

THE **aroclor®** COMPOUNDS

A series of heat-resistant, chemically inert and fire-retarding compounds ranging from mobile "oil-y" liquids through viscous resins and solids that perform unique functions in over a hundred different industrial and product applications.

Monsanto

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The Aroclor* compounds are among the most unique, most versatile chemically-made materials in industry. Aroclors are so useful in so many ways in so many different applications, primarily because of one outstanding characteristic: *inertness.*

The Aroclors do not burn . . . and they impart fire-retardance to compositions in which they are mixed. The Aroclors do not "break down" under mechanical stress; therefore, they make good lubricants, sealants, and expansion media. The Aroclors are not decomposed by, nor do they conduct even tiny amounts of, electricity; therefore, they are outstanding dielectrics. Heat has little effect on the compounds, hence the Aroclors are excellent heat transfer fluids. Since they are compatible with a wide range of synthetic resins, Aroclors make excellent plasticizers. Because Aroclors in formulations "trap" and hold more volatile ingredients, they make volatile insecticides and repellents "last longer" in residual activity.

And, important too, Aroclors are low in cost. Examination of their properties will show literally scores of uses in which no other material can serve.

The following pages describe the physical properties of the Aroclors and some of their many applications. These remarkable materials are manufactured exclusively by Monsanto.

*Aroclor is a trademark of Monsanto Chemical Company for its chlorinated aromatic hydrocarbons and their derivatives, including chlorinated diphenyl. Reg. U. S. Pat. Ofc. In this brochure, Aroclor is frequently used as a plural noun solely to improve the ease of reading and as a convenience to the reader. In every instance of such use, however, the usage refers to Monsanto Aroclor brand of polyphenyl compounds.

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# THE aroclors...

Aroclor compounds are a series of chlorinated biphenyls and chlorinated polyphenyls. They range in form and appearance from mobile oily liquids to fine white crystals and hard transparent resins. Aroclors are non-oxidizing, permanently thermoplastic, of low volatility, and non-corrosive to metals. Aroclors are not hydrolyzed by water, alkalis, or acids. The viscous liquids and resins will not support combustion when heated alone, and they impart fire retardance to other materials.

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

The following table describes the properties of twelve Aroclors, each of which is representative of a series. For almost every Aroclor shown, there is a dark-colored grade of approximately the same physical and chemical characteristics. These darker products are less pure but are lower in price.

Aroclors are used alone for particular physical jobs, such as insulating, heat transfer, sealants and expansion media; and they are used as components or extenders in elastomers, adhesives, paints, lacquers, varnishes, pigments and waxes. The properties imparted by Aroclors (and their usefulness in particular applications) vary in regular gradient over the series. Selection of the right Aroclor for a particular use can generally be made by comparision of the properties, by "blending" two or more, and by adjusting the percentage used in the particular mixture in which the Aroclors will be formulated.

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# general physical properties of

| | Aroclor 1221 Colorless mobile oil | Aroclor 1232 Practically colorless mobile oil | Aroclor 1242 Practically colorless mobile oil | Aroclor 1248 Colorless to light yellow-green, clear, mobile oil | Aroclor 1254 Light yellow viscous oil |
|---|---|---|---|---|---|
| Form | | | | | |
| Color | 100 Max. (APHA) | 100 Max. (APHA) | 100 Max. (APHA) | 100 Max. (APHA) | 100 Max. (APHA) |
| Acidity—Maximum (Mgm. KOH per Gm.) | 0.014 | 0.014 | 0.010 | 0.010 | 0.010 |
| 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<br>Specific Gravity<br>Pounds per Gallon—25°C (77°F) | 1.182-1.192 (25°/15.5°C) 9.85 | 1.270-1.280 (25°/15.5°C) 10.55 | 1.381-1.392 (25°/15.5°C) 11.50 | 1.405-1.415 (65°/15.5°C) 12.04 | 1.495-1.505 (65°/15.5°C) 12.82 |
| Distillation Range—ASTM D-20 (Mod.)<br>Corr. °C | 275°-320° | 290°-325° | 325°-366° | 340°-375° | 365°-390° |
| Evaporation Loss—%—ASTM D-6 Mod.<br>163°C.....5 hrs.<br>100°C.....6 hrs. | —<br>1.0 to 1.5 | —<br>1.0 to 1.5 | 3.0 to 3.6<br>0.0 to 0.4 | 3.0 to 4.0<br>0.0 to 0.3 | 1.1 to 1.3<br>0.0 to 0.2 |
| 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 |
| Fire Point—Cleveland Open Cup.....°C<br>°F | 176°<br>349° | 238°<br>460° | None* | None | None |
| 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 210°F (98.9°C) Sec. (ASTM—D-88) | 30-31 | 31-32 | 34-35 | 36-37 | 44-48 |
| 130°F (54.4°C) | 35-37 | 39-41 | 49-56 | 73-80 | 260-340 |
| 100°F (37.8°C) | 38-41 | 44-51 | 82-92 | 185-240 | 1800-2500 |

*NOTE: Indicates "no fire point up to boiling temperature"

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# some of the aroclor compounds








| Aroclor 1260 Light yellow soft sticky resin | Aroclor 1262 Light yellow sticky clear resin | Aroclor 1268 White to off-white powder | Aroclor 4465 Light-yellow, clear, brittle resin | Aroclor 5442 Yellow transparent sticky resin | Aroclor 5460 Clear, yellow-to-amber, brittle resin | Aroclor 2565 Black, opaque, brittle resin |
|---|---|---|---|---|---|---|
| 150 Max. (APHA) | 150 Max. (APHA) | 1.5 Max. NPA (molten) | 2 Max. NPA (molten) | 2 Max. NPA (molten) | 2 Max. NPA (molten) | — |
| 0.014 | 0.014 | 0.05 | 0.05 | 0.05 | 0.05 | 1.4 |
| 0.00067 (20°-100°C) | 0.00064 (25°-65°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) |
| 1.555-1.566 (90°/15.5°C) 13.50 | 1.572-1.583 (90°/15.5°C) 13.72 | 1.804-1.811 (25°/25°C) 15.09 | 1.670 (25°/25°C) 13.91 | 1.470 (25°/25°C) 12.24 | 1.670 (25°/25°C) 13.91 | 1.734 (25°/25°C) 14.44 |
| 385°-420° | 395°-425° | 435°-450° | 230°-320° at 4 mm. Hg. | 215°-300° at 4 mm. Hg. | 280°-335° at 5 mm. Hg. | — |
| 0.5 to 0.8<br>0.0 to 0.1 | 0.5 to 0.6<br>0.0 to 0.1 | 0.1 to 0.2<br>0.0 to 0.06 | 0.2 to 0.3<br>0.0 to 0.02 | 0.2<br>0.01 | 0.03<br>1.5 to 1.7 (at 260°—5 hrs.) | 0.2 to 0.3<br>— |
| None | None | None | None | 247°<br>477° | None | None |
| None | None | None | None | >350°<br>>662° | None | None |
| 31° | 35°-38° | — | — | 46° | — | — |
| 88° | 99° | — | — | 115° | — | — |
| — | — | 150° to 170° (hold pt.) | 60° to 66° | 46° to 52° | 98° to 105.5° | 66° to 72° |
| — | — | 302° to 338° (hold pt.) | 140° to 151° | 115° to 126° | 208° to 222° | 149° to 162° |
| 1.647-1.649 | 1.6501-1.6517 | — | 1.664-1.667 | — | 1.660-1.665 | — |
| 72-78 | 86-100 | — | 90-150 (266°F or 130°C) | 300-400 | — | — |
| 3200-4500 | 600-850 (160°F or 71°C) | — | — | — | — | — |
| — | — | — | — | — | — | — |

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## *PROPERTIES THAT "MAKE JOBS" FOR THE* aroclors




### *"NON-DRYING"*

Aroclors are non-drying. Even when exposed to air in the form of thin films, no noticeable oxidation or hardening takes place. However, when used as components of paints, varnishes or lacquers, they do not retard the rate of drying of the films. Quick drying varnishes and paints can be made using Aroclors in the formulation.

### *"NON-FLAMMABILITY"*

The viscous, oil-like Aroclors and the resins do not support combustion when heated alone, even at their boiling points — temperatures in excess of 350°C. Most of the Aroclors flux readily with other resinous and pitch-like materials to make mixtures that gain in fire retardance properties. Even when incorporated in nitro-cellulose films and rubber foams, Aroclors will retard the rate of burning.

### *"ADHESIVENESS" AND "THERMOPLASTICITY"*

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

The Aroclors are permanently thermoplastic. They apparently undergo no condensation or hardening upon repeated melting and cooling. Clear Aroclor resins can be supplied with softening points up to 105°C. Opaque, crystalline Aroclors can be supplied with initial melting points up to approximately 290°F.

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## 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 negligible effect.

**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 they are, at the same time, fire resistant.

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

## ELECTRICAL RESISTIVITY

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.

## SOLUBILITY

All Aroclors are insoluble in water. They are soluble, however, in most of the common solvents, plasticizers, and resins.

The Aroclor oils and resins are readily soluble in most of the common organic solvents and drying oils. The hard crystalline Aroclors are in general less soluble than the liquids or softer Aroclor resins. All the Aroclors are heavier than water, a valuable property for many applications.

