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MONSANTO
CHEMICALS – PLASTICS

AROCLOR*
A NONFLAMMABLE HYDRAULIC FLUID FOR DIE-CASTING SYSTEMS

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Aroclor 1248, chlorinated biphenyl, the safe and economical organic hydraulic fluid for metal die-casting systems, eliminates the constant threat of serious fire hazard associated with the use of combustible hydraulic fluids in the die-casting industry.

This safe and economical hydraulic fluid has been in continuous satisfactory use in individualized die-casting units for about ten years and in centralized systems for the past two years.

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I. INTRODUCTION

Aroclor 1248, chlorinated biphenyl, the safe and economical organic hydraulic fluid for metal die-casting systems, eliminates the constant threat of serious fire hazard associated with the use of combustible hydraulic fluids in the die-casting industry.

There are not many available noncombustible organic fluids and only very few possess the over-all physical requirements of hydraulic fluids for die-casting systems. Notwithstanding the possibility of sustaining costly fire damage when using relatively inexpensive petroleum oils, the economics involved in replacing petroleum oils with the more expensive noncombustible organic hydraulic fluids is an important factor to the industry. In this connection, it is important to emphasize that Aroclor 1248 appears to be substantially less expensive than the few other available noncombustible organic hydraulic fluids for this purpose.

Aroclor 1248 has been used successfully in die-casting machines for many years and satisfactory continuous service records on Aroclor 1248 extend beyond ten years. It is used throughout the industry as widespread and leading die-casters have installed Aroclor 1248 to replace combustible oils and also to replace other noncombustible organic fluids, because of the demonstrated good performance obtainable with Aroclor 1248 and because of its lower initial cost and lower "make-up" requirements in the system.

II. INDIVIDUALIZED DIE-CASTING SYSTEMS

Aroclor 1248 has been used continuously for many years in individualized die-casting units using machines built by Lester Engineering Company (13), The Hydraulic Press Mfg. Co. (11), H. L. Harvill Mfg. Co. (9), and the Cleveland Automatic Machine Co. (4), as well as excellent "home built" units. Frequently, these machines are equipped with vane type centrifugal pumps such as the ones made by Vickers, Incorporated (21), but other types of centrifugals may also be used.

The Watson-Stillman Company's (22) die-casting machines are used as individualized units equipped with Oilgear piston type pumps made by The Oilgear Company (15). Aroclor 1248 is suggested as a noncombustible hydraulic fluid for installations of this type.

In most instances, the normal operating temperature of the hydraulic fluid is within the range of 80°-120°F. and this temperature may or may not be controlled by jacketed water coolers, depending on the specific design of the die-casting machine. Most of these machines use 60-200 gallons of the hydraulic fluid and operate at pressures ranging as high as 1,000-3,000 p.s.i.

III. CENTRALIZED DIE-CASTING SYSTEMS

Aroclor 1248 has been in continuous satisfactory use for a number of years in centralized die-casting systems consisting of batteries of the machines connected to a central tank of the Aroclor hydraulic fluid. These systems are usually equipped with piston type pumps such as made by The Oilgear Company and have an accumulater in the line to maintain smooth operation. Such centralized systems may operate with 2,000 gallons, or even more, of Aroclor 1248. Systems of this type using Aroclor 1248 and Oilgear pumps have been in continuous service for a number of years with apparently satisfactory performance.

IV. PHYSICAL PROPERTIES OF AROCLOR 1248

The physical properties of Aroclor 1248 are listed below with similar constants for Aroclor 1254. The reason for including Aroclor 1254 is that in some instances, especially for viscosity considerations, it may be desirable to blend small portions of Aroclor 1254 with Aroclor 1248. For more complete data about the low vapor pressure of Aroclors, their low vaporization rates, their viscosity ranges, their noncorrosive properties, high order of stability to heat and corrosive influences, as well as other pertinent qualities, please refer to Monsanto Technical Bulletin No. P-115 entitled, "The Aroclors" (14 bibliography reference).

