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

THE AROCLOR® POLYCHLORINATED POLYPHENYLS

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

TECHNICAL BULLETIN O-FF/1

Monsanto

EXHIBIT
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FUNCTIONAL FLUIDS Monsanto

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Ask your Man from Monsanto for additional Aroclor literature:

Askarel Inspection and Maintenance Guide
Aroclor® Plasticizers Technical Bulletin
Therminol® FR Fluid Heat Systems Engineering Heat Transfer Data

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What are the Aroclor® Polychlorinated Polyphenyls

These 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. Aroclor is non-oxidizing, permanently thermoplastic, of low volatility, and non-corrosive to metals. Aroclor is not hydrolyzed by water, alkalis, or acids. The viscous liquids and resins will not support combustion when heated alone, and they impart fire-resistance to other materials.

Crystalline Aroclor is relatively insoluble, but the liquid and resinous compounds are soluble in most of the common organic solvents, thinners and oils. All Aroclor chlorinated compounds 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.

Aroclor is used alone for a particular physical job, such as insulating, and as a sealant or expansion media. Aroclor is also used as a component or extender in elastomers, adhesives, paints, lacquers, varnishes, pigments and waxes. The properties imparted by Aroclor (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 comparison of the properties, by blending two or more, and by adjusting the percentage used in the particular mixture in which the Aroclor will be formulated.

The following table describes the properties of twelve Aroclor chlorinated compounds, 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.

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General Physical Properties of the Aroclor® Chlorinated Compounds

Form	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
Color	50 Max. (APHA)	50 Max. (APHA)	50 Max. (APHA)	50 Max. (APHA)	50 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	1.182-1.192 (25°/15.5°C)	1.270-1.280 (25°/15.5°C)	1.381-1.392 (25°/15.5°C)	1.405-1.415 (65°/15.5°C)	1.495-1.505 (65°/15.5°C)
Specific Gravity	9.85	10.55	11.50	12.04	12.82
Pounds per gallon — 25°C(77°F)					
Distillation Range — ASTM D-20 (Mod.) Corr. °C	275°-320°	290°-325°	325°-366°	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	73-80	260-340
100°F (37.8°C)	38-41	44-51	82-92	185-240	1800-2500

*[illegible]

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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
50 max. (APHA)	50 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 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	0.2 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	247° 477°	None	None
None	None	None	None	>350° >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 (200°F or 120°C)	300-400	—	—
3200-4500	600-850 (160°F or 71°C)	—	—	—	—	—
—	—	—	—	—	—	—

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RESISTANCE TO DRYING

Aroclor is non-drying. Even when exposed to air in the form of thin films, no noticeable oxidation or hardening takes place. However, when used as a component of paints, varnishes or lacquers, it does not retard the rate of drying of the films. Quick drying varnishes and paints can be made using Aroclor in the formulation.

FIRE-RESISTANCE

Viscous, oil-like Aroclor and the Aroclor resins do not support combustion when heated alone, even at their boiling points — temperatures in excess of 350°C. Most of the Aroclor chlorinated compounds 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, Aroclor 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.

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

STABILITY

Toward Alkalies — Aroclor is remarkably resistant to the action of either hydrolyzing agents or high temperature. It is not affected by boiling with sodium hydroxide solution.

Toward Acids — Experiments were made to determine whether hydrogen chloride is evolved during the treatment of Aroclor 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 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 — Aroclor is a useful heat transfer media because of its stability to heat. 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 fire-resistant.

Toward Oxidation — When Aroclor is subjected 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

Aroclor has 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 Aroclor chlorinated compounds 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. Hard crystalline Aroclor is in general less soluble than the liquid or softer Aroclor resins. Aroclor is heavier than water, a valuable property for many applications.

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Electrical Applications of Aroclor

Aroclor is one of the purest commercial chemical compounds, virtually free of even traces of conducting impurities. For this reason, dielectric properties of Aroclor closely approximate the theoretical maximum for these particular organic compounds. With its stability, heat-resistance and fire resistance — Aroclor can be used for a variety of heavy-duty dielectric applications.

