TO BE RETAINED IN
60 Days
6 Months
2 Year

The AROCLORS

Physical Properties and Suggested Applications

APPLICATION DATA BULLETIN No. P-115

MONSANTO
CHEMICALS AND PLASTICS

MONSANTO CHEMICAL COMPANY

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FOREWORD

The Aroclors*, chlorinated biphenyl and chlorinated poly-phenyls, possess unique properties which enable the fulfillment of requirements not met by other materials. This has won a prominent place for Aroclors, particularly, in the electrical insulating field and in such widely differing applications as nonflammable hydraulic media, high-temperature and high-pressure lubricants, heat-transfer and expansion media, sealing compounds, adhesives and protective coatings, including plastics, pigments, lacquers, paints and varnishes.

This booklet describes the properties of thirteen Aroclors, each of which is representative of a series. For almost every Aroclor described there is a dark-colored grade of otherwise approximately the same physical and chemical characteristics. These darker products are less pure but lower in price.

The Aroclors are efficient and very economical, both when used alone to accomplish results not attainable by other materials and when used as extenders to enhance the properties of other products.

They are produced exclusively by Monsanto Chemical Company.

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General Properties

The Aroclors range in form and appearance from mobile oily liquids to fine white crystals and hard transparent resins. They are non-oxidizing, permanently thermoplastic, of low volatility and non-corrosive to metals. They are not hydrolyzed by water, alkalies or acids. The viscous liquids and the resins will not support combustion when heated alone.

The crystalline Aroclors are relatively insoluble, but the liquid and resinous products are soluble in most of the common organic solvents, thinners and oils. All Aroclors are insoluble in water, glycerine or the glycols, and Aroclor 5460 is insoluble in the lower molecular weight alcohols. Aroclor 4465 is only partly soluble in the lower alcohols.

The excellent electrical properties, fire resistance and inertness of the Aroclors make them useful in many applications.

The properties imparted by the Aroclors and their usefulness for particular applications vary in regular gradients over the series so that the selection of the right Aroclor for a specific use can generally be made simply by a comparison of the physical properties of the several Aroclors.

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GENERAL PHYSICAL PROPERTIE

	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254
Form	Colorless mobile oil	Practically colorless mobile oil	Practically colorless mobile oil	Yellow tinted mobile oil	Light yellow viscous oil
Color	50 Max. (APHA)	60 Max. (APHA)	100 Max. (APHA)	100 Max. (APHA)	150 Max. (APHA)
Acidity—Maximum (Mgm. KOH per Gm.)	0.015	0.015	0.015	0.015	0.015
Average 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°–65°C)
Typical Density					
Specific Gravity 25°/25°C (77°/77°F)	1.182	1.266	1.380	1.445	1.538
Pounds per Gallon—25°C (77°F)	9.85	10.55	11.50	12.04	12.82
Distillation Range—ASTM D-20 (Mod.) Corr. °C	275°–320°	290°–325°	325°–360°	340°–375°	365°–390°
Evaporation Loss—%—ASTM D-6 Mod.					
163°C 5 hrs.	—	—	3.0 to 3.6	3.0 to 4.0	1.1 to 1.3
100°C 6 hrs.	1.0 to 1.5	1.0 to 1.5	0.0 to 0.4	0.0 to 0.3	0.0 to 0.2
Flash Point—Cleveland Open Cup °C	141°–150°	152°–154°	176°–180°	193°–196°	None
°F	286°–302°	305°–310°	348°–356°	379°–384°	
Fire Point—Cleveland Open Cup °C	176°	238°	None*	None	None
°F	349°	460°			
Pour Point—ASTM D-97 °C	Crystals at 1°C	−35.5°	−19°	−7°	10°
°F	Crystals at 34°F	−32°	2°	19.4°	50°
Softening Point—ASTM E-28 °C	—	—	—	—	—
°F	—	—	—	—	—
Refractive Index—D-line—20°C	1.617–1.618	1.620–1.622	1.627–1.629	1.630–1.631	1.639–1.641
Viscosity—Saybolt Universal Sec. (ASTM—D-88) 210°F (98.9°C)	30–31	31–32	34–35	36–37	44–48
130°F (54.4°C)	35–37	39–41	49–56	69–78	260–340
100°F (37.8°C)	40–42	47–50	80–93	185–240	1800–2500

*NONE indicates —"No fire point up to boiling temperature"

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OF SOME OF THE AROCLORS

Aroclor 1260 Light yellow soft sticky resin	Aroclor 1262 Light yellow sticky clear resin	Aroclor 1268 Pale yellow opaque brittle resin	Aroclor 1270 White crystalline powder	Aroclor 4465 Yellow transparent brittle resin	Aroclor 5442 Yellow transparent sticky resin	Aroclor 5460 Yellow transparent resin	Aroclor 2565 Brown-black opaque resin
150 Max. (APHA)	150 Max. (APHA)	1.5 Max. NPA	1.5 Max. NPA	2.0 Max. NPA	1.5 Max. NPA	2.0 Max. NPA	—
0.015	0.02	0.05	0.175	0.05	0.05	0.07	1.1
0.00067 (20°–100°C)	0.00064 (25°–65°C)	0.00067 (20°–100°C)	0.00067 (20°–100°C)	0.00061 (25°–65°C)	0.00123 (25°–99°C)	0.00179 (25°–124°C)	0.00066 (25°–65°C)
1.620 13.50	1.646 13.72	1.810 15.09	1.947 16.23	1.712 14.27	1.434 11.95	1.740 14.50	1.727 14.40
385°–420°	400°–430°	435°–450°	450°–460°	230°–320° at 4 mm. Hg.	215°–300° at 4 mm. Hg.	280°–335° at 5 mm. Hg.	—
0.5 to 0.8 0.0 to 0.1	0.5 to 0.6 0.0 to 0.1	0.1 to 0.2 0.0 to 0.06	0.0 to 0.1 0.0 to 0.02	0.2 to 0.3 0.0 to 0.02	0.2 0.01	0.03 1.5 to 1.7 (at 260°—5 hrs.)	0.2 to 0.3 —
None	None	None	None	None	247° 477°	None	None
None	None	None	None	None	>350° >662°	None	None
31°	37°	—	—	—	46°	—	—
88°	99°	—	—	—	115°	—	—
—	—	135° to 160° (hold pt.)	294° to 300° (hold pt.)	60° to 66°	45° to 50°	100° to 105.5°	66° to 72°
—	—	275° to 320° (hold pt.)	561° to 572° (hold pt.)	140° to 151°	113° to 122°	212° to 222°	149° to 162°
1.617–1.649	1.6501–1.6517	—	—	1.664–1.667	—	1.660–1.665	—
72–78	90–103	—	—	90–150 (266°F or 130°C)	300–400	—	—
3200–4500	600–850 (400°F or 210°C)	—	—	—	—	—	—
—	—	—	—	—	—	—	—

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TABLE II — Resistance of Structural Materials to Aroclors

Metals	Aroclor Number 1248 25°C	1248 125°C	1254 25°C	1254 125°C	4465 125°C	5460 125°C
Aluminum	R	R	R	R	*RR	RR
Copper	R	D	R	D	D	D
Magnesium	RR	R	R	R	RR	*RR
Nickel	RR	R	R	RR	RR	R
Silver	R	R	R	R	R	R
Tin	R	R	R	R	R	R
Zinc	R	R	R	R	R	RR
Mild Steel	RR	R	RR	RR	R	RR
Phosphor Bronze	R	D	R	R	R	R
Red Brass	D	D	R	D	R	De
Stainless Steel (Type 316)	RR	RR	RR	RR	RR	RR
Yellow Brass	R	Re	R	De	Re	Re
Plastics						
Alkyd Resin No. 46594-12	*P	P	*P	P	P	P
Alkyd Resin No. 46594-13A	*D	P	*D	P	P	P
Cellulose Acetate (Fibestos)	D	P	D	P	P	P
Durite Phenol Furfural Resin	*D	P	*R	P	D	P
Formvar Highly Plasticized	De	T	Pe	T	T	T
Formvar Low Plasticized	PS	T	PS	T	T	T
Glyptal 1276	R	P	D	P	P	P
Glyptal 7136	*D	T	*R	T	T	T
Maleic Resin No. 46594-13B	P	P	*P	P	P	P
Maleic Resin No. 46594-13C	P	P	*R	P	P	P
Plexiglas (Methyl Methacrylate)	*D	P	*D	P	P	P
Polystyrene (Lustron B)	P	T	P	T	T	T
Resinox Mineral Filled Melamine Resin	*D	*P	*R	R	*P	*D
Resinox Wood Flour Filled Melamine Resin	*D	P	*R	D	R	P
Resinox Mineral Filled Phenol Formaldehyde	*D	D	*D	D	R	P
Resinox Wood Flour Filled Phenol Formaldehyde	*D	P	*D	*R	D	P
Resinox Rag Filled Phenol Formaldehyde	*D	D	*D	*D	*D	P
Urea Formaldehyde Resin (Plaskon Co.)	*D	P	*D	*P	P	P

Meaning of Abbreviations:

*—Based on weight *gain* calculated as penetration value shown.