TABLE I. Outline of Physical Properties

	Aroclor 1248	Aroclor 1254
Form	Yellow tinted mobile oil	Light yellow viscous oil
Color--APHA	100 Max.	100 Max.
Acidity--Maximum (mgm. KOH/Gm.)	0.015	0.015
Average Coefficient of Expansion - cc/cc/°C.	0.00070 (25°-65°C.)	0.00066 (25°-65°C.)
Density--		
Specific Gravity 25°/25°C. (77°/77°F.)	1.447 to 1.457	1.538 to 1.548
Pounds per Gallon 25°C. (77°F.)	12.08	12.83

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TABLE I. (continued)

			Aroclor 1248	Aroclor 1254
Distillation Range--ASTM D-20 (Mod.) Corr. °C.			340°-375°	365°-390°
Vaporization Rate gms/cm^{2}hr/100°C.			0.000152	0.000053
Flash Point--Cleveland Open Cup		°C.	193°-196°	None
		°F.	379°-384°	
Fire Point--Cleveland Open Cup		°C.	None	None
Pour Point--ASTM D-97		°C.	-7°	10°
		°F.	19.4°	50°
Viscosity--Saybolt Universal Sec. (ASTM D-88)	210°F.	(98.9°C.)	36-37	44-48
	130°F.	(54.4°C.)	69-78	260-340
	100°F.	(37.8°C.)	185-240	1800-2500
Absolute Viscosity--Centipoises	212°F.	(100°C.)	4.2	8.5
	122°F.	(50°C.)	25	146
	77°F.	(25°C.)	208	777

V. NONCOMBUSTIBLE QUALITIES OF AROCLOR 1248

FLASH POINT. Limitations of this test for the prediction of the fire hazard of relatively nonvolatile organic fluids have been recognized by the ASTM committee (1).

FIRE POINT is a more significant measurement. The National Board of Fire Underwriters Laboratories (20) concur that fire tests more truly reflect the (lack of) fire hazard of Aroclor.

SPONTANEOUS IGNITION TEMPERATURE. The combustion resisting qualities of Aroclor 1248 are indicated by its high spontaneous ignition temperature of 704°C. (1,299°F.) determined by Sullivan, Wolfe and Zisman (19), using the convenient apparatus described by Sortman, Beatty and Heron (18).

Under industrial use conditions the spontaneous ignition temperature will be determined by factors including the nature of the hot surface, the amount of liquid impinging on it, the volume of enclosed space, and the ventilation. In this connection, we wish to refer to an

observation concerning the use of Aroclor 1248 as a noncombustible heat-transfer medium in Aroclor heating systems. An accidental failure in one of our Aroclor heating systems demonstrated the nonflammability of Aroclor 1248 and its freedom from the hazard of fire propagation.

An operator's failure to start the circulation of the heat-transfer medium when the gas heater was on resulted in excessive coil temperatures, causing the lower coil (steel) to soften and sag into the fire chamber. A weld ruptured and Aroclor 1248 poured into the red hot fire chamber in contact with the flame. Smoke arose from the heater but there was no internal fire. After the gas flame was cut off, the smoking stopped.

SPRAY FLAMMABILITY. When a line ruptures in a die-casting system where the hydraulic fluid is under relatively high pressure, a spray or mist prevails. The possible fire hazard of Aroclor 1248 under these conditions requires considerations not covered by the foregoing discussions relative to the material in the liquid form. In their comprehensive study, "Flammability of Higher Boiling Liquids and Their Mists", Sullivan, Wolfe and Zisman determined the spray flammability limit of numerous materials in accordance with the percentage of oxygen required for combustion. This value was then correlated with the results of incendiary firing tests of the fluid conducted at the Naval Proving Ground, Dahlgren, Virginia. The per cent oxygen requirement for Aroclor 1248 combustion in the spray flammability limit studies was established at 64%. It was observed that fluids requiring over 45-50% of oxygen in the spray test failed to cause a fire in the incendiary test. These results firmly establish the nonflammable and noncombustible qualities of Aroclor 1248. Moreover, these results on spray flammability studies seem most pertinent since they reflect conditions prevailing in the case of pressurized systems such as used in metal die-casting. Therefore, we are taking the liberty of presenting the data in the following Table II as taken from the publication by Sullivan, Wolfe and Zisman to compare this highly significant spray flammability rating given to selected chlorinated hydrocarbons, organic phosphates, etc. Benzene and a petroleum oil are included for comparison purposes.