DIELECTRICS FOR ASKAREL TYPE CAPACITORS AND TRANSFORMERS

Aroclor is used per se in capacitors and is formulated for the liquid coolant-insulation fluids in transformers. 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.

Aroclor is the only liquid in low cost commercial supply that meets these exacting requirements.

Aroclor liquids 1242, 1248, 1254, and 1260 are used directly, or 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.

Aroclor liquids 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 fluorescent 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 its nonflammability, high resistivity, dielectric strength and low power factor, liquid and resinous Aroclor is extremely useful as an impregnating compound. An important application of Aroclor in the electrical field is the use of Aroclor 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 superior dielectric sealants to close the pores of carbon resistors, and to seal electrical bushings and terminals.

To attain the lowest possible loss factor and gain resistivity, Aroclor is often treated with about 0.20% by weight of Attaupulgus clay or Fullers earth. To activate the earth it should be heated to 450°-500°F.

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-257-43 (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%	290-330°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 x 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%.

*Determined by special request.

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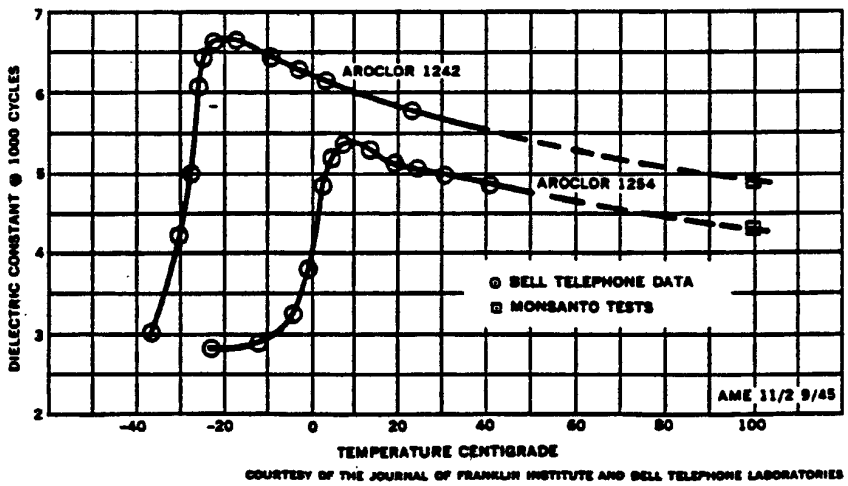
TYPICAL CAPACITOR AROCLOR

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.
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. 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.: Color, APHA — 60 max. Acidity, mg. KOH/g. — 0.01 max. Inorg. Chlorides, ppm — 0.10 max. 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.

DIELECTRIC CONSTANT VS. TEMPERATURE
Aroclor® 1242 & Aroclor® 1254



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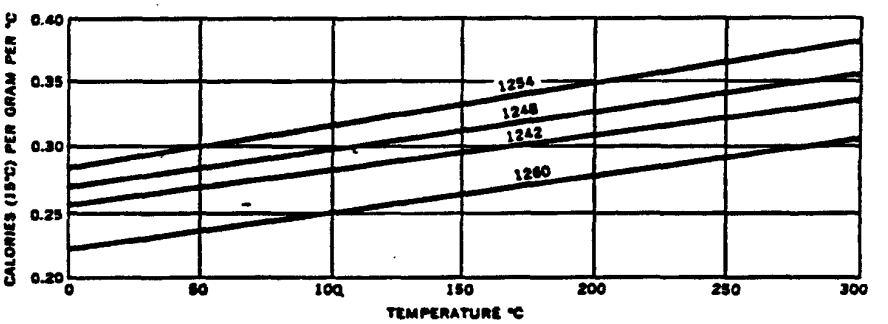
Mechanical Applications of Aroclor

Because Aroclor chlorinated compounds 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. Aroclor does not attack metals even at high temperature; it resists oxidation, chemical and mechanical breakdown under a wide variety of environmental conditions. Aroclor liquids used as lubricants impart a high degree of extreme pressure lubricity.

