diluted and mixed with an uncontaminated supplementary supply of air which entered at the same site at the rate of 28.2 liters per minute.

Each group of animals consisted of 1 cat, 2 guinea pigs, 2 rabbits and 4 rats.

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Sampling and Analysis of Contaminated Air. In each experiment 2 or 3 samples of air were drawn from the chamber, at the rate of 1 liter per minute for 5 minutes, through 2 absorption towers (2.25" x 13" outside diameter), each containing 100 ml of purified hexane. The sample passed through a fritted-glass disc in the first absorber and an impinger in the second.

The content of Pydraul F-9 in the air so collected was determined by measuring, by means of a Beckman spectrophotometer, the ability of the solution to transmit ultraviolet radiations of wave-length 246 mμ. A curve relating the transmission at 246 mμ of known concentrations of Pydraul F-9 in hexane over the range of 4.7 to 71 micrograms per ml was shown in Figure 5 of the report of March 11, 1953.

Experimental Results

The fate of each animal exposed to air laden with a mist of Pydraul F-9 in 5 experiments is shown in Tables 1 to 5, and the data are summarized in Table 6.

Experiment No. 1 (4.0 hours, 0.45 mg/l). The cat, rabbits and rats survived throughout and following their exposure for 4 hours to air bearing a mist of Pydraul F-9 in the concentration of 0.45 mg per liter (Tables 1 and 6), but both guinea pigs died on the 13th and 22nd days, respectively, after that on which they had been exposed. Except for salivation by the cat and dyspnea on the part

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of the guinea pigs, no signs of intoxication were observed. The fur of the animals was moist, but no irritation of the eyes was observed. The 2 guinea pigs lost 25 and 31 per cent of their initial weight, respectively, but only transitory losses in weight occurred among the remaining animals (Table 1).

On microscopic examination of the tissues of the guinea pigs, which died in the second and third weeks, respectively, after their last period of exposure, nonspecific toxic changes were found, consisting in severe diffuse degeneration of the brain, liver and kidneys, and pulmonary hyperemia. The cat and one of the rabbits showed similar changes in slight to moderate degree, but the viscera of one of the rats were normal except for slight inflammatory lesions of the lung and kidneys which resulted from intercurrent infection.

Experiment No. 3 (2.0 hours, 0.45 mg/l). One cat, 1 guinea pig, 2 rabbits and 4 rats, which were exposed for 2 hours to air laden with a mist of Pydraul in the concentration of 0.45 mg per liter, survived during and after the period of exposure, but the other guinea pig died 39 days later (Tables 2 and 6). The signs of intoxication were similar to those mentioned previously. Losses in weight on the part of all of the animals, except the guinea pigs, were negligible. The surviving guinea pig had not recovered its initial weight completely, in 52 days after the period of exposure.

The tissues of 1 rat and 1 guinea pig that survived were normal, as were those of the cat, except for slight fatty change in the liver.

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One of the 2 rabbits had lesions of infectious origin in the brain, heart and kidneys. The guinea pig that died after a delay of 39 days, had diffuse degeneration of the brain, liver and kidneys, slight pulmonary edema and hyperemia of the other viscera.

Experiment No. 5 (3.25 hours, 0.21 mg/l). All members of this group of animals, with the exception of 1 guinea pig, survived during and following exposure for an initial period of 2.25 hours to air bearing Pydraul F-9 in the concentration of 0.21 mg per liter, and an additional period of 1 hour, continuous with the initial period, during which the concentration was 0.105 mg per liter of that (Tables 3 and 6). The cat exhibited some excess of salivation, and one of the guinea pigs developed labored respiration, but no other signs of intoxication were observed. Except for the one guinea pig which died on the 17th day after that of the exposure, the losses in weight on the part of the animals were small and transitory.

When the surviving animals were killed for examination, the tissues of the cat, 1 rabbit and 2 of the rats were found to be normal. The guinea pig that died was found to have multiple pulmonary abscesses, in association with degenerative changes in the other viscera. The other guinea pig had inflammatory (infectious) lesions of minor consequence in the lungs and also in the kidneys.

Experiment No. 4 (1.0 hour, 0.26 mg/l). All of the animals of a group composed of 1 cat, 2 guinea pigs, 2 rabbits and 4 rats survived, without any signs of intoxication, during and following their

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exposure for 1 hour to air containing a mist of Pydraul F-9 in the concentration of 0.26 mg per liter (Tables 4 and 6). The losses in weight sustained by the animals were small and transitory.

When those animals were killed for examination, their tissues were found to be essentially normal, their being a scattering of minor inflammatory (infectious) lesions in certain of their viscera.

Experiment No. 2 (0.5 hour, 0.26 mg/l). All of the animals of another group (1 cat, 2 guinea pigs, 2 rabbits and 4 rats) survived throughout and after exposure for 0.5 hour to the mist of Pydraul F-9 in the concentration of 0.26 mg per liter. Their losses in weight were negligible.

The cat and 1 guinea pig, when killed on the 8th day after that of the exposure, were found to have slight fatty changes in the liver, but their remaining viscera were normal. One rabbit and 1 rat had extensive infectious lesions of low grade in brain, heart, liver and kidneys.

Discussion

Houghto-Safe 271, as determined in terms of its glycol content by the method of Bricker and Roberts (Anal. Chem. 21:1331, 1949), was found to be present for a few minutes in the concentration of 50 micrograms per liter at the "blow-off" sight gauge in the pump room of the U.S.S. Lake Champlain, in which Houghto-Safe 271 was being used as a hydraulic fluid in the catapult and elevator systems.

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Ordinarily the concentrations of the Houghto-Safe 271 on the carrier were many times less than that found at the "blow-off" site.

In the foregoing experiments animals have been subjected to exposure for more than 3 hours to concentrations of Pydraul F-9 which were several times higher than the highest concentration of Houghto-Safe 271 which occurred (for a few minutes) in the pump room of the U.S.S. Lake Champlain. The essentially harmless effects of such experimental exposure to Pydraul speak for themselves.

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Table 1

The Mortality, Length of Survival, and Changes in Weight of Animals Exposed to the Mist of Pydraul in Air

(Experiment No. 1)

Concentration (mg/l)	Duration of Exposure (hours)	Identification Number	Initial Weight (kg)	Changes in Weight Expressed As Percentage of Initial Weight		Fate	Length of Survival After Exposure
				Loss Resulting from Exposure	Subsequent Gain		
0.45	4.0	Cat A-568	2.920	0.0	8.8	Survived	Killed 9 days
		Guinea Pig B-866	0.844	31.2	-	Died	22 days
		Guinea Pig B-867	0.725	25.5	-	Died	13 days
		Rabbit J-942	3.292	0.7	3.2	Survived	Killed 9 days
		Rabbit J-943	3.064	2.9	4.7	Survived	Killed 9 days
		Rat N-297	0.259	5.4	11.6	Survived	Killed 9 days
		Rat N-298	0.224	3.1	12.5	Survived	Killed 9 days
		Rat N-299	0.222	1.4	9.5	Survived	Killed 9 days
		Rat N-600	0.242	4.1	8.7	Survived	Killed 9 days

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Table 2

The Mortality, Length of Survival, and Changes in Weight of Animals Exposed to the Mist of Pydraul in Air

(Experiment No. 3)

Concentration (mg/l)	Duration of Exposure (hours)	Identification Number	Initial Weight (kg)	Changes in Weight Expressed As Percentage of Initial Weight		Fate	Length of Survival After Exposure
				Loss Resulting from Exposure	Subsequent Gain		
0.45	2.0	Cat A-570	2.664	0.0	12.6	Survived	Killed 8 days
		Guinea Pig B-870	0.800	13.4	6.6	Survived	Killed 52 days
		Guinea Pig B-871	0.693	34.2	-	Died	39 days
		Rabbit J-594	3.132	1.5	4.7	Survived	Killed 8 days
		Rabbit J-960	2.938	0.1	9.2	Survived	Killed 8 days
		Rat N-605	0.230	0.0	3.0	Survived	Killed 8 days
		Rat N-606	0.217	0.0	9.2	Survived	Killed 8 days
		Rat N-607	0.220	0.0	6.8	Survived	Killed 8 days
		Rat N-608	0.241	0.0	3.7	Survived	Killed 8 days

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Table 3

The Mortality, Length of Survival, and Changes in Weight of Animals Exposed to the Mist of Pydraul in Air

(Experiment No. 5)

Concentration (mg/l)	Duration of Exposure (hours)	Identification Number	Initial Weight (kg)	Changes in Weight Expressed As Percentage of Initial Weight		Fate	Length of Survival After Exposure
				Loss Resulting from Exposure	Subsequent Gain		
0.21 (1)	3.25	Cat A-583	3.214	0.0	16.3	Survived	Killed 19 days
		Guinea Pig B-916	0.692	3.9	-	Survived	Killed 19 days
		Guinea Pig B-917	0.838	15.3	-	Died (2)	17 days
		Rabbit J-1000	3.570	2.4	7.8	Survived	Killed 19 days
		Rabbit K-1	3.879	5.7	10.4	Survived	Killed 19 days
		Rat N-668	0.212	0.9	7.5	Survived	Killed 19 days
		Rat N-669	0.249	3.6	8.4	Survived	Killed 19 days
		Rat N-670	0.239	2.1	4.6	Survived	Killed 19 days
		Rat N-771	0.205	2.4	3.9	Survived	Killed 19 days

(1) During the last hour the concentration was only about 1/2 of this.

