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FINAL REPORT

ON

SALES SERVICE WORK ON FUNCTIONAL FLUIDS

1954 - 1955

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Monsanto Chemical Company
Organic Chemicals D vision
St. Louis Research Department

Work done by:

R. E. Hatton
A. J. Bindbeutel
R. S. Mitchell
J. D. Sullivan

Prepared by:

R. E. Hatton

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3. H. K. Nason - File
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I. INTRODUCTION

Monsanto's line of functional fluids includes four products which are full fledged sales items. These are Skydrol 7000, a fire resistant aircraft hydraulic fluid, and Pydrauls F9, 150, and 600, fire resistant industrial functional fluids. Customers using these fluids have raised numerous questions concerning the fluids and their life and utility under specified conditions. In attempting to answer such questions, samples of used fluid and system deposits were evaluated and various fluid properties were determined. New competitive fire resistant synthetic fluids were examined to provide data for the sales effort and to keep abreast of developments in the general field. These activities have been labeled sales service work and are detailed in this report.

II. SUMMARY AND CONCLUSIONS

Service was rendered to seven companies on Skydrol 7000 and to twenty-seven companies on the Pydraul series. This service ranged from analysis of a single sample of used fluid to determine reusability through studies of system deposits and components to involved evaluation of Pydraul F9 recovery technics. Data derived from these studies were supplied to the customer through the Sales Department for his immediate use in his particular situation. Such activities have helped in securing Monsanto's present position in the field and in the promotion of functional fluids.

Additional properties of Pydraul F9 were determined. These included flammability, evaporation rates, and compatibility.

Several fire resistant industrial functional fluids competitive to the Pydraul series were examined. Hougto-Safe 271 and Dasco E36-500 were shown to be typical water base fluids. The Cellulube series were found to be essentially triaryl phosphate fluids.

III. REFERENCES

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2. Final Report, "Functional Fluids-Application Research, 1952-1954", 117-2508, by R. E. Hatton, L. W. Bannister, W. E. Koerner, O. B. Cecil, August 4, 1954.

3. Final Report, "Functional Fluids", 117-2380, by R. E. Hatton, May 21, 1953.

4. Progress Reports, "Functional Fluids-Application Research 1954-55", 117-2815

5. Progress Reports, "Navy Shipboard Fluid" 117-3011

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IV. EXPERIMENTAL WORK AND DISCUSSION

A. Evaluation of Customer Samples

As any new functional fluid is installed and is used in an actual mechanical system, certain problems connected with that particular application arise. Many of these problems are mechanical in nature, others are concerned with fluid characteristics. These latter problems have led to the evaluation of many samples submitted by our customers through Sales Department personnel. Such studies are necessary to insure our present position, to promote our present fluids, and to develop new uses for present fluids and leads for new products.

Much of the information obtained on these samples is only of immediate interest to the customer and is of value only to his particular application. Such information has been supplied directly to the customer through the Sales Department and will not be repeated in this report. It is felt that such data are of little permanent value because of the lack of actual details concerning contamination, conditions of use, dilution, etc. and the specificity of the customer's operating routines and equipment.

A list of the samples evaluated is given in the following tables divided according to the fluid involved. These tables contain the customer concerned and a reference to the Monsanto personnel requesting the work and the date of the request. Information felt to be of future utility obtained in these studies follows each table.

1. Skydrol 7000

Sales service samples of Skydrol 7000 evaluated for customers are listed in Table 1.

TABLE I

Customer	Location	Reference
New York Air Brake Co.	Watertown, New York	F.H.Langenfeld, 6-28-54
United Air Lines		F.H.Langenfeld, 12-20-54
Bell Aircraft Corp.	Buffalo, New York	H.S.Litzsinger, 12-9-54
New York Air Brake Co.	Watertown, New York	H.S.Litzsinger, 1-18-55
Capital Airlines		F.H.Langenfeld, 2-14-55
New York Air Brake Co.	Watertown, New York	H.S.Litzsinger, 2-18-55
Delta-C and S Airlines		F.H.Langenfeld, 4-25-55
Northwest Airlines		F.H.Langenfeld, 5-31-55
Maintainance Corp.	North Hollywood, Calif.	A.P.Vance, 8-11-55

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2. Pydraul F9

Sales service samples of Pydraul F9 evaluated for customers are listed in Table II.

TABLE II

Customer	Location	Reference
Cuno Engineering Corp.		J.S.Harris, 11-24-53
Eastern Metal Products Company	Tuckahoe, N.Y.	R.A.Geisman, 11-30-53
Hardy Manufacturing Co.	Union City, Ind.	J.S.Harris, 12-14-53
Aluminum Co.of America	Garwood, N.J.	R.A.Geisman, 12-14-53
General Motors-Brown, Lipe,Chapin Division	Syracuse, N.Y.	J.S.Harris
Trico Products Corp.	Buffalo, N.Y.	J.S.Harris, 3-3-54
Empire Die Casting Co.	Cleveland, Ohio	J.S Harris, 4-14-54
General Motors-Brown, Lipe,Chapin Division	Syracuse, N.Y.	J.S.Harris, 4-20-54
Hydraulic Press Mfg.Co.	Mount Gilead, Ohio	J.S.Harris, 4-26-54
General Electric Co.- Lamp Division	Cleveland, Ohio	J.S.Harris, 6-17-54
Trico Products Corp.	Buffalo, N.Y.	J.S.Harris, 6-10-54
Canadian General Electric Company		J.S.Harris, 9-13-54
General Motors- Rochester Prod.Div.	Rochester, N.Y.	J.S Harris, 10-1-54
U.S.Steel Co.- Benjamin Fairless Works	Morrisville, Pa.	J.S.Harris, 10-22-54
Racine Hydraulics and Machinery Co.	Racine, Wisconsin	J.S.Harris, 10-22-54
Aluminum Co.of America	Garwood, N.J.	J.S.Harris, 11-1-54
General Motors Corp.- Fabricast Division	Malvern, Arkansas	F.H.Langenfeld, 2-14-55
Hardy Manufacturing Co.	Union City, Ind.	F.H.Langenfeld, 2-15-55
Trico Products Corp.	Buffalo, N.Y.	F.H.Langenfeld, 2-22-55
Mall Tool Co.	Chicato, Ill.	F.H.Langenfeld, 4-19-55
U.S Steel Corp. -	Fairless Hills, Pa.	F.H.Langenfeld, 4-19-55
Coulter Mfg. Co.		F.H.Langenfeld, 5-11-55
Bendix Aviation- Scintilla Magneto Division	Sidney, N.Y.	F.H.Langenfeld, 6-20-55
Alloy Die Casting Co.	Los Angeles, Calif.	F.H.Langenfeld, 8-23-55
Kitchen Quip, Inc.	Waterloo, Ind.	M.C.Plummer, 9-8-55
Aluminum Co. of America	Cleveland, Ohio	F.H.Langenfeld, 10-14-55
Emerson Electric Mfg.Co.	St. Louis, Mo.	F.H.Langenfeld, 11-25-55
U.S Metal Refining Co.	Carteret, N.Y.	F.H.Langenfeld, 11-25-55

