Pl. Ex. 4
Papageorge Dep.
8/8/72 JE

TECHNICAL BULLETIN

AROCLOR® PLASTICIZERS

A series of inert, chemically-resistant, fire-retarding plasticizers compatible with wide variety of resins.

TECHNICAL BULLETIN O/PL-306A

Monsanto

AROCLOR®
PLASTICIZERS

A series of inert, chemically-resistant, fire-retarding plasticizers compatible with wide variety of resins.

TECHNICAL BULLETIN O/PL-306A

CAUTION: see sections entitled Toxicity and Safe Handling, and Environmental Hazzards, on page 12.

"Nothing contained herein shall be construed as a recommendation to use any product in conflict with any patent. MONSANTO MAKES NO WARRANTIES AS TO THE FITNESS OR MERCHANTABILITY OF ANY PRODUCTS REFERRED TO. No guarantee of satisfactory results from reliance upon contained information or recommendations and disclaims all liability for any resulting loss or damage."

Organic Chemicals Division/800 N. Lindbergh Blvd./St. Louis, Missouri 63166

HARTOLDMON0028680

Introduction

The unique Aroclor® plasticizers are among the most versatile chemically produced materials available. One outstanding characteristic — *inertness* — makes Aroclor useful in many ways for many different applications. The major benefits offered by Aroclor include:

- Chemical Resistance
- Fire Retardance
- Compatibility with most resins
- Nonoxidation
- Adhesivity
- Low Cost

Monsanto's Aroclor plasticizers comprise a series of chlorinated biphenyls and chlorinated polyphenyls. They vary from mobile, oily liquids to white crystals and hard, transparent resins.

Twelve of the Aroclor plasticizers, each of which represents a series, are discussed in this bulletin. An understanding of the system for designation of each Aroclor should prove useful in the evaluation of the property gradations among them. The last two digits indicate the approximate weight percentage of chlorine in the product, and the first two digits indicate the type of material, as follows:

12 — chlorinated biphenyls

25 — blend of chlorinated biphenyls and chlorinated triphenyls (75:25)

44 — blend of chlorinated biphenyls and chlorinated triphenyls (60:40)

54 — chlorinated triphenyls

For nearly every Aroclor mentioned, a darker, less-pure grade exists, with about the same physical and chemical characteristics, but lower in price.

Solubility

The Aroclor liquids and resins are readily soluble in most common organic solvents and drying oils. Although all Aroclor plasticizers are insoluble in water, the hard, crystalline materials are generally less soluble than the liquids and softer resins. Solubilities of some Aroclor plasticizers are shown in Table 1.

HARTOLDMON0028681

TABLE 1

SOLUBILITIES OF AROCLOR® PLASTICIZERS IN VARIOUS SOLVENTS

Solvent	Aroclor 1242		Aroclor 1248		Aroclor 1254		Aroclor 1268		Aroclor 4465		Aroclor 5460
	25°C	Hot	25°C	Hot	25°C	Hot	Cold	Hot	Cold	Hot	25°C
Acid											
Acetic Acid	S	S	—	—	S	S	—	—	SS	S	—
Oleic Acid	S	S	—	—	S	S	—	—	S	VS	—
Benzoic Acid	10.0[31°C]	—	10.0[32°C]	—	—	—	—	—	—	—	—
Aldehyde											
40% Formaldehyde	I	I	I	I	I	I	I	I	I	I	—
Furfural	VS	VS	VS	VS	VS	VS	SS	SS	VS	VS	—
Amine											
Aniline	S	S	—	—	S	S	—	—	VS	VS	—
Pyridine	132.5[30°C]	440[99°C]	—	—	114[31°C]	425[100°C]	—	—	VS	VS	—
Chloro derivatives											
Amyl chlorides — mixed	S	S	S	S	S	S	—	—	VS	VS	—
Carbon Tetrachloride	S	S	S	S	S	S	—	—	VS	VS	156
Chloroform	S	S	S	S	S	S	S	S	VS	VS	—
Dichloroethylene	—	—	—	—	—	—	—	—	VS	VS	—
Ethylene Dichloride	S	S	S	S	S	S	S	S	VS	VS	—
Monochlorobenzene	S	S	S	S	S	S	—	—	VS	VS	—
Orthodichlorobenzene	—	—	—	—	—	—	—	—	VS	VS	—
Tetrachlorethane	S	S	S	S	S	S	—	—	VS	VS	—
Trichlorethane	S	S	S	S	S	S	—	—	VS	VS	—
Trichlorethylene	S	S	S	S	S	S	—	—	VS	VS	—
Drying Oil											
Tung Oil	S	S	S	S	S	S	—	—	VS	VS	—
Linseed Oil	S	S	S	S	S	S	I	S	VS	VS	—
Ester											
Amyl Acetate	S	S	S	S	S	S	S	S	VS	VS	—
Butyl Acetate	S	S	S	S	S	S	S	S	VS	VS	—
"Cellosolve"® Acetate	S	S	S	S	S	S	—	—	VS	VS	—
Cottonseed Oil	S	S	S	S	S	S	—	—	S	VS	—
DiButyl Phthalate	S	S	S	S	S	S	S	S	S	VS	—