RR—Excellent resistance—less than 1.0×10^{-6} cm/day penetration or .00014 in/yr.

R—Good resistance—has penetration between 1.0×10^{-6} and 10×10^{-6} cm/day or between 0.00014 and 0.0014 in/yr.

D—Doubtful resistance, penetration between 10×10^{-6} cm/day and 100×10^{-6} cm/day or between 0.0014 and 0.014 in/yr.

P—Poor resistance—penetration greater than 100×10^{-6} cm/day or 0.014 in/yr.

PS—Poor resistance due to visible local action although weight change indicates greater resistance.

e—Following the letter indicating resistance signifies material may be better than indicated if totally immersed since weight loss is believed to come from oxidation of the part of test strip exposed to air.

T—Material alone will not stand temperature.

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ADHESIVENESS

The Aroclor resins ahdere strongly to smooth surfaces, such as glass, metal and varnished or lacquered coatings.

The softer Aroclors are indicated where a flexible, non-drying, water-resistant strongly adhesive material is required.

The Aroclor adhesives are thermoplastic; are readily applied hot without solvent; do not require high temperatures for easy application, and are set immediately upon cooling.

SPECIFIC VOLUME

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

Temp. °F	Aroclor 1248 Specific Volume ml/gm
0	0.674
100	0.699
200	0.726
300	0.755
400	0.790
500	0.828
600	0.870

AVERAGE COEFFICIENTS OF EXPANSION, AROCLOR 1248

The average coefficient of expansion of Aroclor 1248 per degree F. within the various temperature ranges indicated in the table below was determined by using the simple formula $Vt = Vt^1 [1+a (t - t_1)]$. The coefficient, a, has been calculated at 100°F increments, as follows:

Temp. Range F	Average Coefficient of Expansion cc/cc/ F
0 to 100	0.00037
100 to 200	0.00039
200 to 300	0.00040
300 to 400	0.00046
400 to 500	0.00048
500 to 600	0.00051

CORROSION

The Aroclors show practically no corrosive effect on metals within normal ranges of temperature. They do attack many plastics materials of construction as shown in Table II.

FIG. 1

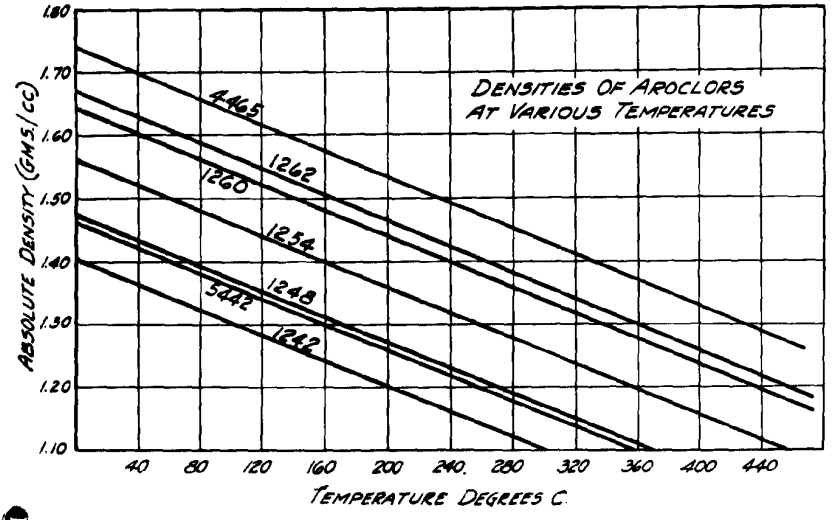

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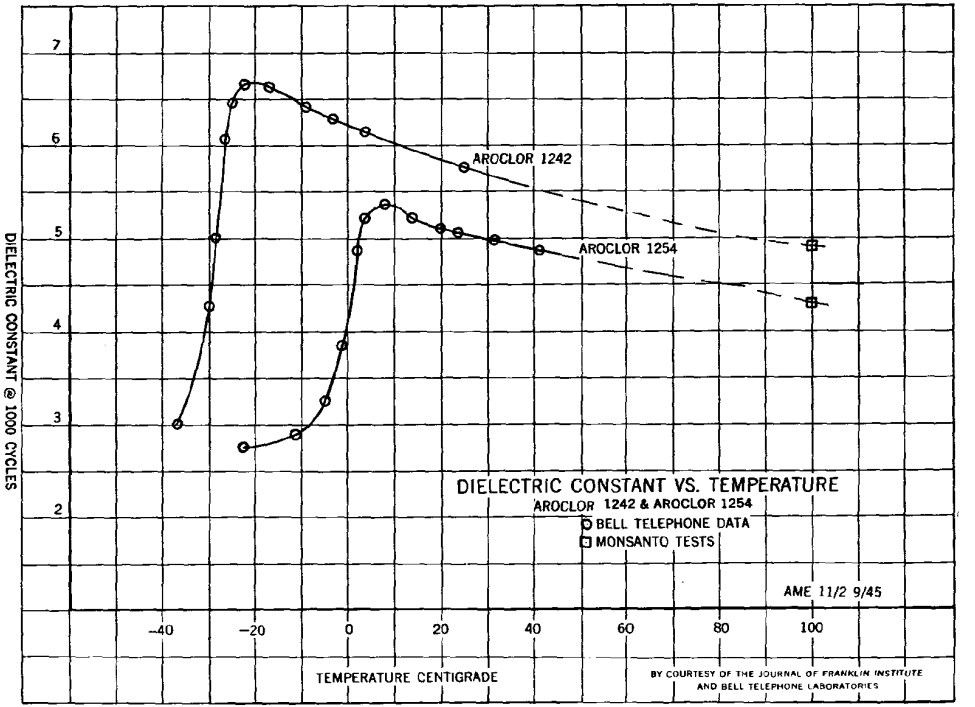
FIG. 2



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DENSITY

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

ELECTRICAL PROPERTIES

The Aroclors have extremely interesting electrical characteristics: high resistivity and dielectric strength and low power factor. The dielectric constant ranges from 3.4 to 5.0 at 100°C. and 1000 cycles, depending upon the particular Aroclor.

The dielectric constants of Aroclors 1242 and 1254 at various temperatures are shown graphically in Figure 2. The electrical properties of the Aroclors are shown in Table III.

NON-DRYING PROPERTIES

The Aroclors are non-drying, and when they are exposed to the air, even in thin films, no noticeable oxidation or hardening takes place. However, when used as ingredients of lacquers, they do not retard the rate of drying of the lacquer films. Quick drying varnishes and paints may be made with Aroclor resins.

NONFLAMMABILITY

The viscous Aroclor oils and the resins do not support combustion when heated alone, even at their boiling points — temperatures above 350°C Most of the Aroclors flux readily with resinous and pitch-like materials to give a product having a decreased fire hazard. When incorporated in nitrocellulose films and rubber foams the Aroclors retard the rate of burning.

SOLUBILITY

All Aroclors are insoluble in water. Solubilities of some of the Aroclors in the more common substances are shown in Table VI.