(2) Death unrelated to exposure, not tabulated elsewhere.

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Table 4

The Mortality, Length of Survival, and Changes in Weight of Animals Exposed to the Mist of Pydraul in Air

(Experiment No. 4)

Concentration (mg/l)	Duration of Exposure (hours)	Identification Number	Initial Weight (kg)	Changes in Weight Expressed As Percentage of Initial Weight		Fate	Length of Survival After Exposure
				Loss Resulting from Exposure	Subsequent Gain		
0.26	1.0	Cat A-587	3.449	1.4	8.1	Survived	Killed 15 days
		Guinea Pig B-914	0.737	0.0	8.3	Survived	Killed 15 days
		Guinea Pig B-915	0.717	0.0	6.7	Survived	Killed 15 days
		Rabbit J-998	3.686	0.0	8.5	Survived	Killed 15 days
		Rabbit J-999	3.815	0.0	2.8	Survived	Killed 15 days
		Rat N-664	0.208	1.9	10.6	Survived	Killed 15 days
		Rat N-665	0.227	4.8	9.3	Survived	Killed 15 days
		Rat N-666	0.204	4.9	6.4	Survived	Killed 15 days
		Rat N-667	0.220	2.3	8.6	Survived	Killed 15 days

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Table 5

The Mortality, Length of Survival, and Changes in Weight of Animals Exposed to the Mist of Pydraul in Air

(Experiment No. 2)

Concentration (mg/l)	Duration of Exposure (hours)	Identification Number	Initial Weight (kg)	Changes in Weight Expressed As Percentage of Initial Weight		Fate	Length of Survival After Exposure
				Loss Resulting from Exposure	Subsequent Gain		
0.26	0.5	Cat A-569	3.337	0.0	4.3	Survived	Killed 8 days
		Guinea Pig B-868	0.800	0.0	3.8	Survived	Killed 8 days
		Guinea Pig B-869	0.788	0.0	16.1	Survived	Killed 8 days
		Rabbit J-961	2.374	0.0	7.6	Survived	Killed 8 days
		Rabbit J-962	2.772	0.0	2.1	Survived	Killed 8 days
		Rat N-601	0.244	2.9	5.3	Survived	Killed 8 days
		Rat N-602	0.220	2.3	6.8	Survived	Killed 8 days
		Rat N-603	0.260	0.8	3.5	Survived	Killed 8 days
		Rat N-604	0.226	0.4	4.9	Survived	Killed 8 days

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Table 6

Conditions of Formation of Mist of Pydraul and Summary of Data As to the Fate of Animals Exposed to the Mist

Experiment Number	Amount of Pydraul Aspirated (mg/min)	Gauge Pressure (psi)	Rate of Passage of Air Through Aspirator (converted to room conditions) (l/min)	Concentration of Pydraul Found in Chamber (mg/l)	Duration of Exposure (hours)	Number of Fatalities/Number of Animals Exposed			
						Cats	Guinea Pigs	Rabbits	Rats
1	67.5	29	30.9	0.45	4.0	0/1	2/2	0/2	0/4
3	70.0	29	30.9	0.45	2.0	0/1	1/2	0/2	0/4
5	56.0	24	45.0 (1)	0.21 (2)	3.25	0/1	0/1	0/2	0/4
4	61.6	27	46.5 (1)	0.26	1.0	0/1	0/2	0/2	0/4
2	51.7	29	30.9	0.26	0.5	0/1	0/2	0/2	0/4

(1) An additional supplementary supply of air (28.2 l/min) was passed through the chamber.

(2) During the last hour the concentration was only about 1/2 of this.

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The Toxicity of the Vapors of Aroclor 1242® and Aroclor 1254®

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INVESTIGATION of the physiological response of animals to the inhalation of two Aroclors, namely 1242 and 1254,® was undertaken because in the earlier literature[1] dealing with the toxic effects of Aroclors, no distinction has been drawn between the toxic effects of chlorinated biphenyls and those of chlorinated naphthalenes, despite the differences in the chemical composition, physical characteristics, and industrial applications of these classes of compounds. In the case of the chlorinated biphenyls, at least, further toxicological investigation and consideration were required to demonstrate the relationship between the extent of their chlorination and their toxicity.

Properties

AROCLOR 1242 is a light, straw-colored, mobile liquid. According to Benignus, of Monsanto Chemical Company, it contains 42.0 ± 0.5% of chlorine, an amount which corresponds to a chlorinated biphenyl with three chlorine atoms in unassigned positions. The physical and chemical properties are given in Monsanto Application Bulletin No. O-P-115. Its specific gravity at 25°/25°C is 1.378 to 1.388; it has a distillation range of 325° to 360°C; a refractive index (D-line at 20°C) of 1.627 to 1.629; a Saybolt Universal viscosity at 100°F of 80 to 93 seconds, and a flash point (Cleveland Open Cup) of 176°-180°C. Its vapor pressure is about 4 mm at 150°C and about 30 mm at 200°C. Although insoluble in water and glycerine, it is soluble in most organic substances. At 745 mm of mercury and 25°C, the concentration of 1 mg of the vapor of Aroclor 1242 per liter of air is equivalent to 96.9 ppm by volume.

Aroclor 1254, which corresponds to pentachlorobiphenyl, is a light, straw-colored, viscous liquid. The positions of the chlorine atoms have not been established. The molecular weight of pentachlorobiphenyl is 326.445, of which 54.3% is chlorine. Benignus has reported that Aroclor 1254 contains 55.0 ± 0.5% of chlorine. Bulletin No. O-P-115 describes Aroclor 1254 as having a specific gravity at 25°/25°C of 1.538 to 1.548; a distillation range of 365° to 390°C, a refractive index (D-line at 20°C) of 1.639 to 1.641, and a Saybolt Universal viscosity at 100° F of 1,800 to 2,500 seconds. The vapor pressure at 150°C is about 1.3 mm, and at 200°C is about 9 mm. The material is soluble in most organic substances, but it is insoluble in water and glycerine. At 745 mm of mercury and 25°C the concentration of 1 mg of Aroclor 1254 per liter is equivalent to 76.5 ppm by volume.

Experimental Method

EXPOSURE TO THE VAPOR: In a preliminary experiment (No. 1) with the vapor of Aroclor 1242, a group of animals was confined for seven hours on each of five days per week in a rectangular plywood chamber (volume 600 liters), of which the inner metal lining was coated with a baked chemically resistant plastic, through which was passed a stream of air laden with Aroclor 1242 in a known concentration. The stream of air, conditioned with respect to temperature (75° ± 3°F inside the chamber), dust and humidity, entered the chamber through an "Anemostat," located at the center of its top, at the rate of 500 liters per minute, as measured by an inclined manometer attached

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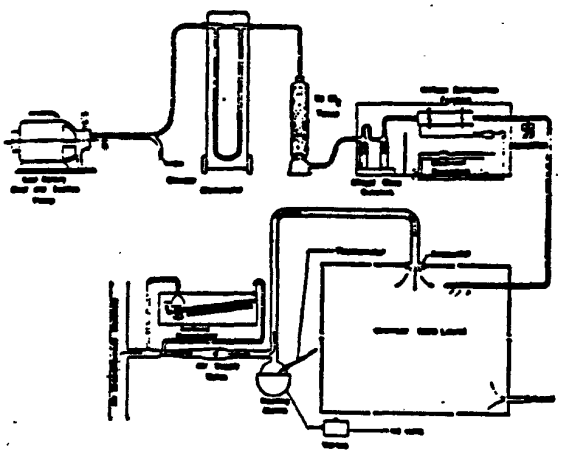


Fig. 1.
Schematic diagram of equipment for volatilizing Aroclor, chamber, and equipment for combustion and collection of samples.

to a venturimeter (Fig. 1). The air was withdrawn by suction from the chamber through an exit tube located on the rear wall near the floor, equidistant from the sides.

Aroclor 1242 was volatilized from a heated glass well maintained at 132° to 138°C. The air passed over the surface of the liquid before entering the chamber (Fig. 1).

In a second similar experiment performed on the same Aroclor (No. 2), the temperature of the liquid was kept at 100° to 105°C.

While the second experiment with Aroclor 1242 was in progress, an experiment involving the vapor of Aroclor 1254 (No. 1) was carried out in a second chamber similar to the first except for the absence of a plastic inner lining. The rate at which air flowed over liquid Aroclor 1254, which was maintained at 130° to 135°C, was 400 liters per minute.

In order to accustom the animals to the experimental procedure, they were kept in their respective chambers for seven hours on each of four consecutive days during the week prior to the introduction of the Aroclor vapor into the chamber. For purposes of control (No. 1), a third group of animals was confined, throughout a like period before and during the period of the exposure to the Aroclors, in another chamber supplied only with conditioned air.

A second set of experiments with each of the Aroclors at lower concentrations was conducted in the same chambers. In the third experiment with Aroclor 1242, which was heated to 55° to 60°C, the air passed over the liquid at the rate of 800 liters per minute. In the second experiment with Aroclor 1254, the liquid was maintained between 115° and 125°C while 700 liters of air per minute passed over its surface before entering the chamber. The animals exposed in each of these experiments, as well as a second group of controls, were confined in separate 600 liter chambers during a seven hour period on each of five days per week during the week preceding the initial exposure of the test animals to the vapor of the respective Aroclors.