HARTOLDMON0028682

Diethyl Phthalate	S	S	S	S	S	S	—	—	S	VS	—
Ethyl Acetate	S	S	S	S	S	S	SS	SS	S	VS	—
Ethyl Lactate	S	S	S	S	S	S	I	S	VS	VS	—
Ethylene Glycol Diacetate	S	S	S	S	S	S	—	—	VS	VS	—
Methyl Acetate	S	S	S	S	S	S	SS	SS	S	S	—
Tricresyl Phosphate	S	S	S	S	S	S	—	—	SS	S	—
Ether. Ethyl Ether	S	S	S	S	S	S	S	S	S	—	—
Ether Alcohol											
Carbitol®	$224^{31°C}$	$307^{99°C}$	VS	VS	$173^{26°C}$	$259^{98°C}$	I	S	SS	—	—
Cellosolve	S	S	S	S	S	S	I	S	S	—	—
Diethylene Glycol®	—	—	—	—	—	—	—	—	S	—	—
p,p'-Dihydroxy Ethyl Ether	$16.9^{21°C}$	$19^{99°C}$	SS	SS	$8^{30°C}$	$10^{100°C}$	—	—	SS	—	—
Hydrocarbon											
Benzene	VS	VS	VS	VS	VS	VS	S	S	VS	VS	143
Gasoline	VS	VS	VS	VS	VS	VS	—	—	VS	VS	—
Kerosene	VS	VS	VS	VS	VS	VS	SS	S	VS	VS	—
Mineral Spirits	VS	VS	VS	VS	VS	VS	S	S	VS	VS	—
Paraffin	$2.0^{27.5°C}$	S	$2.0^{28°C}$	S	—	S	—	—	5.0	S	—
Pine Oil	S	S	VS	VS	S	S	S	S	S	S	—
Toluene	VS	VS	VS	VS	VS	VS	S	S	VS	VS	142
Turpentine	VS	VS	VS	VS	VS	VS	S	S	VS	VS	—
Xylene	VS	VS	VS	VS	VS	VS	S	S	VS	VS	178
Hydroxy derivatives											
Amyl Alcohol	S	S	—	—	S	S	SS	S	S	S	—
n-Butyl Alcohol	S	S	—	—	S	S	I	SS	SS	S	—
Ethyl Alcohol (3-A)	$23.3^{23°C}$	$80.0^{70°C}$	—	—	$10^{27°C}$	$28^{75°C}$	I	I	SS	—	—
Glycerine	I	I	I	I	I	I	I	I	I	I	—
Methyl Alcohol	$42.5^{29°C}$	$88.5^{60°C}$	—	—	$15^{26°C}$	$22.2^{65°C}$	—	—	SS	—	—
Phenol — 90%	$194^{30°C}$	S	—	—	SS	S	SS	S	S	S	—
[illegible]											
Nitrobenzene	S	S	—	—	S	S	—	—	VS	—	—
Water	I	I	I	I	I	I	I	I	I	I	—

I — Insoluble SS — Slightly Soluble S — Soluble VS — Very Soluble.
Figures show grams of Aroclor per 100 milliliters of solvent at 25°C unless otherwise indicated.