The Aroclor oils and resins are readily soluble in most of the common organic solvents and drying oils. The hard crystalline materials are in general less soluble than the Aroclor oils or softer resins. Compatibility data on Aroclors in nitrocellulose lacquers are shown on page 18.

SPECIFIC HEAT AND THERMAL CONDUCTIVITY

The specific heat at different temperatures of several of the Aroclors is shown in Figure 3. This, together with the thermal conductivity data given in Table IV, enable calculations involved in the use of Aroclors as high-temperature, low pressure, fluid heat-transfer media.

***TABLE III* — Electrical Properties**

Aroclor	Dielectric Constant at 1,000 Cycles (1) 25°C	100°C	Volume Resistivity (2) Ohm—cm at 100°C, 500 Volts D.C.	Dielectric Strength (3)	Power Factor (4) 100°C, 1,000 Cycles
1232	5.7	4.6			
1242	5.8	4.9	Above 500×10^9	Greater than 35KV	<0.1%
1248	5.6	4.6	Above 500×10^9	Greater than 35KV	<0.1%
1254	5.0	4.3	Above 500×10^9	Greater than 35KV	<0.1%
1260	4.3	3.7	Above 500×10^9	Greater than 35KV	<0.1%
1268	2.5	—			
5442	3.0	4.9	Above 500×10^9		
5454	2.7	4.2			
5460	2.5	3.7			
4465	2.7	3.3			

(1) ASTM D-150-47T
(2) ASTM D-257-46
(3) ASTM D-149-44
(4) ASTM D-150-47T

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FIG. 3

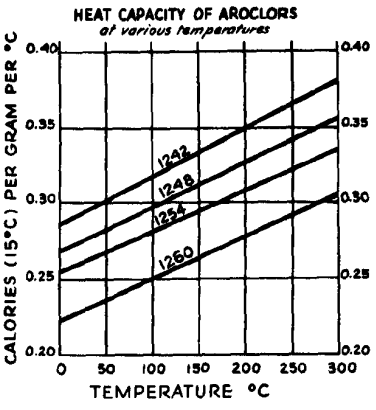

Table IV

Thermal Conductivity of Aroclor 1248

Temperature °C.	°F.	BTU./(hr./Sq. Ft./°F./Ft.	Calories, gram/Sec./Sq.Cm./°C./Cm.
30	90	0.0680	281 x 10^{-6}
60	140	0.0687	284 x 10^{-6}
100	212	0.0697	288 x 10^{-6}

STABILITY

Toward Alkalies

The Aroclors are remarkably resistant to the action of either hydrolyzing agents or high temperature. They are not affected by boiling with sodium hydroxide solution.

Toward Acids

Experiments were made to determine whether hydrogen chloride is evolved during the treatment of Aroclors with sulfuric acid. Aroclor 1254 (selected as typical) was stirred with an equal volume of ten per cent sulfuric acid for a period of 150 hours. Any gases escaping from the reaction flask had to pass through a trap filled with silver nitrate solution, which solution would give a precipitate of silver chloride if any HCl came in contact with it. After 150 hours of treatment, neither the trap solution nor the acid layer in the treating flask showed any hydrogen chloride present.

Even prolonged treatment (255 hours) with concentrated sulfuric acid indicated only a slight trace (too small for quantitative measurement) of hydrogen chloride in the acid layer.

Toward Heat

Because of their stability to heat, the Aroclors are useful heat-transfer media. Aroclor 1254 and particularly the less viscous Aroclor 1248 are recommended for this purpose because they may be heated at temperatures up to 315°C (600°F) in a closed system for long periods without appreciable decomposition and are at the same time nonflammable.

Toward Oxidation

When Aroclors are subjected to a bomb test at 140°C with 250 pounds oxygen per square inch oxygen, there is no evidence of oxidation as judged by development of acidity or formation of sludge.

SURFACE TENSION

The surface tension of Aroclor 1254 in dynes per centimeter is as follows:

Temperature	Surface Tension—dynes/cm.
25°C	50.3
80°C	44.0
100°C	42.0

THERMOPLASTICITY

The Aroclors are permanently thermoplastic. They apparently undergo no condensation or hardening upon repeated melting and cooling. The clear Aroclor resins are now being produced with softening points up to 105°C. The opaque crystalline solids are produced with initial melting points up to approximately 290°C.

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TABLE VI — Solubility of Aroclors in 100 Milliliters of Various Solvents

Aroclor / Type of Solvent	1242 25°C	1242 Hot	1248 25°C	1248 Hot	1254 25°C	1254 Hot	1270 Cold	1270 Hot	4465 Cold	4465 Hot	5460 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	3.7	—	VS	VS	156
Chloroform	S	S	S	S	S	S	—	—	VS	VS	—
Dichlorethylene	—	—	—	—	—	—	3.0	—	VS	VS	—
Ethylene Dichloride	S	S	S	S	S	S	—	—	VS	VS	—
Monochlorobenzene	S	S	S	S	S	S	2.9	—	VS	VS	—
Orthodichlorobenzene	—	—	—	—	—	—	—	—	VS	VS	—
Tetrachlorethane	S	S	S	S	S	S	—	—	VS	VS	—
Trichlorethane	S	S	S	S	S	S	3.3	—	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	—	—	VS	VS	—
Ester											
Amyl Acetate	S	S	S	S	S	S	—	—	VS	VS	—
Butyl Acetate	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	VS	—
Diethyl Phthalate	S	S	S	S	S	S	—	—	S	VS	—
Ethyl Acetate	S	S	S	S	S	S	—	—	S	VS	—
Ethyl Lactate	S	S	S	S	S	S	—	—	S	VS	—
Ethylene Glycol Diacetate	S	S	S	S	S	S	—	—	VS	VS	—
Methyl Acetate	S	S	S	S	S	S	—	—	VS	VS	—
Tricresyl Phosphate	S	S	S	S	S	S	—	—	S	S	—
Ether: Ethyl Ether	S	S	S	S	S	S	S	S	SS	S	—
Ether Alcohol											
Carbitol	224 31°C	307 99°C	VS	VS	173 26°C	259 98°C	—	—	S	—	—
Cellosolve	S	S	S	S	S	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	3.5	—	VS	VS	143
Gasoline	VS	VS	VS	VS	VS	VS	—	—	VS	VS	—
Kerosene	VS	VS	VS	VS	VS	VS	—	—	VS	VS	—
Mineral Spirits	VS	VS	VS	VS	VS	VS	—	—	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	—
Toluene	VS	VS	VS	VS	VS	VS	—	—	VS	VS	142
Turpentine	VS	VS	VS	VS	VS	VS	—	—	VS	VS	—
Xylene	VS	VS	VS	VS	VS	VS	—	—	VS	VS	178
Hydroxy — derivatives											
Amyl Alcohol	S	S	—	—	S	S	—	—	S	S	—
n-Butyl Alcohol	S	S	—	—	S	S	—	—	SS	S	—
Ethyl Alcohol (3-A)	23.3 29°C	80.0 70°C	—	—	10 27°C	28 78°C	—	—	SS	—	2
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	—	—	S	S	—
Ketone											
Acetone	S	S	—	—	S	S	—	—	S	S	260
Miscellaneous											
Carbon Disulfide	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 S — Soluble SS — Slightly Soluble VS — Very Soluble

Figures show grams of Aroclor per 100 milliliters of solvent at 25°C unless otherwise indicated.