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TABLE II. Flammability of Certain Higher Boiling Liquids and Their Mists

Fluid	Viscosity Cs. at 100°F.	Flash Pt. (COC) (1) °F.	Fire Pt. (COC) (1) °F.	S.I.T.(2) °F.	Spray Flammability Limit % Oxygen
Naval Ordnance hydraulic oil O.S. 1113	41.8	315	340	505	14
Benzene	0.58	12	-	1295	12
Chlorobenzene	0.59	90	-	-	14
o-Dichlorobenzene	0.84	165	-	-	29
1,2,4-Trichlorobenzene	1.1	260	None	>1000	44
Trichlorddiphenyl (Aroclor 1242)	17.7	350	633	1230	45
AROCLOR 1248 (Tetrachlorodiphenyl)	45.4	380	None	1300	64
Diphenyl ether	2.6	265	275	-	11
Chlorodiphenyl ether	3.0	260	335	-	27
Dichlorodiphenyl ether	4.9	300	465	-	33
Trichlorodiphenyl ether	8.7	325	4901	-	42
Trimethyl phosphate	-	225	245	903	47
Tributyl phosphate	2.6	285	370	-	27
Trioctyl phosphate	8.1	380	465	680	13
Tricresyl phosphate	29	500	685	1170	19
Hexamethyl tetraphosphate	38.3	>510	None	920	31
Tetrabutyl pyrophosphate	8.9	465	720	845	14
Dioctylphenyl phosphonate	11.5	435	480	630	21
Diphenyl mono (p-tert-butyl phenyl) phosphate	40.3	465	720	1076	12
Di-(o-chlorophenyl) monophenyl phosphate	34.3	510	>760	1296	21

(1) Cleveland Open Cup
(2) Spontaneous ignition temperature

In light of the importance of spray flammability as demonstrated to be the most significant determination of the noncombustible qualities of higher boiling fluids and their mists, it is indeed interesting to note the lack of correlation between this value and other constants, such as

flash point, fire point and especially the spontaneous ignition temperature.

VI. RESISTANCE OF STRUCTURAL MATERIALS TO AROCLOR 1248

The noncorrosive qualities of Aroclor 1248 and the strong resistance of structural materials to Aroclor 1248 are highly important factors in the practical use of Aroclor as a hydraulic medium in die-casting systems. The following Table III indicates the resistance of structural materials to Aroclors 1248 and 1254.

TABLE III. Resistance of Structural Materials To Aroclors 1248 and 1254

Metals	1248		1254	
	25°C.	125°C.	25°C.	125°C.
Aluminum	R	R	R	R
Copper	R	D	R	D
Magnesium	RR	R	R	R
Nickel	RR	R	R	RR
Silver	R	R	R	R
Tin	R	R	R	R
Zinc	R	R	R	R
Mild Steel	RR	R	RR	RR
Phosphor Bronze	R	D	R	R
Red Brass	D	D	R	D
Stainless Steel	RR	RR	RR	RR
Yellow Brass	R	Re	R	De

RR--Excellent resistance--less than 1.0×10^6 cm/day penetration or 0.00014 in/yr.

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

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

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.

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VII. PACKING MATERIALS AND GASKETS SUITABLE FOR USE WITH AROCLOR 1248 IN DIE-CASTING SYSTEMS

Results of accelerated laboratory tests show that Hycar P., Koroseal, Perbunan, Neoprene and various other "rubbers" are softened by Arcclors, especially at elevated temperatures. Accordingly, questions arise about the use of these materials for gaskets on die-casting machines using Aroclor. However, from practical experience in the operation of die-casting machines, it has been noted that fittings, such as the ball joints made by Chiksan Tool Company (3), containing a small Neoprene gasket have given very good service under long continuous use when installed in die-casting systems operated with Aroclor. Also, Neoprene lined, metalized flexible tubes used on the return lines of the die-casting machines appear to give good service with Aroclor. In some instances it appears almost necessary to use flexible tubes, especially on the return lines of the die-casting machines. If possible to do so, it would seem desirable to use rigid lines fitted with ball joints such as made by Chiksan or Barco Swivel Joints (2).

