

Monsanto

FROM: J. K. Sears - Galt 1730
(NAME-LOCATION-PHONE)

DATE : June 9, 1981

SUBJECT : Phthalate Plasticizers as Capacitor
Fluids

REFERENCE : JHO/JKS 5/18/81

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John, your memo of 5/18/81 asks about the possible use of Santicizer® 900 as a capacitor fluid to beat DOP at the job. We get questions similar to this several times a year from someone. Most questions we can answer immediately. Yours prompted some measurements and a closer look. I am going to answer more than you asked.

You say Aerovox and Armel-Dublier combined use about 3 million pounds of DOP per year. We would like to get a large part of that business as well as that from other capacitor manufacturers. We should sample any of the industry that is willing to test a candidate with Santicizer 900 (but not Santicizer 900P) as soon as we can.

This memo should show us what to do to get back into this market, if we can at all, or it should put this question to rest neatly for a long time to come. It is concerned with five aspects or parameters of a capacitor fluid:

- 1) Dielectric constant, DK (should be high).
- 2) "Cleanability", or its ability to be cleaned up to give good resistivity; a low dissipation factor is the only indicator we have for this.
- 3) Stability; its ability to maintain good resistivity in use.
- 4) Volatility (should be low).
- 5) Price.

In Plasticizers we have significant data on only 1, 4 and 5 and bits, pieces and hunches on 2 and 3. A 6th parameter, flame retardance, went out with PCBs.

As I see it, the industry has compromised on DOP. Phosphates have high dielectric constants but poor cleanability. Benzyl phthalates have higher dielectric constants than DOP but poor stability. Adipates and tri-

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mellitates are low in DK. Dialkyl phthalates win by default of others. DOP has a reasonably high D.K. with reasonably low volatility. It can be cleaned up rather well, and is reasonably stable. Its price is low. Three years ago, DOP was the best choice they had. Three years from now that may not be so. This memo is based on my assumption that a small compromise can be made in any parameter 1, 4 or 5 (but not in 2 and 3 which are marginal now) for a significant improvement in any of the 5 parameters.

By copy of this memo I am asking Bill Koerner, Quent Thompson and Caludette Dethridge to correct any errors they may find in my assumptions and my understanding of capacitor fluids. I am asking them to supply answers to questions I raise if they know them, and to let me know if they see anything to suggest the Plasticizers Division has a good chance technically to put a product into this field.

Also, by copy of this memo I am suggesting questions for Diane Clay to ask the above companies. This is the very first action I see needed now, but samples need not be held up until we have the answers.

Data We Have:

Table 1 gives data we have on file which bear directly on the value of a phthalate plasticizer as a dielectric fluid for capacitors. The phthalates are arranged in order of increasing molecular weight as indicated by the average number of carbons in each alkyl chain. When two or more plasticizers have the same molecular weight, I have listed the most linear one first. Those that follow are increasingly branched.

The data show that they are all close together in dielectric constants (DK). The differences, however, are very significant. A capacitor company would like something even slightly higher than DOP, if it can be cleaned up electrically and if the price is right. The "best" phthalate on the sheet, then, would be di(methyl isobutyl carbonyl) phthalate, DK 5.98, except, I presume, it is too expensive. I expect it is far too volatile as well. Diisohexyl phthalate is the "next best". Does anyone use it? If not, I assume it is because it is too volatile. I believe it can be cleaned up, but I do not know. Is it possible that in DOP the ethyl group in the 2- position gives it unusual stability for capacitor use, as it gives it unusual stability compared to other branching, for plasticizer uses? If so maybe the oxo-alcohol phthalates can't win.

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You will notice that for each molecular weight, increased branching increases volatility as shown, by volatile loss from PVC sheet. Therefore for low volatility linearity is desirable. Dicapryl phthalate (DCP) and DOP are the only exceptions in the table, but DCP is the ester of a secondary alcohol, octanol-2, so is not quite comparable to anything else in the table.

You will also see that above C₈ increased branching lowers the dielectric constant. Again linearity is good. Santicizer® 900 is definitely better (slightly) than Exxon's DINP, if it can be cleaned up properly. It is better than DOP in volatility but poorer in DK.

It is so close to Santicizer 711 that it raises the old question of why Santicizer 711 failed in this use. Was it low DK, price only, or poor cleanability or stability? Probably it was a combination, and Santicizer 900 might step in at the right price.

The linear and near linear dinonyl phthalates are far better than DOP in volatility but just almost as good in DK. Price would kill them unless volatility is a big enough factor to justify a high price. Can we find what price would be justified? If Santicizer 900 eventually comes on strong and we still have 7 - 9 - 11 alcohols, a linear di C₉ phthalate might be the best product.

Look below C₈ and you see, in contrast to the above, that increased branching increases the DK. Jayflex 77 and ICI's diisooheptyl phthalate have DK's of about 5.3 which is better than DOP at 5.19. Does anyone use them? Are they too volatile? Can they be cleaned up and made stable or not? Why are they not the best capacitor fluids in the world? Unfortunately we hurt DK by going to our linear C₇, and the improvement in volatility in the linear is not enough.

