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T E C H N I C A L  B U L L E T I N

# AROCLOR® PLASTICIZERS

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

**TECHNICAL BULLETIN O/PL-306A**

Monsanto

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

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

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## 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.

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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 | — |
| Dichlorethylene | — | — | — | — | — | — | — | — | 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 | — |

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| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | $16.9^{23°C}$ | $19^{99°C}$ | 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) | $23.3^{29°C}$ | $80.0^{78°C}$ | — | — | $10^{27°C}$ | $28^{75°C}$ | 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 | — |
| Ketone: Acetone | S | S | — | — | S | S | I | I | S | S | 260 |
| Miscellaneous | | | | | | | | | | | |
| Carbon Disulfide | S | S | — | — | S | S | S | S | VS | VS | — |
| 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.

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TABLE 2

CHEMICAL AND PHYSICAL PROPERTIES OF REPRESENTATIVE AROCLOR® PLASTICIZERS 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 | 48 | 54 |
| *Acidity*, mg KOH/g, maximum | *0.014 | *0.014 | *0.015 | *0.010 | *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) | 0.00068 (25°-65°C) | 0.00070 (25°-65°C) | 0.00066 (25°-85°C) |
| *Specific Gravity* | *1.182-1.192 (25°/15.5°C) | *1.270-1.280 (25°/15.5°C) | *1.381-1.392 (25°/15.5°C) | *1.405-1.415 (65°/15.5°C) | *1.495-1.505 (65°/15.5°C) |
| *Density*, pounds per gallon, 25°C | 9.85 | 10.55 | 11.50 | 12.04 | 12.82 |
| *Distillation Range*, °C, corrected (ASTM D-20, modified) | 275-320 | 290-325 | 325-366 | 340-375 | 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<br>3.0-3.6 | 0-0.3<br>3.0-4.0 | 0-0.2<br>1.1-1.3 |
| *Flash Point* (Cleveland Open Cup), °C<br>°F | 141-150<br>286-302 | 152-154<br>305-310 | 176-180<br>348-356 | 193-196<br>379-384 | None to boiling point |
| *Fire Point* (Cleveland Open Cup), °C<br>°F | 176<br>349 | 238<br>460 | None to boiling point | None to boiling point | None to boiling point |
| *Pour Point* (ASTM E-97), °C<br>°F | 1 (crystals)<br>34 (crystals) | —35.5<br>—32 | —19<br>2 | —7<br>19.4 | 10<br>50 |
| *Softening Point* (ASTM E-28), °C<br>°F | — | — | — | — | — |
| *Refractive Index*, n D-20 20°C | 1.617-1.618 | 1.620-1.622 | 1.627-1.629 | 1.630-1.631 | 1.639-1.641 |
| *Viscosity*, Seconds Saybolt Universal (ASTM D-88) 100°F (37.8°C)<br>130°F (54.4°C)<br>210°F (98.9°C) | *38-41<br>35-37<br>30-31 | *44-51<br>39-41<br>31-32 | *82-92<br>49-56<br>34-35 | 185-240<br>*73-80<br>36-37 | 1800-2500<br>260-340<br>*44-48 |

*Monsanto Specifications.

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| *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 | 13.91 | 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<br>0.5-0.8 | 0-0.1<br>0.5-0.6 | 0.01<br>0.2 | 0-0.02<br>0.2-0.3 | 0.2-0.3 | 0.03 | 0-0.06<br>0.1-0.2 |
| None to boiling point | None to boiling point | 247<br>477 | None to boiling point | — | None to boiling point | None to boiling point |
| None to boiling point | None to boiling point | > 350<br>> 662 | None to boiling point | — | None to boiling point | None to boiling point |
| 31<br>88 | 38-38<br>99 | 46<br>115 | — | — | — | — |
| — | — | *46-52<br>115-126 | *60-66<br>140-151 | *66-72<br>149-162 | *98-105<br>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<br>*72-79 | 600-850 (160°F; 71°C)<br>*88-100 | 300-400 | 90-150 (266°F; 130°C) | — | — | — |

*Monsanto Specifications.

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## Density

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

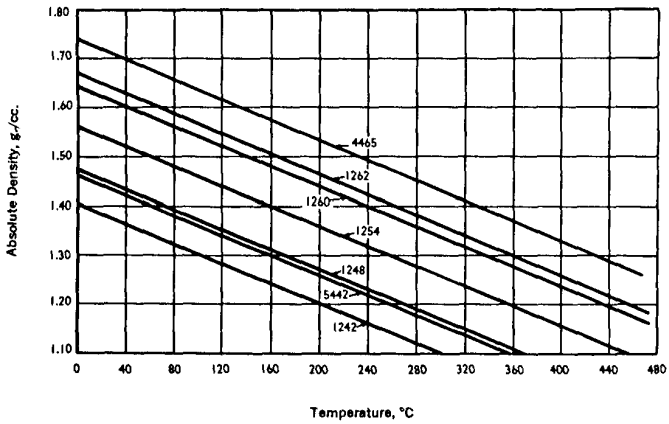



Fig. 1 — Densities of Aroclor® Plasticizers at Various Temperatures

## 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 |

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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 |
| *Cloratin**-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.

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

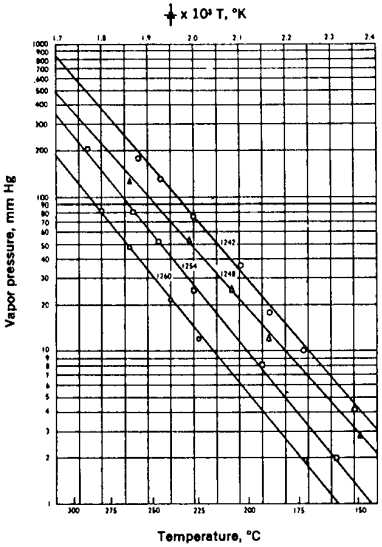



**Fig. 2 — Vapor Pressures of Aroclor® Plasticizers**

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 |

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## Viscosity

The viscosities of the Aroclor plasticizers vary according to whether the base material is a biphenyl or a polyphenyl and on the degree of chlorination. In general the low-chlorinated biphenyls have the lowest viscosities (Figure 3).

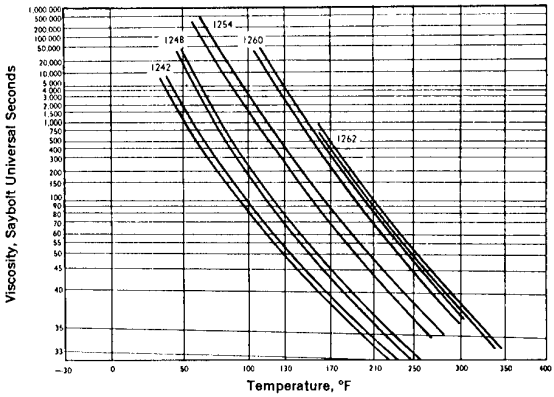



Fig. 3 — Viscosity Ranges of Some Aroclor® Plasticizers

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*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.



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### *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.

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*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 |

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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) 547-9148

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 5564, Station B
Tel. (803) 239-9171

NEW YORK, NEW YORK 10001
350 Fifth Ave.
Tel. (212) 556-6100

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

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