*Trademark of Union Carbide Corp.

HARTOLDMON0028683

TABLE 2

CHEMICAL AND PHYSICAL PROPERTIES OF REPRESENTATIVE AROC[illegible] AND RESINS

Property	*Aroclor 1221*	*Aroclor 1232*	*Aroclor 1242*	*Aroclor 1248*	*Aroclor 1254*
Appearance	Clear, mobile oil	Clear, mobile oil	Clear, mobile oil	Clear, mobile oil	Light-yellow viscous liquid
Color, maximum	*100 APHA	*100 APHA	*100 APHA	*100 APHA	*100 APHA
Chlorine, percent	20.5-21.5	31.5-32.5	42	[illegible]	54
Acidity, mg KOH/g, maximum	*0.014	*0.014	*0.015	*0.[illegible]	*0.010
Moisture, ppm, maximum	—	—	*50	*50	*50
Ave. Coefficient of Expansion, cc/cc/°C	0.00071 (15°-40°C)	0.00073 (25°-100°C)	0.00[illegible] (25°-[illegible])	[illegible] (25°-[illegible]°C)	0.00066 (25°-65°C)
Specific Gravity	*1.182-1.192 (25°/15.5°C)	*1.270-1.280 (25°/15.5°C)	*1.3[illegible] (25°/15.5°C)	[illegible]-1.415 ([illegible].5°C)	*1.495-1.505 (65°/15.5°C)
Density, pounds per gallon, 25°C	9.85	10.55	11.50	12.[illegible]	12.82
Distillation Range, °C, corrected (ASTM D-20, modified)	275-320	290-325	325-[illegible]	340-[illegible]	365-390
Evaporation Loss, %, 100°C, 6 hours (ASTM D-6, mod.) 163°C, 5 hours	1.0-1.5	1.0-1.5	0-0.4 3.0-3.6	0-0.[illegible] 3.0-4.[illegible]	0-0.2 1.1-1.3
Flash Point (Cleveland Open Cup), °C °F	141-150 286-302	152-154 305-310	176-[illegible] 348-[illegible]	193-[illegible] 379-[illegible]	None to boiling point
Fire Point (Cleveland Open Cup), °C °F	176 349	238 460	None to boiling point	None to boiling point	None to boiling point
Pour Point (ASTM E 97), °C °F	1 (crystals) 34 (crystals)	—35.5 —32	—19 2	—7 18.4	10 50
Softening Point (ASTM E-28), °C °F	—	—	—	—	—
Refractive Index, n D-20 20°C	1.617-1.618	1.620-1.622	1.627-1.[illegible]	1.630-[illegible]31	1.639-1.641
Viscosity, Seconds Saybolt Universal (ASTM D-88) 100°F (37.8°C) 130°F (54.4°C) 210°F (98.9°C)	*38-41 35-37 30-31	*44-51 39-41 31-32	*82-[illegible] 49-5[illegible] 34-35	[illegible] [illegible] 3[illegible]-37	1800-2500 260-340 *44-48

*Monsanto Specifications.