In all experiments, the period of exposure or confinement (controls) was seven hours per day on five days per week for several weeks. In all instances, the original group consisted of one cat, six guinea pigs, ten mice, four rabbits, and ten rats. Among both the experimental and control groups, several animals died from extraneous causes during the course of these experiments and were replaced very soon thereafter. In the second experiment with Aroclor 1242, in the first experiment with Aroclor 1254, and in the comparable group of controls, representative animals were killed throughout the experiment.

METHOD FOR THE DETERMINATION OF THE AROCLORS IN AIR: These materials were determined quantitatively by virtue of the fact that, on thermal decomposition, they yield hydrochloric acid which with silver nitrate, forms a suspension, the density of which could be measured by means of the Beckman spectrophotometer at 500 mμ.

On each day, two samples of air from each chamber were collected by passing air at the rate of one liter per minute (for 15 minutes in the case of the higher concentrations and for 45 minutes in case of the lower concentrations) through a fused silica combus-

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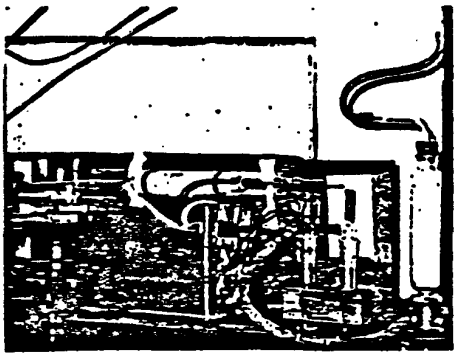


Fig. 2.
Humidifier, furnace, and sampling towers.

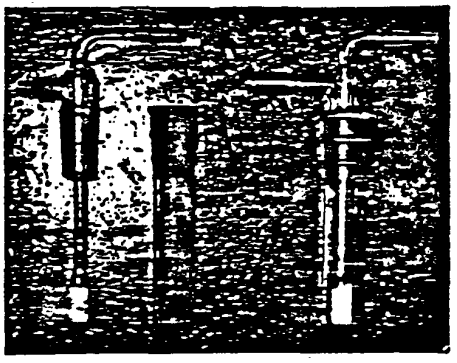


Fig. 3.
Sampling towers. (Midget Bubblers)

tion furnace, and then through two midget bubblers, in series, each containing 10 ml of 0.1 N sodium hydroxide. A quartz tube (13 mm outside diameter, 7 mm inside diameter and 16.25 inches in length) contained several strips of folded platinum foil. The middle nine inches of the tube were wrapped with a heating unit. The heating unit of the furnace (Fig. 2) consisted of 20 feet of B. and S., gauge 22, nichrome wire (1 ohm per foot), and was covered with asbestos cement. The sample of air was humidified by a cotton wick saturated with water placed 0.5 inch upstream from the quartz tube. With the furnace maintained at 850°C, the Aroclor was decomposed in the presence of H_2O to form HCl; this was absorbed in 0.1 N sodium hydroxide in midget bubblers (Fig. 3) equipped with fritted-glass bubblers (Mine Safety Appliance Company No. 43867).

The 0.1 N sodium hydroxide was prepared by dissolving 4.0 g of pellets (ACS specifications 0.01% Cl) in about 50 ml of double-distilled water. To this were added 10 g of arsenic trioxide (chloride-free) dissolved in water and filtered through Whatman No. 42 filter paper. The combined solutions were diluted to 1,000 milliliters.

The sample was transferred to a 25 ml graduated cylinder to which one drop of a solution of phenolphthalein was added (1 g of phenolphthalein dissolved in 100 ml of CP methanol). The solution was neutralized with 3N nitric acid (190 ml CP concentrated nitric acid diluted to 1,000 ml with double-distilled water) and diluted to 23 ml with double-distilled water. One ml of 3N nitric acid was added to obtain a pH of 1. After adding 1 ml of a solution of silver nitrate (3 g of $AgNO_3$ diluted to 1,000 ml with double-distilled water), the suspension was mixed by inversion. After standing 30 minutes, the transmission of wave-length 500 mμ was measured in a 50 cm cell by means of a Beckman spectrophotometer which was set against a corresponding cell containing a reagent blank.

The amount of Aroclor was estimated by means of a standardized curve prepared from known quantities of sodium chloride. A curve presenting the transmission values at 500 mμ of suspensions prepared from sodium chloride ranging from 5.0 to 120 micrograms per 25 ml of final suspension is shown in Fig. 4. On the basis of 42.0% of chlorine in Aroclor 1242 and 55.0% in Aroclor 1254, one microgram of sodium chloride is equivalent to 1.442 micrograms of Aroclor 1242 or to 1.1028 micrograms of Aroclor 1254.

Experimental Results

MORTALITY—AROCLOR 1242: No signs of intoxication were observed in any of the members of a group of 31 animals (Experiment No. 1), all of which survived throughout a period of 24 days, on 17 of which they were subjected to the inhalation of air bearing 8.6 micrograms of Aroclor 1242 per liter (0.83 ppm) for seven hours (Table I).

One cat, four guinea pigs, six mice, two rabbits, and eight rats survived without

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signs of intoxication throughout their exposure (Experiment No. 2) for seven hours on each of 82 days over a period of 120 days to air bearing the vapor of Aroclor 1242 in the concentration of 6.83 micrograms per liter (0.66 ppm). Certain other survivors (two guinea pigs, three mice, one rabbit, and two rats) were subjected to fewer periods of exposure (cf. Table I). The deaths from extraneous causes among the exposed animals were fewer than those which occurred among the corresponding group of controls (No. 1, Table I). One cat, three mice, three guinea pigs, three rabbits, and eight rats survived following confinement for seven hours on 84 days over a period of 122 days, in a chamber in which the air, conditioned with respect to dust, humidity and temperature, contained no vapor of either Aroclor. Ten more survivors (three guinea pigs, four mice, one rabbit, and two rats) were subjected to fewer periods of confinement (cf. Table I).

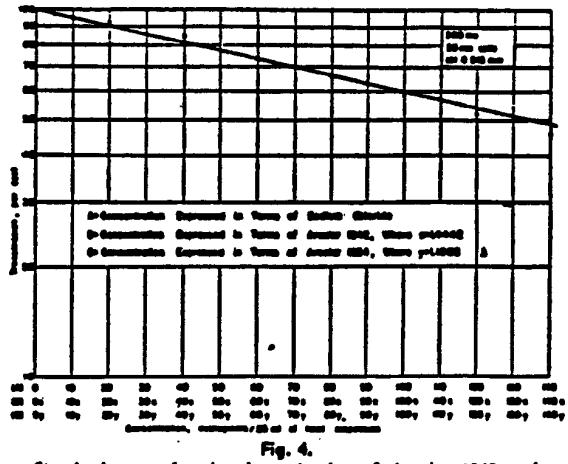


Fig. 4.
Standard curve for the determination of Aroclor 1242 and Aroclor 1254.

In another experiment (No. 3, Table I-A) in which animals were exposed to air bearing Aroclor 1242 in the concentration of 1.9 micrograms per liter (0.18 ppm) for seven hours per day on 150 days over a period of 214 days, the incidence of mortality among

TABLE I.
SUMMARY OF DATA ON MORTALITY AMONG ANIMALS EXPOSED TO THE VAPOR OF AROCLOR 1242 OR AROCLOR 1254 IN AIR
(Higher concentrations)

Material	Concentration γ/l	Concentration ppm	Duration of Exposure (hours)	Number of Animals that Survived: Cats	Guinea Pigs	Mice	Rabbits	Rats	Expt. No.
Aroclor 1242	5.60	0.53	17 × 7	1	6	10	4	10	1
Aroclor 1242	6.83	0.66	82 × 7	1	6[1,1]	9[1,2,2]	3[2]	10[2,2]	2
Aroclor 1254	5.40	0.41	82 × 7	1	6[1,1,1]	10[2,4]	4[1,2]	10[2]	1
Control	0	0	84 × 7	1	6[1,1,4]	7[1,3]	4[2]	10[1,2]	1

[1]One of the animals was exposed on only 65 to 77 days
[2]One of the animals was exposed on only 41 to 58 days
[3]One of the animals was exposed on only 20 to 23 days
[4]Five of the mice were exposed on only 74 days
[5]Three of the mice were exposed on only 14 to 18 days
[6]One of the rabbits was exposed on only 19 days

TABLE I-A.
SUMMARY OF DATA ON MORTALITY AMONG ANIMALS EXPOSED TO THE VAPOR OF AROCLOR 1242 OR AROCLOR 1254 IN AIR
(Lower concentrations)

Material	Concentration γ/l	Concentration ppm	Duration of Exposure (hours)	Number of Animals that Survived: Cats	Guinea Pigs	Mice	Rabbits	Rats	Expt. No.
Aroclor 1242	1.90	0.18	150 × 7	1	6[2]	8[2,3]	3[1,1,3]	10[2]	3
Aroclor 1254	1.50	0.11	150 × 7	1	7[1,2,3]	10[2,2,2,3]	4	11[2]	2
Control	0	0	150 × 7	1	6[2]	10[1,2,2,2,2,3]	5[1,2,3]	10[2]	3

[1]One of the animals was exposed on only 26 to 37 days
[2]One of the animals was exposed on only 41 to 55 days
[3]One of the animals was exposed on only 130 to 139 days
[4]One of the animals was exposed on only 5 to 13 days
[5]One of the animals was exposed on only 107 to 120 days
[6]One mouse was exposed on only 66 days

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the various species, with the exception of the rabbits (which died during an epidemic of pneumonia), was no greater than that encountered among a similarly constituted control group (Experiment No. 2, Table I-A).

