

Monsanto

FROM (NAME & LOCATION) J. G. Bryant - St. Louis

DATE December 14, 1970

CC:

SUBJECT New Dielectric for Liquid Filled Cables,
Transformers and Circuit Breakers

REFERENCE September 30, 1970 memo

TO :

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STLCOPCB4059854

The purpose of this report is to follow up the actions outlined in the September 30 memo which have either been completed or reevaluated. The information to date is summarized in this report together with an outline of needed action and target dates. Since there have been several reports issued on various phases of the work, the input to this report is a summary of these actions. In respect to these inputs a special acknowledgement is made to M. F. Baber, D. E. Roush, J. J. Roder, J. S. Pullman, and R. Weiss for each of their important contributions.

SUMMARY

The primary emphasis on the application of the new dielectric fluid has been liquid filled-force cooled cables. From an electrical standpoint, the cable fluid application is somewhat unique in that you need adequate heat transfer characteristics, high dielectric strength, low dissipation factor, low dielectric constant, a fluid completely void of gas or gaseous forming materials and complete electrical compatibility of the fluid with the system. The alkalate benzene high boiler is the only candidate to meet these requirements and it meets them only after vigorous refinement.

Alkalate benzenes have been used for some time in liquid filled cable applications both as an additive and for cable filling. We have quoted and worked with Rio Light and Power in Brazil and Pirelli of Italy. Also, in the U.S. the cables have been looked at by Westinghouse and General Electric. Small amounts of alkalate benzenes are presently added to the cable system to improve the electrical properties. The prime problem has been the high price (80 cents plus per gallon) for alkalate benzenes. As with other dielectric fluids, the pricing must be competitive. The high boiler can be priced competitively with fluids presently being used for the application.

However, we can ruin our chances of entering this market by excessive pricing of the product.

The market potential of two million gallons in the U.S. for this fluid is presently being met with polybutenes priced at an average of fifty cents per gallon. The total market based on fifty cents per gallon is expected to grow from the \$1 million to \$1.5-\$2.0 million by 1975.

Although preliminary tests in our laboratories have indicated the alkalate benzene high boiler would be an acceptable candidate, complete electrical compatibility must be demonstrated. Compatibility tests are now being run. We must still gain customer acceptance. We are proceeding with samples for testing by the customers.

As previously mentioned, the alkalate benzene hi-boiler in its present state will not meet the need. However, by closing up the storage tank vents and by installing adsorbers which should be existing, the material can be brought within the desired specifications. The cost of these changes combined with the material costs would amount to about 15 cents per gallon. With a selling price ceiling of 50 cents per gallon, a reasonably good gross profit could be realized. Again the product will have to be priced below 50 cents to develop a market.

Also, at a reasonably low price the alkalate benzene high boiler probably has other applications in specialty transformers and switch gear where the needs are presently being filled with mineral oils or synthetics.

FUTURE ACTIONS

1. Submit samples for customer evaluation.
2. Establish the electrical compatibility of the high boiler with the cable system.
3. Write product specifications.
4. Determine plant needs to produce specification material.
5. Determine sales price for material.
6. Write a market plan.

APPLICATION

In recent years there has been an active interest in the U.S. on underground power distribution around cities because of the excessively high cost for "right of way" and public opinion against overhead cables. As underground installation is expensive, too, the load on the underground cables is increased. The increased load causes increased heat which then necessitates liquid filled cables to dissipate the heat. Once the conductor reaches 85°C, then forced circulation cooling must be used to remove the heat. The cooling fluid for this system is where our candidate fluid has application. To better understand the requirements, the cable system must be understood.

CABLE SYSTEM

The system must handle primarily 138KV to 345 KV. The typical cable consists of stranded wire (normal power transmission is along the surface rather than the core) wrapped with paper insulation. The cables are wrapped in a bundle with paper insulation and a spacer to create voids for circulation and placed in an 8-inch schedule 20 pipe. Since the cables must be made

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up in advance to field installation, the insulation is thoroughly impregnated with a high viscosity polybutene ^{base} to completely displace any air in the insulation which may lead to corona when the system is installed and energized. High viscosity polybutene is used to impregnate the cables because an immobile fluid is needed to avoid storage leakage and "messy" installation.

Once the cable is installed, low viscosity polybutene ^{or mineral oil} is used as the circulating fluid. Obviously there is no compatibility problem with the polybutenes. However, when other cheaper fluids are used as the circulated coolant they leech out the high viscosity polybutene. The fluids must be compatible physically but more importantly must be compatible electrically. When cheaper circulation fluids such as mineral oils are used there can be lowering of electrical properties because of incompatibility.

FLUID REQUIREMENTS

The electrical properties tend to combine both the capacitor and transformer requirements. First, the dielectric strength must be high to provide the desired insulation. The dielectric constant must be low to avoid a high capacitance buildup and the need for power factor correction. The dissipation or power factor must be low to avoid power factor corrections. The gaseous content or gas forming components must be low to avoid corona which would cause cable failure.

The material must have a low pour point of -45°C or lower. The heat transfer properties must be adequate and the viscosity fairly low. Also, physiologically the fluid must have a low or light color similar to polybutene.