Aroclor 1260	*Aroclor* 1262	*Aroclor* 5442	*Aroclor* 4465	*Aroclor* 2565	*Aroclor* 5460	*Aroclor* 1268
Light-yellow, soft, sticky resin	Light-yellow sticky, viscous resin	Clear yellow sticky resin	Clear, light-yellow, resin	Black, opaque, brittle resin	Clear, yellow-to-amber, brittle resin or flakes	White to off-white powder
*150 APHA	*150 APHA	*2 NPA (molten)	*2 NPA (molten)	—	*2 NPA (molten)	*1.5 NPA (molten)
60	61.5-62.5	42	65	65	58.5-60.6	68
*0.014	*0.014	0.05	0.05	1.4	0.05	0.05
*50	—	—	—	—	—	—
0.00067 (20°-100°C)	0.00064 (25°-65°C)	0.00123 (25°-99°C)	0.00061 (25°-65°C)	0.00068 (25°-65°C)	0.00179 (25°-124°C)	0.00067 (20°-100°C)
*1.555-1.566 (90°/15.5°C)	*1.572-1.583 (90°/15.5°C)	1.470 (25°/25°C)	1.670 (25°/25°C)	1.734 (25°/25°C)	1.670 (25°/25°C)	1.804-1.811 (25°/25°C)
13.50	13.72	12.24	13.91	14.44	13.81	15.09
385-420	390-425	215-300 (4 mm. Hg)	230-320 (4 mm. Hg)	—	280-335 (5 mm. Hg)	435-450
0-0.1 0.5-0.8	0-0.1 0.5-0.6	0.01 0.2	0-0.02 0.2-0.3	0.2-0.3	0.03	0-0.06 0.1-0.2
None to boiling point	None to boiling point	247 477	None to boiling point	—	None to boiling point	None to boiling point
None to boiling point	None to boiling point	> 350 > 662	None to boiling point	—	None to boiling point	None to boiling point
31 88	38-38 99	46 115	—	—	—	—
—	—	*46-52 115-126	*60-66 140-151	*66-72 149-162	*98-105 208-222	*150-170 (hold 302-338 point)
1.647-1.649	1.6501-1.6517	—	1.664-1.667	—	1.660-1.665	—
3200-4500 *72-78	600-850 (160°F; 71°C) *86-100	300-400	90-150 (266°F; 130°C)	—	—	—

*Monsanto Specifications.

HARTOLDMON0028685

Density

All the Aroclor plasticizers are heavier than water, a valuable property for many applications. Densities are shown in Figure 1.