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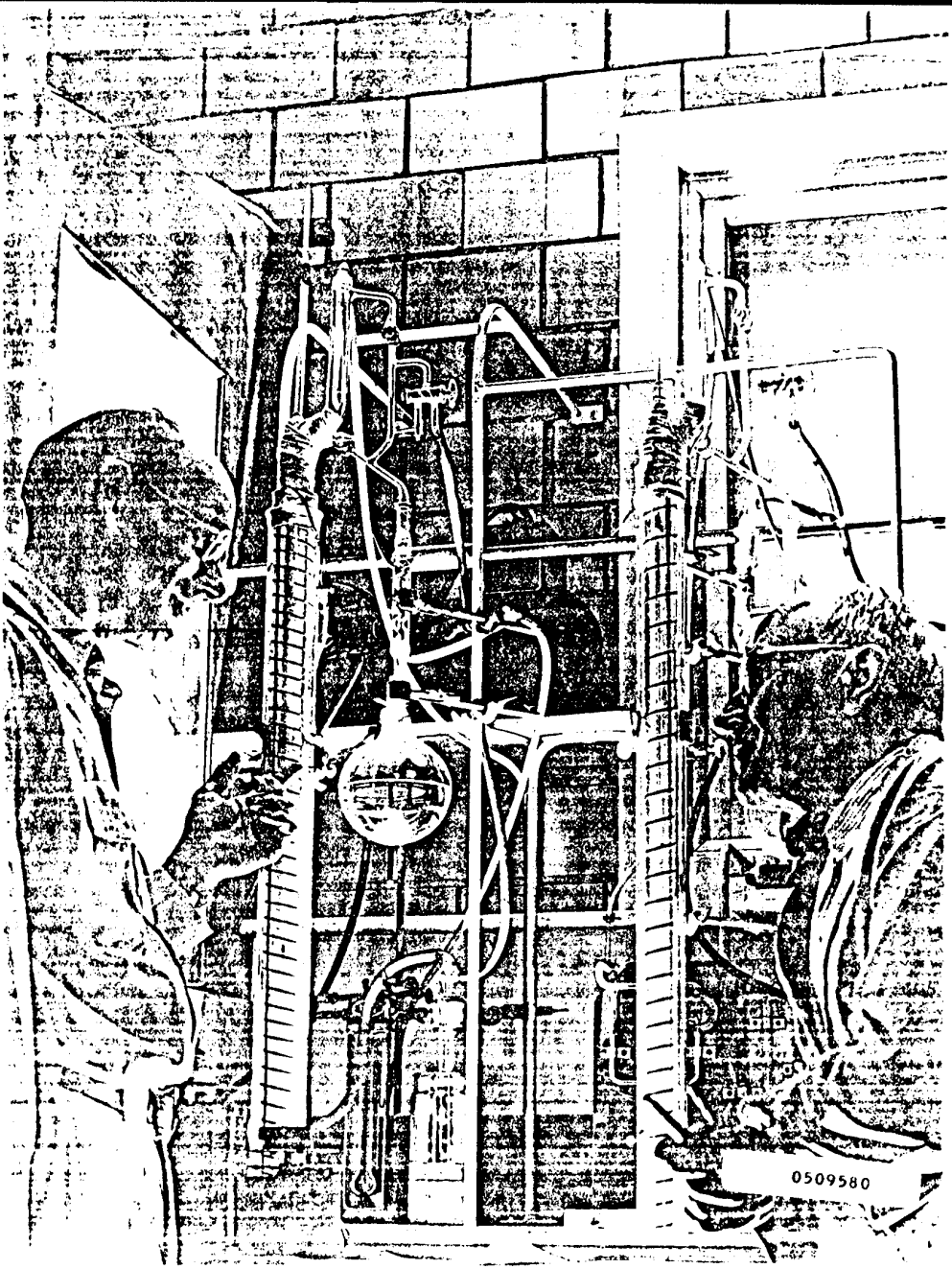


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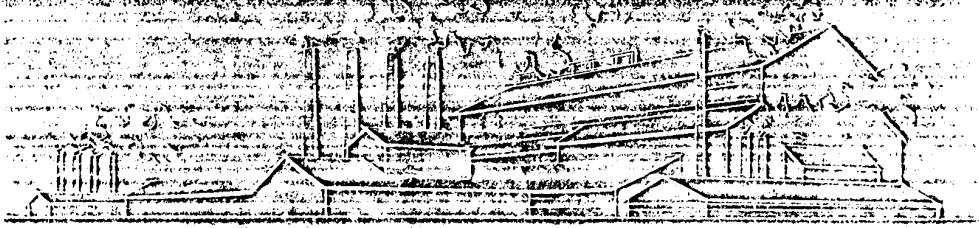
# industrial applications of the aroclors

Because of the unique properties of the Aroclors, these inert, durable oily liquids and resins have found a variety of special jobs in systems operation, manufacturing uses and product formulating. Wherever an inert liquid is required in engineering — wherever an extender, a "tack-imparting" ingredient, or a low cost additive is needed to impart flame retardance, chemical resistance, or to slow evaporation — Aroclors may serve the need.

The following applications will indicate the many ways Aroclors are used.



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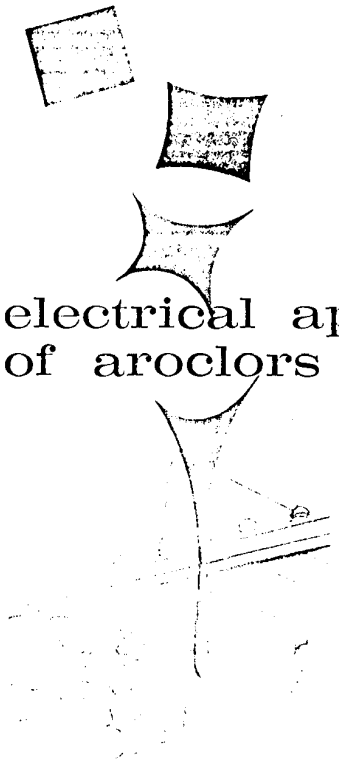

*Aroclors are among the purest commercial chemical compounds, virtually free of even traces of conducting impurities. For this reason, the Aroclors' dielectric properties closely approximate the theoretical maximum for the particular organic compound. With their stability, heat resistance and flame resistance — Aroclors can be used for a variety of heavy-duty dielectric applications.*

# electrical applications of aroclors

## DIELECTRICS FOR ASKAREL TYPE TRANSFORMERS AND CAPACITORS

Monsanto Aroclors are used *per se* and are formulated for the liquid coolant-insulation fluids in transformers and capacitors. Such dielectrics must be highly pure with dependably minimal traces of electrolytes. They must be chemically stable and non-corrosive to a wide variety of structural materials. Most important, the dielectric fluid must be fire-resistant.

Aroclors are the only liquids in low cost commercial supply that meet these exacting requirements.

Liquid Aroclors "1242," "1248," "1254," and "1260" are used directly, or these are carefully formulated with chlorinated benzene and other additives to make askarel fluid for particular needs. Typical formulated askarel fluids are shown on the following pages.

Aroclors "1242" and "1254" themselves or in special formulations are used as the dielectric in fixed paper capacitors, for the power factor correction in utility transmission lines; for home appliances such as air conditioners, furnaces, washers and driers; for electric motors; and for ballast in fluo-

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rescent fixtures. There are also a number of applications in DC systems, in condensers, and the new energy storage capacitors.

The Aroclor fluids can be used in a wide variety of applications requiring a specialized dielectric. Monsanto works closely with electrical equipment makers to develop the proper dielectric with the exact physical properties required by the engineering of the equipment.

## *IMPREGNATING COMPOUNDS*

Because of their nonflammability, high resistivity, and dielectric strength and low power factor, the liquid and resinous Aroclors are extremely useful materials for many applications as impregnating compounds. An important application 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. Because they possess high purity and excellent electrical resistance, Aroclor 1254, 5460 and 1268 make excellent dielectric sealants: to close the pores of carbon resistors, and to seal electrical bushings and terminals.

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 0.10% based on the weight of Aroclor, followed by filtration. Treatment is improved if the Aroclor is heated to 50-55°C.

## *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 $500 \times 10^9$ | Greater than 35KV | <0.1% |
| 1248 | 5.6 | 4.6 | Above $500 \times 10^9$ | Greater than 35KV | <0.1% |
| 1254 | 5.0 | 4.3 | Above $500 \times 10^9$ | Greater than 35KV | <0.1% |
| 1260 | 4.3 | 3.7 | Above $500 \times 10^9$ | Greater than 35KV | <0.1% |
| 1268 | 2.5 | — | | | |
| 5442 | 3.0 | 4.9 | Above $500 \times 10^9$ | | |
| 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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## TYPICAL TRANSFORMER ASKAREL

(MIXTURE OF AROCLOR AND CHLOROBENZENES)

| *Property* | *Typical* |
|---|---|
| Visc. @ 37.8°C. (ASTM D88) | 41-45 Sec. Saybolt Univ. |
| Spec. Gravity @ 15.5/15.5°C., (ASTM D287) | 1.563-1.571 |
| Color, APHA | 150 max. |
| Condition | Clear |
| Acidity, mg. KOH/g. | 0.01 max. |
| Pour Pt., °C., (ASTM D97) | −44°C., or lower |
| Inorganic Chlorides, ppm | 0.10 max. |
| Refractive Index @ 25°C. | 1.6075-1.6085 |
| Distillation Range (ASTM D20) Corrected for stem and barometric pressure | |
| First drop | 210°C. min. |
| 35% | 240-256°C. |
| 55% | 290-350°C. |
| 65% | 385-400°C. |
| 95% | 395-415°C. |
| Corrosion | After heating with aluminum for 6 hrs. @ 200-220°C., the aluminum must not be corroded either on visual or weight inspection. |
| | The askarel fluid meets the following specifications: |
| | Color, APHA 200 max. |
| | Acidity, mg. KOH/g. 0.01 max. |
| | Inorg. Chlorides, ppm 5 max. |
| | Condition Clear |
| Water Content, ppm. | 30 max. |
| Resistivity, 100°C., 500v., 0.1" gap | $100 \times 10^9$ ohm-cm., min. |
| Dielectric Strength, 25°C. | 35 KV., min. |
| Dielectric Constant, 100°C., 1000 cycles* | 3.8-4.2 |
| Tin Tetraphenyl* | 0.125% ± 0.01% by weight |
| Burn Point, (ASTM D92)* | None up to Boiling Point |
| Fixed Chlorine* | 60.5 ± 0.5 |
| Arc Formed Gases* (Oxygen Free Liquid @25°C.) | Total combustible gases including carbon monoxide, hydrogen and volatile hydrocarbons. |
| Electrical Stability* | After heating for 96 hours @ 100°C in a closed container, the resistivity should not decrease more than 10%. |

## TYPICAL CAPACITOR AROCLOR

| *Property* | *Typical* |
|---|---|
| Visc. @ 37.8°C. (ASTM D88) | 82-92 seconds Saybolt Univ. |
| Specific Gravity @ 25/15.5°C (ASTM D287) | 1.381-1.392 |
| Color, APHA | 50 max. |
| Condition | Clear |
| Acidity, mg. KOH/g. | 0.01 max. |

*Determined by special request.

