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

AROCLOR®

resins and plasticizers for chlorinated rubber

TECHNICAL BULLETIN
No. O/PL-311A

Monsanto

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AROCLOR® RESINS AND PLASTICIZERS FOR CHLORINATED RUBBER

Some important *applications* for protective and decorative chlorinated-rubber-based coatings plasticized with Aroclor® compounds—

Wood and metal on yachts, barges, and other marine craft

Structural steel for bridges, buildings, roofs, and powerlines

Structural materials at chemical plants, pulp-and-paper mills, textile mills, petroleum refineries, and gas works for protection against acid fumes, alkalies, and gas

Tank cars and other railroad equipment and construction machinery for protection against corrosive materials and weathering

Equipment and stop-off lacquers used in electroplating

Masonry floors and walls, and highway markings

Cable coatings requiring flame retardance, chemical resistance, and excellent electrical properties

Flame-retardant finishes

Important *properties* imparted to chlorinated-rubber coatings by Aroclor plasticizers and resin extenders—

Chemical Resistance

Corrosion Resistance

Adhesivity

Flame Retardance

Flexibility

Electrical Resistance

Weather Resistance

Nonoxidation

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INTRODUCTION

Monsanto's Aroclor chlorinated biphenyls and chlorinated terphenyls are used as plasticizers and resins for chlorinated-rubber-based lacquers, varnishes, and paints. These protective coatings are flame retardant, corrosion resistant, chemical resistant (to acids, alkalies, and water), and have good electrical insulating properties.

When properly pigmented, these coatings have unusually good weatherability. Chlorinated-rubber films plasticized with an Aroclor compound grip common structural materials in strong adhesive bonds, and the addition of an Aroclor compound improves the flexibility and life of chlorinated-rubber coatings.

The formulations suggested in this bulletin are given as starting points or guides for development of new formulations that capitalize on the outstanding qualities of these compounds.

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NUMBERING AROCLOR COMPOUNDS

The first two digits of the number of an Aroclor compound represent its molecular type, as:

12—chlorinated biphenyls

44—blend of chlorinated biphenyls and chlorinated terphenyls

54 chlorinated terphenyls

The last two digits indicate the weight percentage of chlorine in the product. For example:

Aroclor 1248 is a chlorinated biphenyl that contains 48-weight-per cent chlorine

Aroclor 5460 is a chlorinated terphenyl with 60-weight-per cent chlorine

The physical properties of the Aroclor plasticizers vary gradually with the degree of chlorination. Compounds with low percentages of chlorine, such as Aroclor 1221 and 1232, are clear and very fluid. Aroclor 1242, with 42-per cent chlorine, resembles vegetable oil; the product with 48-per cent chlorine is slightly more viscous and looks like a medium-grade mineral oil. At 54-per cent chlorine, the compound is quite viscous. At higher chlorine percentages, the chlorinated biphenyls become gumlike. At 68-per cent chlorine, the range is complete; Aroclor 1268 is a white powder. Both chlorinated terphenyls (Aroclor 5442 and 5460) are yellow solids.

The gradual change in physical properties often allows a processor to select a plasticizer particularly suited for his operation. If a dry mix is desired, Aroclor 1268 acts as a flame retarding filler. It is also possible to use it as a solvent-plasticizer at higher processing temperatures. Complete physical properties and specifications for the Aroclor compounds are listed in technical bulletin O/PL-306, "Aroclor Plasticizers."

PROPERTIES OF CHLORINATED RUBBER

Chlorinated-rubber-based coatings are used extensively for resistance to corrosion, moisture, fungus, mold, and other destructive agents.

Parlon † chlorinated rubber is a mixture of two polymers, with an average chlorine content of 67-per cent, made by chlorination of natural rubber. Its typical properties, according to the manufacturer, Hercules Inc., Wilmington, Delaware, are listed in Table 1:

†Trademark of Hercules, Inc.