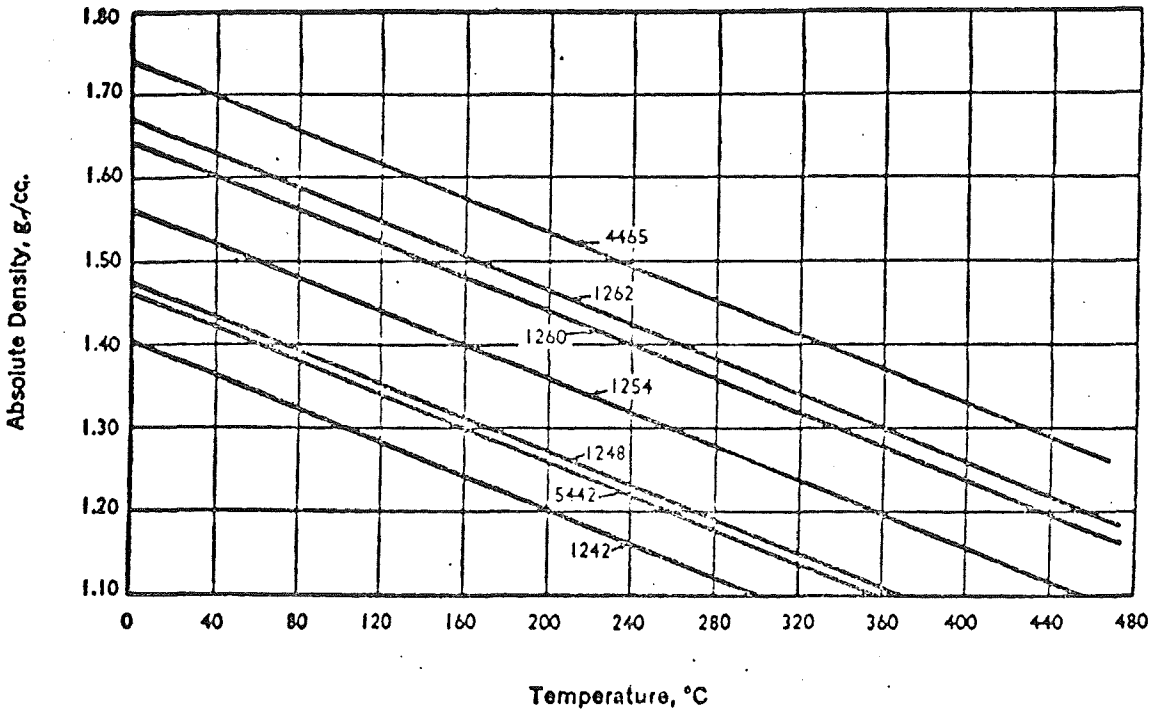

Fig. 1 — Densities of Aroclor® Plasticizers at Various Temperatures

Specific Volume

The specific volume of Aroclor 1248 at different temperatures is as follows:

Temperature (°F)	*Aroclor® 1248 Specific Volume (ml/g)*
0	0.674
100	0.699
200	0.726
300	0.755
400	0.790
500	0.828
600	0.870

HARTOLDMON0028686

The low vaporization loss of Aroclor plasticizers is indicated in Table 3.

TABLE 3

VAPORIZATION RATES OF AROCLOR® PLASTICIZERS

Plasticizer (Surface area: 12.28 sq. cm.)	*Wt. Loss (g)*	*Exposure at 100°C (hr.)*	*Vaporization Rate (g/sq. cm./hr.)*
Aroclor 1221	0.5125	24	0.00174
Aroclor 1232	0.2572	24	0.000874
Aroclor 1242	0.0995	24	0.000338
Aroclor 1248	0.0448	24	0.000152
*Cloretin**-42-S	0.0745	48	0.000126
Dioctyl phthalate	0.0686	48	0.000117
*Dutrex*** 25	0.0256	24	0.000087
Aroclor 1254	0.0156	24	0.000053
Shell Dutrex 20	0.0047	24	0.000016
Aroclor 1262	0.0039	24	0.000013
Aroclor 1260	0.0026	24	0.000009
Aroclor 4465	0.0064	72	0.000007
Aroclor 5442	0.0039	72	0.000004
Aroclor 5460	0.0032	72	0.000004
Tricresyl phosphate	0.0010	24	0.000003

It is concluded that the vaporization rates of Aroclor plasticizers — especially the most widely used 1254 and 1260 — compare most favorably with the similar constants of other plasticizers selected specifically for these tests because of their low vaporization rates.

*Trademark of Hercules, Inc.

**Trademark of Shell Oil Co.

HARTOLDMON0028687

The vapor pressures of several Aroclor plasticizers are indicated in Figure 2 over the temperature range 150° to 300°C.