One cat, five guinea pigs, six mice and nine rats survived throughout the entire period of their subjection to the vapor of Aroclor 1242. Seven additional survivors (one guinea pig, two mice, three rabbits, and one rat) were exposed intermittently to the vapor of Aroclor 1242 over a shorter period of time (cf. Table I-A). Among the group of controls (Experiment No. 2, Table I-A), one cat, five guinea pigs, four mice, two rabbits, and nine rats survived throughout the entire period of confinement, for seven hours on each of 150 days over 213 days in a chamber supplied with conditioned air. Eleven other control animals (one guinea pig, six mice, three rabbits, and one rat) survived during a shorter total period of intermittent confinement (Table I-A). No signs of intoxication were observed among experimental or control animals.

MORTALITY—AROCLOR 1254: One cat, three guinea pigs, four mice, two rabbits, and nine rats survived throughout their exposure, for seven hours on each of 83 days over a period of 121 days, to air containing Aroclor 1254 in the concentration of 5.40 micrograms per liter (0.41 ppm). Certain other animals (three guinea pigs, six mice, two rabbits, and one rat) were killed for examination after 33 to 74 periods of exposure (Table I). The incidence of mortality from extraneous causes among the exposed and control animals (Experiment No. 1), with the exception of the rabbits, was comparable (Table I).

One cat, four guinea pigs, six mice, four rabbits, and 10 rats survived (Experiment 2, Table I-A) following their exposure for seven hours on each of 150 days over a period of 213 days to air containing Aroclor 1254 in the concentration of 1.5 micrograms per liter, (0.11 ppm). Eight other animals (three guinea pigs, four mice, and one rat) survived through 30 to 139 periods of exposure. The incidence of fatalities among the exposed group was slightly less than that encountered among the controls (Experiment 2, Table I-A).

TABLE II.
THE AVERAGE CHANGES IN WEIGHT OF EXPERIMENTAL AND CONTROL ANIMALS
(Higher concentrations)

Species of Animal	Number of Animals	Average Initial Weight (kg)	Average Change in Weight Expressed as Percentage of Initial Weight
Aroclor 1242 - 5.60 γ/l - Experiment No. 1			
Cat	1	2.963	+ 2.1
Guinea Pig	6	0.549	− 2.0
Mouse	10	0.024	+ 9.1
Rabbit	4	2.961	+ 7.7
Rat	10	0.328	+ 2.1
Aroclor 1242 - 6.83 γ/l - Experiment No. 2			
Cat	1	2.271	+22.2
Guinea Pig	6	0.404	+56.4
Mouse	9	0.021	+21.2
Rabbit	5	2.587	+56.5
Rat	10	0.212	+17.6
Aroclor 1254 - 5.40 γ/l - Experiment No. 1			
Cat	1	2.320	+22.1
Guinea Pig	6	0.409	+40.7
Mouse	10	0.021	+22.9
Rabbit	4	2.722	+39.7
Rat	10	0.227	+ 6.9
Conditioned Air - Controls - Experiment No. 1			
Cat	1	2.382	+ 6.6
Guinea Pig	6	0.418	+44.6
Mouse	7	0.022	+17.4
Rabbit	4	2.764	+44.5
Rat	10	0.211	+16.4

TABLE II-A.
THE AVERAGE CHANGES IN WEIGHT OF THE SURVIVORS AMONG THE ORIGINAL GROUPS
(Lower Concentrations)

Species of Animal	Number of Animals	Average Initial Weight (kg)	Average Change in Weight Expressed as Percentage of Initial Weight	P
Aroclor 1242 - 1.9 γ/l - Experiment No. 3				
Cat	1	1.730	+115.0	—
Guinea Pig	5	0.514	+ 42.1	< 0.05
Mouse	6	0.0228	+ 21.5	< 0.05
Rat	9	0.214	+ 39.9	< 0.05
Aroclor 1254 - 1.5 γ/l - Experiment No. 2				
Cat	1	2.288	+ 15.2	—
Guinea Pig	6	0.487	+ 32.5	< 0.05
Mouse	6	0.0243	+ 17.0	< 0.05
Rabbit	4	2.958	+ 44.4	< 0.05
Rat	10	0.222	+ 22.7	< 0.05
Conditioned Air - Controls - Experiment No. 3				
Cat	1	2.329	− 7.2	—
Guinea Pig	6	0.500	+ 54.7	—
Mouse	6	0.0257	+ 12.5	—
Rabbit	4[1]	2.622	+ 52.5	—
Rat	9	0.218	+ 22.7	—

[1]Includes two early replacements.

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No general or specific signs of intoxication were noted among the experimental animals during or after their exposure.

GROWTH: The pertinent data relating to the changes in weight of the animals of the various groups are presented in Table II and II-A.

Although comparable controls were not weighed during the first experiment with Aroclor 1242 (17 x 7.0 hrs.—8.60 micrograms per liter) all of the animals, except the guinea pigs, appeared to gain normally in weight during the period of exposure. Despite a small net loss by the guinea pigs in this experiment, they were actually gaining weight at the termination of the period of exposure.

The animals exposed to the vapor of Aroclor 1242 in the concentration of 6.83 micrograms per liter (Experiment No. 2) or to Aroclor 1254 in the concentration of 5.40 micrograms per liter (Experiment No. 1), with the exception of the guinea pigs that were exposed to the vapor of Aroclor 1254, grew equally as well as the controls (Experiment No. 1, Table II).

The growth of the surviving experimental animals in the groups initially exposed to the lower concentrations of the vapor of Aroclor 1242 (Experiment No. 3, 1.9 micrograms per liter) and Aroclor 1254 (Experiment No. 2, 1.5 micrograms per liter) was unaffected. No significant differences in the average change in weight of the experimental and the control groups were found by the use of the "t" test (Table II-A).

WEIGHT OF LIVER AND KIDNEYS: The weights of the livers and kidneys and the relationships of their weights to the body weights (expressed as grams per 100 grams of body weight) of the animals that survived following exposure to the vapor of Aroclor 1242 in the concentration of 6.83 micrograms per liter, are shown in Table III, which also gives the corresponding data on the controls. Comparison by the "F" test of the variances of the ratios of the livers or kidneys to the body weights of rats, guinea pigs and rabbits exposed to the vapor of Aroclor 1242 (6.83 micrograms/liter), with those of the controls, revealed no significant differences ($P>0.05$) except in the case of the livers of the rats. Application of the "t" test to the mean values (Table III) revealed no significant differences between the test and control groups of guinea pigs, rats, and rabbits.

Comparable values for rats, guinea pigs and rabbits exposed to Aroclor 1254 in the concentration of 5.40 micrograms per liter

TABLE III.

SUMMARY OF THE DATA ON THE RELATIONSHIP OF THE WEIGHT OF THE LIVER OR THE KIDNEYS TO THE BODY WEIGHT OF ANIMALS EXPOSED TO THE VAPOR OF AROCLOR 1242 OR AROCLOR 1254

Aroclor 1242 - 6.83 γ/l - 82 ± 7 hrs.
Aroclor 1254 - 5.40 γ/l - 83 ± 7 hrs.
Controls - 0 γ/l - 84 ± 7 hrs.

Compound	Organ	Species of Animal	n	Average Organ Weight (g)	Average Body Weight (g)	Ratio of Weight of Organ x 100 to Body Weight	t	P
Aroclor 1242	Liver	Rat	9	11.2	240	4.64	1.2281	0.20-0.30
Aroclor 1242	Liver	Guinea Pig	6	25.8	640	4.68	0.4291	>0.50
Aroclor 1242	Liver	Rabbit	3	122.0	4,023	2.94	1.5085	0.10-0.20
Aroclor 1254	Liver	Rat	10	12.8	239	5.34	3.3992	<0.01
Aroclor 1254	Liver	Guinea Pig	6	25.9	581	4.51	0.0000	>0.50
Aroclor 1254	Liver	Rabbit	4	120.0	2,537	2.53	1.0122	>0.50
Aroclor 1242	Kidneys	Rat	9	1.55	240	0.773	0.5542	>0.50
Aroclor 1242	Kidneys	Guinea Pig	6	5.0	640	0.805	0.7257	0.40-0.50
Aroclor 1242	Kidneys	Rabbit	3	18.6	4,023	0.468	0.4177	>0.50
Aroclor 1254	Kidneys	Rat	10	2.1	239	0.778	0.4198	>0.50
Aroclor 1254	Kidneys	Guinea Pig	6	4.6	581	0.806	0.5411	>0.50
Aroclor 1254	Kidneys	Rabbit	4	15.8	2,537	0.464	0.3168	>0.50
Control	Liver	Rat	10	9.8	242	4.18	—	—
Control	Liver	Guinea Pig	6	20.3	286	4.51	—	—
Control	Liver	Rabbit	4	102.3	3,993	2.61	—	—
Control	Kidneys	Rat	10	2.0	242	0.807	—	—
Control	Kidneys	Guinea Pig	6	4.8	666	0.721	—	—
Control	Kidneys	Rabbit	4	19.5	2,993	0.504	—	—

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are also given in Table III. Application of the "t" test to the differences in the mean values which characterized the experimental and control animals (Table III) shows that the weights of the livers of the exposed rats were significantly greater than those of the controls, the ratio of the liver to the body weight of the former being 5.34 g per 100 g of body weight, that of the latter being 4.15 g per 100 grams. In all other instances tested (livers and kidneys of both guinea pigs and rabbits and kidneys of rats) the differences were statistically insignificant.