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A resin bonded felt filter was submitted by the Cuno Engineering Corp. for evaluation. The Cuno filter cartridge No. 2278-C1 was received and a portion placed in Pydraul F9 on November 24, 1953. The beaker containing this combination was allowed to stand at room temperature until December 14, 1953. The cartridge was removed and allowed to drain. By qualitative observations only, it appeared that the filter was not softened. Felt fibers did not separate from the cartridge. These data do not indicate that such a filter would operate satisfactorily with Pydraul F9 but that the resin bond is not dissolved by the Pydraul F9.

3. Pydraul 600

Sales service samples of Pydraul 600 evaluated for customers are listed in Table III.

TABLE III

Customer	Location	Reference
Aluminum Co.of America , Chapman Hydraulic Press	Bellwood, Ill.	J.S.Harris, 12-22-54 F.H.Langenfeld, 3-21-55
Machinery	Los Angeles,Calif.	C.W.Fetzner, 10-28-55

A bottle of Pydraul 600 from Alcoa, Bellwood, Illinois, via HPM was received and examined. This bottle was claimed to have been filled with foam from an HPM machine using Pydraul 600. The gas above the liquid was examined to determine, if possible, whether the gas causing the foaming is air entering the system through leaks or nitrogen from the accumulators.

Part of the gas was displaced from the bottle with water. Analysis indicated that the oxygen to nitrogen ratio was 1.0 to 4.1 corresponding to 19.6% oxygen and 80.4% nitrogen. This would indicate that the gas over the Pydraul 600 was essentially air and the foam problem was due mainly to air entrainment.

4. Pydraul 150

Several samples of Pydraul 150 were evaluated for the customer listed in Table IV.

TABLE IV

Customer	Location	Reference
U.S.Steel Corporation	Gary, Indiana	F.H.Langenfeld, 8-15-55

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B. Study of Fluid Properties

1. Flammability of Pydraul F9 via Incinerator Spray Test

The behavior of Pydraul F9 on spraying into open flames in an incinerator was examined. This work was done to provide data for insurance personnel as requested by the Sales Department.

A spray outfit was assembled from materials supplied by Douglas Aircraft Co. The equipment was designed so that nitrogen pressure could be placed upon a reservoir containing the fluid under test and the fluid forced through a small orfice and formed into a fine spray. The pressure used in the tests was 1000 psi. The fluid was drawn up into the reservoir by the use of a suction pump. This equipment was set up in front of the plant incinerator in which a wood fire had been built and after the entire incinerator had become hot because of the burning of waste paper. Temperatures of 1100 to 1400°F. were measured in the incinerator by means of optical pyrometry.

Three fluids were used, Pydraul F9, DTE Medium (mineral oil), and Houghto-Safe 271 (water base fluid). Spraying the DTE Medium into the incinerator resulted in vigorous burning as the fluid contacted the flames and hot surfaces. Spraying Pydraul F9 tended to increase the flames slightly, the fluid vaporizing and burning. There was no flash back. Spraying Houghto-Safe 271 resulted in no increase in flames. These results demonstrate Pydraul F9's fire resistant properties under the test conditions. The good results obtained on the water base fluid indicate the effectiveness of water as a snuffer when the entire fluid is vaporized. Pydraul F9 was decidedly better than the mineral oil.

2. Evaporation Rates of Pydraul F9, Mineral Oil, and Water Base Fluid

The relative evaporation of several fluids was determined in response to a Sales Department request. The procedure used is as follows: 250 ml. beakers were filled approximately 3/4 full with the fluid under study weighed, covered with ribbed type watch glasses, and allowed to stand in the laboratory at room temperature. The fluids examined were Pydraul F9, DTE Medium (mineral oil) and Houghto-Safe 271 (water base fluid). A similar volume was used in each case, being about 180-190 ml. The fluid weights were about 230, 160, and 185 grams, respectively. The beakers were weighed periodically and the weight losses observed were as follows:

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Total Days	Total Loss in Weight, Grams Pydraul F9	DTE Medium	Houghto-Safe 271
0	0.0	0.0	0.0
15	0.1	0.1	23.1
34	0.1	0.1	50.1
45	0.1	0.1	69.6
65	0.1	0.1	80.4

These data show that the Pydraul F9 and the mineral oil, DTE Medium have lost no appreciable amount while the water base fluid, Houghto-Safe 271, has lost about 40% by weight in 65 days. Both Pydraul F9 and DTE Medium were unchanged in appearance. The Houghto-Safe 271 sample decreased greatly in volume and the solids which are normally present seemed to increase slightly in amount. These data point up the problems involved in maintaining the proper concentration of water in water base fluids and the greater permanence of Pydraul F9.

3. Pydraul F9 Compatibility

Compatibility data were determined for Pydraul F9. Mixtures of 50:50, Pydraul F9:benzene and Pydraul F9:hexane were prepared. Both mixtures were completely miscible at room temperature and at 0°C.

C. Study of Competitive Fluids

1. Houghto-Safe 271

A fire resistant hydraulic fluid competitive with Pydraul F9 was introduced by the E. F. Houghton Co. A partial analysis was carried out in the following manner.

A sample was fractionated under reduced pressure. The first fraction consisted of water, accounting for approximately 50% of the composition. The second fraction obtained accounted for about 25% of the composition and was subsequently identified as dipropylene glycol. The remaining 25% of the material was left as residue. No analyses were performed on the residue.

The results of the analyses performed on the glycol fraction are given in the following table along with values for dipropylene glycol.

Material \ Property	Specific Gravity	Refractive Index	Boiling Point (atmos)	% Carbon	% Hydrogen
Glycol fraction from "Houghto-Safe"	25/25°C 1.0211	n_D^{25} 1.4392	227°C	53.1%	10.49%
Dipropylene Glycol	20/20°C 1.0252	n_D^{20} 1.4440	232°C	53.71%	10.52%

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These results show that the fraction in question was slightly contaminated dipropylene glycol. This fraction was odorous also indicating contamination. No analyses were carried out on the residue from the distillation.