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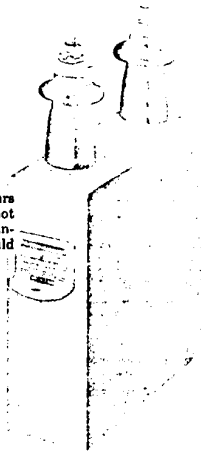
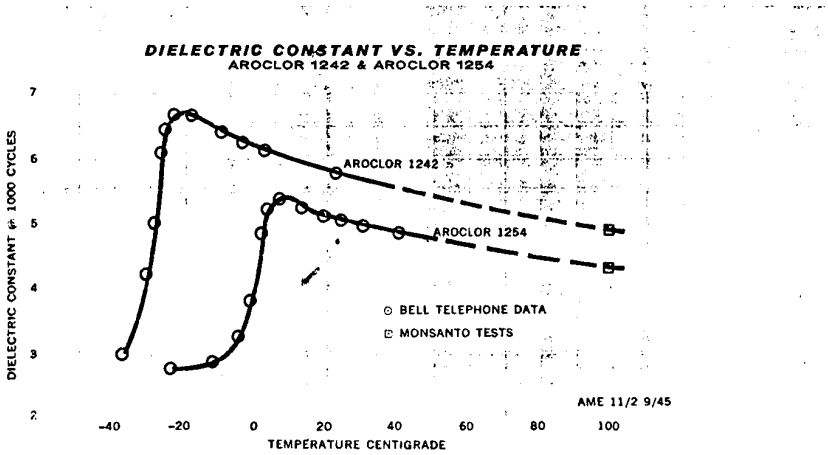
## *Typical Capacitor Aroclor (continued)*

| *Property* | *Typical* |
|---|---|
| Pour Pt., °C. (ASTM D97) | −14 or lower |
| Inorganic Chlorides, ppm. | 0.10 max. |
| Refractive Index @ 25°C. | 1.6240-1.6260 |
| Distillation Range (ASTM D20) Corrected for stem and barometric pressure | 10% 325°C. min.<br>90% 360°C. max. |
| Corrosion | After heating with aluminum for six hours at 210°C ± 10°C the aluminum must not be corroded either on visual or weight inspection and the Aroclor 1242 should meet the following specs.:<br>Color, APHA 60 max.<br>Acidity, mg. KOH/g. 0.01 max.<br>Inorg. Chlorides, ppm 0.10 max.<br>Condition Clear |
| Water Content, ppm | 35 max. |
| Resistivity 100°C. 500 volts DC @ 0.1" gap | 500 x $10^9$ ohm-cm., min. |
| Dielectric Constant 100°C. @ 1000 cycles (ASTM D924) | 4.7-4.9 |
| Flash Point Cleve. Open Cup* | 170°C., min. |
| Fire Point °C.* | None to boiling point |
| Sulfates (ASTM-D117-31)* | None |
| Fixed chlorine content (Carius)* | 41.5-42.5% |
| Specific Heat @ 25°C.* | 0.29 |
| Evaporation @ 100°C for 6 hrs.* | 0.4% max. |
| Dielectric Strength (KV) (ASTM D877)* | 35 Min. |

*Determined by special request.



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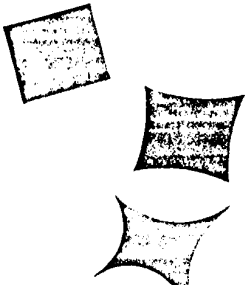


*Because Aroclors have excellent shear resistance, heat stability, and are chemically stable . . . they can serve in dozens of mechanical applications for transferring mechanical power, heat, and variable pressures. Aroclors do not attack metals even at high temperature; they resist oxidation, chemical and mechanical breakdown under a wide variety of environmental conditions. In addition, the Aroclor liquids used as lubricants impart a high degree of extreme pressure lubricity.*

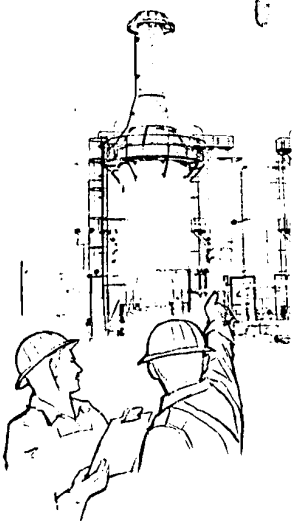
# mechanical applications of aroclors

## HEAT TRANSFER

Aroclors are outstanding for use as the heat transfer liquids in indirect heating systems. Aroclor systems can transfer closely controllable, uniform heat to chemical processing vessels, food cookers, potato chip fryers, drying ovens and other installations where the fire source must be removed from the point where the processing heat is used. Aroclor 1248 is used most frequently in such indirect heating systems.

Heat transfer with Aroclors has many advantages. Processing heat up to 600°F. can be delivered in a *non-pressurized* system, reducing the construction costs of the heating system. The fluid in properly engineered systems will last without significant degradation for from five to seven years. The systems present no fire or explosion hazard, since the Aroclor does not support combustion. In addition, there is no day to day conditioning of boiler water, inasmuch as the Aroclor requires no conditioning, and Aroclor systems require a minimum amount of insulation. Aroclor systems operating at atmospheric pressure have been used successfully since 1941. Aroclor systems can operate safely and efficiently on gas, oil or electricity.

Photo courtesy of Fluid Heat Development Division Yuba Consolidated Industries, Inc.



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Aroclors 1242, 1248 and 1254 are used as a circulating heat transfer medium with great success. Good circulation and a well designed heating system are necessary to prevent local overheating. Aroclor 1248, however, is recommended for universal use up to 315°C (600°F) because of its fluidity at low temperatures and its fire-resistance. The liquid Aroclor 1248 is readily pumpable with centrifugal pumps to temperatures as low as 50°F.

In processes where a cooling cycle must also be introduced, provision can easily be 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 1232 can be substituted for the Aroclor 1248. If low outside temperatures are encountered, the less viscous Aroclor 1242 can be used.

Aroclor 1232 may be used where outdoor temperatures as low as 20°F are encountered. While Aroclor 1232 is serviceable for unpressurized heat transfer, this Aroclor compound is not quite as fire resistant as "1248" or "1242."

Monsanto has available an "Engineering Heat Transfer Data" booklet that gives design guidance on Aroclor systems. In addition, Monsanto can suggest sources for Aroclor heaters and equipment.

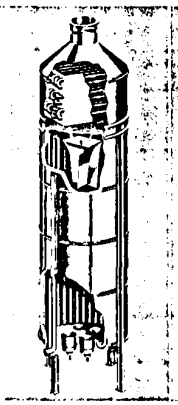

Photo courtesy of Western Precipitation Corp.

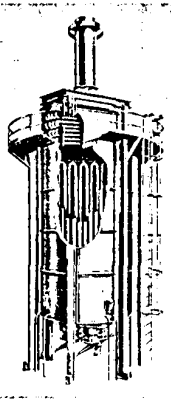

Photo courtesy of Struthers Wells Corp.

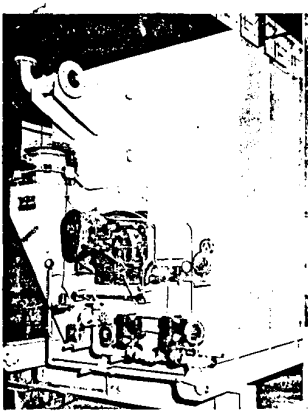

Photo courtesy of Union Iron Works

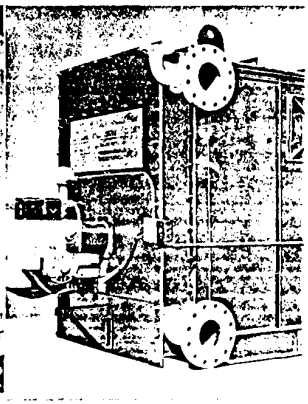

Photo courtesy of The International Boiler Works Co.

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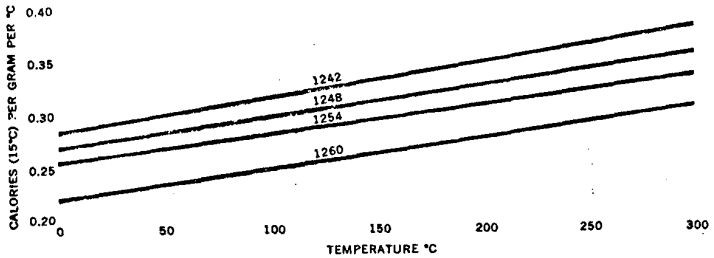
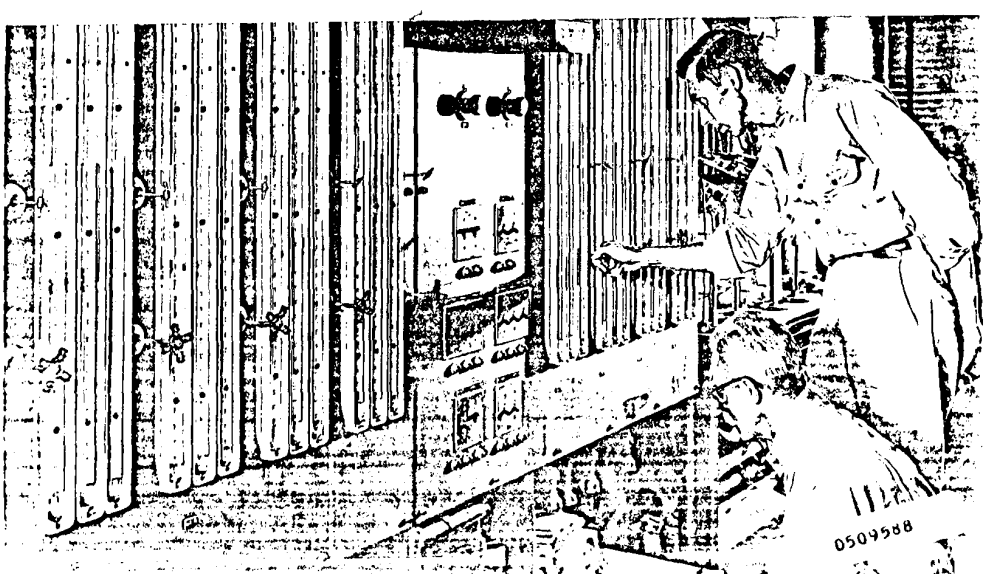
## *HEAT CAPACITY OF AROCLORS*
AT VARIOUS TEMPERATURES




## *THERMAL CONDUCTIVITY OF AROCLOR 1248*

| Temperature °C. | Temperature °F. | BTU./Hr./Sq. Ft./ °F./Ft. | Calories, gram/Sec./ Sq.Cm./°C./Cm. |
|---|---|---|---|
| 30 | 86 | 0.0570 | $236 \times 10^{-4}$ |
| 60 | 140 | 0.0564 | $233 \times 10^{-4}$ |
| 100 | 212 | 0.0555 | $229 \times 10^{-4}$ |



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## EXPANSION MEDIUM

Because of their stability at high temperatures and ability to withstand frequent temperature cycles without gum formation, the liquid Aroclors are used as the actuating medium in bellows controls, thermostats, industrial temperature control regulators and other kinds of automation equipment.