The organs of the animals exposed to the lesser concentrations of the vapor of the Aroclors were not examined in this manner because of the borderline character of the results associated with the higher concentrations.

LIVER FUNCTION: Data were obtained as to the apparent prothrombin activity of the blood (measured by the method of Kato[3]) of certain animals that had been exposed (1) to the vapor of Aroclor 1242, in the concentration of 6.83 micrograms per liter; (2) to the vapor of Aroclor 1254 in the concentration of 5.40 micrograms per liter; and (3) to conditioned air alone. In Table IV the percentile relationships of the clotting power have been calculated arbitrarily by dividing 100 times the average clotting time of the blood of the control animals by the clotting time of the blood of the experimental animals on the same day. No diminution in the clotting power of the blood, as a measure of the impairment of the function of the liver, was induced by the exposure of the animals to the vapor of Aroclor 1242 in air in the concentration of 6.83 micrograms per liter, or to the vapor of Aroclor 1254 in the concentration of 5.40 micrograms per liter.

This functional test was not applied to animals subjected to the lower concentrations, because of the negative results obtained when the animals were subjected to the higher concentrations.

HEMATOLOGICAL RESULTS: Determina-

TABLE IV.

THE EFFECT OF EXPOSURE TO THE VAPOR OF AROCLOR 1242 OR AROCLOR 1254 IN AIR FOR SEVEN HOURS PER DAY ON FIVE DAYS PER WEEK OVER A PERIOD OF SEVERAL MONTHS UPON THE APPARENT PROTHROMBIN CONTENT OF THE BLOOD OF CATS AND RABBITS

Relation of "Prothrombin Time" of Control and Exposed Animals Expressed Arbitrarily in Terms of Percentage Change in Clotting Time of Blood 100 x Clotting Time of Blood of Control Animals / Clotting Time of Blood of Exposed Animals		Time of Sampling in Relation to Period of Exposure: Days Before First Period	Time of Sampling in Relation to Period of Exposure: Serial Number of Period After Which Blood Was Drawn
Aroclor 1242 - 6.83 γ/l - Experiment No. 2			
Cat A-448	Rabbits (Average)		
100.0	89.6	3	
90.3	92.5	2	
112.6	106.1		10
101.5	99.0		30
97.4	96.8		45
116.2	108.7		59
	101.5		82
	100.0		1
Aroclor 1254 - 5.40 γ/l - Experiment No. 1			
Cat A-446	Rabbits (Average)		
100.0	97.1	3	
100.0	96.9	2	
	81.5		3
98.5	90.0		10
	99.6		15
113.6	102.0		30
	112.1		32
101.5	97.0		45
92.5	96.4		59
90.0	96.2		82
	100.0		1

[1]Determination made 15 days after 32nd period of exposure.
[2]Determination made 14 days after 33rd period of exposure.

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TABLE V.

THE AVERAGE NUMBERS OF ERYTHROCYTES AND LEUCOCYTES AND THE AVERAGE CONCENTRATION OF HEMOGLOBIN IN THE PERIPHERAL BLOOD OF EXPERIMENTAL AND CONTROL ANIMALS

Compound	Concentration (γ/l)	Experiment Number	Species of Animal	Erythrocytes: (Thousands) per mm³	Leucocytes: per mm³	Hemoglobin: g/100 ml
Aroclor 1242	6.83	2	Guinea Pig	5,781	10,112[1]	14.4[1]
			Rabbit	4,068	9,755	12.1
Aroclor 1254	5.40	1	Guinea Pig	5,886	12,927	14.5[2]
			Rabbit	6,486[2]	10,811	12.2
Controls	0	1	Guinea Pig	5,729	12,124	12.9
			Rabbit	5,909	11,890	12.2

[1]Value significantly less than that yielded by controls.
[2]Value significantly greater than that yielded by controls.

tions of the numbers of erythrocytes and leucocytes and of the hemoglobin content in the peripheral blood of the guinea pigs and rabbits subjected to inhalation of the vapor of Aroclor 1242 in the concentration of 6.83 micrograms per liter, are given in Table V, which also includes comparable results on control animals. Application of the "t" test to differences in the mean values for the experimental and control animals yielded borderline evidence of significant differences in the number of leucocytes and in the concentration of the hemoglobin in the blood of the guinea pigs. These differences were small and of opposite sign (the numbers of leucocytes in the blood of the test animals were low, while the hemoglobin content was high), as well as being subject to individual variations, and they cannot be regarded as of physiological significance. Somewhat comparable results were obtained when guinea pigs and rabbits were subjected to Aroclor 1254 in the concentration of 5.40 micrograms per liter. No physiological significance is attached to the slightly elevated hemoglobin content of the guinea pigs.

PATHOLOGICAL FINDINGS: In all of the experiments, animals were killed from one to 15 days after the final period of exposure.

In the first experiment with Aroclor 1242 (8.60 micrograms per liter), all of the animals were examined postmortem, and since gross examination of the viscera did not reveal any significant alterations, the tissues of only representative animals (one cat, four guinea pigs, six mice, four rabbits and six rats) were sectioned and examined microscopically. No abnormalities were found in the viscera of these animals.

In the second experiment with Aroclor 1242 (6.83 micrograms per liter), and in the first experiment with Aroclor 1254 (5.40 micrograms per liter), which were carried out simultaneously, the deaths that occurred among the test and control animals were the apparent result of an appreciable incidence of pneumonia. The lesions of certain of the animals were those of frank pneumonia; in others such lesions were not fully developed. Degenerative changes in the viscera were usually found, in varying degrees of severity, in association with the pneumonia, but in certain animals, test and control alike, the degenerative changes were more evident than the pneumonia. The similarity of the lesions in test and control animals, and the lack of characteristic evidence of chemical pneumonitis, led to the reasonable, but not altogether certain, conclusion that all of these fatalities resulted from intercurrent disease among the animals, and not from the effects of their exposure to the Aroclors. For practical purposes, this conclusion was subjected to the critique of further experiments involving more prolonged exposure of animals to somewhat lower concentrations. Except in the case of the rats exposed to Aroclor 1254, the survivors subjected to the higher concentration of either Aroclor had normal viscera.

All of the animals exposed to the vapor of Aroclor 1242 in the concentration of 1.9 micrograms per liter were examined postmortem, and the viscera of most of them were examined microscopically. The few deaths among the exposed group were attributed to incidental infectious pulmonary disease. All exposed survivors, except two rabbits that had hepatic lesions of coccidiosis, had normal viscera. The control animals (Experiment No. 2) that died were found to have had pneumonia. Of those that sur-

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vived, one rat, two guinea pigs, and one mouse had focal or diffuse cytoplasmic vacuolation of the hepatic cells. The remaining control animals had normal viscera.

All of the animals exposed to the vapor of Aroclor 1254 in the concentration of 1.5 micrograms per liter were examined postmortem, and the viscera of most of them were examined microscopically. A guinea pig that died exhibited chronic pyelonephritis, pulmonary hyperemia and edema, and degenerative lesions in the brain and liver. The visceral lesions were related, no doubt, to the renal infection. The deaths of four mice were attributable to acute bronchitis and pneumonia. The viscera of the cat that survived were normal. Of the seven guinea pigs that were living when the experiment was terminated, three had normal viscera and four had slight alterations of hepatic cells characterized by cytoplasmic vacuolation. Ten mice survived, and of these six had normal viscera and four had slight degenerative changes in the liver. Four rabbits killed one to 15 days after the last period of exposure had diffuse hepatic degeneration. The character of the lesions varied from cloudy to hyaline or hydropic degeneration and included varying degrees of fatty metamorphosis. The other viscera of these animals were normal. All of the rats were examined and found to have slightly to moderately severe degenerative lesions of the liver. The lesions of greatest severity were found in the rat that was killed and examined on the first day after the last period of exposure. Two rats had chronic pyelonephritis, and the remainder had slight degeneration of the renal tubules.

Discussion: In terms of mortality, growth (except that of guinea pigs) and non-occurrence of pathological changes, the vapor of Aroclor 1242 in the concentration of 8.6 micrograms per liter (approaching saturation) appeared to be non-injurious to experimental animals subjected thereto for seven hours on each of 17 days over a period of 24 days.

Experimental animals subjected to but a slightly lower concentration of Aroclor 1242 (6.83 micrograms per liter) for seven hours per day on each of 82 days over the period of 120 days suffered no injury on the basis of any of the following criteria: mortality, growth, pathology, organ enlargement, liver function or hematological changes.

More prolonged exposure of animals to a lower concentration of Aroclor 1242, (1.9 micrograms per liter) over the period of seven months was likewise without harm in terms of growth, mortality and the absence of pathological changes.