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FIG. 4

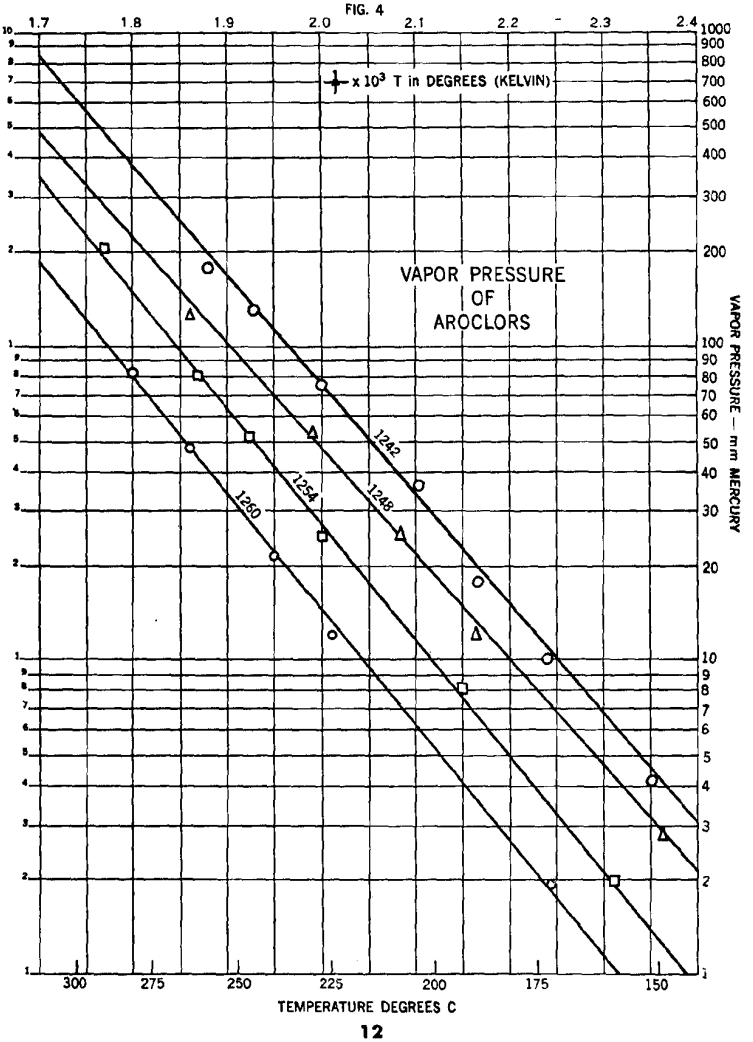

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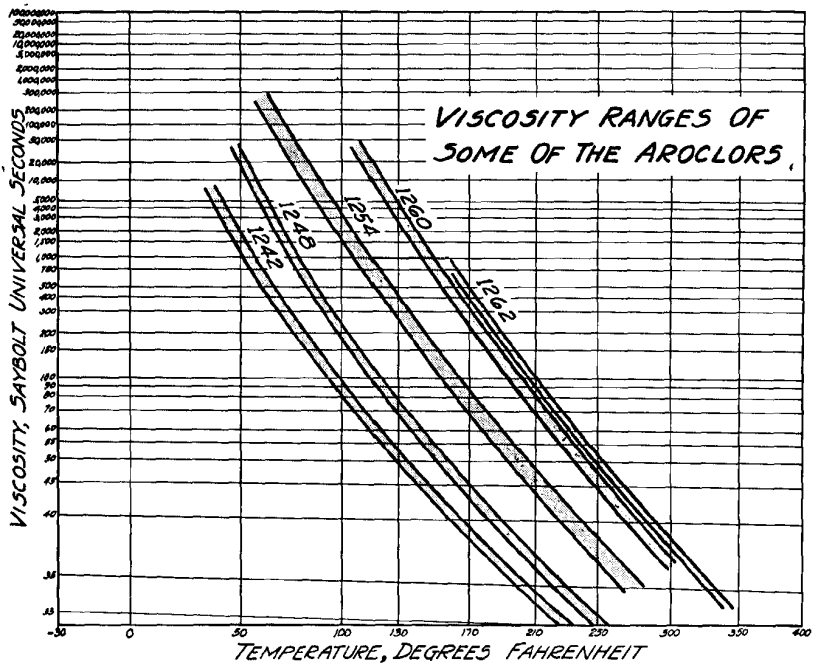
FIG. 5



VAPORIZATION LOSS

The low vaporization loss of Aroclors is indicated in the following Table VII.

It is concluded that the vaporization rates of Aroclors—especially 1254 and 1260 which are the most widely used members of the Aroclor family in the plasticizer field, compare most favorably with the similar constants of other plasticizers selected specifically for these tests because of their low vaporization rates.

VAPOR PRESSURES

The vapor pressures of several Aroclors are indicated in Figure 4 over the temperature range, 150° to 300°C. The following estimated vapor pressures of several Aroclors at 100°F shown in Table VIII were determined by extrapolation from the values shown in Figure 4.

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TABLE VII

Vaporization Rates

Sample	Wt. Loss Gms.	Hours Exposure	Surface Area Cm^2	Vaporization Rate gms./$cm.^2$hr./100°C.
Aroclor 1221	0.5125	24	12.28	0.00174
Aroclor 1232	0.2572	24	12.28	0.000874
Aroclor 1242	0.0995	24	12.28	0.000338
Aroclor 1248	0.0448	24	12.28	0.000152
Clorafin-42-S	0.0745	48	12.28	0.000126
Flexol-DOP (dioctyl phthalate)	0.0686	48	12.28	0.000117
Dutrex 25	0.0256	24	12.28	0.000087
Aroclor 1254	0.0156	24	12.28	0.000053
Dutrex 20	0.0047	24	12.28	0.000016
Aroclor 1262	0.0039	24	12.28	0.000013
Aroclor 1260	0.0026	24	12.28	0.000009
Aroclor 4465	0.0064	72	12.28	0.000007
Aroclor 1270	0.0045	72	12.28	0.000005
Aroclor 5442	0.0039	72	12.28	0.000004
Aroclor 5460	0.0032	72	12.28	0.000004
Tricresyl phosphate	0.0010	24	12.28	0.000003

TABLE VIII

Approximate Vapor Pressures
Calculated 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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APPLICATIONS

ADHESIVES

Liquid and resinous Aroclors are noted commercially in the adhesives field for their usefulness in preparing synthetic adhesives and as additives in protective coatings to improve adhesion. This quality of the Aroclors is related to their plasticizing action on the plastics materials commonly used in adhesives and coatings.

Interesting examples are the use of Aroclors in adhesives and coatings based on polystyrene, vinyl polymers, ethylcellulose, chlorinated rubber and other plastics materials, usually polymers.

Aroclor adhesives are thermoplastic and can be prepared either with or without solvents. Hot-melt Aroclor adhesives do not require high temperatures for easy application and are set immediately upon cooling.

Aroclors strongly resist attack by water, acids, alkalies, and other common corrosive influences as well as organisms. By proper selection of materials, adhesives utilizing Aroclors can be made to possess outstanding resistance against all of these destructive influences.

The most widely used Aroclors in the adhesives field are 1254, 1260, 4465 and 5460.

ELECTRICAL EQUIPMENT

Because of their nonflammability, high resistivity and dielectric strength and low power factor, the liquid and resinous Aroclors are extremely useful materials for the electrical industry.

Aroclors are used to impregnate capacitors or condensers and transformers. Since the liquid Aroclors will absorb sufficient moisture from the atmosphere to impair the electrical characteristics, it is customary to treat Aroclor intended for this application before use with a dehydrating clay. An effective product for this purpose is Attapulgus clay 80/300 mesh dried for 4 hours at 400°C. and used at the rate of 0.125% based on the weight of Aroclor, followed by filtration. Treatment is improved if the Aroclor is heated to 80-85°C.

Another important use of Aroclors in the electrical field is the use of Aroclors 1260, 4465 and 5460 in wire or cable coatings and as impregnants for cotton and asbestos braided insulation.

Aroclor 5460 is useful as an impregnant for carbon radio resistors to reduce the influence of moisture.

EXPANSION MEDIUM

Because of their stability under variations in temperature and freedom from gum formation from oxidation, the Aroclors are useful as expanding media in bellows controls and in thermostats.

HYDRAULIC MEDIUM

Power Transmission

The Aroclors are superior hydraulic media for power transmission. Because of their greater density and E. P. characteristics they approach more closely the theoretical transmission values for mechanical power as illustrated in Figure 6. This greater efficiency makes possible a reduction in the size of the hydraulic coupling design.

In order to meet extremely low-temperature weather conditions, it is necessary to adjust the freezing point of the Aroclor selected by the addition of a pour point depressant. Suitable adjustments can be made in the composition to reach a pour point of minus 65°F.