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 |

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

| Temp. °F. | 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 |

## LIQUID SEALANT FOR FURNACE ROOFS

The liquid Aroclors 1248 and 1254, because of their low vapor pressures and fire-resistance, make excellent liquid sealants. These non-evaporating fluids have good flow at slightly elevated temperatures and are chemically stable at elevated temperatures. Consequently, the liquid Aroclors make excellent fluid sealants for any application where the use of oil would create a fire hazard. In the trough of annealing furnaces, for example, Aroclors make dependable fire-safe roof seals.

## VACUUM DIFFUSION PUMP OIL

The fluid Aroclors 1248 and 1254 are highly stable to air; they make good oils for vacuum pumps at a much lower cost than high priced silicone type oils. These Aroclors operate efficiently in vacuum diffusion pumps used to pull high vacuum for metalizing plastics; dehydrating foods, medicinals; and for drying capacitor cones.

## DUST ENTRAPMENT

Because Aroclors are non-drying and tacky, they make excellent coatings for capturing dust, lint and other fine air-borne particles. Aroclors 1260 and 5460 are used successfully to coat fibrous glass air filter pads, metal mesh and other materials used for filtering air and gas streams.

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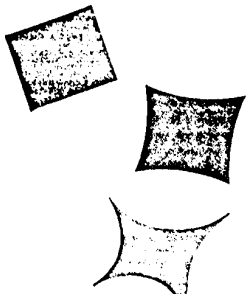
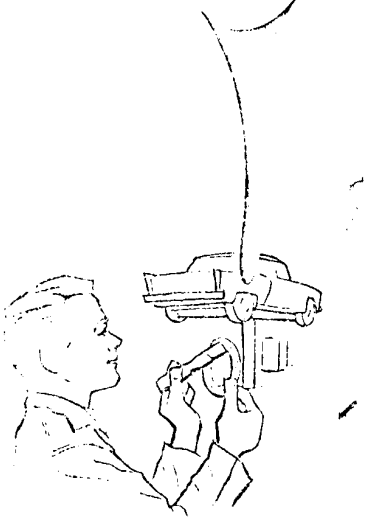


*With their wide range of physical properties, their inertness, lubricity, and vapor-suppressing characteristics — Aroclors can be valuable ingredients in an extraordinary variety of formulated products. They are compatible with a variety of solvents, oils, resins. They are virtually non-volatile and permanently thermoplastic; they will not react with other chemicals in the formulation. In addition, their low cost makes their use for special purposes eminently practical and economical.*

# aroclors in special product formulations



## SEALERS FOR GASKETS

Aroclors — particularly when hot — swell rubbers like Hycar, Koroseal, PerBuna N, and Neoprene. Wherever seals and gaskets of natural or synthetic rubber tend to shrink under heat and use, Aroclors 1232, 1242 or 1254 can be used as a swelling agent to tighten the shrunken seal. An example is in automotive transmission oil: a small amount of Aroclor in the oil swells the seal *in place*, saving the cost of tearing down the equipment to replace the seal or gasket. Aroclors can be used in gasket sealing compounds to swell the rubber after the gasket or seal is in place.

## DEDUSTING AGENT

Aroclor 1254 is a low cost dedusting agent which can "hold down" the dusting of a variety of chemical products. Because Aroclor 1254 resists both combustion and oxidation, it can be used to control dusting of highly reactive compounds. As a typical example,* a few tenths of one percent will control the dusting of calcium hypochlorite.

*Covered by U. S. Patent No. 2,921,911, issued January 19, 1960, and assigned to Pennsalt Chemicals Corp.

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Aroclor 5460 and 1254 act as vapor suppressants. The United States Department of Agriculture scientists reported that the inclusion of from 5 to 25 parts per hundred by weight of Aroclor increased the effective kill-life of a lindane spray up to ten times. A painted or metallic surface sprayed with certain chlorinated insecticides fortified with Aroclor will remain toxic to flies, ants, roaches, silverfish up to 2 to 3 months. The Aroclor resins suppress the rapid evaporation of the volatile insecticides without adding odor or other objectionable residue. Formulation into insecticides is quite simple; the Aroclor is dissolved in a suitable solvent compatible with the insecticide formulation, and mixed in. The most pronounced effect for increasing the kill-life of the insecticide is obtained with lindane, chlordane and BHC. Aroclors are recommended for chlorinated insecticide formulations to be used for non-crop spraying. Their low cost makes this use a most practical way to lower the ultimate cost of insect control.

Aroclors are compatible with various natural waxes, such as carnauba and others, including those used to formulate casting wax. Aroclors help impart to the finished casting wax a number of desirable properties: hardness without brittleness; resistance to shrinking; sharp definition; sharp melting point; and fire-resistance. Waxes formulated with Aroclors are non-tacky and highly stable. Aroclor-containing waxes are widely used in making dental castings, in the precision casting of aircraft parts, and for casting costume jewelry. Aroclors 1254, 4465 and 5460 are the ones most frequently used, the proportions dependent upon the properties required in the finished wax. Much of the highest quality precision casting wax used in the "lost wax" process is formulated with Aroclors.

Aroclors 1254, 1268 and 5460 are used in the manufacture of specialized abrasives. Because of their excellent bonding characteristics, high thermal stability and resistance to oxidation and corrosion — Aroclors are used as the carriers for abrasive materials. A major use is as part of the bonding agent in specialized grinding wheels.

For specialized lubricants requiring good extreme pressure (EP) characteristics, the liquid Aroclors make excellent additives. The Aroclors impart high temperature stability, excellent lubricating qualities, and weather and corrosion resistance. As an example, Aroclors are used to formulate grease and pipe thread compounds for use in oxygen systems. Greases formulated with Aroclors have a high chemical resistance, are suitable for use in contact with corrosive chemicals. Gear oil lubricants containing Aroclors have good resistance to sheer degradation and high

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temperature stability. Added in small amounts to railroad car journal box oils, Aroclors impart better extreme pressure lubricity and reduce the incidence of "hot boxes."

The heat-resisting, nonflammable characteristics of the Aroclors make them attractive in themselves as lubricants under conditions of high temperature. As an example: in governor systems of central power stations, Aroclor 1248 is well suited to this lubricating application.

Straight Aroclor 1254 gives 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.

As an extreme pressure (EP) 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 two Aroclors represent one of the more satisfactory carriers for the element chlorine as an extreme pressure base, possessing the following advantages:

1. **STABILITY** . . . even at higher temperatures, which assures there will be neither separation of components nor appreciable change in physical or chemical properties during long periods of operation.
2. **NON-VOLATILE.** Many other types of chlorine bearing compounds are so volatile as to render them unfit for long periods of service. The Aroclors are non-volatile at normal temperatures.
3. **NON-OXIDIZING.** Aroclors do not oxidize nor "thicken up" to an objectionable degree.
4. **NON-CORROSIVE** . . . toward metal surfaces.
5. **NON-ABRASIVE.** Aroclors exerts 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 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 weight Oil* | Aroclor 1248 | Pour Pt. | Gravity at 15.5°C. | Approx. Pounds Gal. |
|---|---|---|---|---|---|
| 1 | 50 | 50 | 0°F | 1.1263 | 9.4 |
| 2 | 25 | 75 | +5°F | 1.2703 | 10.6 |

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

*Bright Stock: Gravity, API 22-23



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### Aroclors In Industrial Cutting Oils

Aroclor 1254 is used to formulate the finest quality "straight" and "soluble" or emulsifiable-type cutting oils. The Aroclor functions as an excellent extreme-pressure lubricant and it is far superior to aliphatic chlorinated hydrocarbons because of its higher order of thermal stability. The heat resistance is most important in cutting oils for machining high grade steel. With Aroclor cutting oils there is a lower degree of hydrolysis which minimizes the staining of the metal.

## *AROCLORS IN ADHESIVES*

Aroclors are outstandingly useful ingredients in the formulation of various types of adhesives. Besides a plasticizing action on the adhesive's resin base, they add valuable properties to the adhesive bond. Aroclors offer a variety of property improvements to adhesives based on polyvinyl acetate, to rubber cements and to hot melt adhesives.

Aroclors strongly resist attack by water, acids, alkalies and other common corrosive influences, as well as microorganism attack. By proper selection of materials, adhesives containing Aroclors can have outstanding resistance to most of the destructive factors that injure bonding properties.

### Hot Melt Adhesives

A typical starting formulation for a cellulose acetate butyrate hot melt adhesive with Aroclor 5460 is:

| | Parts by Weight |
|---|---|
| Half-second cellulose acetate butyrate | 35.00 |
| Aroclor 5460 | 30.00 |
| Dioctyl phthalate | 15.00 |
| Newport V-40 | 19.89 |
| Santonox* | 0.1 |
| Syn Fleur #6 | 0.01 |

The above coating can be applied at about 350°F. Ventilation should be provided.

A typical starting formulation for an ethyl cellulose hot melt adhesive with Aroclor 5460 is:

| | Parts by weight |
|---|---|
| Ethyl cellulose, 50 cps | 24 |
| Aroclor 5460 | 7 |
| Lopor No. 45 Mineral Oil | 57 |
| Bakers No. 15 Castor Oil | 5 |
| Epoxy soybean oil | 3 |
| Paraffin wax (m. p. 135°F) | 3 |
| Santonox* | 1 |

*Santonox Monsanto Chem. Co. trademark. Registered U. S. Pat. Ofc.



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### Heat Sealing Adhesives

Chlorinated rubber and Aroclors 1254 and 1260 make excellent heat sealing and label adhesives. These adhesives have high chemical resistance and extremely low moisture vapor transmission. A typical starting formulation is:

| | Parts by weight |
|---|---|
| Parlon (125 centipoise type) | 20 |
| Aroclor 1254 | 6 |
| Aroclor 5460 | 6 |
| Toluene | 68 |

### PVAc Emulsion Adhesives

Aroclors 1221, 1232, and 1242 impart excellent tack and strong bonding power to polyvinyl acetate emulsion adhesives. They readily blend with simple stirring and since they are liquid at room temperature no pre-melting is required. The hardness required in the adhesive's end use can be varied to suit simply by selection of the Aroclor without materially changing other properties. The Aroclors are compatible with PVAc emulsions at a level of up to 11 parts of Aroclor in 100 parts of PVAc emulsion.