Physical properties were determined for Houghto-Safe 271. The data are as follows:

Viscosity,	210°F.	8.56 cs.
	170°F.	13.46 cs.
	130°F.	24.10 cs.
	100°F.	41.9 cs.
	77°F.	70.4 cs.
	68°F.	88.3 cs.
	50°F.	149.4 cs.
	25°F.	375 cs.
Sp. Gr. 25/25°C.		1.0525
Flash Point		280°F.
Fire Point		280°F.
Pour Point		+ 5°F.

2. Dasco E36-500

Another fire resistant fluid is Dasco E36-500, a water base fluid. Our sample contained large amounts of sediment. After filtration, the viscosity was 66.3 cs. at 100°F.; separation occurred at 210°F. The Dasco was completely soluble in water, slightly soluble in benzene with separation occurring if larger amounts of benzene were used. The material does not behave like Ucon 200 in this respect; Ucon 200 being not miscible with benzene.

A flash and fire point determination was run on Dasco E36-500. The fluid boiled vigorously at 210°F. and the temperature stabilized until about half the volume remained. The temperature then invreased slowly with some boiling. The flash point was found to be 260°F. and the fire point 290°F. This is the usual behavior for water base fluids.

3. Cellulube Fluids

The Celanese Corporation of America introduced a series of industrial fire resistant hydraulic fluids under the trade name "Cellulube". The first three grades available were Cellulube X-90, Cellulube 150, and Cellulube 220. All are yellow in color with a green fluoresence. Samples of each grade were examined and the physical properties are as follows:

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Sample	Cellulube X-90	Cellulube 150	Cellulube 220
Viscosity, 210°F.	3.26 cs.	4.43 cs.	5.04 cs.
Viscosity, 100°F.	17.30 cs.	35.23 cs.	49.16 cs.
Viscosity, 20°F.	420[illegible] cs.	3130 cs.	8670 cs.
Viscosity Index	+ 35	- 31	- 45
Acidity	0.04 N.N.	0.05 N.N.	0.04 N.N.
Specific Gravity, 25/25°C.	1.2059	1.1624	1.1449
Refractive Index, 25°C.	1.5602	1.5546	1.5518
Flash Point	410°F.	450°F.	440°F.
Fire Point	620°F	640°F.	685°F.
Pour Point	-40°F.	-15°F.	-10°F.

None of these fluids contain chlorine as indicated by the copper-flame test. Based upon the physical properties, it appears that these are principally triaryl phosphates. Celluflex 150 appears to be a perfect match for tricresyl phosphate. Celluflex X-90 is very similar in properties to cresyl diphenyl phosphate (Santicizer 140 or Celluflex 112). It should be possible to prepare a triaryl phosphate similar to Cellulube 220 by proper selection of the cresylic acid used.

The data obtained thus far do not unequivocally identify these products but certainly all evidence does indicate triaryl phosphate variations.

The composition of Cellulube 220 was elucidated by studying the type of cresylic acid derivable by hydrolysis of the ester.

A sample of Cellulube 220 was hydrolyzed by potassium hydroxide and the cresylic acid then isolated. Distillation of the cresylic acid through a 50 plate column gave the following information as reported by the Analytical Laboratory:

2% phenol and o - cresol
25% meta and para cresols
39% low boiling (less than 215°C) xylenols
Balance high boiling (more than 215°C) xylenols and other high boilers.
This information is based on boiling points.

The phosphorus content of this sample of Cellulube 220 was 7.5%.

Based upon data concerning property and composition of triaryl phosphates and these data, it is felt that Cellulube 220 is a triaryl phosphate and could be duplicated easily given a cresylic acid similar to that described. Work along these lines is reported under Job Number 3011.

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Another Cellulube is 2013 which was reported to be under test by the Navy. A second sample of Cellulube 150 (Lot 13-54-21) was obtained. Properties of these two samples are as follows:

Sample	Cellulube 2013	Cellulube 150
Viscosity, cs., 210°F.	5.07	4.23
100°F.	50.64	32.31
20°F.	9230	-----
Viscosity Index	-51	-----
Acidity, NN	0.06	0.09
Specific Gravity, 25/25°C.	1.1453	-----
Refractive Index at 25°C.	1.5517	-----
Flash Point, °F.	460	455
Fire Point, °F.	650	635
Pour Point, °F.	+ 5	-20

The Cellulube 2013 seems quite similar to Cellulube 220.

V. ACKNOWLEDGMENT

The analyses performed by the members of the J. F. Queeny Plant Analytical Laboratory are gratefully acknowledged.

R. E. Hatton

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FINAL REPORTS

ON

EXPLORATORY PLASTICIZER AND STABILIZER

EVALUATION WORK FOR THE PHOSPHATE DIVISION

Job No. 2-02-750.01-2595

AND

SALES SERVICE WORK FOR PHOSPHATE DIVISION

Job No. 2-02-750.01-2563

Monsanto Chemical Company
Organic Chemicals Division
St. Louis Research Department

Work done by:

Reported by:

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1. File
2. J. R. Darby
3. J. H. Lum - F. B. Zienty - File
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I. INTRODUCTION

In the past, (for the most part that period of time covered by the two job numbers associated with this report), there has existed a working relationship between Research and the old Phosphate Division, similar to that now in effect between Research and the Plasticizer Sales Dept. The two job numbers concomitant with this report have been combined in an effort to conveniently assimilate the work that was the outcome of this working relationship.

All work included in this report was concerned primarily with either improving customer relations or supplying the Phosphate Division Sales force with graphic information displaying the merits of their products and/or the possible shortcomings of competitive materials.

Some of the information contained herein is the result of work done at the request of specific customers, while other facts were garnered in recognition of their being informative to the trade as a whole.

Other work in this report concerns application work on current (at that time) Phosphate Division products, and the screening of new products, potentials for exploitation in either the plasticizer, stabilizer, or other related fields.

II. SUMMARY

The nature of the work contained in this report was necessarily diverse, being gleaned, as it was, from two separate job numbers of varied scope.

Three general classifications of work will suffice to categorize a summary of the information recorded herein. The first consideration was directed toward application work on present products, which entailed the intensive study of the stabilization of HB-40 and the Aroclors. New stabilization systems were initiated, and old systems were revised in an effort to achieve improved stabilization of these products. Intensive evaluations of a highly competitive product, Panaflex BN-1, was also included in this work.