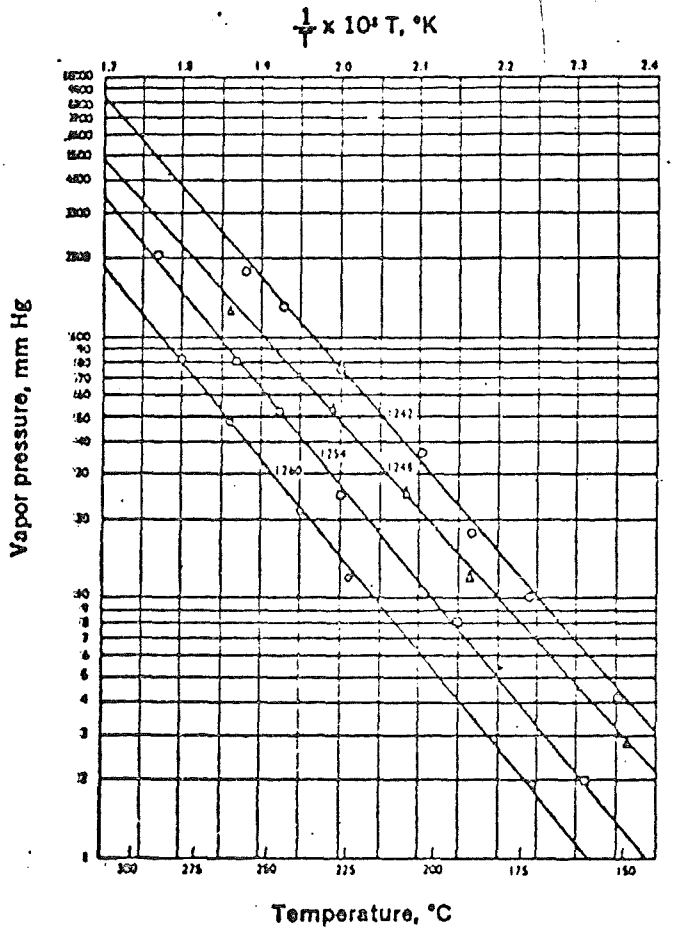

Fig. 2 — Vapor Pressures of Aroclor® Plasticizers

The estimated vapor pressures of several Aroclor plasticizers at 100°F shown in the following table were determined by extrapolation from the values shown in Figure 2.

Approximate Vapor Pressure of Aroclor® Plasticizers Estimated at 100° F (37.8° C)

Aroclor 1232	0.005 mm. Hg
Aroclor 1242	0.001 mm. Hg
Aroclor 1248	0.00037 mm. Hg
Aroclor 1254	0.00006 mm. Hg

HARTOLDMON0028688

The viscosities of the Aroclors ... according to whether the base material is a ... on the degree of chlorination. In general ... have the lowest viscosities (Figure 3).

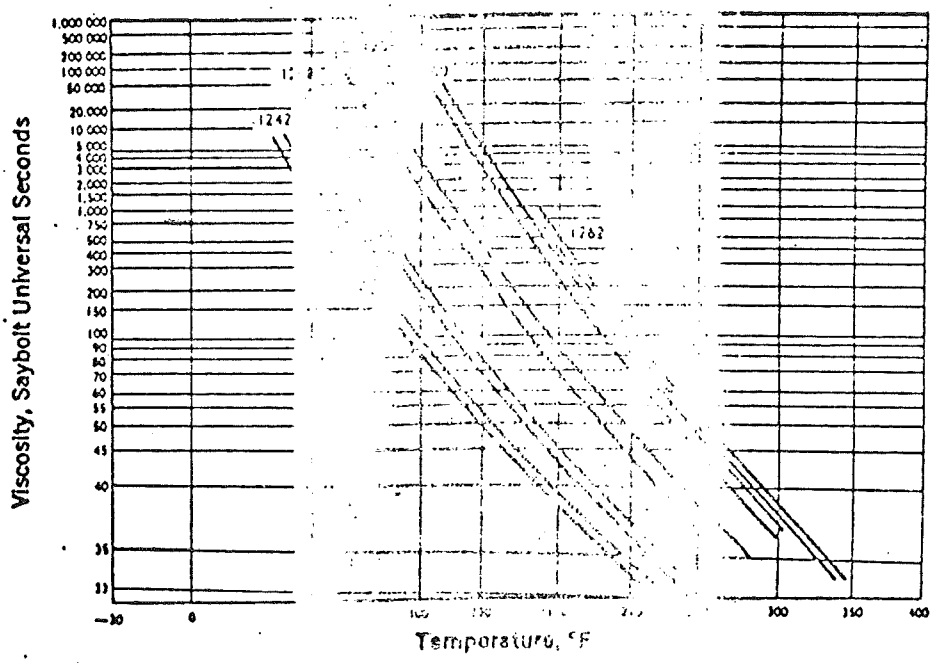

Fig. 3 — Vis ... ity Ranges of Some Aroclor® Plas ...

HARTOLDMON0028689

Inhalation

At ordinary temperatures the Aroclor chlorinated polyphenyls have not presented industrial toxicological problems. The hazard of potential toxic exposure varies with their volatility: the lower-chlorinated, more-volatile ones present more of a potential problem from the standpoint of both inhalation and skin contact. When Aroclor plasticizers are used at elevated temperatures, engineering controls must be applied, either by the use of closed systems or by effective local-exhaust ventilation together with general workroom exhaust.

Vapor of the liquid Aroclor plasticizers at room temperature should not be breathed in a confined space, and no vapor of any Aroclor evolved at elevated temperatures should be allowed to be dispersed into the general workroom.