An excellent type of hot melt book binding adhesive can be made as follows:

| | Parts by weight | | |
|---|---|---|---|
| | Formula 17 | Formula 18 | Formula 19 |
| Gelva polyvinyl acetate resin V-7 | 100 | 65 | — |
| Ethyl cellulose | — | 15 | — |
| Gelva C-SV-16R | — | — | 100 |
| Santicizer 160 | — | 16 | — |
| Rosin WW | 75 | — | 75 |
| Dibutyl phthalate | 30 | — | 30 |
| Aroclor 1254 | 55 | 4 | 55 |

By changing the type of polyvinyl acetate resin utilized in the hot melt, the viscosity of the melt can be increased or decreased without changing the ratio of resin to plasticizer.

### Polyurethane Resin Adhesives

An excellent flocking adhesive containing Aroclor 1254 can be made as follows:

| | | Parts by weight |
|---|---|---|
| Part A — | Multranil FLD* | 100 |
| | Aroclor 1254 | 20 |
| | Mondur *C | 5 |
| Part B — | Multranil FLD* | 100 |
| | Mondur C* | 5-10 |

Part A is applied to the fabric by knife coating and allowed to dry thoroughly. The fabric is then coated with Part B, and the material is flocked immediately.

*Mobay Chemical Co. trademark. Registered U. S. Pat. Ofc.

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### Epoxy Adhesives

Aroclors can be used to extend epoxy resin adhesives. The extending greatly reduces the formulation cost with a minimum effect on the bonding characteristics of the adhesive.

Aroclors can be used to extend or substitute Carnauba Wax and reduce the cost of the wax formulation. Several practical formulas are available using Aroclors to make wax blends that possess the qualities of Carnauba Wax. These blends can be used 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.

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 formulation 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.

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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, ethyl cellulose, cellulose acetobutyrate, benzyl cellulose or vinyl resins. Selection of materials for use in combination with Aroclors depends on 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% 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.

An excellent melt coating for paper and cloth was reported by W. M. Gearheart and F. M. Ball, OFFICIAL DIGEST, Vol. 343, 1953:

| | |
|---|---|
| Half-second Butyrate | 50% |
| Dioctyl phthalate | 9.9% |
| Aroclor 1260 | 40% |
| Ionol | 0.1% |

This coating may be applied by knife or roller at 350°F; the application requires no solvent. This coating on paper or fabric has extremely good flexibility.

Aroclor 4465 is a useful resin for compounding rotogravure and other printing inks. 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

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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.

The Aroclors are also used as vehicles for carrying the pigments used 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 for ceramic decoration.

## PAPER TRANSPARENTIZER

A treating liquid that makes paper transparent for use as tracing paper, window envelopes, and special packaging can be formulated with Aroclor 5460 and polybutenes. A typical economical formulation is:

| | |
|---|---|
| Aroclor 5460 | 30% |
| Indopol H-300 | 25% |
| Toluene | 45% |

In the paper treating formula, the proportions of Aroclor to Indopol may be varied from 2:1 to 1:2 respectively.

## MASTICS, SEALING AND CAULKING COMPOUNDS

Aroclors and polybutenes can be blended with inorganic fillers to make excellent sealing and caulking compounds. A typical "filler" would be:

| | |
|---|---|
| Whiting | 50% |
| Talc | 30% |
| Lithopone | 10% |
| 7 M Asbestos | 10% |

By combining selected Aroclors and Indopol polybutenes, it is possible to produce a wide range of hardness, viscosity, flow and bonding characteristics in durable sealing and caulking compounds.

Excellent mastics, too, can be prepared by blending selected Aroclor resins with Indopol polybutenes. The mastics have good adhesive qualitites for specialized uses such as sealing of automobile body construction.

## PERMANENT TACK COATINGS

Aroclors and Indopol polybutenes can be blended in a variety of proportions to make permanently tacky coatings. These coatings may be applied to fabric or paper to provide a permanently "sticky" surface. Insecticides, for example, can be blended into such coatings to make insect traps or insect barriers on tree trunks for tree foliage or fruit protection. These coatings can also be used for tapes and sign backing.

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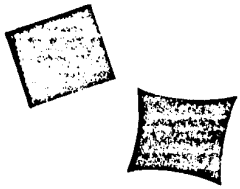
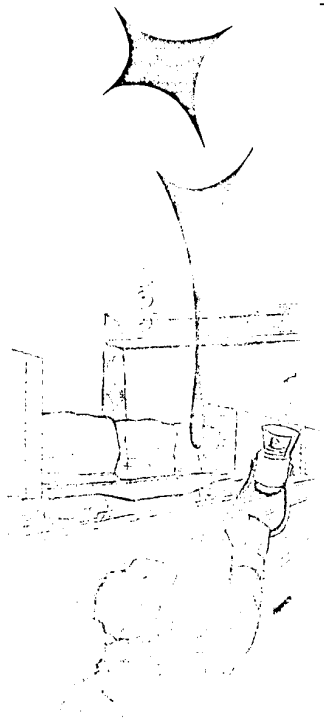


*Aroclors are valuable as low cost plasticizers for a variety of applications. Aroclors improve chemical resistance, flame retardance, oxidation resistance, and reduce the cost of plasticized elastomers. Depending upon the use, the various Aroclor compounds offer a number of benefits to the user.*

# aroclors in plastics



In almost all formulations, the use of a selected Aroclor as a plasticizer reduces the cost per pound of the formulation.

Another valuable use of Aroclors in the plastics field is as a grinding and dispersing medium for pigments.

The Aroclor compounds are compatible with most common plastic materials; they are compatible to the extent of practical use with the following:

Asphalt
Benzyl Cellulose
Carnauba Wax
Cellulose Acetate Butyrate
Chlorinated Rubber
Coumarone-Indene Resins
Dammar Resin
Ester Gum
Ethyl Cellulose
Epoxy Resins
Manila Gum
Nitrocellulose
Paraffin
Phenolic Resins
Polyethylene
Polyester Resins
Polystyrene Resins
Polyiso-Butylene
Polyurethanes
Polyvinyl Acetate
Polyvinyl Chloride and
Polyvinyl Butyral
Polyvinylidene Chloride
Rosin
Rubber
Styrene Butadiene Co-Polymers
Vinyl Resins

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Aroclors are not compatible with cellulose acetate or with phenolic resins in the final stage of condensation.

In selecting the proper Aroclor for a given use, the degree of *flexibility* imparted increases progressively in the order of: hard resinous Aroclor, soft resinous Aroclor, liquid Aroclor. Conversely, the *hardness* of the plasticized elastomer increases progressively with the choice of: liquid Aroclor, soft resinous Aroclor, hard Aroclor resin.

## POLYVINYL CHLORIDE

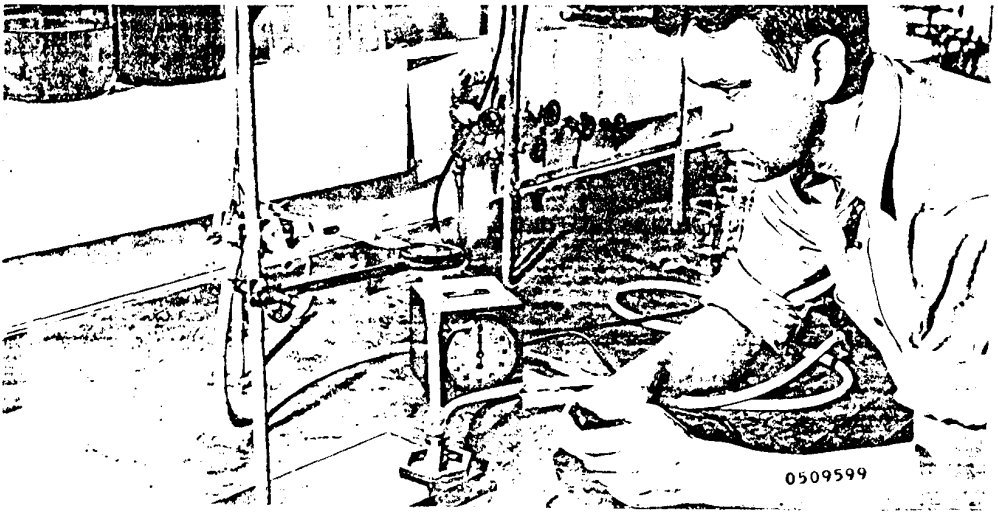
The Aroclors are valuable as secondary plasticizers, or plasticizer-extenders for polyvinyl chloride formulations. The Aroclors impart greatly improved chemical resistance over conventionally ester-plasticized compositions. For example, a formulation plasticized with 3 parts of DOP and 1 part of Aroclor 1254 shows the best chemical resistance of any plasticized polyvinyl chloride formulation evaluated to date.

Aroclor 1262, when used as a co-plasticizer with DOP, greatly reduces the amount of migration of the plasticizer to nitrocellulose lacquers. Aroclor 5460 is frequently used as a plasticizer-resin-extender to make flameproof vinyl tiling compositions.

In vinyl chloride co-polymer resins for solution application, the combination of Aroclor 5460 and Aroclor 1254 is widely used because of its outstanding chemical resistance.

## RUBBER—NATURAL AND SYNTHETIC

The liquid Aroclor compounds — 1221, 1232, 1242 and 1248 — have a strong plasticizing action on rubber, both natural and synthetic. Aroclors 1254 and 1260,

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when milled into rubber, impart permanent tackiness and adhesion to the composition.

Aroclors 2565, 4465, 5460 and 1268, when incorporated in neoprene rubber in amounts as high as 40 parts per 100 parts of rubber make compositions that are extremely flame retardant.

The Aroclors generally show a high degree of compatibility with epoxy resins; this group of materials is one of the very few plasticizers that possess such high compatibility with these materials. The lower Aroclor numbers, 1221 and 1232, impart a high degree of flexibilizing to epoxy compounds. The more resinous and solid Aroclors have little effect on the flexibility of the compound; in fact, they tend to act as reinforcing materials. Aroclors have little effect on epoxy resins' hardness, tensile or compressive yield strength. The ultimate compressive strength can be improved by using solid Aroclors in phthalic anhydride cured systems.