Technical service for specific customers of the Phosphate Division formed the second phase of this work. This section dealt only with problems which were submitted by specific customers for a particular evaluation or opinion.

Finally, there was the evaluation of new exploratory products submitted in an effort to keep pace with an expanding market and competitive developments. The exploratory products evaluated were of potential interest in the stabilizer field and in the secondary plasticizer field of application, the latter being part of the search for a replacement for [illegible] HB-40.

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III. CONCLUSIONS

As a result of the work described in this report, the following conclusions were found to be substantiated by experimental procedure:

Several organophosphorous compounds impart an excellent degree of stabilizing power to PVC formulations exposed to ultraviolet light. They were found to prolong stabilization action, in many cases, beyond the excellent period of 1000 hrs. exposure, when incorporated into current stabilization systems or mutations of those systems. The most promising synergistic light-stabilizing action was displayed by:

a) Tris (9,10 epoxyoctadecyl) phosphite
b) 9,10 Epoxyoctadecyl diisopropyl phosphite
c) Bis (9,10 epoxyoctadecyl) benzene phosphonate
d) Bis (9,10 epoxyoctadecyl) benzene phosphonite
e) Bis (9,10 epoxyoctadecyl) methane phosphonate

Formulation combinations of phosphonates and epoxy alcohol approach, but do not quite achieve, the stabilizing effectiveness of epoxyphosphonates.

HB-20 (T-2, slightly hydrogenated) was seen to be of potential importance as the ultimate choice as a replacement for HB-40.

The organophosphorous compounds which displayed such promising stability to ultra-violet, have little value with respect to resisting heat degradation. They are poor heat stabilizers per se and impart no synergistic effect in stabilizer combinations.

Panaflex BN-1 (Pan American Chem) is much superior to HB-20 and HB-40 in a consideration of volatility. Heat and light stability tests, however, fail to determine any superiority of this product over HB-20 and HB-40.

Aroclors 1254 and 1260 achieve their best stability when stabilized with Paraplex G-60, Dyphos, and Mark XV.

IV. PATENT SITUATION

There have been several patent applications filed using information described in this report. However, the chemists who submit the prospective plasticizers or stabilizers thoroughly cover the patent situation from their respective positions. A thorough report on the patent situation therefore may be found in related project reports.

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V. EXPERIMENTAL PROCEDURES

All the test methods used in this report are contained in the revised, comprehensive supplement entitled, Standard Test Methods, Plasticizer Applications Lab.

This supplement contains essentially all of the test methods used in the Plasticizer Applications Laboratory, and will be enlarged as the need for new or more expansive methods of testing arise.

VI. DETAILS

A. Application Work on Present Products

In the course of this work there have been requests emanating from the Phosphate Division for application work concerning several of the products produced by, and/or of considerable interest to the Phosphate Division. Work of this nature enabled that Department to maintain a cognizance of advancements, technical and commercial, in the field and potential market-improving changes for Monsanto products.

1. Stabilization of HB-40

Heat and light stability screening tests were carried out on thirteen variously-stabilized HB-40 samples in standard formulations of HB-40 (stabilized), DOP, and polyvinyl chloride.

The stabilized HB-40 samples were identified as follows:

M-1180	HB-40	stabilized with	o-tolylbiguanide
M-1181	"	"	cadmium dibutyldithiocarbamate
M-1182	"	"	cadmium di-iso-propyldithiophosphonate
M-1183	"	"	phenyl arsonic acid
M-1184	"	"	1,1-dicyclohexyl-2-phenyl urea
M-1185	"	"	tin salt of diethyl dithiocarbamate
M-1186	"	"	bis-(1-piperidyl thiocarbonyl) disulfide
M-1187	"	"	N-(2-hydroxy-3-n-butoxypropyl) ethylene diamine
M-1188	"	"	butasan
M-1189	"	"	1,3-dimorpholinopropanol-2
M-1190	"	"	triphenyl stibine and tributyl phosphite
M-1191	"	"	triphenyl stibine
M-1192	"	"	1,3-dimorpholinopropanol-2 and phenyl arsonic acid
M-1193	HB-40 unstabilized		

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Heat tests showed most of the above formulations to be decidedly inferior, even to unstabilized HB-40. Only two, those stabilized with triphenyl stibine-tributyl phosphite, and with triphenyl stibine, were equivalent, but not superior to HB-40 unstabilized.

Light stability tests were carried to completion at 400 hrs. ultraviolet exposure. After this time it was apparent that the stabilizer-HB-40 combinations possessed little or no apparent favorable effect, concerning heat or light stability.

2. Stabilization of Aroclors

a. In an effort to determine the best stabilizer system for use with Aroclors 1254 and 1260, formulations containing these Aroclors and DOP were stabilized using the following methods:

(1)

Paraplex G-60
Mark XI (barium cadmium laurate)
Mark XX (triphenyl phosphite)

(2)

Paraplex G-60 (Epoxidized soy bean oil)
Dyphos (dibasic lead phosphite)
Mark XV (cadmium phosphite)

(3)

Paraplex G-60
Plumb-O-Sil C (lead silicate)
DS-207 (lead stearate)

(These formulations were prepared with both Opalon 300 and Vinylite VYNW)

Stability results show that the Aroclor compositions achieved slightly superior stability when used with Opalon 300, rather than VYNW resin.

The stabilization system consisting of Paraplex G-60, Dyphos, and Mark XV afforded the best heat and light stability (of systems tested) to compounds containing Aroclors 1254 and 1260. The epoxy-cadmium system was nearly equivalent to the aforementioned system. Heat stability displayed by these Aroclors was excellent, but the light stability of the same compounds was poor.

b. Ferro Chemical Co. reported that DOP-Aroclor mixtures show essentially the same stability as DOP, alone, in PVC. An attempt was made to correlate Ferro's results by determining the light stability of Aroclors 1254, 1260 and 1262, together with DOP, and stabilizers. The Ferro stabilizers 1820, 1900 and 903.

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Contrary to Ferro's results, it was determined that the light stability is noticeably inferior in the mixtures of Aroclor and DOP, as compared to DOP, alone.

3. Evaluation of Panaflex BN-1

Panaflex BN-1, a high-boiling hydrocarbon oil from Pan American Chemicals, is a competitive product of HB-40 and HB-20 by virtue of its lower price, lower volatility, and its supposedly improved light stability over HB-40 and HB-20.