Inhalation tests on animals indicate that the maximum safe concentration of vapor is in the range of from 0.5 to 1.0 milligram of the lower-chlorinated Aroclor plasticizers per cubic meter of air. The threshold limit values (maximum allowable concentration for an 8-hour working day) set by the American Conference of Government Hygienists are 1.0 milligram of the lower-chlorinated Aroclor compounds per cubic meter of air and 0.5 milligram of the more-highly-chlorinated compounds, such as Aroclor 1254, per cubic meter of air.

Skin Contact

Schwartz patch tests on 200 volunteers showed that Aroclor 1254 was neither a primary skin irritant or a sensitizer.

Prolonged or repeated skin contact with the Aroclor plasticizers must be avoided by the use of gloves and protective garments, because of the possible occurrence of a condition called chloracne. Although reports of this condition caused by Aroclor are rare, it can be produced by excessive skin contact. If any Aroclor is spilled on the skin the skin should be washed in the usual manner with a soap solution.

A burn caused by contact with a hot Aroclor should be treated like any ordinary burn. Aroclor plasticizer adhering to the burned area need not be removed immediately, unless treatment of the burn demands it, in which case either soap and water or repeated washings with a vegetable oil are recommended.

HARTOLDMON0028690

Environmental Hazards

Aroclor 1232, Aroclor 1242, Aroclor 1248, Aroclor 1254, Aroclor 1260, Aroclor 1262, Aroclor 1268, Aroclor 4465, and Montar 1 all contain polychlorinated biphenyls (PCB) of various types and in varying amounts. PCB residues in small amounts have been found in the environment and some studies have indicated that they may be harmful to certain forms of animal life. Extreme care should therefore be taken by all users of PCB-containing products to prevent any entry into the environment through spills, leakage, use, disposal, vaporization or otherwise. Further, the products in which PCB materials are used, or which are formulated using PCB materials as a component, should be given careful study to eliminate the possibility that PCB might reach the environment as a result of use in a given application.

Some specific applications where the use of PCB should definitely be avoided are in paints and sealants for swimming pools, paints and waterproofing agents in silos and other buildings where food products for humans or animals are stored, and as a component of any container or wrapping used in the packaging of food products.

HARTOLDMON0028691

Shipping

Freight Classification	
Aroclor 1221, 1232, 1242, 1248, 1254, 1260, 1262	Synthetic Resin, Liquid, NOIBN
Rail Classification	
Aroclor 1268, 4465, 5442, 5460	Synthetic Resin, Other Than Liquid, NOIBN
Truck Classification	
Aroclor 1268	Synthetic Resin, Powder, NOI
Aroclor 4465, 5442, 5460	Synthetic Resin, Lumps or Solid Mass, NOI
Shipping Regulations	None
Standard Containers	
Aroclor 1221	Tank car, 520-lb. steel drum, 50-lb. can
Aroclor 1232	Tank car, 550-lb. steel drum, 50-lb. can
Aroclor 1242, 1248, 1254, 1260, 1262	Tank car, 600-lb. steel drum, 50-lb. can
Aroclor 1268	200-lb. fiber drum, 25-lb. fiber drum
Aroclor 4465	500-lb. steel drum, 50-lb. can
Aroclor 5442	450-lb. steel drum, 50-lb. can
Aroclor 5460 (flaked)	50-lb. bag

HARTOLDMON0028692

DISTRICT SALES OFFICES ALL DIVISIONS

AKRON, OHIO 44313
260 Springside Drive
Montrose Development Park
Tel. (216) 666-4111

ATLANTA, GEORGIA 30326
Lenox Towers East
3400 Peachtree Rd. N. E. — Suite 1711
Tel. (404) 577-2260

BOSTON, MASSACHUSETTS 02149
Everett Station
Tel. (617) 387-5010

CHICAGO, ILLINOIS
3158 Des Plaines Ave.
Des Plaines, Illinois 60018
Tel. (312) 296-6688