All of the Aroclors, when used at a rate of 15 to 20 parts per hundred of resin, greatly retard the burning rate of epoxy compositions. If a small amount of antimony oxide is added in addition to the Aroclor compounds, the materials then become non-burning.

Aroclor 5460, when used in low density polyethylene to the extent of 20% — in combination with 10% antimony oxide — makes the compound self extinguishing. Compared to other materials that make polyethylene self extinguishing, Aroclor 5460 has much less effect on tensile, yield and elongation properties. In addition, the heat stability of the Aroclor compound is greatly superior to the other materials commonly used to make polyethylene self-extinguishing.

Incorporation of the solid, resinous Aroclors will make asphalt self extinguishing. Possible applications of this type of formulation include caulking compounds, roofing compounds and sound-deadening coatings. Normally, 30% of an Aroclor such as 5460 will make an asphalt mixture that is self extinguishing.

Incorporation of Aroclor in a polyester resin in combination with antimony oxide greatly reduces the burning rate of polyester resins. A mixture of sufficient amounts of selective Aroclors will produce polyesters that are self extinguishing.

Considerable interest has been displayed in the use of Aroclors in phenolic laminating resins, to make compounds that are flame resistant. Normally, the higher molecular weight Aroclor, such as Aroclors 1260, 1262 and 5460 are evaluated for this purpose.

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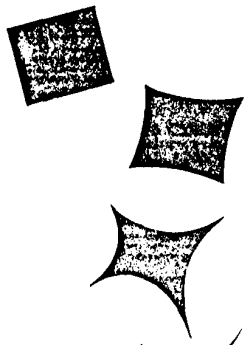
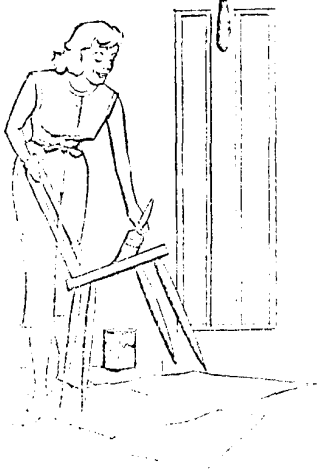


*Aroclors are soluble in paint and varnish oils and solvents and are compatible with most film-forming coating resins. The Aroclor compounds improve adhesion to the substrate. Adding Aroclors to paint, varnish or lacquer formulations imparts properties to the film that correspond to the particular character of the Aroclor used. The hard, resinous Aroclors tend to give increased hardness to films; the viscous Aroclors impart flexibility.*

*Aroclors are excellent grinding and dispersion 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. Moreoever, the coating composition does not support combustion.*

# aroclors in paint, varnish and lacquer formulations



## *VARNISHES AND ALKYDS*

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

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 they can be more readily mixed with the oils.

Aroclor 1260 is best for short oil varnishes that are required at the same time to be flexible. The Aroclors impart water and alkali resistance, and with these qualities enhance the value of the other resins used in the varnish. The suggested starting formulation is two parts by weight of oil, one part of Aroclor 1260 and one part of other resin. These



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proportions can be varied as required. The Aroclor may be considered to function in the formulation as an oil, with the difference that it does not oxidize and lose its flexibility.

Resins of the alkyd, phenolic or ester gum type, with a harder Aroclor such as 5460, may also be used in making varnish formulations.

## EPOXY RESIN COATINGS

The high compatibility of Aroclor compounds with epoxy resins makes these materials of great value in formulating epoxy coatings. Normally, 10 to 15% of Aroclor 1260 or 1262 is added to the epoxy composition to improve flexibility with a minimum effect on the corrosion resistance and adhesive characteristics of the film.

## NITROCELLULOSE COATINGS

In pyroxylin or nitrocellulose lacquers, the Aroclors can function both as plasticizers modifying the properties of the film and as film-forming bodying resins. Aroclors are highly compatible with nitrocellulose and with other resins and plasticizers commonly used in lacquer formulating. They impart weather resistance, luster, adhesion and decreased burning rate. The Aroclors' 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 make the Aroclors of special value in coatings for electrical insulating materials.

To illustrate the modification possible to obtain by changes in formulation, three lacquer 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 second R. S. Nitrocellulose | 100 parts by weight |
| Tricresyl Phosphate | 120 parts by weight |
| Aroclor 1242 | 80 parts by weight |

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

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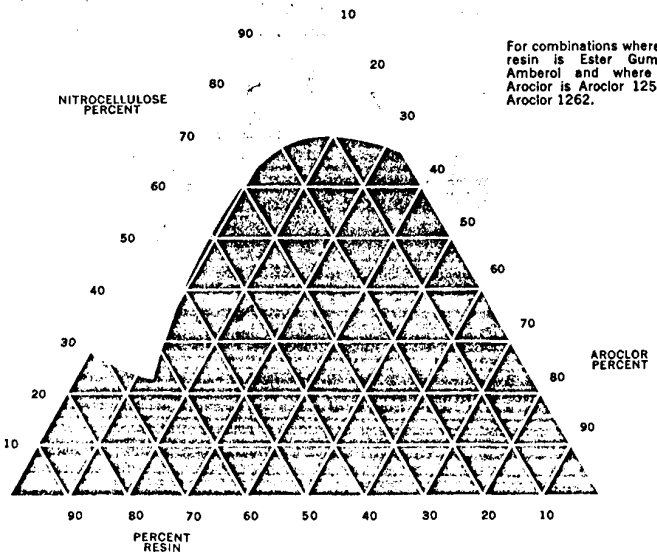
In the trilinear diagrams, the compositions, represented by any point in the unshaded areas, are those which produce homogeneous lacquer films. On the other hand compositions represented by points in the shaded areas produce impractical, segregated, brittle or soft films. For detailed information as 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).

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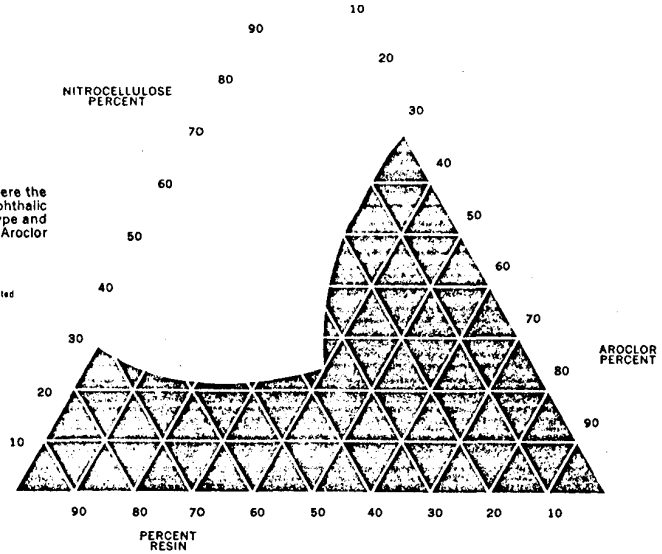
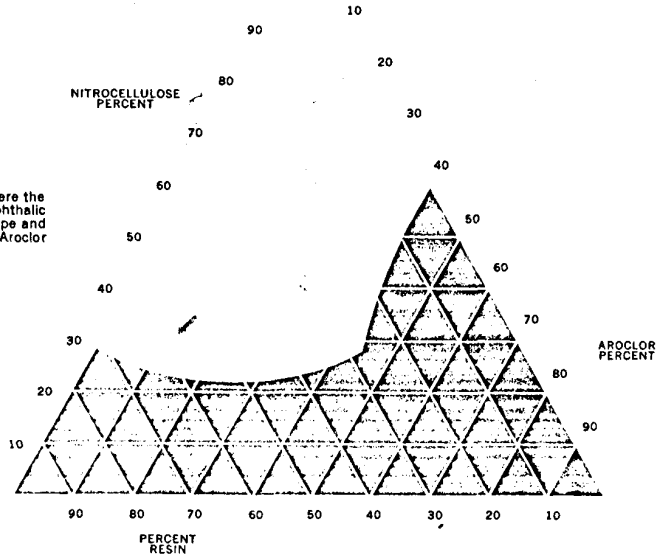
For combinations where the resin is of the phthalic anhydride-glucerol type and where the Aroclor is Aroclor 1262.*

*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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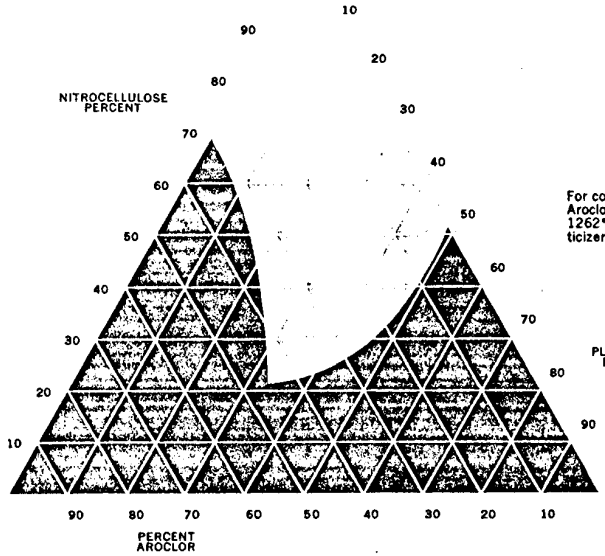
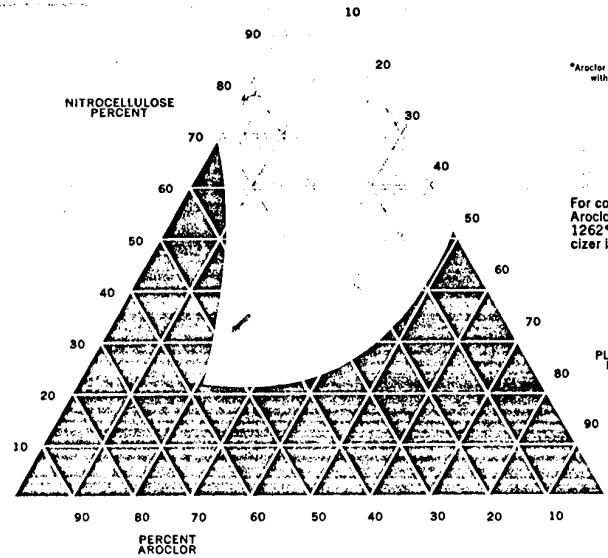



For combinations where the Aroclor resin is Aroclor 1262* and where the plasticizer is Dibutyl Phthalate.




