ENCLOSURE (B) 33

STUDIES ON A VISCOSITY INDEX IMPROVER

by

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LIST OF TABLES
AND ILLUSTRATIONS

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SUMMARY

Isobutylene, obtained by the dehydration of isobutyl alcohol at 400°C in the presence of alumina, was liquefied and diluted with gasoline and then was polymerized at (-)40°C with aluminum chloride. Topping this polymerized oil up to 250°C at 5mm of vacuum, the residual oil was obtained in 43% yield (by weight) based on isobutyl alcohol. By adding 13% of the above-mentioned residual oil to Texaco aero engine oil #80, the viscosity at 210°F was raised from 77 to 121 S.U.S. and the viscosity index was raised from 94 to 101.

This blended oil was tested twice, using the Ricardo type single-cylinder engine. One test was for 30 hours and the other for 19 hours, and it was observed that the blended oil was somewhat more subject to decomposition and gave greater wear of piston rings than the aero engine oils then in practical use.

I. INTRODUCTION

A. History of Project

The aero engine oil had been produced from Midcontinent crude oil by the solvent extraction method at the Third Naval Fuel Depot, and its yield was restricted mainly by the minimum viscosity index requirement of 90.

In April 1942, it was reported that a compound named "Exanol" was marketed as a viscosity index improver by the Standard Oil Co. In order to test the practical application of these compounds, the isobutylene polymer was prepared and blended with the Texaco aero engine oil #80 and tested by the Ricardo type single-cylinder engine in January 1943.

B. Key Research Personnel Working on Project

Chem. Eng. Lt. Comdr. A. WAKANA
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II. DETAILED DESCRIPTION

A. Test Procedures and Conditions

1. Preparation of the Isobutylene Polymer. Isobutylene, which was obtained from the dehydration of isobutyl alcohol at 400°C in the presence of alumina, was liquefied and diluted with gasoline which had been previously treated with aluminum chloride. The isobutylene was then polymerized at (-) 40°C with aluminum chloride in the usual manner reported in the published literature. The polymerization product was washed with water, and the gasoline and lighter fractions up to 250°C at 5mm Hg were distilled. The residual oil was pale yellow in color and sticky. The yield of the residual oil was 43% by weight based on isobutyl alcohol.

2. Engine Test. Blending 13 parts of this polymer to 100 parts of aero engine oil #80, the viscosity of the oil was raised from 77 S.U.S. to 121 S.U.S. at 210°F and the viscosity index was raised from 94 to 101. This oil was tested using the Ricardo single-cylinder engine, first for 30 hours and then for 19 hours, and these results were compared with the results obtained from the aero engine oil in actual use. Operating conditions are shown in Table I(B)33.

B. Summary of Data

1. Properties of the oils used in the engine tests are shown in Table II(B)33.

2. Operating Conditions. As shown in Figures 1(B)33 and 2(B)33, no abnormalities were found.

3. Engine Inspection. After running, the engine inspection showed that from the standpoint of cleanliness the aero engine oil in actual use was the best, the Texaco aero engine oil #80 was next, and the blended oil was third.

4. Change in Lubricating Oils During Use. Alteration of the lubricating oils during use is shown in Table III(B)33 and IV(B)33. At five hour intervals, 500cc of the oil were removed and its properties were determined. The increase of acid value and the sludge was perceptible.

5. Wear of Piston Rings. As shown in Tables V(B)33 and VI(B)33, the piston wear with the blended oil was somewhat larger than with the aero engine oil in actual use.

III. CONCLUSIONS

It was possible to produce the aero engine oil, by adding the isobutylene polymer to the lower viscosity oil, but it will be necessary to improve its heat stability before it can be used in aircraft engines.

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Table I(B)33
TEST CONDITIONS IN THE RICARDO SINGLE-CYLINDER ENGINE

	Test No.	
	1	2
Duration of Test (hrs)	30	19
Engine Speeds (RPM)	1500	1600
Compression Ratio	4.5	5.4
Oil Temperature at Inlet (°C)	70	90
Cooling Water Temperature at Outlet (°C)	60	60-80
Air Temperature (°C)	50	30
Fuel	87 gas	92 gas
Initial Oil Charge (kg)	27*	27*

*No supply during the test.

Table II(B)33
PROPERTIES OF THE OILS USED IN ENGINE TESTS

	Specific Gravity (d^{15}_{4})	Flash Point (°C)	Conradson Carbon (%)	Viscosity S.U.S. 100°F	Viscosity S.U.S. 210°F	Viscosity Index	Acid Value	Saponification Value
Aero Engine Oil in Actual Use*	0.8958	261	0.7	1778	122	95	0.1	0.7
Texaco Aero-Engine Oil #80	0.8865	226	0.4	708	77	94	0.04	0.2
Above Plus Isobutylene Polymer	0.8869	220	0.4	1620	121	101	0.1	0.1

*Prepared by solvent extraction from Osage crude oil at the Third Naval Fuel Depot.