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TABLE 1 — Typical Properties of Chlorinated Rubber

General

Form as shipped	White, granular powder
Color of film	Water white
Odor	None
Clarity of film	Good
Taste	None
Moisture, per cent, as shipped	0.5 Maximum

Physical

Specific gravity	1.64
Specific volume, as shipped, cubic inches per pound	16.9
Bulking value, gallons per pound	0.0735
Refractive Index, at 25°C	1.554

Chemical Resistance to:

Acids, weak	excellent
Acids, strong	excellent
Alkalies, weak	excellent
Alkalies, strong	excellent
Salt spray	good
Alcohols	excellent
Ketones	soluble
Esters	soluble
Hydrocarbons, aromatic	soluble
Hydrocarbons, aliphatic	good
Oils, mineral	good
Oils, animal	poor
Oils, vegetable	poor

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Electrical (clear, unplasticized film*)

Specific surface resistance, ohms x 10^{16}	2000
Dielectric strength, volts per mil (ASTM method)	2300
Dielectric constant at 25°C and 1000 cycles	3.1
Power factor at 25°C and 1000 cycles	0.0015 to 0.0030
Power factor at 25°C and 1000 cycles, after immersion in water for 140 hours and surface wiped dry	0.0027

Mechanical (clear, unplasticized film*)

	20-cp. type	*1000-cp. type*
Tensile strength, dry, pounds per square inch	4270	4850
Tensile strength, wet, pounds per square inch	4100	4360
Elongation, dry, per cent	3.6	3.3
Elongation, wet, per cent	3.8	3.4
Modulus of elasticity, pounds per square inch	1.4×10^5	....
Hardness, Sward index, per cent of glass	90	....

Note: Flexibility of Parlon† film increases with viscosity of Parlon used.

Thermal (clear, unplasticized film*)

Burning rate	nonflammable
Effect of dry heat on film	stable at 125°C
Softening point, °C	decomposes at 135 to 150

Physical-Chemical (clear, unplasticized film*)

Effect of sunlight	Discolors and embrittles
Effect of aging	Very slight
Effect of hot water	Blushes
Effect of cold water	None
Moisture absorption (80% relative humidity for 24 hours), per cent	0.27
Moisture-vapor permeability of 0.003-inch film (grams water/square centimeter/0.01 centimeter/hour at 21°C)	0.2×10^4

*Laid down from toluene solution

†Trademark of Hercules, Inc.

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VISCOSITY TYPES

TABLE 2 — Parlon† Viscosity Types

Viscosity Type	*Viscosity Range (centipoises)*
5 cp	5 to 7
10 cp	8 to 12
20 cp	16 to 25
125 cp	110 to 190
1000 cp	800 to 2000

Examples of actual or suggested applications of the several viscosity types are as follows:

Type	*Example of Use*
5 cp.	In printing inks and as a fortifier for alkyd resin enamels
10 cp.	In high-solid finishes and as a fortifier for alkyd resin and oleoresinous varnishes and enamels
20 cp.	As a film-former in protective coatings and as a fortifier in enamels and varnishes
125 cp.	As a film-former in protective coatings, in paper lacquers, adhesives, and textile finishes
1000 cp.	As a film-former in adhesives, textile finishes, and other finishes where flexibility is important

SOLVENT COMPATIBILITY

Solvents and solvent mixtures suggested for use in preparing formulations with Aroclor and Parlon are given in Table 3:

TABLE 3 — Suggested Solvents for Compositions with Aroclor® and Parlon†

Amsco Solv[a] B and E	Methyl isobutyl ketone
Amyl acetate	Methyl salicylate
Butyl acetate	Mobilsol[c] Nos. 74, 75
Carbon tetrachloride	Notol[d]
Cellosolve[b]	Octyl acetate
Diacetone alcohol	Solvesso[e] 100
Diethyl carbonate	Tollac[d]
Ethyl acetate	Toluene
Ethylene dichloride	Trichloroethylene
High-Flash naphtha	Union[f] Aromatic Solvent 3553-10
Methyl acetate	Union Solvent No. 30
Methyl ethyl ketone	Xylene

†Trademark of Hercules, Inc.

a) Trademark of American Mineral Spirits Co.
b) Trademark of Union Carbide Chemical Co.
c) Trademark of Socony Mobil Oil Co.
d) Trademark of Neville Chemical Co.
e) Trademark of Esso Standard Oil Co.
f) Trademark of Union Oil Co.

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FORMULATIONS AND PROPERTIES OF CHLORINATED RUBBER

Chlorinated-Rubber Films

Chlorinated rubber is very hard & brittle; consequently, plasticizers and plasticizing resins must be added to make useful coatings. To make chemical- and corrosion-resistant coatings, the modifiers must likewise be nonreactive with acids, alkalies, and salts. As little as five per cent of a saponifiable material, such as linseed oil, alkyd resin, or ester plasticizer, seriously detracts from the alkali resistance of the finished coating. Monsanto compounds, such as Aroclor 5460 and Aroclor 1254 or 1260, are the best available plasticizing resin and plasticizers, respectively, since they are unaffected by acids, alkalies, or salts. The following table summarizes some of the benefits imparted to chlorinated-rubber coatings by Aroclor plasticizers:

TABLE 4 — Benefits of Aroclor® Plasticizers in Chlorinated Rubber

	GOOD ADHESION TO				RESISTANCE TO					
® Aroclor	Alum-inum	Steel	Transite	Cello-phane	10% Hydro-chloric Acid	5% Sodium Hydrox-ide	Sodium Chlor-ide	Water	Sward Hard-ness	Cold-Check Resist-ance
1254	—	—	X	X	X	X	X	X	35	3
1260	—	—	X	X	X	X	X	X	40	4
5460	X	X	X	—	X	X	X	X	22	2

Aroclor 1262 and 5460, resinous types, show good compatibility in chlorinated-rubber films laid down from toluene solution containing 20-per cent of the plastic in ratios of 2:1 and 1:1 (Parlon to Aroclor). The plasticizer types, Aroclor 1252, 1254, and 1260, also have good compatibility. Formulations and properties of films derived from both resin- and plasticizer-type Aroclor are listed in Table 5:

TABLE 5—Formulations Containing Aroclor® Resins or Plasticizers

Ingredient	Parts by Weight								
Parlon,† 20-cp	16	16	16	12	12	12	20	20	20
Aroclor® 5460	8	8	8	12	12	12	—	—	—
Aroclor 1254 or 1260	—	—	—	—	—	—	4	7	20
Santicizer® 160 or Dibutyl phthalate	—	4	—	—	3	—	—	—	—
Tung oil, Thermolyzed, 976	—	—	5	—	—	3.75	—	—	—
Xylene or butyl acetate	76	72	71	76	73	72.25	76	73	70

†Trademark of Hercules, Inc.

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The Aroclor compounds impart the following advantages to the films cast from these lacquers:

Adhesion

Unplasticized chlorinated-rubber films have very poor adhesion. The lacquer film containing Aroclor 5460 adheres well to aluminum, bare steel, primed steel, galvanized iron, and Transite surfaces. The lacquer films plasticized with Aroclor 1254 or 1260 give good adhesion to Transite, cellophane, galvanized iron, and primed-steel surfaces.

Though compounds with an Aroclor alone possess pronounced adhesion qualities, better adhesion to all of the surfaces results if mixtures of Aroclor or varied contents are used.

Resistance to Aqueous Solutions

Chlorinated-rubber films with Aroclor 1254 or 1260 (plasticizers) and Aroclor 5460 (resin) show satisfactory resistance to solutions of 10-per cent hydrochloric acid, 5-per cent sodium hydroxide, 5-per cent sodium chloride, and water-spot tests.

Film Hardness

Softer films are produced with Aroclor 5460 in ratios of 5:10 and 10:10 (Aroclor and Parlon) than with other commercial resins in similar mixtures. Likewise, softer films result from Aroclor 1254 or 1260 in ratios of 2:10 and 5:10 (Aroclor and Parlon) than with other commercial plasticizers at these concentrations. These tests show that Aroclor compounds have strong plasticizing action on chlorinated rubber.

Cold-Check Resistance

Aroclor 5460 is superior to phenol-formaldehyde resins in cold-check resistance imparted to chlorinated-rubber films, but not as good as long-oil-alkyd modification. Aroclor 1260 is a somewhat better plasticizer than Aroclor 1254.

Weather Resistance

Pigmented chlorinated-rubber finishes containing Aroclor have consistently withstood outdoor weather tests, but unpigmented finishes do not weather well regardless of the resin or plasticizer used.

Poor resistance to ultraviolet light is also a weakness of chlorinated rubber. Most pigments (except ultramarine blue) are usable with Parlon and are recommended if the coating is to be subjected to outdoor weather or ultraviolet light. However, pigment protection varies considerably. Inspection of alkyd enamels fortified with Parlon showed weatherability varied from 63 months with chrome green to 4 months for titanium dioxide-iron blue combinations.

Sanding and Polishing Properties

Plastic films compounded with Parlon and Aroclor 5460, 1254, or 1260 have shown satisfactory sanding and polishing characteristics.