HEAT CAPACITY OF AROCLOR® LIQUIDS
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	90	0.0680	281 x 10—⁶
60	140	0.0687	284 x 10—⁶
100	212	0.0697	288 x 10—⁶

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EXPANSION MEDIUM

Because of their stability at high temperatures and ability to withstand frequent temperature cycles without gum formation, Aroclor liquid is 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 cu/cu/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

Because of their low vapor pressures and fire-resistance, Aroclor 1248 and 1254 make excellent liquid sealants. These non-evaporating fluids have good flow at slightly elevated temperatures and are chemically stable at elevated temperatures.

Consequently, Aroclor liquid makes excellent fluid sealants for any application where the use of oil would create a fire hazard. In the trough of annealing furnaces, for example, Aroclor makes dependable fire-safe roof seals.

VACUUM DIFFUSION PUMP OIL

Fluid Aroclor 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. Aroclor operates efficiently in vacuum diffusion pumps used to pull high vacuum for metalizing plastics, dehydrating foods, medicinals, and for drying capacitor cones.

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Aroclor in Special Product Formulations

With their wide range of physical properties, their inertness, lubricity, and vapor-suppressing characteristics — Aroclor chlorinated compounds can be valuable ingredients in an extraordinary variety of formulated products. They are compatible with a variety of solvents, oils and resins. 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.

SEALERS FOR GASKETS

Aroclor — particularly when hot — swells rubbers like Hycar*, Koroseal*, PerBuna N, and Neoprene. Wherever seals and gaskets of natural or synthetic rubber tend to shrink under heat and use, Aroclor 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. Aroclor 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,(1) a few tenths of one percent will control the dusting of calcium hypochlorite.

*Hycar and Koroseal are registered trademarks of B. F. Goodrich Co.

(1) Covered by U. S. Patent No. [illegible], issued January [illegible], [illegible], and assigned to Pennsalt Chemicals Corporation.

INSECTICIDES

Aroclor 5460 and 1254 act as vapor suppressants. United States Department of Agriculture scienttists 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 and 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. Aroclor is 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.

PRECISION CASTING WAXES

Aroclor is compatible with various natural waxes, such as carnauba and others, including those used to formulate casting wax. Aroclor helps 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 Aroclor are non-tacky and highly stable. Waxes containing Aroclor are widely used in making dental castings, in the precision casting of aircraft parts, and for casting costume jewelry. Aroclor 1254, 4465 and 5460 are most frequently used . . . proportions dependent upon the properties re-

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quired in the finished wax. Much of the highest quality precision casting wax used in the lost wax process is formulated with Aroclor.

AROCLOR IN ABRASIVES

Aroclor 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 — Aroclor is used as the carrier for abrasive materials. A major use is as part of the bonding agent in specialized grinding wheels.

AROCLOR IN SPECIALIZED LUBRICANTS

For specialized lubricants requiring good extreme pressure (EP) characteristics, the Aroclor liquids make excellent additives. They impart high temperature stability, excellent lubricating qualities, and weather and corrosion resistance. As an example, Aroclor is used to formulate grease and pipe thread compounds for use in oxygen systems. Greases formulated with Aroclor have a high chemical resistance and are suitable for use in contact with corrosive chemicals. Gear oil lubricants containing Aroclor have good resistance to sheer degradation and high temperature stability. Added in small amounts to railroad car journal box oils, Aroclor imparts better extreme pressure lubricity and reduces the incidence of hot boxes.