The following are the results of the activated carbon volatility tests at 87°C. on films containing DOP and various concentrations of HB-20 and Panaflex BN-1:

HB-20			Panaflex BN-1		
Plasticizer (PHR)			Plasticizer (PHR)		
DOP	HB-20	Volatility	DOP	Panaflex BN-1	Volatility
50	0	4.8%	50	0	4.8%
40	10	17.3	40	10	13.2
35	15	20.4	35	15	13.8
25	25	24.1	25	25	13.7
20	30	22.8	20	30	12.0
15	35	18.7	15	35	11.7
10	40	16.5	10	40	9.0
0	50	11.3	0	50	2.6

Heat and light stabilities of Panaflex BN-1 were determined on films containing 25 PHR DOP and 25 PHR Panaflex BN-1, with the epoxy-cadmium stabilizing system. Its light stability is as poor as that found in films containing HB-20. Panaflex BN-1 also induces yellowing in a relatively short exposure time. Its heat stability was perhaps a little inferior to that of HB-20.

B. Technical Service for Specific Customers

Frequently the situation arises where a customer is confronted with a problem concerning the use of one or more of our products in his particular field of production and requests technical service toward the solving of that problem. Work done in conjunction with these requests is considered "Sales Service" and was performed in order to improve customer relations.

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1. U. S. Equipment

a. Two dry blends used in extruding clothes line were evaluated for physical properties for U. S. Equipment. Both compounds contained HB-40 and Aroclor 1254. Both had fairly good low temperature properties but were very volatile. Yellowing was evident on exposure to ultraviolet.

Formulations:	I	II
Opalon 300	100	100
Dicapryl Phthalate	30	36
HB-40	10	20
Aroclor 1254	30	30
Paraplex G-60	3	3
Atomite	30	30
Mark XI	2	2
Mark XX	1	1
Acrawax	2	2
Titanox RA	8	8

Properties:	I	II
Tensile strength	2156 psi	1888 psi
Shore Hardness	83	73
Low Temp. Flex.	-26.4°C.	-36.7°C.
Volatility	24.5%	26.0%
Light Stability (Weatherometer)		
100 hrs.	Sl. yellowing	Yellowed
200 hrs.	Increased yellowing	Yellowed
300 hrs.	Same	Same

b. Samples of clothesline from U.S. Equipment Co. containing dicapryl phthalate, HB-40, and Aroclor 1254 displayed excellent stability in both Fadeometer and Weatherometer.

2. Western-Textile

The Western Textile Co. requested shore hardness data on resins containing DOP, HB-20, and Aroclor 1254. The following formulation was found to meet the shore hardness of 85 desired by the customer:

Opalon 300	100
DOP	30.5
Aroclor 1254	30.5
HB-20	11
Paraplex G-60	3
Mark XI	2
Mark XX	1
Mineral Oil	1
Stiff	100

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C. Exploratory Stabilizers

Ten exploratory stabilizers were evaluated under this job number, during this period; all were submitted from Anniston. In evaluating exploratory compounds as potential stabilizers it is usual to test them both as primary stabilizers and in combination with several accepted stabilizing systems. This increases the possibility of observing any stabilizing action inherent in the product.

Following is a list of the stabilizers evaluated, with the evaluation results:

M-1526 Bis (9,10-epoxyoctadecyl) benzene phosphonate
M-1527 Bis (9,10-epoxyoctadecyl) benzene phosphonite
M-1528 Bis (9,10-epoxyoctadecyl) methane phosphonate
M-1529 Tris (9,10-epoxyoctadecyl) phosphite
9,10-Epoxyoctadecyl diisopropyl phosphite
M-2043 Bis (beta-chloroethyl)ethylenephosphonate
M-2044 Dibutyl allylphosphonate
M-2045 Bis (2-butyloctyl) phosphite
M-2046 Bis (2-octyl)-2-ethylhexanephosphonate
M-2047 Bis (beta-chloroethyl) beta-chloroethane phosphonate

These ten compounds were incorporated into DOP-plasticized PVC, alone, with epoxidized oleyl alcohol, with Mark XI, and with Mark XI and Paraplex G-60. The testing of the combinations of phosphonates and epoxy alcohol was an effort to approach the stabilizing effectiveness of previously tested epoxyphosphonates, with a system which might be economically more practical and patentable.

Heat tests consisted of sample exposure in a 170°C. circulating air oven with samples removed at 20 minute exposure intervals.

1. Heat Test Results

Generally speaking, heat stability tests indicated the organophosphorous compounds to be of little value in obtaining a synergistic effect. They are poor stabilizers, alone, and only fair when included in stabilizer systems. M-1526, M-1527, M-1528, and M-1529 were essentially equivalent to each other and to the control in the Mark XI-G-60 system; but were less efficient with the removal of Paraplex G-60.

9,10 epoxyoctadecyl diisopropyl phosphite was slightly inferior to the aforementioned four samples.

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Bis (beta-chloroethyl) ethylenephosphonate (M-2043) and dibutyl allylphosphonate(M-2044), in combination with G-60 and Mark XI displayed somewhat better heat stability than the control sample.

Bis (2-butyloctyl) phosphite (M-2045), bis (2-octyl)-2-ethylhexanephosphonate (M-2046), and bis (beta-chloroethyl) beta-chloroethane phosphonate (M-2047) were seen to be poor heat stabilizers in relation to current stabilization systems.

2. Light Test Results

The ten organophosphorous compounds gave results of interest in that exceptional long-term light stability was displayed by several of the compounds.

Bis (9,10 epoxyoctadecyl) benzene phosphonate (M-1526) and bis (9,10 epoxyoctadecyl) benzene phosphonite (M-1527) showed excellent stabilizing effects with G-60 and Mark XI for 1000 hrs. exposure. The stabilizing effects were, however, reduced upon the removal of some of the G-60.

Bis (9,10 epoxyoctadecyl) methane phosphonate (M-1528) resisted sample breakdown for more than 1000 hrs. when incorporated into the epoxy-cadmium system.

Tris (9,10 epoxyoctadecyl) phosphite (M-1529) was seen to possess excellent stabilizing action, not only in combination with G-60 and Mark XI, but also with Mark XI, alone. This situation was unique in this series of stabilization studies. Extended exposure to ultraviolet resulted in a remarkable resistance to breakdown for 1400 hours, a much greater stabilizing effect than displayed by standard stabilizer systems.