For pipe connection, welded joints are not necessary but in the case of welded flange connections, these may be satisfactorily gasketed by the use of a thin sheet of aluminum. Various packing materials suitable for use with Aroclor at elevated temperatures include Garlock Packing Company's (8) #7021, 1/8 inch asbestos fiber sheet for flange connections. Garlock's #117 braided packing is used in valves and Garlock #234 packing is used for pumps; also, Garlock #431 and Chevron 7050-C materials are suitable packings. Likewise, Durametallic (6) spiral asbestos fiber may be used. Doubtless, Johns-Manville Corp. (12) and others have comparable packing materials which would be suitable. In all instances, when ordering packing, it should be indicated to the supplier that the material is intended for use with Aroclor 1248.

Teflon, duPont's (7) polytetrafluroethylene, is not attacked by hot Aroclor (130°C.) and is to be recommended as a gasket material. Thiokol is not attacked by Aroclors at ordinary temperatures and especially Thiokol 1605-A appears of interest for use with Aroclors in die-casting systems. The maximum temperature ranges at which Thiokol is suitable are indicated as follows:

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

Dow Corning's (5) Silastic, Silicone 180 is very resistant to hot Aroclor and use of this material is suggested. The changes in properties of Silicone 180 when immersed in hot Aroclor for 70 hours at 150°C. are summarized as follows:

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1. Lowering of the hardness by about 20 points.
2. Improvement in the elasticity by several points.
3. Practically no change in tensile strength
4. An appreciable increase in the ultimate elongation.

Other types of packing materials recommended by the manufacturer for use in Aroclor installations include the following Palmetto (16) packings:

Hydraulic Service (Normal Temperatures)

Rod packing	- Palmetto Pyramid Packing #2510
U Ring packing	- Palmetto U Ring Packing #2610
Flange packing	- Palmetto Flange Packing #2810
Kup packing	- Palmetto Kup Packing #2710
Sheet packing & gaskets	- Palmetto Hi-4 Sheet Packing #2910

Heat-Transfer Service

Rod packing	- Palmetto High Pressure Packing #2200
Sheet packing & gaskets	- Palmetto Hi-4 Sheet Packing #2910

With reference to the manufacturer and also the user of die-casting equipment, it is highly advantageous if the same packing materials generally used with oil can be used also with Aroclor 1248. In this connection, in the case of the Oilgear Company hydraulic equipment, it is noted that such packings as Thiokol, which is used for gaskets, and Garlock #431, which is used as ram packings on most Oilgear equipment, can be used either with oil or with Aroclor 1248.

Vickers, Incorporated advise that all packing materials will have to be other than those normally used for petroleum base fluids to prevent rapid deterioration, and these are available through Vickers, Incorporated for their own equipment, or many of the suppliers of standard sealing elements.

VIII. LUBRICATION

Aroclor 1248 has lubricating properties and is used in die-casting systems most frequently without the addition of added lubricants. However, in the case of piston type pumps where high lubricity is a requirement, sometimes the practice is to add not more than 5% of a high lubricity oil to the Aroclor. Oils of this type in use are DTE medium heavy high lubricity oil and Pennsylvania Refining Company's (17) #90 VI light stock oil. Other similar oils are available for this purpose.

Aroclor 1248 is recognized in the industry as an EP lubricant and its heavy load carrying quality without seizure is reflected by tests made with a hydraulic fluid containing a substantial proportion of Aroclor. The data pertains to results with an Almen test machine. During the standard test, the hydraulic fluid carried the full 30-pound load normally used as maximum on the Almen test. The torque at maximum load passed, average of 2 runs, was found to be 28.5 for the hydraulic fluid built on Aroclor as compared with a value of 14.0 for SAE 10 motor oil.