The heat-resisting, nonflammable characteristics of the Aroclor chlorinated compounds 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, Aroclor 1248 and 1254 materially increase the load-carrying properties without reducing the viscosity of the resulting composition. These two compounds 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, 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. Aroclor is non-volatile at normal temperatures.
3. NON-OXIDIZING. Aroclor does not oxidize nor thicken up to an objectionable degree.
4. NON-CORROSIVE. Aroclor does not attack metal surfaces.
5. NON-ABRASIVE. Aroclor exerts no abrasion on the machined surfaces.
6. NON-HYDROLYSIS. Aroclor does not hydrolyze in the presence of water, thus avoiding the generation of hydrochloric acid.
7. COMPATIBILITY. Aroclor is completely miscible with mineral oils.
8. COLOR. Aroclor does not darken or change the color of lubricating oil.

TOWOLDMON0002667

Where lubrication is subjected to water displacement exposure, for example in the lubrication of bridge rollers, a heavier-than-water lubricant can be prepared from mixtures of Aroclor and oil. 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.

*Straight Stock: Gravity API 22-23

AROCLOR 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 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.

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Appendix

Methods for Emulsifying and Making Stock Solutions of Aroclor

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 Aroclor

(Portion 1)	16 lbs. of Aroclor
	1 lb. of stearic acid
(Portion 2)	8 lbs. of water
	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 highspeed emulsifying stirrer . . . or process through a colloid mill.

Emulsifiable Concentrated Stock Solutions of Aroclor

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® anionic wetting agent

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

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SOLUBILITY OF AROCLOR® CHLORINATED COMPOUNDS 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 31°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 25°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	—	—	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	S	S	—	—
Ether Alcohol											
Carbitol®	224 31°C	307 99°C	VS	VS	173 39°C	259 99°C	—	—	SS	—	—
Cellosolve	S	S	S	S	S	S	—	—	S	—	—
Diethylene Glycol	—	—	—	—	—	—	—	—	S	—	—
p-p' Dihydroxy Ethyl Ether	16.9 22°C	19 99°C	SS	SS	8 39°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 99°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 30°C	80.0 70°C	—	—	10 27°C	28 70°C	—	—	SS	—	—
Glycerine	I	I	I	I	I	I	I	I	I	I	—
Methyl Alcohol	42.5 30°C	66.5 60°C	—	—	15 30°C	22.2 60°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	—