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APPLICATIONS

Alkali-Resistant Coatings

Products containing Aroclor and chlorinated rubber are highly resistant to alkalies and moisture. Paints with combinations of Aroclor and chlorinated rubber are used in large quantities for concrete floors, walls, swimming pools, and other surfaces. Paint formulations are suggested in Table 6:

TABLE 6 — Paints for Alkaline Surfaces

Ingredients	Basement Floors (parts)	Fed-Spec. TT-P-91 (parts)
Parlon† (20-cp.) chlorinated rubber	100	100
Medium-oil, drying alkyd resin	...	...
Long-oil, drying alkyd resin	45	...
Aroclor® 1254	55	56
Aroclor 5460	...	33
Titanium Dioxide	89	89
Zinc Oxide	11	11
Silica Flour	17	...
Carbon Black	1	3
Magnesium Silicate	...	...
Bentone* 34 gelling agent	12	12
Epichlorohydrin	...	...
Xylene	239	...
Hi-Flash naphtha	...	...
Turpentine	...	26
Solvesso‡ 100	...	...
Solvesso 150	...	237

†Trademark of Hercules, Inc.
*Trademark of National Lead Co.
‡Trademark of Esso Standard Oil Co.

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Chemical-Resistant Finishes

Particular care is necessary in choosing resins and plasticizers for chemical-resistant paints. Chlorinated-rubber formulations with an Aroclor plasticizer have proven outstanding for acid and alkali resistance. Five suggested formulations are shown in Table 7.

TABLE 7 — Formulations for Chemical-Resistant Paints

Ingredients	Exterior[a] use, acids (parts)	Exterior[b] use, alkalies (parts)	Maximum[c] resistance, acids and alkalies (parts)	Soap[d] resistant (parts)
Parlon,† (20-cp.) chlorinated rubber	100	100	100	100
Phenolic resin	...	40	...	...
Alkyd resin	40	...	...	...
Aroclor® 1254	30	30	45	...
Aroclor 1260	...	...	33	...
Aroclor 5460	...	...	...	50
Tung oil, Thermolyzed, 976	30	30	...	64
Iron oxide	100	100	100	...
Titanium dioxide	...	...	...	150
Zinc oxide	...	...	...	50
Epichlorohydrin	...	...	0.5	...
Stabilizer	...	...	5	...
Xylene	325	325	...	245
Toluene	...	...	...	100
Solvesso‡ 100	...	...	250	...
Hi-Flash naphtha	...	...	...	86
Turpentine	...	...	28	...

These formulations were applied to metal bars or panels and tested for resistance:

a) Excellent outdoor protection to metal surfaces in acid-manufacturing plants
b) Good performance on exteriors of alkali-producing plants
c) Excellent resistance to acids, alkalies, and salt solutions (Also adhered well to glass and other surfaces)
d) Good resistance to warm, soapy water
NOTE: No finishes with an Aroclor compound or chlorinated rubber are recommended for continuous exposure at temperatures above 140° F.

†Trademark of Hercules, Inc.
‡Trademark of Esso Standard Oil Co.

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Continuous Metal-Painting Process

A recently-developed continuous-painting process for finishing metal offers savings on capital investment, plant space, and operating costs. The technique utilizes the physical properties of trichloroethylene, the only solvent in the paint. Metal parts enter the unit covered with grease and leave the other end completely painted and dry to the touch. Detailed information about the process can be obtained from E. I. DuPont de Nemours & Co., Inc., Wilmington, Delaware. The formulation in Table 8 has given good characteristics in this continuous-painting system:

TABLE 8 — Formulation for Continuous-Painting Process

Ingredients	Parts by Weight	
	Vehicle	Pigment[a] Dispersion
Parlon† (20-cp) chlorinated rubber	100	....
Long-oil, drying, alkyd resin	15	23.7
Aroclor® 1254	50	...
Titanium Dioxide (Rutile)	...	100
Bentone 38 gelling agent*	....	1.25[b]
Epoxy stabilizer	3.9	...
Trichloroethylene	217	53.5

a) Add pigment dispersion to vehicle after 24 hours in pebble mill
b) Add gelling agent to pigment dispersion during last two hours of grind

Marine Finishes

The marine industry makes great use of chlorinated-rubber coatings plasticized with Aroclor compounds to protect wood and metal on boats, barges, and other marine equipment. They resist salt water, and their hard finish deters algae and other marine growth. A suggested formula for a white marine paint is given in Table 9:

TABLE 9 — Formulation for a White Marine Paint

Ingredients	Parts by Weight
Parlon† (20-cp) chlorinated rubber	77
Long-oil, oxidizing, alkyd resin	23
Aroclor® 1254	23
Titanium dioxide	96.5
Xylene	87.5
Hi-Flash Naphtha	77

*Trademark of National Lead Co.
†Trademark of Hercules, Inc.