*Aroclor 1260 may be substituted without material change.

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

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## CHLORINATED RUBBER AND STYRENE-BUTADIENE COPOLYMERS

Aroclors are outstanding for compounding modified rubber finishes. They impart exceptional corrosion resistance, chemical resistance, oxidation resistance to these coatings, and improve adhesion. Typical applications include masonry coatings for swimming pools, stucco homes and highway paints, as well as protective and decorative coatings for steel structures, railway tank and gondola cars, wood and metal maritime equipment.

In rubber base coatings, Aroclor 1254 is used as a liquid flexibilizing plasticizer and commonly used in combination with Aroclor 5460 which serves as a resin fortifier. The outstanding chemical resistance, corrosion resistance and oxidation resistance of rubber base Aroclor coatings make them outstanding protective coatings for chemical plants, boats, highway marking, and masonry. Monsanto Technical Bulletins No. PL-306, PL-311, and PL-326 cover the use of Aroclors in rubber base coatings.



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## CELLULOSE ACETATE BUTYRATE LACQUERS

The higher Aroclor compounds are widely used with cellulose acetate butyrate, in the manufacture of low cost lacquers that are flame resistant. Typical uses for this type of lacquer include paper coating, lacquers for plastics and strippable coatings for paint booths.

A typical paper lacquer with minimum tendency to curl is reported* to contain the following:

| | By Weight |
|---|---|
| Half-second Butyrate | 20% |
| Aroclor 1260 | 20% |
| Acetone | 10% |
| Isobutyl Acetate | 10% |
| Ethyl Alcohol | 10% |
| Toluene | 30% |

## ETHYL CELLULOSE COATINGS

The Aroclors are highly compatible with ethyl cellulose. The liquid Aroclors impart great flexibility, the resinous Aroclors impart great hardness. For example, 75 parts by weight of Aroclor 1242 with 100 parts of ethyl cellulose produces great flexibility and a slight tackiness. Aroclor 5460 on the other hand — in the same proportion — produces a very hard and somewhat brittle composition.

For coatings of high gloss and exceptional weathering properties to be applied to rigid surfaces, compositions containing equal parts by weight of Aroclor 5460 and ethyl cellulose are recommended. For more flexibility in the coating one of the softer Aroclors should be used — either alone or as a partial replacement for the Aroclor 5460.

Ethyl cellulose formulations plasticized with Aroclors find end use applications as protective lacquers, adhesives, and as strippable coatings.

The solid Aroclor compounds, such as Aroclor 5460 are widely used in hot melt applications for the protection of tools and metal parts. They are normally used with ethyl cellulose or cellulose acetate-butyrate resins.

## CREPE RUBBER COATINGS

Aroclor 1262 is used as a low cost plasticizer for crepe rubber in paint compositions. Used in concentrations of 5 to 50% based on the weight of the rubber polymer, it increases the gloss and alkali resistance of the film and strengthens the adhesion of the film to steel.

*W. M. Gearhart and F. M. Ball, OFFICIAL DIGEST, Vol. 343, 1953.

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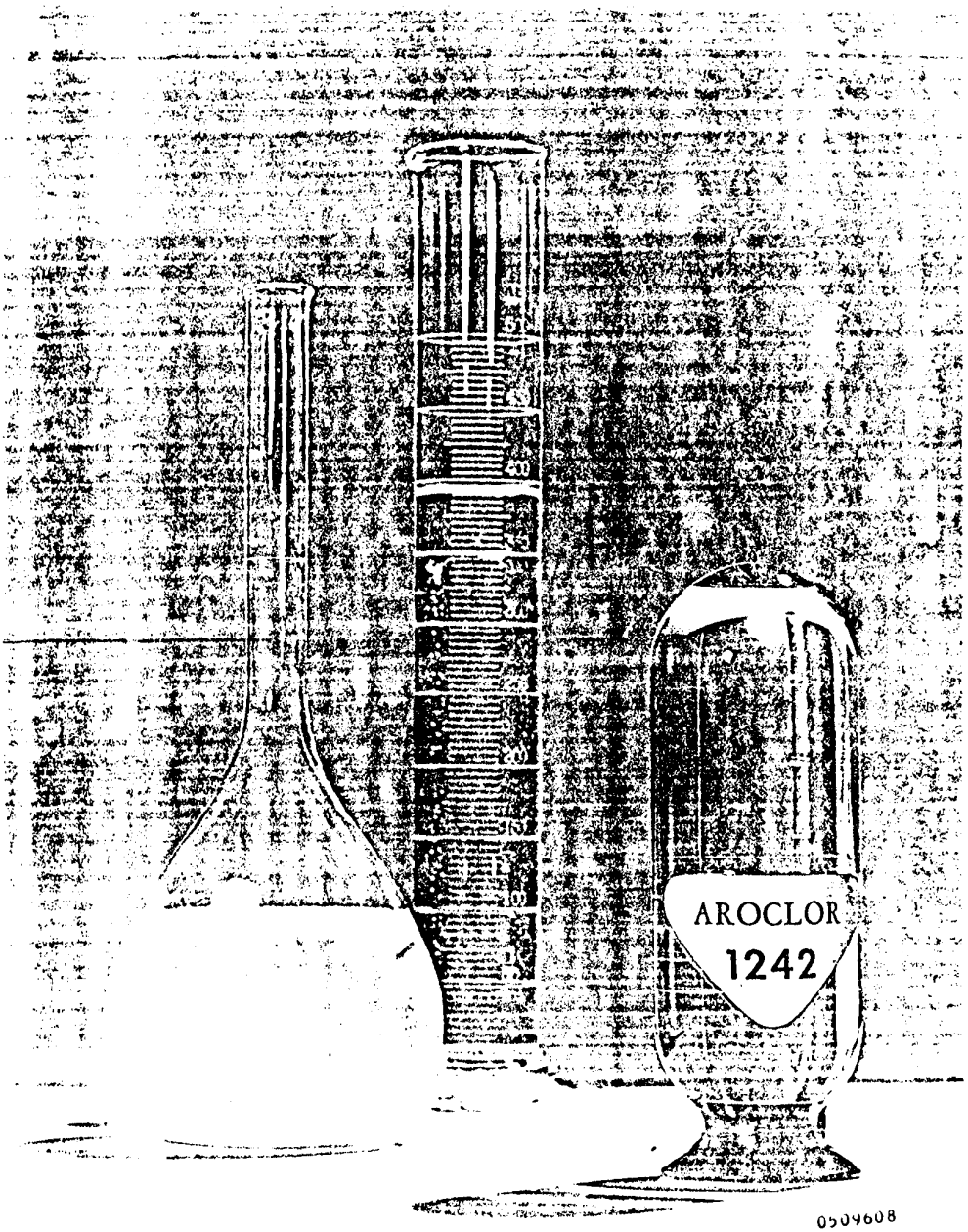


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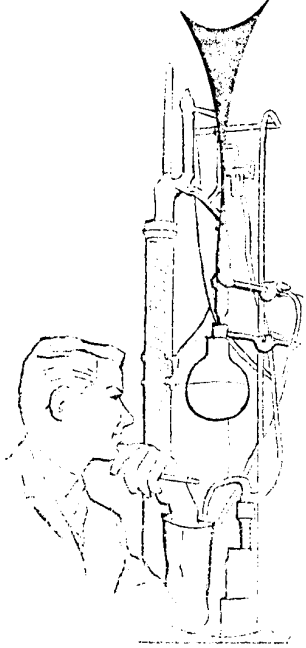
appendix

## METHODS FOR EMULSIFYING AND MAKING STOCK SOLUTIONS OF AROCLORS

There are several simple methods for making Aroclor emulsions; the one used may be selected to suit the kind of Aroclor and type of formulation in which it will be used.

### Emulsifying Viscous Aroclors

| | |
|---|---|
| (Portion 1) | 16 lbs. of Aroclor<br>1 lb. of Stearic Acid |
| (Portion 2) | 8 lbs. of water<br>4 oz. Triethanolamine |



Heat the Aroclor to a workable viscosity (180°F plus) and stir in the stearic acid thoroughly. Heat the water to almost boiling (207°F) and stir in the triethanolamine thoroughly. Pour the Aroclor-stearic acid portion *into* the water portion agitating vigorously. Then process the combined portions with a high-speed emulsifying stirrer . . . or process through a colloid mill.

### Emulsifying Liquid Aroclors

| | |
|---|---|
| (Portion 1) | 100 parts Aroclor 1254<br>4 parts Oleic Acid |
| (Portion 2) | 92 parts water<br>2 parts Ammonium Hydroxide (28%)<br>2 parts Lustrex* X-810 |

Mix the ammonium hydroxide and Lustrex X-810 thoroughly in the warmed water, using vigorous agitation. Mix the Aroclor 1254 and Oleic Acid, heat to 45°C and agitate vigorously. Maintain the 45°C temperature and agitation — and add in *slowly* the water portion. Continue agitation for one-half hour till phase inversion is complete.

### Emulsifiable Concentrated Stock Solutions of Aroclors

79 parts of Aroclor
16.70 parts of toluene
3.55 parts of isopropyl alcohol
1.00 parts of Sterox* CD (non-ionic emulsifier)
0.75 parts of Santomerse* #3 (anionic wetting agent)

The above formulation is readily emulsifiable with water. If the more resinous Aroclors are used, increase the amount of toluene (or xylene) as needed to dissolve the Aroclor resin.

*Trademarks Monsanto Chemical Co., Reg. U. S. Pat. Otc.