IX. VISCOSITY

The viscosity of Aroclor 1248 seems to be within the range required in the normal operation of many industrial pumps and hydraulic equipment. As previously indicated, the viscosity of Aroclor 1248 can be increased by the addition of Aroclor 1254. In light of the influence of temperature on the viscosity of Aroclor, this factor should be given consideration with reference to the operation of the pumps or hydraulic system in which Aroclor is used.

As a general indication of the viscosity requirements for different types of pumps, Vickers, Incorporated specifies the following for use with its pumps:

Industrial Machinery Installations
(Ambient Temperature 50°F. to 90°F.)

	Type of Installation	Oil Viscosity
Vane Type Pumps	Machine tools operating at pressures up to 1000 p.s.i.	150-225 S.S.U. @ 100°F.
	Presses and other heavy machinery	275-315 S.S.U. @ 100°F.
Piston Type Pumps	All industrial machinery	275-315 S.S.U. @ 100°F.
Piston Type and Gear Type Fluid Motors	All industrial machinery	150-315 S.S.U. @ 100°F.

Vickers recommends that the oil temperatures in the hydraulic circuit should be maintained between 60° and 130°F. If, for reasons of non-operation for extended periods, the temperature drops below 60°F., the fluid should be warmed to that temperature before starting operations.

Coolers should be provided to prevent temperatures in excess of 130°F., which will comply with the temperatures demanded by the Joint Industry Conference Hydraulic Standards, and should also avoid the necessity of having to use vent ducts from any open or semi-open reservoir.

Referring to the fact that the specific gravity of Aroclor 1248 is greater than the similar value of average petroleum base fluids used, inlet conditions to pumps should be carefully scrutinized to insure the absence of cavitation.

X. FILTRATION

It seems prudent to maintain clean oil regardless of the specific hydraulic fluid used in die-casting systems. Small particles of dirt metal chips and sand from the castings seem to work their way into the hydraulic fluid whether the installation is a new one or one that has been in service for many years. Aroclor 1248 has a tendency to suspend such impurities. Although it is not always practiced, nevertheless, it seems important to provide adequate filtration so that abrasive particles are removed from the system and the Aroclor 1248 is kept clean.

Many die-casting machines are equipped with internal fine mesh wire screens. These filters are suitable for removing the larger particles but to keep the Aroclor in a satisfactory clean condition, the recommendation is to filter the Aroclor through a bed of suitably processed granular Fuller's earth. There are available a number of satisfactory filtering mechanisms or oil purifiers which may be used continuously or intermittently. Probably one of these filters available as a convenient portable model would be the most economical as it could be used to clean the oil in a number of die-casting machines. As one example of a supplier of such equipment, we wish to refer to the Honan-Crane Corporation (10).

XI. DERMATOLOGY AND TOXICOLOGY

Results of standard skin patch tests using over 100 individuals show that Aroclor 1254 is neither a skin irritant nor a skin sensitizer (14). We would expect that these results would serve to indicate that Aroclor 1248, which is only slightly lower in chlorine content than Aroclor 1254, is also neither a skin irritant nor a skin sensitizer.

Although the vapor pressure of Aroclor 1248 is quite low and for all practical purposes the material is nonvolatile, nevertheless, when Aroclors are heated to elevated temperatures, vapors arise and these vapors bear a degree of toxicity and should not be breathed. This

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consideration is, of course, minimized in the case of using Aroclor 1248 in die-casting systems, which are necessarily thoroughly enclosed to prevent even the smallest kind of a leak, and the operating temperature is relatively low since practical operation never exceeds about 140°F.

Aroclor 1248 has been used for over ten years in individualized and centralized die-casting systems with complete freedom from any trouble or fear of any toxic effects. If Aroclor 1248 comes in contact with the worker's skin, the skin should be washed in an ordinary manner with soap and water. If the Aroclor is sufficiently hot so as to cause a burn when in contact with the skin, the burn should be treated in the same manner 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 soap and water or repeated washings with a vegetable oil is recommended.

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(6) Durametallic Corp., 1936 Hall Street, Kalamazoo 24-F, Michigan.

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