The steepness of the viscosity-temperature curve of the Aroclors is a handicap to the application of Aroclors to many types of fluid transmission. This curve can be flattened to a marked degree by introduction of a viscosity-index corrector. By proper choice of viscosity modifiers and pour point depressants, the viscosity-temperature curve can be made to coincide with any standard hydrocarbon oil viscosity curve.

Information will be gladly furnished.

Hydraulic Pressure Medium

Use of D.T. Light Oil (mineral base) or other flammable oils as hydraulic media in the operation of pressurized systems in the vicinity of open flames or metallic surfaces heated to elevated temperatures has resulted in substantial property damage and also serious burns including loss of

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life as a result of fire. Zinc and aluminum alloy die-casting machines and hydraulic mechanisms used to operate doors and other equipment around industrial furnaces are excellent examples of operations where it is prudent to use a noncombustible hydraulic medium for safety reasons.

Some of these systems operate under pressures as high as 2000 pounds per square inch. When a line ruptures under these conditions, the hydraulic medium is emitted in the form of a spray or a fine mist over a wide area. Such a mist presents unusual requirements with reference to the noncombustible qualities of the hydraulic medium. For safety under these conditions, it is essential that the oil must have a relatively high oxygen requirement in order not to support combustion when impinged on a hot metal surface or when in contact with fire. Ability to fulfill this requirement is not adequately reflected merely by the factors that an oil does not possess a flash point, and a fire point in conjunction with a high spontaneous ignition temperature.

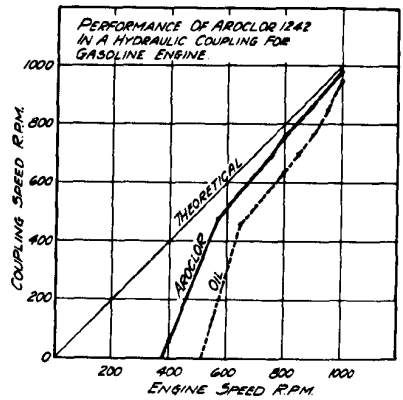
Spray flammability to a large degree seems to be a separate consideration. Tests conducted by the Navy indicated that high boiling liquids requiring more than approximately 45 percent oxygen in the spray flammability tests failed to cause a fire in the incendiary firing tests also conducted by the Navy. The percent of oxygen requirement for Aroclor 1248 combustion in the spray flammability limit study was established at 64 percent. This result firmly establishes the nonflammable and noncombustible qualities of Aroclor 1248 and in this respect strongly recommends Aroclor 1248 as an unusually safe hydraulic medium.

Other desirable qualities of Aroclor 1248 for this specific use are its extremely high order of stability under heating and pressure, lubricating qualities, noncorrosiveness, moisture resistance and relative freedom from odor.

Aroclor 1248 is used commercially in centralized zinc and aluminum die casting systems. Such installations may involve operation with as much as 2000 gallons of Aroclor 1248 distributed to about 15 die-casting machines. Under proper operating conditions the Aroclor make-up in the system is very low. Normal operating temperatures of the hydraulic medium may be in the range of 70 to 120°F. Centralized systems utilize piston-type pumps and an accumulator is used for smooth operation.

In some instances, Aroclor 1248 is used in combination with a high lubricity oil in the proportions of 20 gallons of Aroclor and not more than one gallon of the oil. The hydraulic medium is kept clean and free of suspended particles by passage through a centrifugal or by filtering it through a properly prepared bed of Attapulgus earth.

Aroclor 1248 is also used in individual or unit die-casting systems usually equipped with vane-type pumps. Frequently these individual die-casting machines have built-in filters. However, if the machine is not already provided with a filter, either a portable or permanent filter should be provided in order to keep the hydraulic medium



Liquid Heating Medium

Aroclors 1242, 1248 and 1254 are used as a circulating heating medium with great success. Good circulation and a well designed heating system are necessary to prevent local overheating of the Aroclor heating medium. Aroclor 1248 is rec-

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ommended for universal use up to 315°C (600°F) because of its fluidity at low temperatures and its nonflammability.

In processes where a cooling cycle must also be introduced, provision can be easily made for shunting circulating Aroclor through a water cooled heat exchanger, thus employing one medium for both heating and cooling.

In special cases, Aroclors 1242 and 1254 can be substituted for the Aroclor 1248. If extremely low outside temperatures are encountered, the less viscous Aroclor 1242 can be used, but it has the disadvantage of being flammable above 330°C (626°F).

Higher temperatures up to 325°C (617°F) can be attained in the heating medium if Aroclor 1254 is used. Provision can easily be made for warming the Aroclor after a shut-down so that it can be pumped.

Design for a simple, effective liquid Aroclor heating system for small unit operations is available and described in Monsanto Technical Bulletin No. P-130.

LUBRICATION

Air Compressors

The presence of oil, oil vapors or mixtures of oxygen and oil fractions in the discharge lines and receivers of air compressors presents a constant hazard which needs only a particle of hot carbon to create a serious explosion.

This problem has been solved by engineers of one large user of this type equipment by employing Aroclor 1254 as the internal lubricant for high compression air compressors. Their experience with more than 15 high-pressure compressors of various types is reported in the American Machinists Magazine, September 28, 1944. This use of Aroclors is described in Monsanto Technical Bulletin No. P-128.

Cutting Oils

Aroclors are used commercially in high quality cutting oils of the "straight" oil and "soluble" oil types.

High Temperature

The heat-resisting, nonflammable characteristics of the Aroclors make them attractive as lubricants under conditions of high temperature, as, for example, in governor systems of central power stations. Aroclor 1248 is well suited to this application. Straight Aroclor 1254 gave excellent results on a roller bearing test operating at 255°-260°F with much less carbonization or decomposition than the usual spindle oil under the same conditions.

Extreme Pressure

It is a well accepted hypothesis in the lubrication industry that by the addition of certain elements such as chlorine, sulfur and others in the proper form to a lubricating oil, a certain chemical combination takes place with the iron or steel metal bearing surfaces. These surface compositions tend to prevent seizure of the rubbing surfaces under extreme loads and under which loads, if the sole lubricant were a pure mineral oil, seizure or scoring would result at once through film failure.

As an extreme pressure (E. P.) lubricant base added to a petroleum hydrocarbon oil in amounts up to approximately 15% by weight, Aroclors 1248 and 1254 materially increase the load-carrying properties without reducing the viscosity of the resulting composition. These Aroclors represent one of the more adequate carriers for the element chlorine as an extreme pressure base, possessing the following advantages:

1. *Stability.* They are stable, even at higher temperatures, which permits neither separation of components nor appreciable change in physical or chemical properties during long periods of operation and should not cause continued chemical action on metal parts except the particular chemical metal surface combination which is necessary to effect high load-carrying capacities.

2. *Non-volatile.* Many other types of chlorine bearing compounds are so volatile as to render them unfit for long periods of service because of the escape of the elements from the lubricant. The Aroclors are non-volatile at normal temperatures.

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3. *Non-oxidizing.* Aroclors do not oxidize or thicken up to an objectionable degree.

4. *Non-corrosive.* Aroclors are non-corrosive toward metal surfaces.

5. *Non-abrasive.* Aroclors exert no abrasion on the machined surfaces.

6. *Non-hydrolysis.* Aroclors do not hydrolyze in the presence of water, thus avoiding the generation of hydrochloric acid.

7. *Compatibility.* Aroclors are completely miscible with mineral oils.

8. *Color.* Aroclors do not darken or change the color of the lubricating oil.