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## SOLUBILITY OF AROCLORS IN 100 MILLILITERS OF VARIOUS SOLVENTS

| Arocior | 1242 | | 1248 | | 1254 | | 4465 | | 5460 |
|---|---|---|---|---|---|---|---|---|---|
| Type of Solvent | 25°C | Hot | 25°C | Hot | 25°C | 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 | — |
| Furfural | VS | VS | VS | VS | VS | VS | 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 | VS | VS | — |
| Dichlorethylene | — | — | — | — | — | — | VS | VS | — |
| Ethylene Dichloride | 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 | 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 | VS | VS | — |
| Ethylene Glycol Diacetate | S | S | S | S | S | S | VS | VS | — |
| Methyl Acetate | S | S | S | S | S | S | S | S | — |
| Tricresyl Phosphate | S | S | S | S | S | S | SS | S | — |
| **Ether: Ethyl Ether** | S | S | S | S | S | S | S | — | — |
| **Ether Alcohol** | | | | | | | | | |
| Carbitol | 224 31°C | 307 99°C | VS | VS | 173 26°C | 259 98°C | SS | — | — |
| 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 | 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 75°C | SS | — | — |
| Glycerine | 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—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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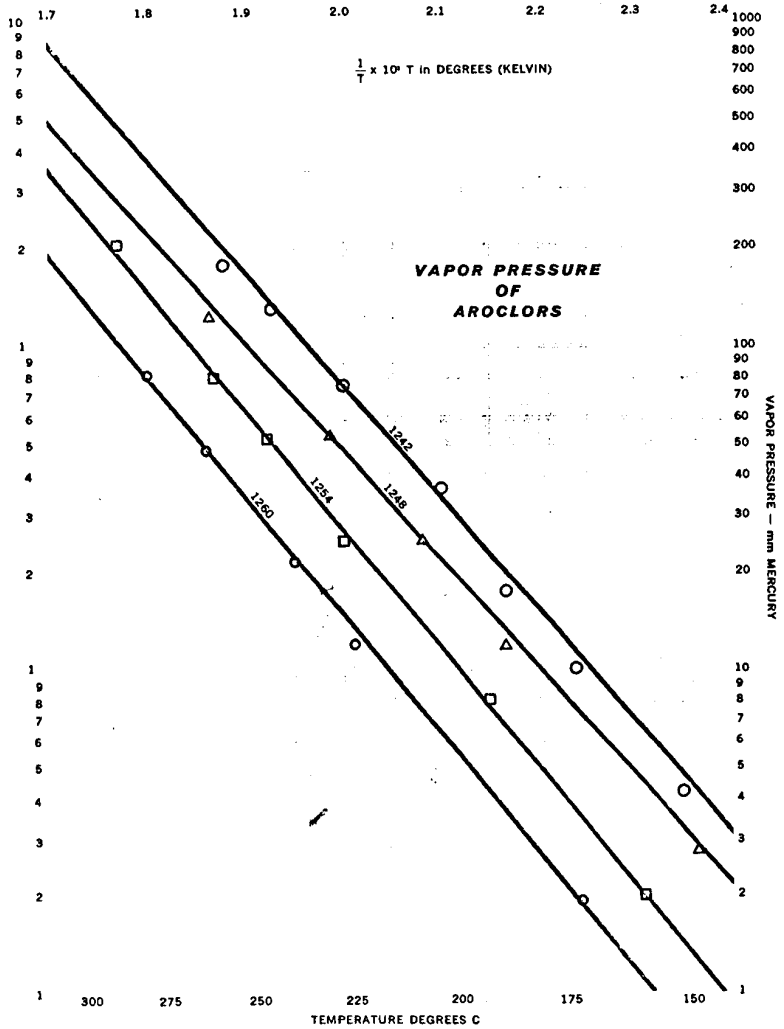


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## *VAPORIZATION RATES*

### *At 100°C and 760 mm. Hg.*

| Sample | Wt. Loss Gms. | Hours Exposure | Surface Area $Cm.^2$ | Vaporization Rate $gms./cm.^2hr.$ |
|---|---|---|---|---|
| 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 |
| 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 |

## *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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## 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 $1.0 \times 10^{-4}$ cm/day penetration or .00014 in/yr.

R—Good resistance—has penetration between $1.0 \times 10^{-4}$ and $10 \times 10^{-4}$ cm/day or between 0.00014 and 0.0014 in/yr.

D—Doubtful resistance, penetration between $10 \times 10^{-4}$ cm/day and $100 \times 10^{-4}$ cm/day or between 0.0014 and 0.014 in/yr.

*P—Poor resistance—penetration greater than $100 \times 10^{-4}$ 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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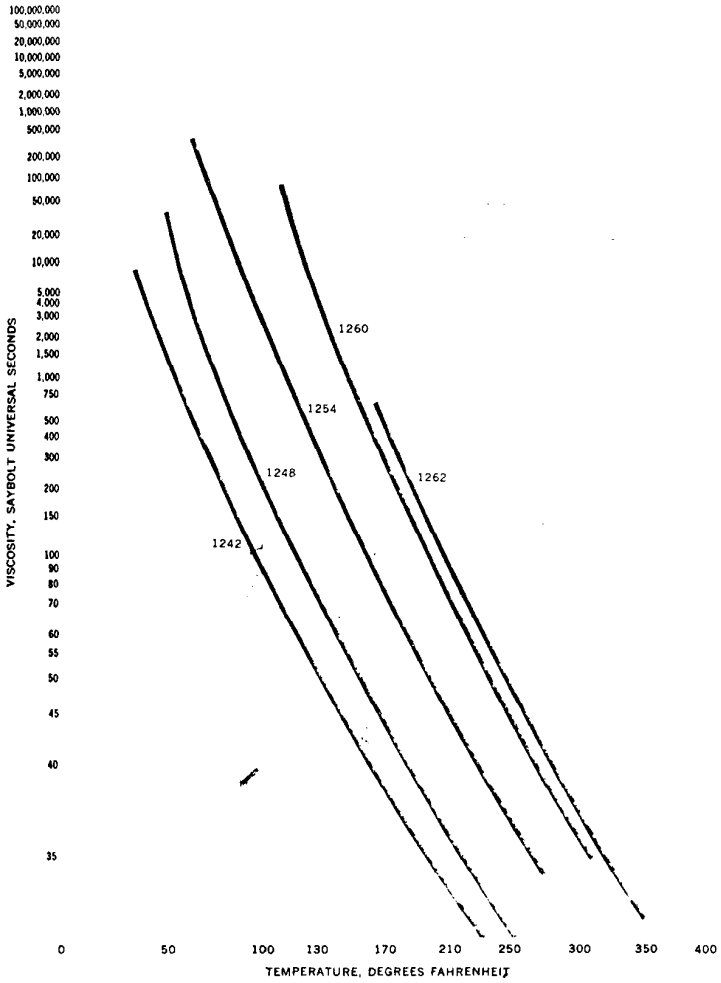
## VISCOSITY RANGES OF SOME OF THE AROCLORS

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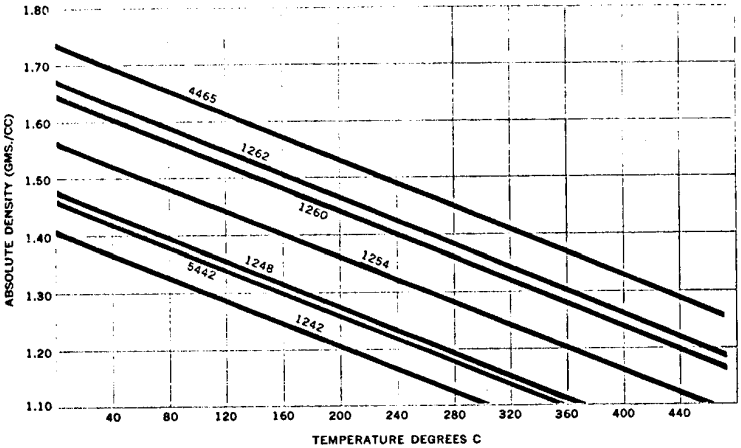
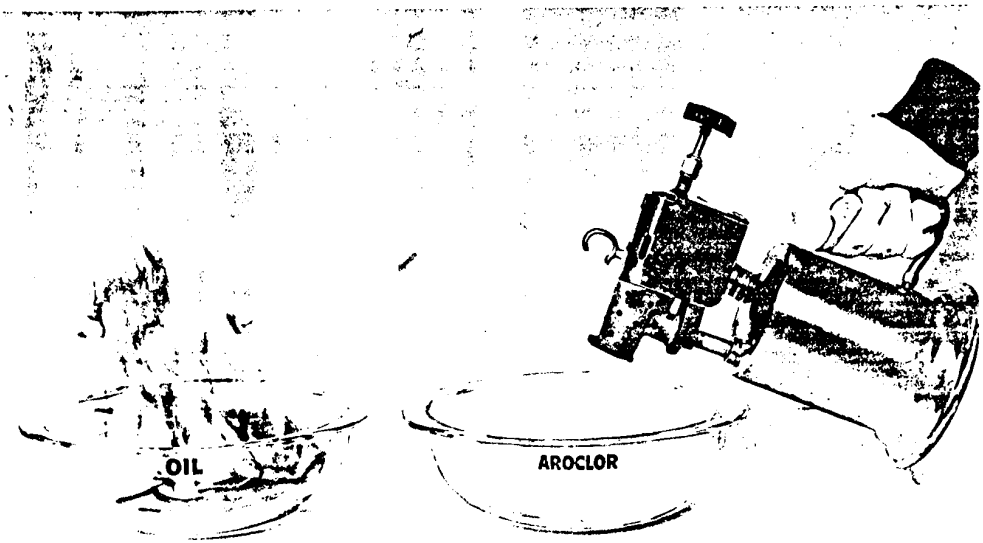
## DENSITIES OF AROCLORS AT VARIOUS TEMPERATURES

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At ordinary temperatures Aroclors have not presented industrial toxicological problems. Where Aroclor vapors may be encountered in workrooms, local exhaust ventilation together with general workroom exhaust is recommended.

Skin patch tests with a polyvinyl chloride free film plasticized with 11.5% by weight of Aroclor 1254 (about 25% 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. Skin patch tests with 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% by weight of paint solids and the finished coated fabric contained approximately 7% by weight of Aroclor 5460 showed that this painted fabric did not produce a 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.

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fire retardant

inert

shear resistant

heat stable

lubricating

# aroclors for...

physically "adjustable"

adhesive

non-volatile

low cost

thermoplastic

FILM FORMING

IMPREGNATING

INSULATING

HEAT TRANSFER

DEDUSTING

INERT MATRIXES

PLASTICIZING

BULKING

COATING

"TACKIFYING"

REDUCING VOLATILITY

Aroclors are the only low cost, inert, inter-compatible liquids and solids whose intermixing can provide insulating, lubricating, fire retardant liquids ranging from the consistency of light mineral oil to the most viscous syrup (or solid resin) which will do so many jobs in industry.

vision • 800 North Lindbergh Blvd. • St. Louis 66, Missouri

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