SCREENING OF VARIOUS CANDIDATES

Several process streams were evaluated from Alvin, Texas and several from Texas City. All these streams fall short of meeting the need with the exception of the alkalate high boiler streams. There are two alkalate high boiler streams which result from the two alkalate feed streams. These streams are known as the alkalate high boiler light (MCS 1071) and alkalate high boiler heavy (MCS 1072). The other candidates were eliminated for the following reasons: the aromatic oils were too low in flash point; the resin oils were too high in unsaturates and felt to be too reactive in considering the system; also, the resin oil is from a dwindling process and the source of supply was not believed dependable. Also, the stream requires hydrogenation to improve the stability. Of the ethyl benzene only the bottoms 5D4 were considered because of the low flash point. Even with 5D4 the flash point is marginal, the power factor on 5D4 cannot be lowered sufficient to meet the specs, and the low resistivity confirms the poor power factor reflecting undesirable electrical

properties. The color is extremely dark and would physiologically kill any chances the material may have even if it were acceptable on other properties. The attached table lists the properties of the various candidates.

PROPERTIES OF THE ALKALATE HIGH BOILER STREAM

Once the material is dried and adsorptive refined, it closely meets the desired specifications of the polybutene. See the comparison in the attached table. The high water content (80 ppm) was the cause for the poor dielectric strength obtained in the first alkalate high boiler samples. The water may be moisture pick up in the storage system, in which case the problem may be resolved by closing up the system. However, if the moisture is attributed to the actual process the removal can still be accomplished but would be more expensive. Like other dielectric fluids, the alkalate high boiler must be adsorptive refined to improve the electrical performance.

The color is slightly darker than polybutene but probably sufficiently close to be acceptable. It must be understood that as the material presently comes off the process it cannot be used.

Since the alkalate streams are divided into high and low streams, the high boiler also varies accordingly. The high boiler "highs" MCS 1072 are more viscous which is less desirable, but is only slightly out of the desired range. However, when the lows are blended the material meets the requirements. Although it would be desirable to store the two products separately and blend according to need, this would not be economical and probably is not necessary. We believe a suitable solution can be worked out in the requirements to take the material as it leaves the process.

Although additional research work must be conducted on compatibility of the high boiler with the cable system, no problem is anticipated. The electrical compatibility of especially the high boiler and the polybutene will be checked in Monsanto laboratories. Customers will test compatibility of the cable system. This is slightly different from our original plan to have an independent laboratory evaluate the product but probably more desirable.

ACTIONS TAKEN TO DEVELOP THE MARKET

Research

Samples of various candidates have been screened. Most likely candidates have been selected. Manufacturing process has been

reviewed to simplify handling of product. Compatibility tests for screening the candidates against polybutene have been run. Samples have been prepared for customer testing.

Production

Availability of product and approximate inter-division price have been established.

Market

Contacts have been made with utility (customer) and cable manufacturers. Test arrangements have been made for evaluating the product.

ACTIONS NEEDED

Research

1. Evaluate the compatibility of 1071 with polybutene, particularly the effect of concentrations on power factor.
2. Evaluate the system compatibility - customer testing
3. Write a complete product specification
4. Evaluate plant process and determine needs for meeting specification

Production

1. Review present system and establish additional equipment necessary for producing the desired product
2. Establish with production any change in the collect system necessary to produce the desired product

Market

1. Establish pricing
2. Obtain orders
3. Expand application to other areas such as switch gear and transformers
4. Expand other heat transfer applications which may be developed out of the system

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SPECIFIC PLANS AND TARGET DATES FOR ACTION ACCOMPLISHMENT (REFER TO ACTIONS NEEDED)

<u>Action</u>	<u>Specific Plan</u>	<u>Responsibility</u>	<u>Target Date</u>
1a.	Evaluate electrical properties of polybutene - power factor 1. heavy 2. light	J. C. Wygant R. H. Munch	1/30/71
1b.	Evaluate various concentrations of polybutenes with high boiler as a function of the effect on power factor	J. C. Wygant R. H. Munch	2/15/71
2.	Evaluate customer compatibility data.	J. C. Wygant R. H. Munch J. G. Bryant J. J. Roder D. E. Roush	2/15/71
3.	Write a product specification	J. C. Wygant J. G. Bryant D. E. Roush	1/30/71
4.	Evaluate plant process and determine needs for meeting specification	J. G. Bryant	2/15/71

Production

1.	Review the present system and establish additional equipment necessary for producing the desired product	J. G. Bryant	12/30/70
2.	Establish with production any change in the collect system necessary to produce the desired product.	J. G. Bryant	2/15/71

Market

1.	Establish pricing	J. G. Bryant D. E. Roush	2/28/71
2.	Obtain orders	J. G. Bryant J. S. Pullman J. J. Roder	3/15/71
3.	Expand application to other areas such as switch gear and transformers	G. R. Graham J. G. Bryant M. F. Baber	