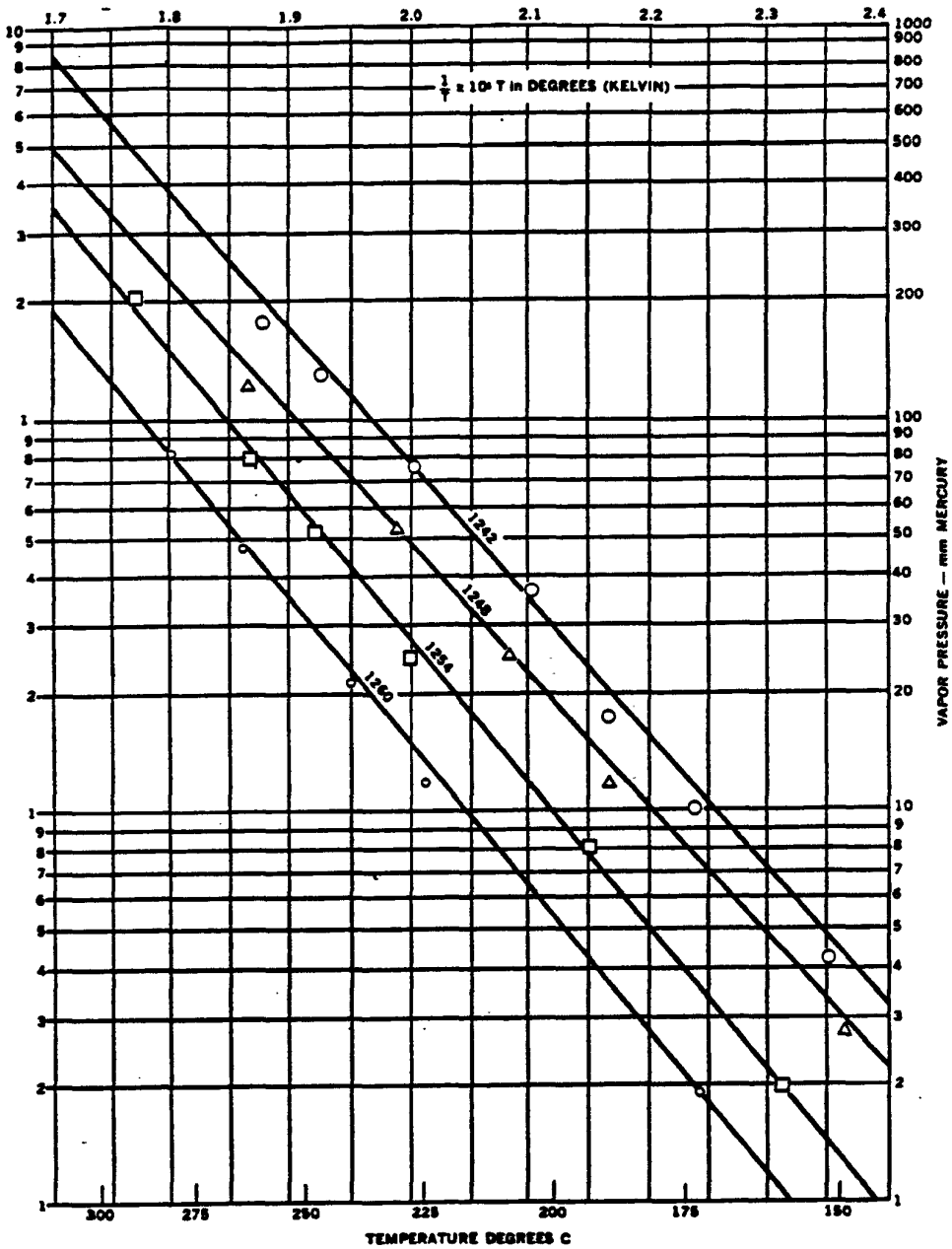
I — Insoluble S — Soluble SS — Slightly Soluble VS — Very Soluble
Figures show grams of Aroclor per 100 milliliters of solvent at 25°C unless otherwise indicated.

*Carbitol is a registered trademark of Union Carbide and Carbon Co.

GBRN 000283

TOWOLDMON0002670

VAPOR PRESSURE OF AROCLOR® CHLORINATED COMPOUNDS



TOWOLDMON0002671

VAPORIZATION RATES

Sample	Wt. Loss Gms.	Hours Exposure	Surface Area Cm.²	Vaporization Rate gms./cm.²hr./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
42% chlorinated paraffin	0.0745	48	12.28	0.000126
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

*Dutrex is a registered trademark of the Shell Oil Co.

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.