Submerged Lubrication

Under conditions of lubrication subjected to exposure to water displacement such, for example, as lubrication of bridge rollers, a heavier-than-water lubricant can be prepared from mixtures of Aroclor and oil, of which the following are typical examples:

Mix No.	—% by Wt.— Oil*	Aroclor 1248	Pour Point	Gravity at 15.5°C	Approx. lbs./gal.
1	50	50	0°F	1.1263	9.4
2	25	75	+5°F	1.2703	10.6

*Bright Stock: Gravity API 22-23

Viscosity 210° F—160 Saybolt Secs.
Color ASTM—7-8
Flash Point—545°F
Pour Point—15°F

GASKETS AND PACKING MATERIALS

Particularly in the use of Aroclors at elevated temperatures, as encountered in Aroclor heat-transfer installations, and to a lesser extent in the use of Aroclors as hydraulic media careful selection of gasket and packing materials is required. Hot Aroclors plasticize and swell "rubber" materials including Hycar P, Koroseal, Perbunan and Neoprene. Although materials of this type are used as gaskets in certain Aroclor installations, careful consideration must be given them in light of expected operating condition to assure that satisfactory performance will be obtained.

Thiokol is not attacked by Aroclors at ordinary temperatures but cannot be recommended for use with Aroclors at elevated temperatures. This is apparent from the following temperature ranges indicating the maximum temperature beyond which various types of Thiokol are not stable:

Thiokol Type A.....150 to 200°F. max.
Thiokol Type FA.....150 to 200°F. max.
Thiokol Type ST.....250 to 300°F. max.

Resistoflex, polyvinyl alcohol, resists attack by Aroclors but since this polymer is soluble in water, its consideration for practical use involves drastic limitations where water or moisture must be considered.

Silastic (Dow Corning's Silicone 180) is remarkably resistant to deterioration from contact with hot Aroclors and is suggested for gaskets. The following changes in physical properties were noted when Silastic was immersed in Aroclor for seventy hours at 150°C.

1. Hardness was lowered about 20 points.
2. Elasticity was improved several points.
3. Practically no change in tensile strength.
4. An appreciable increase in the ultimate elongation.

Teflon (duPont's poly tetra fluoroethylene) is not attacked by hot Aroclor (130°C.) and is to be recommended as a gasket material. So far attempts to make Teflon diaphragms for valves have not been very successful in some cases because the Teflon seems to lack the desired flexibility.

It is indicated that leather gaskets and leather packing compositions are satisfactory for use with Aroclors. Frequently, thin sheets of aluminum are used satisfactorily as gaskets at flanged joints. Garlock Packing Company's No. 7021, 1/8 inch asbestos fiber sheet is used at the flange connections in several of Monsanto's Aroclor heat-exchange units. Garlock's braided No. 117 packing is used in the valves and Garlock's No. 234 material is used for packing the Aroclor pumps.

Also, Durametallic Corporation's Type B-7 Dura Plastic is used as packing for Aroclor pumps. It is also understood that Garlock No. 431 and Chevron No. 7050-C materials are satisfactory as

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packing. Likewise Durametallic's Spiral Asbestos Fiber may be used. Doubtless, Johns-Manville and others have comparable packing materials which would be suitable.

The following materials are being used satisfactorily as pipe thread compounds in Aroclor units:

1. Plastic Lead Seal, Durametallic Corporation.
2. Ordinary white lead.
3. Glyptal No. 2, General Electric Company.

DERMATOLOGY AND TOXICOLOGY

Skin patch tests with a polyvinylchloride free film plasticized with 11.5 percent by weight of Aroclor 1254 (about 25 per cent based on the weight of the vinyl resin) and a similar amount of dioctyl phthalate showed that this film was not a primary irritant or a sensitizer.

Also, skin patch tests on Aroclor 1254 alone applied to gauze and placed in contact with the skin showed no primary irritancy or sensitization. Other skin patch tests using canvas coated with Aroclor 5460 and an oil modified alkyd resin, in such a manner that the Aroclor concentration in the paint film on the fabric was about 17 percent by weight of paint solids and the finished coated fabric contained approximately seven percent by weight of Aroclor 5460 showed that this painted fabric did not produce primary irritancy or sensitization of the skin.

If Aroclors are spilled on the skin, the skin should be washed in the usual manner with soap solutions. If accidental burns occur from contact with hot Aroclors, the burn should be treated the same as any ordinary burn. Aroclor adhering to the burned area need not be removed immediately unless treatment of the burn demands it, in which case use soap and water or repeated washings with a vegetable oil.

At ordinary temperatures Aroclors have not presented industrial toxicological problems.

If Aroclors are used at elevated temperatures such as 200°or 300° C. in open systems, methods must be designed to exhaust any vapors arising from these open systems. This applies especially to lower chlorinated Aroclors where experimental work on animals indicates that the maximum safe concentration of vapors in workrooms is in the range of 0.5 to 1.0 milligrams per cubic meter of air. In the case of more highly chlorinated Aroclors such as Aroclor 1268, the allowable limit is about 10 milligrams per cubic meter of air and accordingly, Aroclors of this type are believed to be of a much lower order of toxicity.

Where Aroclor vapors may be encountered in workrooms, local exhaust ventilation together with general workroom exhaust is recommended.

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SUGGESTED USES FOR AROCLORS

in

PLASTICS, PIGMENTS, LACQUERS, PAINTS, VARNISHES and WAXES

The Aroclors are compatible with most of the common plastics materials (see compatibility table on this page). The degree of flexibility imparted by the Aroclors diminishes progressively in the order of liquid Aroclor — soft resin — hard resin. The hardness of the resulting compositions increases in the same order. Usually a satisfactory balance between flexibility and hardness can be obtained either by selecting the Aroclor of proper physical characteristics or by using a mixture of two or more Aroclors.

Compatibility With Various Materials

Asphalt	C
Benzyl Cellulose	C
Carnauba Wax	C
Cellulose Acetate	I
Cellulose Aceto Butyrate	C
Chlorinated Rubber	C
Coumarone and Indene Resins	C
Dammar Resin	C
Ester Gum	C
Ethyl Cellulose	C
Manila Gum	I
Nitrocellulose	C
Paraffin	C
Phenolic Resins	Varies.*
Polystyrene Resins	C
Polyiso-Butylene	C
Rosin	C
Rubber	C
Sulfur	C
Styrene-Butadiene Co-polymers	C
Vinyl Resins	C

C — Indicates compatibility to a degree sufficient to be of value.

I — Indicates incompatibility.

* Not compatible in final stage.

ETHYL CELLULOSE

The Aroclors are very compatible with ethyl cellulose, the liquids imparting great flexibility and the resinous products great hardness. 75 parts by weight of Aroclor 1242 with 100 parts of ethyl cellulose produces great flexibility and just a slight tackiness. Aroclor 5460 in the same proportion produces a very hard and somewhat brittle composition. Aroclor 4465 produces hard films which are not brittle at ordinary temperature.

For coatings of high gloss and exceptional weathering qualities to be applied to rigid surfaces, compositions containing equal parts by weight of Aroclor 5460 and ethyl cellulose are suggested. If greater flexibility is required, one of the softer Aroclors should be used, either alone or as a replacement for part of the Aroclor 5460 and the proportion of Aroclor should be decreased.

A typical formula is as follows:

Ethyl Cellulose	15%
Aroclor 1260	15%
Toluene	56%
Butanol	14%
	100%

GRAPHIC ARTS

The Aroclors are used as vehicles for carrying pigments employed in glass decoration. When the decorations have been applied and the glass is fired, the Aroclors volatilize without carbonization and thus avoid discoloration of the glass. Aroclors 1254 and 4465 are used.

Aroclor 4465 is a useful resin for compounding rotogravure inks.

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A mimeograph ink suitable for use on bond paper contains the following ingredients:

Aroclor 4465	40%
Lubricating Oil (SUV 1200 @ 100°F)	35%
Paraffin Oil (SUV 76 @ 100°F)	20%
Carbon Black	4%
Oil Soluble Dye	1%

Aroclor 4465 may also be used in the preparation of imitation gold leaf. A thin coating of the Aroclor is applied hot to one side of paper. While it is still hot, bronze powder is spread upon the coating. The bronze powder adheres to the Aroclor completely covering the paper. This product is used in making the "gold leaf" letters on books, etc. The paper treated with Aroclor and bronze powder is placed upon the book binding. A hot die is pressed upon it. The Aroclor softens and sticks the bronze to the binding and forms a coating over it to protect it from tarnishing.