9,10 epoxyoctadecyl diisopropyl phosphite imparted a slightly more stabilizing effect to the epoxy cadmium system, but showed less interesting properties when its concentration was increased, or when the concentration of Paraplex G-60 was decreased.

Samples M-2043 through M-2047 were slightly less effective in apparent light stabilizing action than the five samples reported above.

The best light stability was displayed by the series containing G-60 and Mark XI, with all five (M-2043 thru M-2047) possessing very good long-term stability. Both bis (beta-chloroethyl) ethylene phosphonate (M-2043) and bis (2-butyloctyl) phosphite (M-2045) are good with Mark XI

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The bis (2-butyloctyl) phosphite (M-2045) and bis (2-octyl)-2-ethylhexanephosphonate (M-2046) displayed a greater synergistic effect when used with Paraplex G-60, rather than epoxidized oleyl alcohol, while the other samples showed results to be equal between G-60 and the epoxy alcohol.

When used alone, these five organophosphorous compounds were shown to possess poor stabilizing qualities.

Formulations used in this work are as follows:

SERIES "A"

	Opalon 300	DOP	M-1526	M-1527	M-1528	M-1529	9,10 Epoxy-octadecyl Diisopropyl Phos.	Mark XI	G-60
1.	100	47	3						
2.	"	"		3					
3.	"	"			3				
4.	"	"				3			
5.	"	"	3						
6.	"	"		3				2	
7.	"	"			3			2	
8.	"	"				3		2	
9.	"	"	3					2	
10.	"	"		3				2	3
11.	"	"			3			2	3
12.	"	"				3		2	3
13.	"	"	1.5					2	1.5
14.	"	"		1.5				2	1.5
15.	"	"			1.5			2	1.5
16.	"	"				1.5		2	1.5
17.	"	"					3		
18.	"	"					3	2	
19.	"	"					1	2	3

SERIES "B"

	Opalon 300	DOP	M-2043	M-2044	M-2045	M-2056	M-2047	Epoxy Oleyl Alc.	Mark XI	G-60
1.	100	47	3							
2.	"	"		3						
3.	"	"			3					
4.	"	"				3				
5.	"	"					3			
6.	"	"	3							
7.	"	"		3						
8.	"	"			3					
9.	"	"				3				
10.	"	"					3			

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SERIES "B" (Cont'd)

	Opalon 300	DOP	M-2043	M-2044	M-2045	M-2046	M-2047	Epoxy Oleyl Alc.	Mark XI	G-60
11.	100	47	3						2	
12.	"	"		3					2	
13.	"	"			3				2	
14.	"	"				3			2	
15.	"	"					3		2	
16.	"	"	3							3
17.	"	"		3						3
18.	"	"			3					3
19.	"	"				3				3
20.	"	"					3			3
21.	"	"	3						2	3
22.	"	"		3					2	3
23.	"	"			3				2	3
24.	"	"				3	3		2	3
25.	"	"							2	3
26.	"	"							2	3

The charts which follow contain the results of both heat and light tests run on the foregoing formulations (henceforth identified by formulation number). The indicative numbers in each chart refer to the visual color and appearance of the exposure samples at the corresponding time.

Color Key Code:

0	Colorless	5	Amber
1	Discolored	6	Dark Amber
2	Lt. Yellow	7	Brown
3	Yellow	8	Black
4	Lt. Amber	S	Spotted sample

Heat Stability - Series "A"

Min. at 170°C.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	4	4	5	5	1	1	2	2	1	1	1	1	1	1	1	1	0	0	1
40	5	5	6	7	2	2	3	2	2	2	2	2	2	2	2	2	1	0	1
60	5	6	8	8	5	5	7	3	2	2	2	2	2	2	2	2	1	0	2
80	6	6			6	7		5	2	2	2	2	2	2	2	2	2	1	2
100	6	7			8			8	3	2	3	2	3	3	3	3	5	3	2
120	7								3	3	3	3	5	5	5	4	6	3	3
140									5	3	3	3	5	8	8	6	8	3	3
160									8	5	5	3	8			8		4	4
180										8	8	5						6	6
200												8						8	8

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Light Stability - Series "A"

Hours	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
50	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	6	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300	6	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	S	0	0
400	7	5	5	5	S-4	0	0	0	0	0	0	0	0	0	0	0	S	0	0
500	7	6	6	6	S-4	0	0	0	0	0	0	0	0	0	0	0	S	0	0
600	8	8	8	8	5	0	0	0	0	0	0	0	0	0	0	0	S	S	0
700					6	S-4	S-4	0	0	0	0	0	0	0	0	0	S	S	0
800					8	S-4	6	0	0	0	0	0	S-4	S	0	0	S-4	S-4	S
1000						S-4	8	0	0	0	0	0	S-4	S	0	0	6	6	4

Heat Stability - Series "B"

Min. at 170°	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
0	5	0	1	1	1	1	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0
20	6	3	5	6	6	6	6	6	2	4	4	1	3	1	0	3	5	2	3	2	1	1	2	1	1	1
40	6	5	5	6	6	6	6	4	5	5	2	2	5	5	2	5	5	4	3	3	2	2	2	2	1	1
60	6	6	6	6	6	6	6	5	8	8	6	6	6	6	6	5	5	5	3	4	2	2	2	2	2	2
80	8	6	6	8	8	8	8	5			8	8	8	8	8	5	6	5	5	6	2	2	3	2	2	2
100		7	6					6								6	8	6	6	8	3	2	3	3	3	3
120								6										6			3	3	4	6	4	4
140																					4	3	6	8	6	5
160																					5	4	8		8	8
180																					6	5				
200																					8	6				

Light Stability - Series "B"

Hrs.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
0	4	0	2	1	1	1	0	0	0	0	0	0	1	0	0	2	1	2	0	0	0	0	0	0	0	0
50	6	5	6	4	6	0	0	5	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
100	6	5	6	5	6	0	0	6	1	0	0	0	0	0	S	1	0	2	0	0	0	0	0	0	0	0
200	7	6	7	6	6	4	1	6	5	4	0	S	1	S	S	4	1	2	0	4	0	0	0	0	0	0
300	8	7	8	7	8	6	6	7	6	6	0	S	1	S	S	5	4	2	4	5	0	0	0	0	0	0
400	8	7	8	8	8	6	6	7	7	6	0	S	1	S	S	6	6	2	5	6	0	0	0	0	0	0
500	8	8	8	8	8	7	6	7	7	6	0	S	1	S	7	6	7	5	6	8	0	0	0	0	0	0
600						7	7	7	7	6	0	S	1	S	8	6	8	6	8	8	0	0	0	0	0	0
700										7	0	S	1	S	8	8		6			0	0	0	0	0	0
800										7	0	S	1	S	8	8		8			0	0	0	0	0	0
1000										7	0	S	1	S	8	8		8			S	S	S	S	6	6

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D. HB-40 Substitutes

In the light of an increasingly short supply of HB-40 for market consumption, various materials have been developed and examined as possible substitutes for HB-40 in vinyls. In the search for a satisfactory replacement, some exploratory products have been observed to be of interest because of performance and/or price. Others, however, were seen to possess few qualities of a usable nature.