GBRN 000285

TOWOLDMON0002672

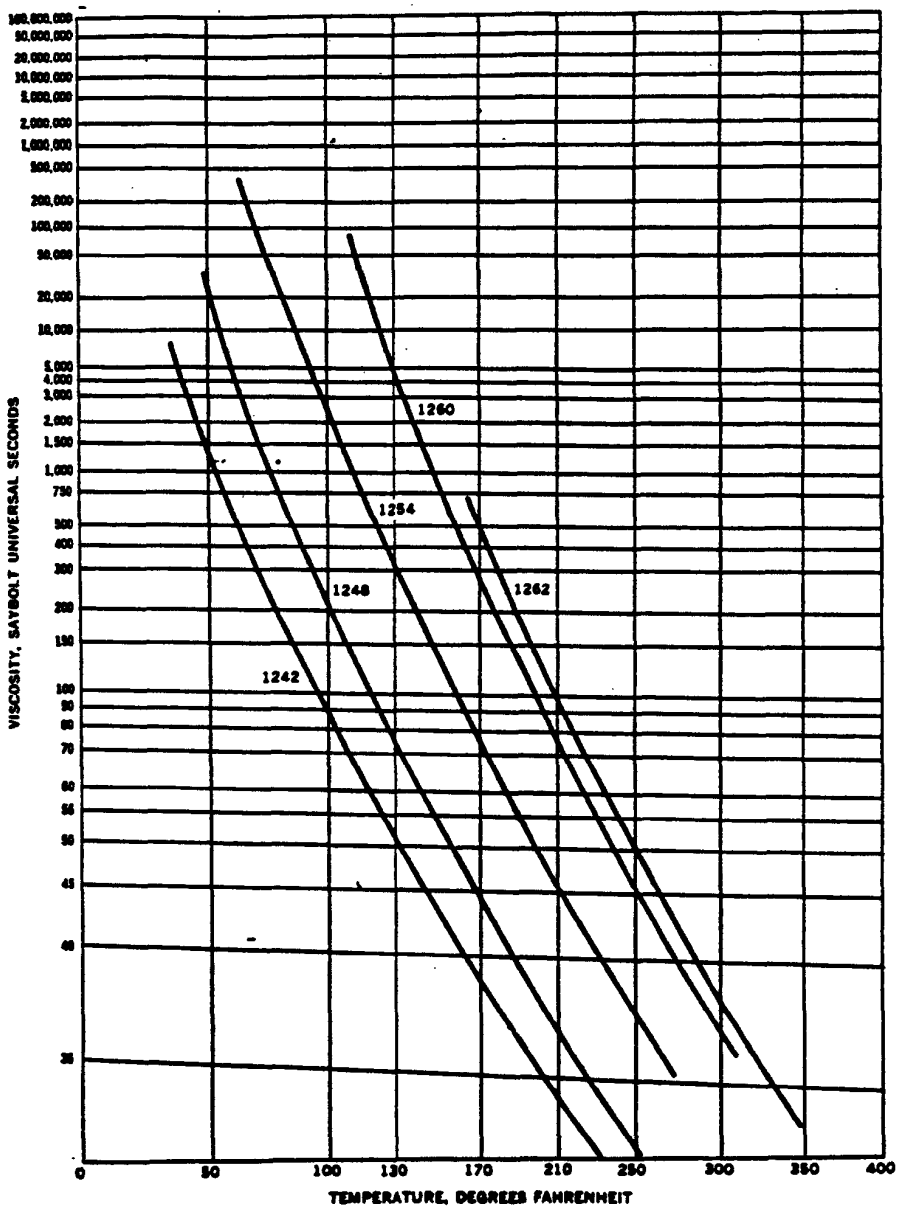
CORROSION RESISTANCE OF STRUCTURAL MATERIALS

Metals	Arocior 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[1] Phenol Furfural Resin	*D	P	*R	P	D	P
Formvar® Highly Plasticized polyvinyl formal resins	De	T	Pe	T	T	T
Formvar® Low Plasticized polyvinyl formal resins	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
Methyl Methacrylate	*D	P	*D	P	P	P
Lustron® B Polystyrene	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 on penetration value shown.
E — Excellent resistance — less than 1.0 x 10^{-4} cm/day penetration or .0004 in/yr.
G — Good resistance — less penetration between 1.0 x 10^{-4} and 10 x 10^{-4} cm/day or between 0.0004 and 0.004 in/yr.
D — Doubtful resistance, penetration between 10 x 10^{-4} cm/day and 100 x 10^{-4} cm/day or between 0.004 and 0.04 in/yr.
P — Poor resistance — penetration greater than 100 x 10^{-4} cm/day or 0.04 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 initially immersed when weight loss is believed to come from oxidation of the part of test strip exposed to air.
T — Material stress cracked by temperature.
(1) — Durite is a registered Trademark of Durite Chemical Co.