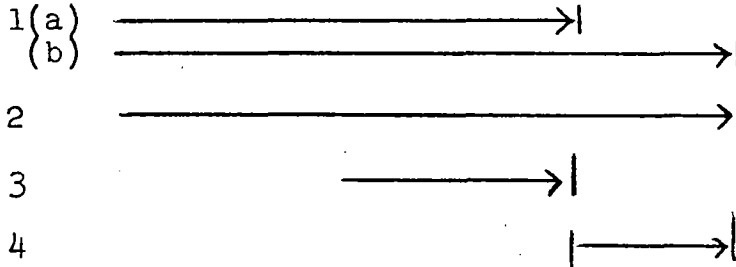
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	<u>Specific Plan</u>	<u>Responsibility</u>	<u>Target Date</u>
4.	Expand other heat transfer applications which may be developed out of the system	D. E. Roush J. S. Pullman J. J. Roder	

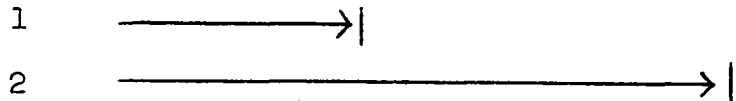
Time Table for Completion of Specific Plans

Action	Dec. '70 15 30	Jan. 15 30	Feb. 15 28	March 15 30
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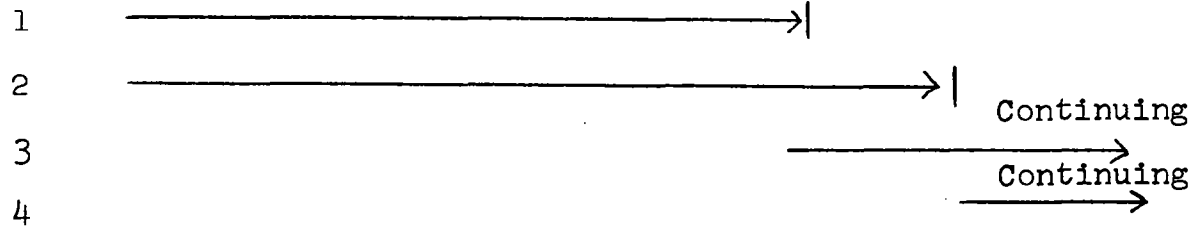
Research



Production



Market



Properties	Low Visc. Polybutene Oil for Pipe Type Cable	Alkalate High Boiler - Light MCS 1071	Alkalate High Boiler - Heavy MCS 1072	Aromatic Oil #1	Resin Oil	Diethyl Polyethyl	Ethyl Benzene Polyethyl	Bottoms 504 (Flux Oil)
Research Identification	130° or higher	180	200	118-130	--	490°	90°	138
Flash Point°C	45 or lower	<-55	<-60	-55	--	--	--	-55
Pour Point°C								
ASTM D97								
Viscosity (SUS)	115 to 140	100 to 125	130-150	20-80	--	--	--	40-50
@37.8°C	38 to 44	39	40.5					
@100°C								
ASTM D88								
Neutralization No. (MAX)	0.02	<0.05		--	--	--	--	--
ASTM D974 MgKOH/g sample								
Free and Corrosive Sulfur	none	should not be a problem - no test data	should not be a problem - no test data	--	--	--	--	--
ASTM D989 Except the copper strip shall be maintained in the oil @ test temp. for 16 hrs.								
Dielectric Strength	35	>50	>50	--	--	--	--	--
ASTM D877 (KV)								
Power Factor (%)	0.1	0.005-0.14*	.22*	--	--	--	--	1.58
60 Hz @ 100°C								
ASTM D924								
Resistivity (10 ¹² -ohm cm)	100	*Values are not consistent with the resistivity values. Values actually much lower.	500	--	--	--	--	6.6
@ 100°C ASTM D1169								
Gas content	To be determined but should be sufficiently low because of the process condition alone			--				
Guaranteed Max. as shipped								
@ 760mm + 0°C								
ASTM D831								
Color Number	1	1	1	dark	dark	dark	dark	dark
ASTM D155-45T								
Visc Properties								
Specific Gravity	.893	.897	.897	.87-0.9 @ 20°C	.91-0.95	--	--	0.942
60/60 (g/cc)								
Cost	\$0.014/lb.	\$0.014/lb.	\$0.014/lb.	\$0.095/gal.	\$0.02/gal.	\$0.039/gal.	<\$0.03/gal.	<\$0.03
Availability	24M lbs/yr.	24M lbs/yr.	8M lbs/yr.	12,600 gal/day	dying source of supply 43M gal/yr.	43M gal/yr.	75-100M lbs/yr.	20M lbs/yr.
	Chocolate Bayou	Chocolate Bayou	Chocolate Bayou	Chocolate Bayou	Chocolate Bayou	Texas City		
Dist. Range °F	560-620	560-620	640	450-485				530-550
Init. B.P.	640-660	640-660	680	(50%) 515-535				560-580
20%								
Water Content after refinement	30 ppm	10	10					
Acceptance or rejection reasons	seems to meet the requirement	slightly heavy on viscosity; otherwise ok		too low flash point	dying source of supply or dark color and too many unsaturates	too low flash point	too low flash point	marginal flash point and color too dark

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