The first consideration here will be the preliminary screening of the various potential substitutes which were submitted. From these evaluations, the product ultimately considered as the most probable HB-40 substitute was chosen. The next part of this report contains a summary of the intensive evaluation results on that product, HB-20 (T-2, slightly hydrogenated). Two special reports have been previously written concerning this product, Special Application Reports No. 779 and No. 1005, both entitled, "Evaluation of HB-20 as a Substitute for HB-40", Job Nos. 117-2595 and 117-2616 (2), respectively, by P. R. Graham.

1. Exploratory Substitute Plasticizers for HB-40

The detailed results of the preliminary screening of all the exploratory products have been listed on Charts Nos. 1 and 2. They have all been studied as extender plasticizers, at various concentrations with DOP.

1,2 & 3 -- T-2, slightly hydrogenated (T-2 is ethyl benzene still bottoms), T-2, moderately hydrogenated, and T-2-HB, slightly hydrogenated displayed fairly attractive compatibility as secondary plasticizers. Volatility of these, while high, is yet within the HB-40 volatility range. Other screening properties were well-balanced. These compounds appeared to be the most likely as HB-40 replacements. A more thorough consideration of T-2, slightly hydrogenated, may be found under part "B" of this same section of the report.

4 -- Chlorinated DDB (dodecyl benzene) high-boiler was one of four treated-DDB-high-boiler samples submitted. The other three, being slightly hydrogenated, half-hydrogenated, and completely hydrogenated, respectively, were found to have no practical compatibility, displaying no improvement over previous DDB-high-boilers, and were not subjected to preliminary screening. The chlorinated DDB possessed an attractive balance of properties at 1:3 DOP.

5,6 -- Limonene polymer (M-1855) and Dutrex 25 (incipient hydrogenation) (M-1856) both achieved compatibility at 1:2 parts DOP. Properties were well-balanced and directly competitive to HB-40.

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8 -- S-2 Aromatic tar (M-1857) proved to be compatible when incorporated, alone, into PVC. Its low temperature flex and shore hardness, however, proved its extreme inefficiency in the role of primary plasticizer. At 1:2 DOP, it was comparable to HB-40.

9,10, & 11 -- Epoxidized limonene dimer (M-2073), limonyl biphenyl (M-2074), and rosin oil (M-2075) all possessed equal plasticizing compatibilities, and while showing no more promise than any of the previous samples, they remained well within the HB-40 range of performance.

12 -- C_{22} aromatic tar, slightly hydrogenated (M-2076) was incompatible even when combined 1 pt.:3 pts. DOP.

14 -- Indonex 632-1/2 (Indoil Co.), hydrogenated (M-2175) also possessed no practical compatibility.

13,15, & 16 -- Three other samples were found to have acceptable compatibility limits, and possess plasticizing properties within the performance range of HB-40. They were; heavy aromatics (Eastern States Pet. Co.), hydrogenated (M-2174), T-2 (Texas City Stream 2) hydrogenated and H_2SO_4 extracted (M-2176), and special anthracene oil (Reilly) hydrogenated (M-2177).

2. Comprehensive Evaluation of HB-20 as an HB-40 Substitute

HB-20 is a slightly hydrogenated still residue from Texas City, a by-product formerly used only for solvent purposes. In a consideration of economics therefore, the potentiality of HB-20 as an extender plasticizer, of the HB-40 type, was very attractive. In view of this desirable quality, extensive testing of this material was felt to be warranted.

In the course of the comprehensive evaluation of HB-20 vs. HB-40, two Special Reports were written, Nos. 779 and 1005, both entitled "Evaluation of HB-20 as a Substitute for HB-40", Job Nos. 117-2595 and 117-2616 (2), respectively, by P. R. Graham. In these reports can be found all the detailed information that was obtained and in addition, descriptive graphs and charts are presented therein. Because of the completeness of coverage in those reports, only a condensed summary of that work will be included here.

Preliminarily, HB-20 compared favorably with HB-40 in most tests run. After a more intensive investigation however, several shortcomings were noted:

More intensive compatibility tests showed HB-20 to be [illegible] less compatible than HB-40.

DSW 620901

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2. HB-20 suffers a serious drawback in that it is unstable to light. No suitable ultra-violet light stabilizer has been found to alleviate the rapid yellowing that is character stic of HB-20 films after exposure to ultra-violet.

3. HB-20 is inferior to HB-40 and other commercial extender plasticizers of this type, in a consideration of volatility and silica migration tests.

4. The relative volatility of this compound is believed to be the causative element in the heavy fuming and disagreeable, discomforting odor that is apparent during processing operations.

Since the completion of this work, HB-20 has been put on the market as a HB-40 replacement and just recently has been considered for application in polyvinyl acetate adhesives.

VII. APPENDIX

Notebook pages used for this work:

A-33748, A-34497, A-34498

A-38910, A-38911, A-38921, A-38925, A-38926, A-38927, A-38928, A-38931, A-38932, A-38933, A-38934, A-38935, A-38940, A-38945, A-38946, A-38948

A-42701, A-42702, A-42703, A-42704, A-42705, A-42706, A-42707, A-42713, A-42714, A-42715, A-42718, A-42719, A-42726, A-42727, A-42740, A-42750