In view of this evidence it is suggested that the tentative allowable concentration of the vapor of Aroclor 1242 should be at least two micrograms per liter (2 mg per cu meter), which is twice that recommended by the American Conference of Governmental Industrial Hygienists[3] for a chlorinated diphenyl of unstated chlorine content.

The exposure of animals to the vapor of Aroclor 1254 in the concentration of either 5.40 or 1.5 micrograms per liter failed to induce harmful effects in the form of retardation of growth (except in the case of guinea pigs exposed to the higher concentration), or of mortality, but histopathologic evidence of apparently reversible hepatic cellular injury was found in the animals. These findings cannot certainly be attributed to the effects of Aroclor 1254 because of the appreciable incidence of pneumonia among both experimental and control animals. When these nonspecific toxic changes in the viscera of the animals were associated with pneumonia, they were readily explained thereby, but they were also found in animals that had been exposed to the vapor of Aroclor 1254 and were free of pneumonia. That these may have represented toxic effects of exposure to Aroclor 1254 finds support in the fact that the livers of the exposed rats (5.40 micrograms per liter) were significantly heavier in relation to their body weight, than were those of control rats. It would appear that this material, which is reported to contain 55% of chlorine, is somewhat more toxic than is Aroclor 1242, which contains only 42% of chlorine. Therefore it is suggested that the threshold concentration of 1 mg per cu meter of air recommended tentatively for safe industrial practice by the American Conference of Governmental Industrial Hygienists[3] is reasonable.

It should be noted that it was necessary to heat these Aroclors in order to increase the rate of volatilization sufficiently to attain the concentrations maintained in these

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experiments. To the extent that their industrial usage is carried out at ordinary temperatures, the hazard of their inhalation may well be slight or entirely absent.

Summary

PROLONGED intermittent exposure of animals to the vapor of Aroclor 1242 (1.90 to 8.63 micrograms per liter) demonstrated no injury. Prolonged exposure to comparable concentrations of Aroclor 1254 resulted in reversible degenerative changes in certain viscera.

The work described in this article was sponsored by the Monsanto Chemical Company, whose financial support is gratefully acknowledged, as is also their assistance in supplying the materials for investigation.

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AFTER almost ten years of hard work on the part of a handful of interested and determined persons, the American Sanitary Engineering Inter-society Board has become a reality. The ASEIB is an incorporated organization sponsored by the American Society of Civil Engineers, the American Society for Engineering Education, the American Public Health Association, the American Water Works Association and the Federation of Sewage and Industrial Wastes Associations. The purpose of the Board is to improve the practice, elevate the standards, and advance the cause of sanitary engineering. The term "sanitary engineering" is employed in the broad sense as defined by the National Research Council, and embraces the entire concept of engineering biotechnology application for control of environmental stresses. As most readers know, this definition includes industrial hygiene, air pollution control and radiological health. The Board of Trustees of the ASEIB is made up of three representatives from each of the sponsoring bodies and three elected at large by the Board. We are happy to announce that two of the Trustees at large are industrial hygiene engineers, namely LT. COL. ALVIN F. MEYER, JR., Headquarters Strategic Air Command. and ALLEN D. BRANDT, Bethlehem Steel Company.

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SUBJECT -

July 9, 1957

Toxicological Investigation Of Aroclor 1270 Ammonia Reaction Product

TEST CONDUCTED FOR: Monsanto Chemical Company, St. Louis, Missouri

MONSANTO PROJECT NO.: Y-57-22 SAMPLE NO. 48; B-574-MEP; 360212

EXPERIMENTAL PROCEDURE -

A) Oral LD_{50} In Rats
The compound was fed by stomach tube to Sprague Dawley strain albino rats as a 25% suspension in corn oil. After the approximate Minimum Lethal Dose was found, groups of rats were fed at levels designed to blanket the toxicity range thereby supplying data for calculation of the LD_{50} which was done according to a modification of the method of Bliss. Observations were made for toxic symptoms and the viscera of selected animals from those succumbing was examined macroscopically. The data are shown in Table I.

B) Skin Irritation In Rabbits
The dry sample was applied to the clipped, intact skin of albino rabbits and observations made over a period of several days for irritation. The data based on the scoring technique of Draize, Woodard and Calvery (J. of Pharm. & Exp. Therapeutics, Vol. 82, No. 4, Dec. 1944), are given in Table II.

C) Eye Irritation In Rabbits
10 milligrams of dry sample were placed in the conjunctival sac of the right eye of each of three albino rabbits and the resulting inflammation scored according to Draize et al. The eye was washed out with warm water after 24 hours. The results are shown in Table III.

SUMMARY -

The Oral LD_{50} for rats was found to be 7.10 grams per kilogram with fiducial limits of 6.72 - 7.56 grams per kilogram.

No irritation developed when the compound was applied to intact rabbit skin.

The compound was classed as a mild eye irritant. Most of the irritation was mechanical in nature. The average maximum score in one hour was 8.6 out of a possible 110.

GBRN002534

YOUNGER LABORATORIES

BY: FRED M. YOUNGER

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EXHIBIT
K-26

TOWOLDMON0001848

[redacted]
St. Louis, Missouri
Stranger Laboratories Certificate of Analysis - Page 2 (7/9/57)

TABLE I

THE ORAL LD_{50} OF AROCLOR 1270 AMMONIA REACTION PRODUCT FOR RATS

Animal No. - Sex	Weight Gm.	Dose Gm./Kg.	Fate
1- Female	220	6.0	Survived
2- Female	195	6.0	Survived
3- Male	250	6.0	Survived
4- Female	200	6.0	Survived
5- Female	190	6.0	Survived
6- Male	225	6.6	Died
7- Male	240	6.6	Survived
8- Female	205	6.6	Died
9- Female	185	6.6	Survived
10- Female	200	6.6	Died
11- Male	215	6.6	Survived
12- Male	200	6.6	Survived
13- Male	210	7.2	Died
14- Female	190	7.2	Died
15- Female	220	7.2	Survived
16- Female	205	7.2	Survived
17- Male	230	7.2	Died
18- Male	215	7.2	Survived
19- Female	200	8.0	Died
20- Female	190	8.0	Died
21- Male	225	8.0	Died
22- Male	240	8.0	Survived
23- Male	245	8.0	Died

DISCUSSION -

The oral LD_{50} was found to be 7.10 grams per kilogram with fiducial limits of 6.72 - 7.56 grams per kilogram. Survival time was 1 - 4 days. There was severe diarrhea, partial paralysis, and irritability.

At autopsy there was liver discoloration, gastrointestinal inflammation, and moderate pulmonary hyperemia.

[redacted]

GBRN002535

TOWOLDMON0001849

TABLE II

SKIN IRRITATION IN RABBITS AFTER APPLICATION OF
'AROCLOR 1270 AMMONIA REACTION PRODUCT'

Animal No.	Numerical Evaluation At The End Of 2 Hours	24 Hours	48 Hours	72 Hours
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Average	0.0	0.0	0.0	0.0

DISCUSSION -

The compound was non irritating to intact rabbit skin when left in contact for two days. A 25% slurry in corn oil gave the same results over a 24 hour exposure period. All animals received a score of zero throughout the test.

TABLE III

EYE IRRITATION IN RABBITS AFTER APPLICATION OF
'AROCLOR 1270 AMMONIA REACTION PRODUCT'

Animal No.	1 Hours	24 Hours	48 Hours	72 Hours
1	8	4	2	0
2	10	6	4	0
3	8	4	2	0
Average	8.6	4.6	2.0	0.0

DISCUSSION -

Initial discomfort appeared to be a result of a foreign substance in the eye rather than being caused by the chemical makeup of the compound. The average score after one hour was 8.6 out of a possible 110. There was moderate redness of the palpebral conjunctivae, slight edema, and moderate lacrimation. Iris and cornea were practically unaffected. The average score overnite was 4.6. At this time the remaining compound was washed out of the eye with the result that all animals were given a score of zero in 72 hours.

The product was classed as a mild irritant with most of the irritation being mechanical in nature.

GBRN002536

TOWOLDMON0001850

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Biochemists . . . Pharmacologists . . . Analysts

5620 TELEGRAPH ROAD
ST. LOUIS 29, MISSOURI
PHONE: TILDEN 6-2540

Certificate of Analysis

June 6th, 1962

UBJECT -

Toxicological Investigation Of: .roclor 1232
Monsanto Sample Number 54
Monsanto Project Number Y-62-52

STUDY CONDUCTED FOR -

Monsanto Chemical Company, St. Louis, Missouri

COPY

EXPERIMENTAL PROCEDURE -

A) Oral LD_{50} (Rats)

The undiluted compound was fed by stomach tube to Sprague-Dawley strain albino rats.

After the approximate Minimum Lethal Dose was determined, groups of male and female rats were fed in increasing doses at increments of 0.1 fractional log intervals at four levels designed to blanket the toxicity range thereby supplying data for calculation of the LD_{50} which was done according to a modification of the method of F. J. de Beer.

Observations were made for toxic symptoms and the viscera of the animals that succumbed were examined macroscopically.

The data are shown in Table I.

B) Skin Absorption LD (Rabbits)

The undiluted compound was applied in increasing doses at increments of 0.2 fractional log intervals to the closely clipped, intact skin of New Zealand white female rabbits.