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Emulsion Paints

If chemical resistance is required on porous surfaces, Aroclor 1254 is often added to chlorinated-rubber-emulsion paints. Hercules, Inc. reports that preferred water phases for such paints are either a 1-per cent-distilled-water solution of Aerosol* OT or a 4-per cent-distilled-water solution of sodium oleate. A lacquer-to-water weight ratio of 2.5 to 1 is suggested for the complete emulsion. Chlorinated rubber of any viscosity may be used. A typical lacquer phase for such an emulsion paint is given in Table 10:

TABLE 10 – Formulation for Lacquer Phase of Emulsion Paint

Ingredients	Parts by Weight
Parlon† chlorinated rubber	28
Aroclor® 1254	14
Aroclor 5460	10
Xylene	24
Hi-Flash naphtha	24

Mastics

Mastic compositions are used to deposit thick films with a minimum number of coats. Mastics modified with Aroclor compounds can effectively seal cracks in concrete, smooth rough concrete surfaces for subsequent glossy coatings, give excellent corrosion resistance under severe conditions, and retard fire. A typical starting formulation is given in Table 11:

TABLE 11 – Mastic Composition

Ingredients	Parts by Weight
Parlon† (20-cp) chlorinated rubber	100
Aroclor® 1254	30
Aroclor 5460	49
Asbestos	160
Titanium Dioxide (Rutile)	25
Toluene	300

Although this mastic formulation adheres well to either wood or masonry, a primer is suggested before application to steel. To further increase fire retardance, replacement of 33 parts of the asbestos by 47 parts of antimony oxide is suggested as a starting formulation.

†Trademark of Hercules, Inc.
*Trademark of American Cyanamid Co.

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Adhesives

Chlorinated-rubber adhesives with an Aroclor plasticizer were developed originally for acid-bottle labels because of their general resistance to chemicals. These adhesives are also of unusual interest because they are flame resistant. A typical formulation is given in Table 12:

TABLE 12 — Formulation for Acid- and Flame-Resistant Adhesive

Ingredients	Parts by Weight
Parlon† (125-cp) chlorinated rubber	20
Aroclor® 1254	6
Aroclor 1260	6
Toluene	68

Electrical Coatings

Because of their desirable electrical properties, these compositions are useful for insulating and protecting electrical wire and apparatus from moisture. With selected fungistats and waxes, coatings of this type are used to protect electronic equipment in the tropics against moisture and fungi. The fire retardance of Aroclor and Parlon combinations is an added dividend in the electrical field.

Printing Inks

Printing inks requiring fast drying time and chemical resistance are often based on chlorinated-rubber compositions plasticized with an Aroclor compound. These inks are especially useful on soap wrappers and boxes, bottle labels, and many other commodities because of their alkali resistance.

†Trademark of Hercules, Inc.

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OTHER MONSANTO PLASTICIZERS COMPATIBLE WITH CHLORINATED RUBBER

The following Monsanto plasticizers (Table 13) are also compatible with chlorinated rubber, but none give the over-all desired qualities attained by using an Aroclor plasticizer:

TABLE 13 — Other Monsanto Plasticizers Compatible With Chlorinated Rubber

Dibutyl phthalate	Santicizer® M-17
Diethyl phthalate	Santolite® MHP plasticizer
Dimethyl phthalate	Tricresyl phosphate
Santicizer® B-16 plasticizer	Triphenyl phosphate
Santicizer® 160	

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TOXICITY AND SAFE HANDLING

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 compounds 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 compounds at room temperature should not be breathed in a confined space, and no vapor of any Aroclor compound 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 compounds 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 per cubic meter of air for the lower-chlorinated Aroclor compounds and 0.5 milligram per cubic meter of air for the more-highly-chlorinated compounds, such as Aroclor 1254.

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 compounds 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 compounds are rare, it can be produced by excessive skin contact. It any Aroclor compound 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 compound should be treated like any ordinary burn. Aroclor compound 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 arerecommended.

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SHIPPING

Freight Classification

Aroclor 1221, 1243, 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 . . . . . Tank car, 600-lb. steel drum, 55-lb. can

Aroclor 1254, 1260, 1262 . . Tank car, 600-lb. steel drum, 60-lb. can

Aroclor 1268 . . . . . 200-lb. fiber drum, 50-lb. can

Aroclor 4465 . . . . . 500-lb. steel drum, 50-lb. can

Aroclor 5442 . . . . . 450-lb. steel drum, 50-lb. can

Aroclor 5460 (flaked) . . . . . 50-lb. bag

Ease of Handling

All Aroclor plasticizers except 1254, 1260 and 1262 can be shipped in bulk year-round. Aroclor 1254 may be difficult to ship in bulk in certain cold parts of North America between November and April unless heated equipment is used. Aroclor 1260 and 1262 cannot be shipped in bulk.

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