CINCINNATI, OHIO 45206
1501 Madison Road
Tel. (513) 751-6707

DETROIT, MICHIGAN
500 Northland Towers West
Southfield, Mich. 48075
Tel. (313) 357-0910

HONOLULU, HAWAII 96812
205 Pacific International Bldg.
677 Ala Moana Blvd., P. O. Box 3824
Tel. (808) 531-2744

HOUSTON, TEXAS 77027
1301 Post Oak Tower
5051 Westheimer Road
Tel. (713) 621-9550

LOS ANGELES, CALIFORNIA 90022
6670 E. Flotilla St.
Tel. (213) 723-2492

NEW YORK, NEW YORK 10017
277 Park Avenue
Tel. (212) 922-4111

ST. LOUIS, MISSOURI 63166
800 N. Lindbergh Blvd.
Tel. (314) 694-1000

SAN FRANCISCO BAY AREA
2710 Lafayette, Santa Clara, Calif. 95052
Tel. (408) 243-0414

SEATTLE, WASHINGTON 98121
2112 Third Avenue
Tel. (206) 622-4203

WILMINGTON, DELAWARE 19803
2005 Concord Pike, Fairfax
Tel. (302) 658-6531

Additional District Offices are maintained by:

Agricultural Division

ALLENTOWN, PENNSYLVANIA 18104
Park Professional Building
2200 Hamilton Street
Tel. (215) 437-5471

DECATUR, ILLINOIS 62523
207 Decatur Professional Building
363 South Main Street
Tel. (217) 423-6031

DES MOINES, IOWA 50310
312 Merle Hay Tower
Tel. (515) 276-8503

FREMONT, NEBRASKA 68025
150 South Main Street
Tel. (402) 727-1230

INDIANAPOLIS INDIANA 46205
Suite 215, 4002 Meadows Drive Building
Tel. (317) 647-9148

KANSAS CITY, MISSOURI 64133
701 Blue Ridge Tower
4240 Blue Ridge Boulevard
Tel. (816) 353-8060

LULING, LOUISIANA 70070
P. O. Box 174
Tel. (504) 784-6263

MANKATO, MINNESOTA 56001
111 Madison East
Tel. (507) 387-3406

MEMPHIS, TENNESSEE 38104
303 Union Plaza Building
1835 Union Avenue
Tel. (901) 278-7811

MUSCATINE, IOWA 52761
P. O. Box 473
Tel. (319) 263-1331

Hydrocarbons & Polymers Division

NEW ENGLAND AREA
730 Worcester St.
Indian Orchard, Mass. 01051
Tel. (413) 788-6911

Lion Oil

EL DORADO, ARKANSAS 71730
Lion Oil Building
Tel. (501) 863-3111

JACKSON, MISSISSIPPI 39209
P. O. Box 10937, Westland Station
Tel. (601) 352-3648

N. LITTLE ROCK, ARKANSAS 72119
410 West 8th Street, P. O. Box 5821
Tel. (501) 376-2437

MEMPHIS, TENNESSEE 38113
1023 Riverside Drive, P. O. Box 13248
Tel. (901) 948-4451

Plastic Products & Resins Division

EUGENE, OREGON 97402
855 Seneca Road
Tel. (503) 342-7201

KENILWORTH, NEW JERSEY 07033
North Seventh St. & Monroe Ave.
Tel. (201) 276-2900

SPRINGFIELD, MASS. 01101
P.O. Box 2130.
Tel. (413) 788-6911

Textiles Division

ATLANTA, GEORGIA 30303
Atlanta Merchandise Mart
240 Peachtree St., N. W.
Tel. (404) 577-2260

CHARLOTTE, NORTH CAROLINA 28210
6230 Fairview Road, Suite 400
Tel. (704) 364-0110

GREENVILLE, SOUTH CAROLINA 29606
McAlister Plaza
P. O. Box 5504, Station B
Tel. (803) 233-8171

NEW YORK, NEW YORK 10001
350 Fifth Ave.
Tel. (212) 556-5100

MONSANTO, 800 N. LINDBERGH BLVD., ST. LOUIS, MISSOURI 63166

3/70

HARTOLDMON0028693