The treated areas were covered with plastic strips and the animals placed in wooden stocks for periods up to twenty-four hours, after which time they were assigned to individual cages.

Observations were made for toxic symptoms and the viscera of the animals that succumbed were examined macroscopically.

The data are shown in Table II.

EXHIBIT
K-27

GBRN002537

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SUMMARY -

Aroclor 1232

A) Oral LD_{50} (Rats)

The Oral LD_{50} for male and female rats was placed at 4470 milligrams per kilogram with lower and upper limits of 3490 to 5720 milligrams per kilogram.

The compound was classed as slightly toxic by oral ingestion in male and female rats.

B) Skin Absorption MLD (Rabbits)

The Minimum Lethal Dose by Skin Absorption in female rabbits was found to be greater than 1260 milligrams per kilogram and less than 2000 milligrams per kilogram.

The compound was classed as mildly toxic by skin absorption in female rabbits.

YOUNGER LABORATORIES

BY: FRED M. YOUNGER

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— Monsanto Chemical Company

GBRN002538

TOWOLDMON0001852

TABLE I

THE ORAL LD_{50} OF 'Aroclor 1232' FOR RATS

Sample Fed Undiluted

Animal No. - Sex	Weight Gm.	Dose Mg./Kg.	Fate
1- Female	210	3160	Survived
2- Female	200	3160	Died
3- Female	215	3160	Survived
4- Male	235	3160	Survived
5- Male	225	3160	Survived
6- Male	245	3980	Survived
7- Female	220	3980	Survived
8- Female	220	3980	Died
9- Female	210	3980	Survived
10- Male	230	3980	Died
11- Male	225	5010	Survived
12- Male	250	5010	Died
13- Female	210	5010	Survived
14- Female	220	5010	Died
15- Female	225	5010	Died
16- Male	235	6310	Died
17- Male	230	6310	Survived
18- Male	220	6310	Died
19- Female	205	6310	Died
20- Male	230	6310	Died

DISCUSSION -

The Oral L_{50} for male and female rats was placed at 4470 milligrams per kilogram with lower and upper limits of 3490 to 5720 milligrams per kilogram.

The compound was classed as slightly toxic by oral ingestion in male and female rats.

Survival time was less than twenty-four hours to four days with most deaths occurring in two days.

Toxic symptoms included sharply reduced appetite, lethargy, diarrhea, and increasing weakness.

At autopsy there was renal and liver congestion as well as inflammation of the gastric mucosa.

TOWOLDMON0001853

TABLE II

THE MINIMUM LETHAL DOSE OF 'Arcolor 1232' BY SKIN ABSORPTION IN RABBITS

Sample Applied Undiluted

Animal No. - Sex	Weight Kg.	Dose Mg./Kg.	Weight Change 5 Days Later Kg.	Fate
1 - Female	2.1	794	+ 0.1	Survived
2 - Female	2.1	1260	0.0	Survived
3 - Female	2.4	2000	- 0.3	Died — 7 Days
4 - Female	2.2	2000	- 0.4	Died — 9 Days
5 - Female	2.5	3160	- 0.5	Died — 5 Days
6 - Female	2.7	5070	-----	Died — 4 Days

DISCUSSION -

The Minimum Lethal Dose by Skin Absorption in female rabbits was found to be greater than 1260 milligrams per kilogram and less than 2000 milligrams per kilogram.

The compound was classed as mildly toxic by skin absorption in female rabbits.

Survival time was four to nine days.

Toxic symptoms included reduced appetite, gradual wasting, lethargy, and weakness after several days to the point of collapse.

At autopsy there was liver discoloration and pulmonary hyperemia macroscopically.

TOWOLDMON0001854

EST NO. Y-62-41
FILE

YOUNGER LABORATORIES

Biochemists . . . Pharmacologists . . . Analysts

5620 TELEGRAPH ROAD
ST. LOUIS 29, MISSOURI

PHONE: TILDEN 6-2540

Certificate of Analysis

June 13th, 1962

SUBJECT -

Toxicological Investigation Of: Aroclor 1221
Monsanto Sample Number 43
Monsanto Project Number Y-62-41

STUDY CONDUCTED FOR -

Monsanto Chemical Company, St. Louis, Missouri

EXPERIMENTAL PROCEDURE -

A) Oral LD_{50} (Rats)

The undiluted compound was fed by stomach tube to Sprague-Dawley strain albino rats.

After the approximate Minimum Lethal Dose was determined, groups of male and female rats were fed in increasing doses at increments of 0.1 fractional log intervals at four levels designed to blanket the toxicity range thereby supplying data for calculation of the LD_{50} which was done according to a modification of the method of E. J. de Beer.

Observations were made for toxic symptoms and the viscera of the animals that succumbed were examined macroscopically.

The data are shown in Table I.

B) Skin Absorption MLD (Rabbits)

The undiluted compound was applied in increasing doses at increments of 0.2 fractional log intervals to the closely clipped, intact skin of New Zealand white female rabbits.

The treated areas were covered with plastic strips and the animals placed in wooden stocks for periods up to twenty-four hours, after which time they were assigned to individual cages.

Observations were made for toxic symptoms and the viscera of the animals that succumbed were examined macroscopically.

The data are shown in Table II.

EXHIBIT
K-28

GBRN002541

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SUMMARY -

Aroclor 1221

A) Oral LD_{50} (Rats)

The Oral LD_{50} for male and female rats was placed at 3980 milligrams per kilogram with lower and upper limits of 3300 to 4775 milligrams per kilogram.

The compound was classed as slightly toxic by oral ingestion in male and female rats.

B) Skin Absorption MLD (Rabbits)

The Minimum Lethal Dose by Skin Absorption in female rabbits was found to be greater than 2000 milligrams per kilogram and less than 3160 milligrams per kilogram.

The compound was classed as slightly toxic by skin absorption in female rabbits.

YOUNGER LABORATORIES

BY: FRED M. YOUNGER

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— Monsanto Chemical Company

GBRN002542

TOWOLDMON0001856

TABLE I

THE ORAL LD_{50} OF 'Aroclor 1221' FOR RATS

Sample Fed Undiluted

Animal No. - Sex	Weight Gm.	Dose Mg./Kg.	Fate
1- Female	215	3160	Survived
2- Female	230	3160	Survived
3- Female	220	3160	Survived
4- Male	245	3160	Died
5- Male	235	3160	Survived
6- Male	250	3980	Survived
7- Female	210	3980	Survived
8- Female	200	3980	Died
9- Female	210	3980	Survived
10- Male	225	3980	Died
11- Male	240	5010	Died
12- Male	235	5010	Survived
13- Female	215	5010	Died
14- Female	205	5010	Died
15- Female	220	5010	Died
16- Male	240	6310	Died
17- Male	250	6310	Died
18- Male	225	6310	Died
19- Female	215	6310	Died
20- Male	230	6310	Died

DISCUSSION -

The Oral LD_{50} for male and female rats was placed at 3980 milligrams per kilogram with lower and upper limits of 3300 to 4775 milligrams per kilogram.

The compound was classed as slightly toxic by oral ingestion in male and female rats.

Survival time was several hours to three days with most deaths occurring in two days.

Toxic symptoms included loss of appetite, diarrhea, increasing weakness, and collapse.

At autopsy there was liver discoloration and inflammation of the gastrointestinal tract.

TOWOLDMON0001857

TABLE II

THE MINIMUM LETHAL DOSE OF 'Aroclor 1221' BY SKIN ABSORPTION IN RABBITS

Animal No. - Sex	Weight Kg.	Dose Mg./Kg.	Weight Change 5 Days Later Kg.	Fate
1 - Female	2.1	794	+ 0.1	Survived
2 - Female	2.4	1260	+ 0.1	Survived
3 - Female	2.5	2000	- 0.1	Survived
4 - Female	2.3	2000	- 0.2	Survived
5 - Female	2.2	3160	- 0.4	Died -- 7 Days
6 - Female	2.4	5010	- 0.5	Died -- 5 Days

DISCUSSION -

The Minimum Lethal Dose by Skin Absorption in female rabbits was found to be greater than 2000 milligrams per kilogram and less than 3160 milligrams per kilogram.

The compound was classed as slightly toxic by skin absorption in female rabbits.

Survival time was five to seven days.

Toxic symptoms included poor appetite and increasing weakness in animals #5 and #6. Moderate muscular impairment developed after three to four days in these same animals.

At autopsy there was liver discoloration and pulmonary hyperemia macroscopically.

GBRN002544

TOWOLDMON0001858

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3620 TELEGRAPH ROAD
ST. LOUIS 29, MISSOURI
PHONE: TILDEN 6-2340

Certificate of Analysis

June 19th, 1962

SUBJECT -

Toxicological Investigation Of: Aroclor 1248

Monsanto Sample Number 37
Monsanto Project Number T-62-35

STUDY CONDUCTED FOR -

Monsanto Chemical Company, St. Louis, Missouri

COPY

EXPERIMENTAL PROCEDURE -

A) Oral LD_{50} (Rats)

The undiluted compound was fed by stomach tube to Sprague-Dawley strain albino rats.

After the approximate Minimum Lethal Dose was determined, groups of male and female rats were fed in increasing doses at increments of 0.1 fractional log intervals at four levels designed to blanket the toxicity range thereby supplying data for calculation of the LD_{50} which was done according to a modification of the method of D. J. de Beer.