TOWOLDMON0002673

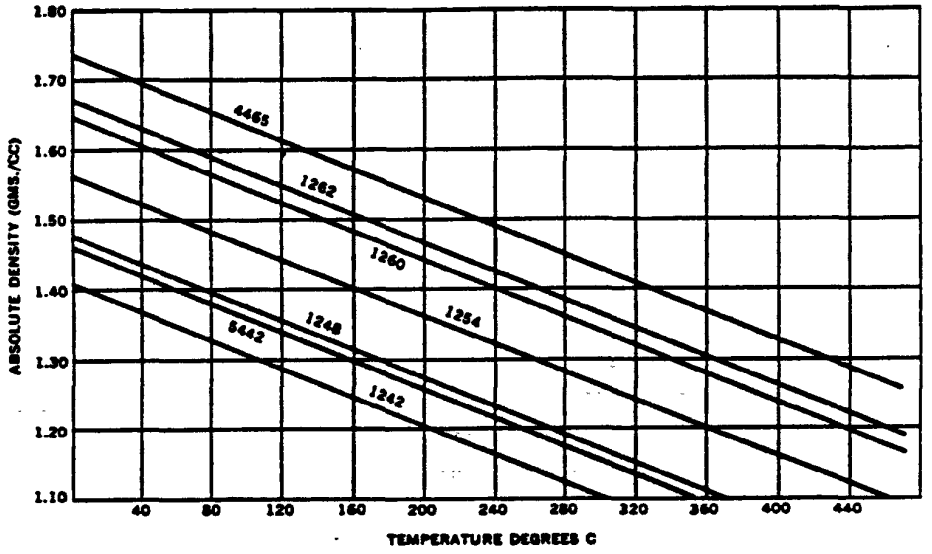
VISCOSITY RANGES OF SOME OF THE AROCLOR® CHLORINATED COMPOUNDS



GBRN 000287

TOWOLDMON0002674

DENSITIES OF AROCLOR® CHLORINATED COMPOUNDS AT VARIOUS TEMPERATURES



TOWOLDMON0002675

Dermatology and Toxicology

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

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

Schwartz patch tests on 200 volunteers showed that neither Aroclor 1254 alone when applied to gauze nor a polyvinyl chloride film containing 11.5-weight-per cent Aroclor 1254 was a primary irritant or a sensitizer. Canvas coated with an oil-modified alkyd resin (17-weight-per cent of the paint-film solids and 7-weight-per cent of the painted fabric was Aroclor 5460) did not produce primary skin irritancy or sensitization according to the same Schwartz technique. Continuous or repeated skin contact with Aroclor must be avoided because of the possible occurence of a condition called chlorance. Although reports of this condition caused by Aroclor are rare, it can be produced by excessive skin contact.

GBRN 000289

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Safe Handling

Vapors of the Aroclor liquids at room temperature should not be breathed in a confined space. Vapors evolved at elevated temperatures should not be allowed to be dispersed into the general workroom. Instead, engineering control must be applied to reduce vapor concentrations below the allowable concentrations mentioned above.

Continuous or repeated skin contact with Aroclor must be avoided by the use of gloves and protective garments. If any Aroclor is spilled on the skin, the skin should be washed in the usual manner with a soap solution.

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

Shipping Information

Freight Classification	
AROCLOR 1221, 1243, 1242, 1248, 1254, 1260, 1262	Synthetic Resin, Liquid, NOIBN
Rail Classification	
AROCLOR 1268, 2565, 4465, 5442, 5460	Synthetic Resin, Other Than Liquid, NOIBN
Truck Classification	
AROCLOR 1268, 2565	Synthetic Resin, Powder, NOI
AROCLOR 4465, 5442, 5460	Synthetic Resin, Lumps or Solid Mass, NOI
Shipping Regulations	None
Standard Containers	
AROCLOR 1221	Tank car, 520-lb. steel drum, 50-lb. can
AROCLOR 1232	Tank car, 550-lb. steel drum, 50-lb. can
AROCLOR 1242, 1248, 1254, 1260, 1262	Tank car, 600-lb. steel drum, 50-lb. can
AROCLOR 1268	200-lb. fiber drum, 50-lb. can
AROCLOR 2565, 4465	500-lb. steel drum, 50-lb. can
AROCLOR 5442	450-lb. steel drum, 50-lb. can
AROCLOR 5460 (flaked)	100-lb. bag

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