IMPREGNATION

The Aroclors may be used to impregnate cloth, paper, wood or asbestos in order to impart moisture and gas resistance, adhesion, insulating properties, alkali or other chemical resistance, flame resistance, or lubricating qualities. For this type of work they are used in combinations with other materials such as waxes, inorganic pigments, asphalt, tars, aluminum stearate, sulphur, etc., in order to obtain exactly the physical characteristics desired for the specific purpose. Aroclors 1254, 4465 and 5460, or the corresponding dark-colored products, are suggested as most applicable.

Wood impregnated by vacuum-pressure method with the following mixture:

Aroclor 4465	70%
Microcrystalline Wax	20%
Sulfur	10%

is definitely tougher, harder and more moisture resistant than untreated wood. This coating is very resistant to acids and alkalies but will be attacked by aromatic, aliphatic or chlorinated hydrocarbons. The surface is not appreciably discolored and can be painted. Various degrees of hardness and adhesion can be obtained by varying the Aroclor: wax: sulfur ratio.

MOISTURE PROOFING

For use as moisture proof coatings on wood, paper, concrete and brick, the Aroclors are best combined with waxes, especially paraffin or carnauba, oils such as mineral oil or drying oils, and synthetic resins including modified alkyds, phenolics, chlorinated rubber, polystyrene, styrene-butadiene co-polymers, ethylcellulose, cellulose aceto butyrate, benzyl cellulose or vinyl resins. Selection of materials for use in combination with Aroclors will depend on the end use requirements of the specific application.

The simplest compositions contain only Aroclor and paraffin. A moisture proofing compound composed of 96% (by weight) of Aroclor 5460 and 4% of paraffin (melting point 54°C) has an ASTM softening point of about 82° C and is very efficient. Substituting Aroclor 4465 for Aroclor 5460 produces a compound with a softening point of about 58°C.

Softening point and viscosity when melted may be further decreased by using mixtures of Aroclors. For example, a composition containing 40% of Aroclor 1260, 56% of Aroclor 5460 and 4% of paraffin will be very soft at ordinary temperatures. Increased proportions of paraffin will also produce softer compounds.

PIGMENT

Aroclor 1270 is a hard, white crystalline product of high melting point, insoluble in most solvents, resistant to chemicals and to oxidation. When ground to a fine powder it makes an excellent organic pigment for use with the various plastics. It may be used alone or with conventional pigments.

PAINTS AND VARNISHES

The Aroclors are soluble in paint and varnish oils and impart properties corresponding to the physical character of the particular Aroclor. The hard resinous Aroclors tend to give increased hardness to the films while the viscous resins impart flexibility.

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The Aroclors do not react chemically with oils, hence there is no advantage in heating together in making a varnish. They are best added as a "chill back" or as a cold cut in the thinning operation. As far as incorporation of the Aroclors is concerned, the only reason for heating is to make the Aroclors liquid so that they can be readily mixed with the oils.

Aroclors 4465 and 5460 will produce paints that are very quick drying and yet have excellent durability. The weight of Aroclor used should be from 30% to 50% of the weight of the oils.

Aroclor 1260 is best for short oil varnishes that are required at the same time to be flexible. The Aroclor may be considered to play the same role as oil, with the difference that it does not oxidize and lose its flexibility on exposure. Resins of the alkyd, phenolic or ester gum type, or a harder Aroclor such as 5460, may be used in making varnish formulations. It is suggested that for two parts by weight of oil, one part of Aroclor 1260 and one part of other resin be used. These proportions can be varied as required. The Aroclors impart water and alkali resistance and in these qualities enhance the value of the other resins used in the varnish.

Aroclors are excellent grinding and dispersing media for pigments used in paints and varnishes. Aroclor 1254 is used to disperse aluminum powder in a paste form which can be incorporated easily into paints and varnishes. The Aroclor imparts excellent leafing qualities, brightness or luster and does not tarnish the aluminum pigment on aging. Moreover, the composition does not support combustion.

RUBBER AND RUBBER SUBSTITUTES

The liquid Aroclors, 1221, 1232, 1242 and 1248 have a strong plasticizing action on rubber, both natural and synthetic. Aroclors 1254 and 1260 are milled into rubber in order to impart permanent tackiness and adhesion. A small amount of Aroclor 1260 added to hard rubber acts as a plasticizer and reduces the brittleness.

Aroclor 1270, being a hard crystalline material of high melting point, can be ground to a powder and then milled into rubber. The milling temperature being below the melting point of the Aroclor, the latter is dispersed through the mass of rubber and acts as an efficient flame reducer. This same procedure can be used with synthetic rubbers to impart fireproofness. From 5% to 25% of Aroclor 1270 based on the weight of the resin is required.

Aroclor 1262 is recommended as a plasticizer for crepe rubber resin in paint compositions. Used in concentrations of 5% to 50%, based on the weight of the rubber resin, it increases the gloss and alkali resistance of the film and increases its adhesiveness toward steel.

Aroclor 1268 used at a level of about three pounds per 200 pounds of Neoprene has excellent working qualities as a plasticizer at 225-325°F. in injection moldings.

MODIFIED RUBBER FINISHES

Chlorinated rubber (Parlon) and copolymers of styrene-butadiene (Pliolite S-5) are used widely as protective and decorative coatings for concrete and masonry structures, steel structures, railway tank and gondola cars, wood and metal maritime equipment.

Aroclor 1254 is used as a plasticizer and Aroclor 5460 is used as a resin fortifier in these coatings which are used where flame resistance, corrosion resistance, chemical resistance, i.e., resistance to acids, alkalies and water and good electrical insulating properties are required.

The use of Aroclors in making these protective coatings is described in Monsanto Technical Bulletin No. P-124, "Aroclors as Used in Chlorinated Rubber," and Monsanto Technical Bulletin No. P-126, "Aroclors as Used in Pliolite S-5."

VINYL RESINS

The Aroclors are compatible with all the vinyl resins and are used mainly as co-plasticizers with tricresyl phosphate, dioctyl phthalate, dibutyl phthalate and other plasticizers for vinyls to impart good plasticizing action, chemical and corrosion resistance and excellent electrical properties at a substantial reduction in cost.

This use of Aroclors is described in Monsanto Technical Bulletin No. P-131, "Aroclors as Co-Plasticizers for Polyvinylchloride" and Technical Bulletin No. P-134, "Aroclor 1254 Co-Plasticizer with DOP for Vinyl Organosols and Pastes."

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Aroclor plasticizers are very attractive for use with dioctyl phthalate in preparing organosols, plastisols or pastes of vinyl plastics used for making free films, textile coatings and coatings for paper. In many of these applications the fire-resistant quality of Aroclors is important. Also, the Aroclors serve as excellent media for grinding and dispersing the pigments used.

It is interesting to note that the vaporization rates of Aroclors, especially Aroclors 1254 and 1260 which are the most widely used members of the Aroclor family in the vinyl plasticizer field, compare most favorably with the similar constants of other commonly used vinyl plasticizers. (See Table VII, Page 14.)

It is also important to note that a free film made up of polyvinylchloride containing 11.5 percent by weight of Aroclor 1254 and a similar amount of dioctyl phthalate along with standard white pigments was found free from irritating or sensitizing the skin in accordance with commonly used skin patch tests. Moreover, similar studies made with Aroclor 1254 alone indicate that this plasticizer is neither a skin irritant nor sensitizer. While this indicates safety in using Aroclor 1254, the use of the plasticizer is not suggested for such items as baby pants or other items that are intimately in contact with the skin.

Another excellent use for Aroclors in vinyl plastics is in the preparation of adhesives. The Aroclors impart outstanding adhesive qualities and give good resistance against water and corrosive influences. Moreover, the Aroclors are resistant against organism attack and when used in combination with other properly selected ingredients, vinyl adhesives can be prepared which strongly resist attack by organisms.