A-44458, A-44469

A-44663, A-44664, A-44665, A-44687, A-50964

L. R. Wangler

J. R. Darby

md

5-31-56

DSW 620902

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Chart

NO.	PLASTICIZER	LOT. NO.	% PLAST.	T_f °C	VOL. % PLAST LOST	HARDNESS INITIAL	HARDNESS AFTER VOL	WATER ABSORPTION % SOL MATTER LOST	WATER ABSORPTION % AB-SORPTION	KEROSENE EXTRACTION % PLASTICIZER LOST	HEAT STABILITY COLOR	HEAT STABILITY RATING	REMARKS
	T-2 Slightly Hydrogenated 1.1 DOP		40	-27.6	24.4	80	85	0.45	0.77	34.1	Yellow	Good	
	T-2 Slightly Hydrogenated 1.2 DOP		40	-28.4	18.5	80	82	0.16	0.50	22.6	Yellow	Good	
	T-2 Slightly Hydrogenated 1.3 DOP		40	-31.8	19.8	78	81	0.17	0.45	28.5	Yellow	Good	
2	T-2 Moderately Hydrogenated 1.2 DOP		40	-29.9	20.5	81	83	0.22	0.52	29.4	Yellow	Good	
	T-2 Moderately Hydrogenated 1.3 DOP		40	-33.6	17.8	78	78	0.18	0.51	33.4	Yellow	Good	
3	T-2 HB Slightly Hydrogenated 1.2 DOP		40	-32.6	18.7	81	83	0.13	0.42	60.6	Yellow	Good	
	T-2 HB Slightly Hydrogenated 1.3 DOP		40	-35.7	15.6	79	77	0.12	0.48	52.7	Yellow	Good	
4	Chlorinated DDB 1.3 DOP		40	-36.9	11.1	79	76	0.05	0.41	77.6	Yellow	Good	
5	Limonene Polymer	M 1855	40										Incompatible: No Sheet on Mill
	Limonene Polymer 1.1 DOP	M 1855	40										Incompatible: Immediate Exudation
	Limonene Polymer 1.2 DOP	M 1855	40	-28.1	14.7	85	84	0.29	0.58	53.3	Dk Yellow	Fair	
6	Dutrex 25 (Incipient Hydrogen)	M 1856	40										Incompatible: Immediate Exudation
	Dutrex 25 Incipient Hydrogen 1.1 DOP	M 1856	40	-22.4	16.7	81	86	0.14	0.41	25.9	Lt Amber	Fair	
	Dutrex 25 (Incipient Hydrogen) 1.2 DOP	M 1856	40	-26.6	13.7	78	81	0.11	0.43	32.5	V Lt Amber	Good-Fair	
7	Dutrex 25 (Control Sample) 1.1 DOP		40	-17.7	14.8	80	86	0.06	0.35	12.6	Dk Amber	Poor	
8	S-2 Aromatic Tar (Dist & Hydrogen)	M 1857	40	>+20	9.7	100	100	0.08	0.24	2.4	Lt Amber	Fair	
	S-2 Aromatic Tar (Dist & Hydrogen) 1.1 DOP	M 1857	40	-21.3	17.6	81	88	0.26	0.55	9.3	Dk Yellow	Fair	
9	Epoxidized Limonene Dimer	M 2073	40										Incompatible: Immediate Exudation
	Epoxidized Limonene Dimer 1.1 DOP	M 2073	40	-17.2	15.1	86	88	0.04	0.61	26.5	Amber	Fair	
	Epoxidized Limonene Dimer 1.2 DOP	M 2073	40	-23.0	14.4	82	84	0.02	0.61	18.7	Lt Amber	Fair	
10	Limonyl Biphenyl	M 2074	40										Incompatible: No Sheet on Mill
	Limonyl Biphenyl 1.1 DOP	M 2074	40	-22.0	16.2	82	83	0.02	0.38	60.6	Lt Yellow	Good	
	Limonyl Biphenyl 1.2 DOP	M 2074	40	-24.3	11.7	80	79	0.01	0.41	40.5	Lt Yellow	Good	
11	Rosin Oil	M 2075	40										Incompatible: No Sheet on Mill
	Rosin Oil 1.1 DOP	M 2075	40	-23.8	23.2	84	90	0.04	0.62	41.5	Dk Yellow	Good	
	Rosin Oil 1.2 DOP	M 2075	40	-25.1	19.7	80	81	0.02	0.64	24.2	Yellow	Good	

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Chart #2

NO.	PLASTICIZER	LOT. NO.	% PLAST.	T_f °C	VOL. % PLAST LOST	HARDNESS INITIAL	HARDNESS AFTER VOL	WATER ABSORPTION % SOL MATTER LOST	WATER ABSORPTION % ABSORPTION	KEROSENE EXTRACTION % PLASTICIZER LOST	HEAT STABILITY COLOR	HEAT STABILITY RATING	REMARKS
12	C22 Aromatic Tar, Sl. Hydrogen (1:2 DOP)	M-2076											Incompatible at 1:3 DOP
13	Heavy Aromatics, Hydrogenated	M 2174	40	+5.9	13.2	94	100	0.19	0.33	3.5	Dk Yellow	Good-Fair	
	Heavy Aromatics, Hydrogenated 1:1 DOP	M 2174	40	-23.3	22.1	78	88	0.20	0.50	12.9	Yellow	Good	
	Heavy Aromatics, Hydrogenated 1:2 DOP	M 2174	40	-25.8	15.8	78	84	0.13	0.43	14.4	Yellow	Good	
14	Indonex 632 1/2, Hydrogenated	M 2175	40										Incompatible: No Spoot on Mill
	Indonex 632 1/2, Hydrogenated 1:1 DOP	M 2175	40										Incompatible: Immediate Exudation
	Indonex 632 1/2, Hydrogenated 1:2 DOP	M 2175	40	-31.9	13.0	81	84	0.09	0.30	63.1	Yellow	Good	Incompatible: Slight Exudation
15	1-2, Hydrogenated & H_2SO_4 Extracted	M 2176	40										Incompatible: Immediate Exudation
	1-2, Hydrogenated & H_2SO_4 Extracted 1:1 DOP	M 2176	40	-26.5	27.2	82	90	0.47	0.72	29.6	Yellow	Good-Fair	
	1-2, Hydrogenated & H_2SO_4 Extracted 1:2 DOP	M 2176	40	-29.7	20.6	80	88	0.34	0.59	27.4	Yellow	Good	
16	Special Anthracene Oil, Hydrogenated	M 2177	40	+8.5	17.5	92	99	0.14	0.36	6.8	Brown	Fair-Poor	
	Anthracene Oil, Hydrogenated 1:1 DOP	M 2177	40	-17.7	24.6	76	86	0.25	0.55	12.0	Dk Yellow	Good	
	Anthracene Oil, Hydrogenated 1:2 DOP	M 2177	40	-24.5	19.1	77	83	0.19	0.41	10.2	Yellow	Good	

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