Observations were made for toxic symptoms and the viscera of the animals that succumbed were examined macroscopically.

The data are shown in Table I.

B) Skin Absorption LD_{50} (Rabbits)

The undiluted compound was applied in increasing doses at increments of 0.2 fractional log intervals to the closely clipped, intact skin of New Zealand white female rabbits.

The treated areas were covered with plastic strips and the animals placed in wooden stocks for periods up to twenty-four hours, after which time they were assigned to individual cages.

Observations were made for toxic symptoms and the viscera of the animals that succumbed were examined macroscopically.

The data are shown in Table II.

EXHIBIT
K-29

GBRN002545

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SUMMARY - [redacted]

Aroclor 1260

A) Oral LD_{50} (Rats)

The Oral LD_{50} for male and female rats was placed at 12,500 milligrams per kilogram with lower and upper limits of 11,000 to 14,250 milligrams per kilogram.

The compound was classed as practically non-toxic by oral ingestion in male and female rats.

B) Skin Absorption MLD (Rabbits)

The Minimum Lethal Dose by Skin Absorption in female rabbits was found to be greater than 794 milligrams per kilogram and less than 1260 milligrams per kilogram.

The compound was classed as moderately toxic by skin absorption in female rabbits.

YOUNGER LABORATORIES

BY: FRED M. YOUNGER

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GBRN002546

TOWOLDMON0001860

TABLE I

THE ORAL LD_{50} OF 'Aroclor 1248' FOR RATS

Sample Fed Undiluted

Animal No. - Sex	Weight Gm.	Dose Mg./Kg.	Fate
1- Female	215	7,940	Survived
2- Female	210	7,940	Survived
3- Female	210	7,940	Survived
4- Male	235	7,940	Survived
5- Male	225	7,940	Survived
6- Male	240	10,000	Survived
7- Female	210	10,000	Died
8- Female	220	10,000	Survived
9- Female	225	10,000	Survived
10- Male	235	10,000	Survived
11- Male	225	12,600	Died
12- Male	245	12,600	Survived
13- Female	205	12,600	Survived
14- Female	220	12,600	Died
15- Female	215	12,600	Survived
16- Male	250	15,800	Died
17- Male	235	15,800	Survived
18- Male	230	15,800	Died
19- Female	220	15,800	Died
20- Female	225	15,800	Died

DISCUSSION -

The Oral LD_{50} for male and female rats was placed at 12,500 milligrams per kilogram with lower and upper limits of 11,000 to 14,250 milligrams per kilogram.

The compound was classed as practically non-toxic by oral ingestion in male and female rats.

Survival time was one to four days with most deaths occurring in three days.

Toxic symptoms included diarrhea, poor appetite, increasing weakness, and collapse.

At autopsy there was inflammation of the gastric mucosa and renal hyperemia macroscopically.

GBRN002547

TOWOLDMON0001861

TABLE II

THE MINIMUM LETHAL DOSE OF 'Aroclor 1248'
BY SKIN ABSORPTION IN RABBITS

Sample Applied Undiluted

Animal No. - Sex	Weight Kg.	Dose Mg./Kg.	Weight Change 5 Days Later Kg.	Fate
1 - Female	2.1	501	- 0.1	Survived
2 - Female	2.6	794	- 0.1	Survived
3 - Female	2.3	1260	- 0.4	Died — 8 Days
4 - Female	2.2	2000	- 0.3	Died — 7 Days
5 - Female	2.5	2000	- 0.3	Died — 6 Days
6 - Female	2.4	3160	- 0.4	Died — 7 Days
7 - Female	2.2	5010	- 0.4	Died — 5 Days

DISCUSSION -

The Minimum Lethal Dose by Skin Absorption in female rabbits was found to be greater than 794 milligrams per kilogram and less than 1260 milligrams per kilogram.

The compound was classed as moderately toxic by skin absorption in female rabbits.

Survival time was five to eight days.

Toxic symptoms included poor appetite, weight loss, increasing weakness, and collapse. Animal #7 developed convulsions after three days.

At autopsy there was liver and renal hyperemia macroscopically.

GBRN002548

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5620 TELEGRAPH ROAD
ST. LOUIS 29, MISSOURI
PHONE: TILDEN 6-2540

Certificate of Analysis

June 19th, 1962

SUBJECT -

Toxicological Investigation Of: Aroclor 1242
Monsanto Sample Number 36
Monsanto Project Number Y-62-34

STUDY CONDUCTED FOR -

Monsanto Chemical Company, St. Louis, Missouri

COPY

EXPERIMENTAL PROCEDURE -

A) Oral LD_{50} (Rats)

The undiluted compound was fed by stomach tube to Sprague-Dawley strain albino rats.

After the approximate Minimum Lethal Dose was determined, groups of male and female rats were fed in increasing doses at increments of 0.1 fractional log intervals at four levels designed to blanket the toxicity range thereby supplying data for calculation of the LD_{50} which was done according to a modification of the method of E. J. de Beer.

Observations were made for toxic symptoms and the viscera of the animals that succumbed were examined macroscopically.

The data are shown in Table I.

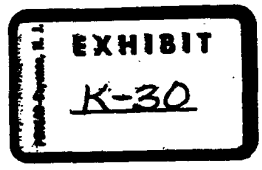
B) Skin Absorption MLD (Rabbits)

The undiluted compound was applied in increasing doses at increments of 0.2 fractional log intervals to the closely clipped, intact skin of New Zealand white female rabbits.

The treated areas were covered with plastic strips and the animals placed in wooden stocks for periods up to twenty-four hours, after which time they were assigned to individual cages.

Observations were made for toxic symptoms and the viscera of the animals that succumbed were examined macroscopically.

The data are shown in Table II.



GBRN002549

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SUMMARY -

Aroclor 1242

A) Oral LD_{50} (Rats)

The Oral LD_{50} for male and female rats was placed at 8650 milligrams per kilogram with lower and upper limits of 7610 to 9775 milligrams per kilogram.

The compound was classed as practically non-toxic by oral ingestion in male and female rats.

B) Skin Absorption MLD (Rabbits)

The Minimum Lethal Dose by Skin Absorption in female rabbits was found to be greater than 794 milligrams per kilogram and less than 1260 milligrams per kilogram. Animal #2 was moderately affected but was not in danger of collapse.

The compound was classed as moderately toxic by skin absorption in female rabbits.

YOUNGER LABORATORIES

BY: FRED M. YOUNGER

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T A B L E I

THE ORAL LD_{50} OF 'Aroclor 1242' FOR RATS

Sample Fed Undiluted

Animal No. - Sex	Weight Gm.	Dose Mg./Kg.	Fate
1- Female	220	6,310	Survived
2- Female	220	6,310	Survived
3- Female	225	6,310	Survived
4- Male	240	6,310	Survived
5- Male	225	6,310	Survived
6- Male	235	7,940	Survived
7- Female	210	7,940	Died
8- Female	215	7,940	Died
9- Female	225	7,940	Survived
10- Male	225	7,940	Died
11- Male	245	7,940	Survived
12- Male	230	10,000	Died
13- Female	215	10,000	Died
14- Female	205	10,000	Died
15- Female	220	10,000	Died
16- Male	235	10,000	Survived
17- Male	250	12,600	Died
18- Male	240	12,600	Died
19- Female	215	12,600	Died
20- Female	215	12,600	Died
21- Male	230	12,600	Died

DISCUSSION -

The Oral LD_{50} for male and female rats was placed at 8650 milligrams per kilogram with lower and upper limits of 7610 to 9775 milligrams per kilogram.

The compound was classed as practically non-toxic by oral ingestion in male and female rats.

Survival time was about twenty-four hours to three days with most deaths occurring in two days.

Toxic symptoms included diarrhea, loss of appetite, increasing weakness, dyspnea, and collapse.

At autopsy there was liver and renal hyperemia macroscopically.

GBRN002551

TOWOLDMON0001865

T A B L E II

THE MINIMUM LETHAL DOSE OF 'Aroclor 1242'
BY SKIN ABSORPTION IN RABBITS

Sample Applied Undiluted

Animal No. - Sex	Weight Kg.	Dose Mg./Kg.	Weight Change 5 Days Later Kg.	Fate
1 - Female	2.4	501	- 0.2	Survived
2 - Female	2.0	794	- 0.2	Survived
3 - Female	2.2	1260	- 0.4	Died - 7 Days
4 - Female	2.3	2000	- 0.3	Died - 10 Days
5 - Female	2.1	2000	- 0.4	Died - 8 Days
6 - Female	2.2	3160	-----	Died - 4 Days
7 - Female	2.4	5010	- 0.5	Died - 6 Days

DISCUSSION -

The Minimum Lethal Dose by Skin Absorption in female rabbits was found to be greater than 794 milligrams per kilogram and less than 1260 milligrams per kilogram. Animal #2 was moderately affected but was not in danger of collapse.

The compound was classed as moderately toxic by skin absorption in female rabbits.

Survival time was four to ten days.

Toxic symptoms included poor appetite with marked weight loss, occasional squealing after several days, and collapse.

At autopsy there was liver discoloration (light color and soft), and pulmonary congestion macroscopically.

TOWOLDMON0001866