NITROCELLULOSE COATINGS

The Aroclors function both as plasticizers and resins and may be used alone with the nitrocellulose or in combinations with other plasticizers or resins. They impart weather resistance, luster, adhesion and decreased burning rate. Their excellent electrical characteristics (high dielectric strength and resistivity and low power factor) and their property of retarding the passage of moisture and gases through nitrocellulose, chlorinated rubber, and other similar plastics films make the Aroclors of special value in coatings for electrical insulating materials.

The accompanying trilinear diagrams show the practical compatibility limits of Aroclors 1254 and 1262 when used in conjunction with some other resins and plasticizers. Aroclor 1260 gives values almost the same as those shown for 1262. The less viscous Aroclors have greater and the more resinous Aroclors less compatibility than for those shown. (See trilinear diagrams that follow.)

To illustrate the differences possible to obtain by changes in formulation, three formulas are given below. All have excellent durability but the third is much softer and more flexible than the other two. Only the solids contents are given.

The amounts tabulated are parts by weight.

Aroclor Lacquers

	No. 1	No. 2	No. 3
½ second Nitrocellulose (dry)	100	100	100
Dammar resin	80	—	—
Ester Gum	—	80	—
Aroclor 1260	20-39	20	80-70
Dibutyl Phthalate	20- 0	20	—
Tricresyl Phosphate	—	—	39-70

No. 1 and No. 2 have excellent sanding and polishing qualities. No. 3 is very flexible but too soft for sanding.

Where extremely high flexibility is desired, as for example in lacquers for high tension automotive cables, the following composition is suggested: 15 — 20 sec. R. S.

Nitrocellulose	100 parts by weight
Tricresyl Phosphate	120 parts by weight
Aroclor 1242	80 parts by weight

WAXES

The use of Aroclors to extend or substitute Carnauba Wax and reduce the cost of the wax formulation is described in Bulletin No. P-132. This bulletin gives several practical formulas using Aroclors in wax blends possessing the qualities of Carnauba Wax for automobile, wood, leather and linoleum polishes.

Selected Aroclors such as 5460 used in conjunction with various waxes make excellent impregnating compounds for furniture drawers, etc., to prevent sticking.

Resinous Aroclors used in combination with waxes make excellent and inexpensive sealers for concrete and masonry surfaces, wood, fiber board and paper products.

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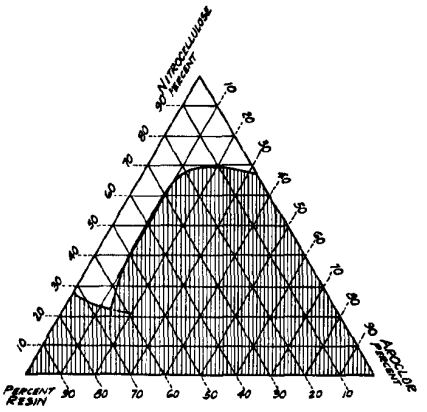
DIAGRAMS SHOWING PRACTICAL COMPOSITION OF LACQUERS USING AROCLORS 1254 AND 1262

In the trilinear diagrams the compositions, represented by any point in the unshaded areas, are those which produce homogeneous lacquer films. On the other hand compositions represented by points in the shaded areas produce impractical, segregated, brittle or soft films. For detailed information as to the derivation and use of these diagrams reference is made to the following articles:

Jenkins & Foster, "Compatibility Relationships of the Aroclors in Nitrocellulose Lacquers," Ind. Eng. Chem. 23, 1362 (1931).

Hofmann & Reid, "Graphical Methods in Lacquer Technology," Ind. Eng. Chem. *20*, 431 (1928); "Formulation of Nitrocellulose Lacquers," Ind. Eng. Chem. *20*, 687 (1928).



For combinations where the resin is Ester Gum or Amberol and where the Aroclor is Aroclor 1254 or Aroclor 1262.

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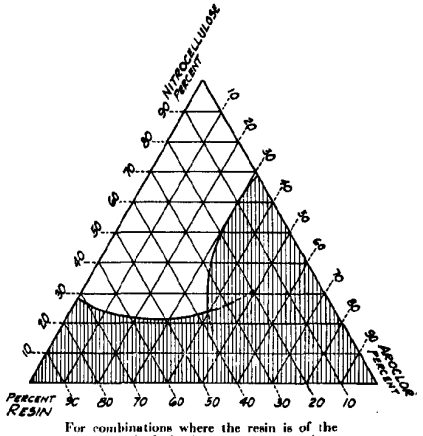
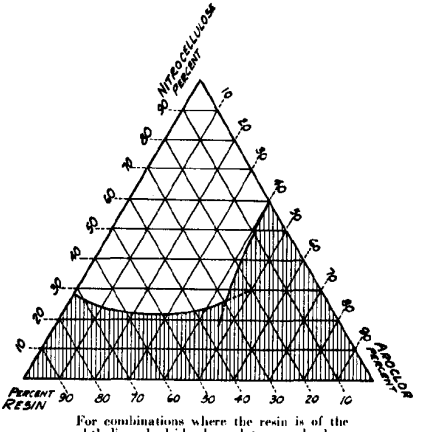
Practical Composition of Lacquers using Aroclors 1254 and 1262

—(continued)



For combinations where the resin is of the phthalic anhydride-glucerol type and where the Aroclor is Aroclor 1262.*

*Aroclor 1260 may be substituted without material change.



For combinations where the resin is of the phthalic anhydride-glycerol type and where the Aroclor is Aroclor 1254.

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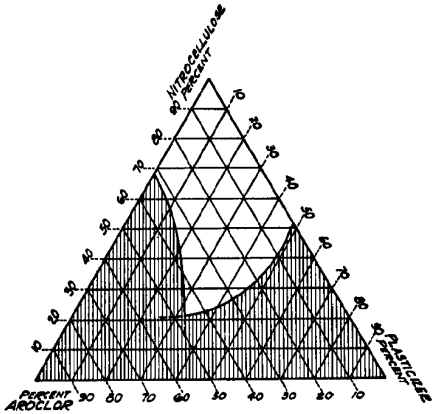
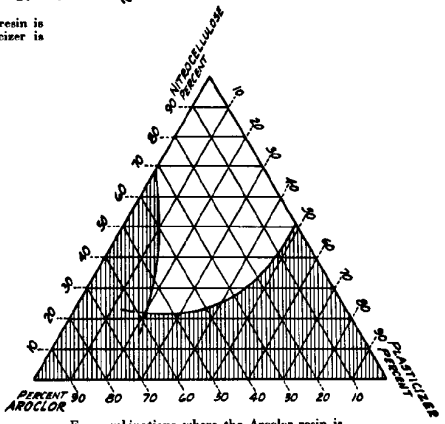
Practical Composition of Lacquers using Aroclors 1254 and 1262

—(concluded)



For combinations where the Aroclor resin is Aroclor 1262* and where the plasticizer is Dibutyl Phthalate.



For combinations where the Aroclor resin is Aroclor 1262* and where the plasticizer is Tricresyl Phosphate.

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Other Literature on Aroclor Applications

Monsanto Technical Bulletin P-115
THE AROCLORS

Monsanto Technical Bulletin P-124
AROCLORS AS USED IN CHLORINATED RUBBER

Monsanto Technical Bulletin P-126
AROCLORS AS USED IN PLIOLITE S-5

Monsanto Technical Bulletin P-128
AROCLOR — INCOMBUSTIBLE LUBRICANTS USED IN HIGH-PRESSURE COMPRESSORS

Monsanto Technical Bulletin P-130
AN INDIRECT AROCLOR HEATER FOR UNIT CHEMICAL OPERATIONS

Monsanto Technical Bulletin P-131
AROCLORS AS CO-PLASTICIZERS FOR POLYVINYLCHLORIDE

Monsanto Technical Bulletin P-132
AROCLORS AS USED TO EXTEND OR SUBSTITUTE CARNAUBA WAX

Monsanto Technical Bulletin P-134
AROCLOR 1254 CO-PLASTICIZER WITH DOP FOR VINYL ORGANOSOLS AND PASTES

Monsanto Technical Bulletin P-137
AROCLOR—A NONFLAMMABLE HYDRAULIC FLUID FOR DIE-CASTING SYSTEMS

PGB 1-52-71

PRINTED IN U.S.A.

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