In the middle of the table the di C₈ phthalates show little effect of branching on DK, as would now be expected, and our data is spotty. I can not find some data, I feel sure we have had.

Santicizer® 790 should be a winner except the nearly linear C₇ group does not help DK.

John and Diane, we are not set up to measure DK at 100°C. We could get set up, I presume, but it would require a lot of testing to be sure we were right. Perhaps Bill Koerner's area or Quent Thompson's group are still set up to get DK at elevated temperatures. Perhaps we could sample Aerovox and persuade them to measure it.

Questions in Summary:

Diane, can you find from Aerovox or Armel-Dublier:

- 1) Can any diisoalkyl phthalte be cleaned up and made stable enough?
- 2) Does Armel-D use Exxon's DINP or their Jayflex 77? If not, why not? This might really tell us what we need to know.
- 3) How much volatility can they stand, and how much is low volatility worth?
- 4) How much can they compromise one property to gain a bit on another?
- 5) What was really wrong with Santicizer® 711 as a fluid?

If any carbonee know the answers, please give me a call at 4-4259.


Kern Sears

Att.
/vw

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TABLE 1

PHTHALATE PLASTICIZERS FOR CAPACITOR FLUIDS:
PROPERTIES FOR PREDICTION OF PERFORMANCE

Plasticizer	Ave. No. Carbons Per Alcohol	% Volatile Loss From PVC at 87°C		Dielectric Constant 1 KH _z 10 100	Dissipation Factor 1 KH _z 10 100
		1 Day	6 Days		
Di-n-hexyl phthalate	6	11.3		5.08 5.09 4.96	.1820 .0170 .0020
Diisohexyl phthalate	6	13.6		5.62 5.69 5.67	- - -
Di(methyl isobutyl carbiny)lphthalate	6	22.8		5.94 5.98 5.96	.0028 .0007 .0012
Di-n-heptyl phthalate Bisoflex 71	7			4.96 4.93 4.94	
Di C ₇ (NTA) Phthalate ME 49, OR-141113 9-25-69	7	4.5	21.0	5.15 5.14 5.21	.0072 .0008 .0006
Di C ₇ Phthalate (NTA?) MIC 220 314	7	5.1	27.6	5.12 5.11 5.08	.0010 .0001 .0004
Jayflex 77, Exxon 1-20-81; DK 5-29-81	7	6.2	-	5.31 5.30 5.34	.0100 .0009 .0070
Diisoheptyl Phthalate	7	7.1	-	5.6 5.3 5.2	- - -
Di-n-octyl Phthalate Morpel X-926	8	- 2.5	-	-	-
Di-nOctyl Phthalate ME-3	8	-	-	5.04 4.96 4.70	.1670 .0100 .0020

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TABLE 1 Cont'd

PHTHALATE PLASTICIZERS FOR CAPACITOR FLUIDS:
PROPERTIES FOR PREDICTION OF PERFORMANCE

Plasticizer	Ave. No. Carbons Per Alcohol	Volatile Loss From PVC at 87°C		Dielectric Constant 1 KH ₂ 10 100	Dissipation Factor 1 KH ₂ 10 100
		1 Day	6 Days		
Dicapryl Phthalate, DCP Hatco.	8	4.6 to 5.4	-	5.00 4.90 4.90	- - -
Di-2-ethyl hexyl Phthalate DOP	8	3.6 to 4.5	20.8	5.15 5.19 4.17	.0052 .0010 .0010
Diisooctyl Phthalate	8	4.3		4.90 4.90 4.90	- - -
Santicizer® 790 p.p. Ba 1 and 2 July 20 (heptyl nonyl phthalate)	8	2.9	13.6	5.01 5.04 5.05	.0016 .0000 .0000
Santicizer 711	8-9	1.9	7.9	4.75 4.76 4.78	.0023 .0002 .0007
Di-n-nonyl Phthalate ME-7	9	0.8	2.7	5.08 5.09 4.96	.0620 .0060 .0010
Di C ₉ Phthalate (NTA) ME-50	9	1.0	3.7	5.00 5.05 5.00	.0006 .0003 .0007
Santicizer 900D 5/29/81	9	1.4	6.1	4.76 4.76 4.79	.0004 .0001 .0056
DINP Exxon 5/29/81	9	1.8	7.5	4.66 4.63 4.63	.0005 .0001 .0054
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TABLE 1 Cont'd.

PHTHALATE PLASTICIZERS FOR CAPACITOR FLUIDS:
PROPERTIES FOR PREDICTION OF PERFORMANCE

Plasticizer	Ave. No. Carbons Per Alcohol	Volatile Loss From PVC at 87°C		Dielectric Constant 1 KH ₂ 10 100	Dissipation Factor 1 KH ₂ 10 100
		1 Day	6 Days		
Di-n-decyl phthalate ME-4 (NTA)	10	0.6	1.5	4.96	.0350
				4.93	.0038
				4.94	.0020
DIDP (multi branched)	10	1.1		4.43	-
				4.43	-
				4.47	-
DUP (nearly linear)	11	0.6 to 0.9	1.7	4.42	-
				4.43	-
				4.45	-

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