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Table III(B)33
CHANGE IN PROPERTIES OF LUBRICATING OIL DURING USE TEST

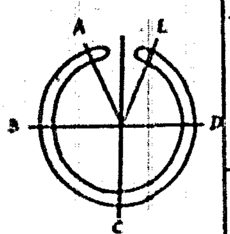
Properties	Sample	0 hr	5 hrs	10 hrs	15 hrs	20 hrs	25 hrs	30 hrs
Specific Gravity (d^{15}_{4})	A	0.8958	0.8954	0.8956	0.8957	0.8960	0.8965	0.8963
	B	0.8869	0.8870	0.8877	0.8879	0.8888	0.8897	0.8908
Flash Point (°C)	A	261	156	155	151	147	141	138
	B	220	147	151	139	147	142	143
Viscosity at 210°F (S.U.S.)	A	122	121	122	124	123	123	125
	B	121	119	122	119	121	122	123
Conradson Carbon (%)	A	0.7	0.9	0.9	1.0	1.0	1.0	1.1
	B	0.5	0.5	0.6	0.6	0.6	0.7	0.7
Volatility Test (%)	A	0.007	0.2	0.2	0.3	0.3	0.3	0.3
	B	0.105	0.3	0.3	0.3	0.4	0.5	0.4
Acid Value	A	0.1	0.2	0.2	0.3	0.3	0.3	0.3
	B	0.1	0.1	0.2	0.2	0.4	0.5	0.9
Sludge (%)	A	0	0.2	0.2	0.2	0.2	0.2	0.3
	B	0	0.2	0.4	0.4	0.4	0.5	0.6

A: Aero engine oil, in actual use B: Blended oil

Table IV(B)33
CHANGE IN LUBRICATING OILS DURING USE 2ND TEST

	Aero Engine Oil in Actual Use		Oil Blended	
	Before Test	After Test	Before Test	After Test
Specific Gravity (d^{15}_{4})	0.8958	0.8968	0.8869	0.8882
Flashing Temperature (°C)	261	218	220	217
Viscosity at 210°F (S.U.S.)	122	126	121	129
Viscosity Index	95	100	101	106
Conradson Carbon (%)	0.7	0.8	0.5	0.6
Sludge (%)	0	0.8	0	0.9
Acid Value	0.1	0.2	0.1	0.2
Saponification Value	0.7	1.6	0.1	2.7

Table V(B)33
WEAR IN WIDTH OF PISTON RINGS AT 1ST RUNNING (mm)



		Aero Engine Oil in Actual Use						Aero Engine Oil Prepared by the Addition of Isobutylene Polymer to the Texaco Aero Engine Oil #80					
Ring No.	Position	Before Running		After Running		Wear in Width	Mean	Before Running		After Running		Wear in Width	Mean
1	A	3.501	3.500	3.495	3.497	0.0045	0.0039	3.495	3.497	3.488	3.490	0.007	0.0048
	B	3.540	3.540	3.542	3.537	0.0015		3.542	3.537	3.543	3.533	0.006	
	C	3.501	3.500	3.493	3.501	0.0035		3.493	3.501	3.493	3.487	0.007	
	D	3.415	3.410	3.410	3.405	0.0050		3.410	3.405	3.408	3.410	0.0015	
	E	3.490	3.448	3.445	3.443	0.0050		3.445	3.443	3.443	3.440	0.0025	
2	A	3.445	3.453	3.451	3.440	0.0035	0.0038	3.451	3.440	3.436	3.439	0.008	0.0072
	B	3.500	3.500	3.492	3.495	0.0065		3.492	3.495	3.440	3.494	0.020	
	C	3.510	3.510	3.510	3.506	0.0020		3.510	3.506	3.506	3.505	0.0025	
	D	3.503	3.500	3.500	3.500	0.0015		3.500	3.502	3.498	3.795	0.0045	
	E	3.460	3.445	3.450	3.452	0.0065		3.450	3.452	3.451	3.450	0.0010	
3	A	3.476	3.472	3.470	3.474	0.0020	0.0036	3.470	3.474	3.465	3.468	0.0055	0.0045
	B	3.539	3.535	3.531	3.531	0.0060		3.531	3.531	3.529	3.527	0.0030	
	C	3.505	3.515	3.530	3.515	0.0020		3.503	3.515	3.510	3.511	0.0020	
	D	3.413	3.405	3.397	3.410	0.0050		3.397	3.410	3.394	3.399	0.0070	
	E	3.450	3.446	3.440	3.455	0.0030		3.455	3.440	3.440	3.445	0.0050	

Table VI(B)33
WEAR IN WIDTH OF PISTON RINGS AT 2ND RUNNING (mm)

Ring No.	Position	Aero Engine Oil in Actual Use						Aero Engine Oil Prepared by the Addition of Isobutylene Polymer to the Texaco Aero Engine Oil #80					
		Before Running		After Running		Wear in Width	Mean	Before Running		After Running		Wear in Width	Mean
1	A	3.472	3.492	3.490	3.490	0.002	0.0019						
	B	3.460	3.460	3.457	3.453	0.005							
	C	3.490	3.489	3.489	3.450	0							
	D	3.440	3.438	3.439	3.439	0.0015							
	E	3.466	3.460	3.463	3.461	0.001							
2	A	3.462	3.469	3.460	3.460	0.001	0.001	3.460	3.460	3.452	3.450	0.009	0.0076
	B	3.415	3.413	3.410	3.410	0.004		3.410	3.410	3.403	3.405	0.006	
	C	3.461	3.478	3.478	3.481	0		3.478	3.478	3.480	3.475	0.0015	
	D	3.530	3.529	3.530	3.529	0		3.530	3.529	3.519	3.516	0.012	
	E	3.491	3.490	3.491	3.490	0		3.491	3.490	3.483	3.480	0.009	
3	A	3.499	3.450	3.499	3.499	0.0005	0.0022	3.501	3.499	3.501	3.494	0.0025	0.0107
	B	3.445	3.447	3.439	3.440	0.0065		3.439	3.440	3.434	3.435	0.005	
	C	3.479	3.480	3.479	3.479	0.0005		3.479	3.479	3.460	3.457	0.0205	
	D	3.506	3.508	3.505	3.508	0.0005		3.505	3.508	3.491	3.487	0.0175	
	E	3.536	3.524	3.518	3.520	0.003		3.518	3.520	3.510	3.512	0.008	

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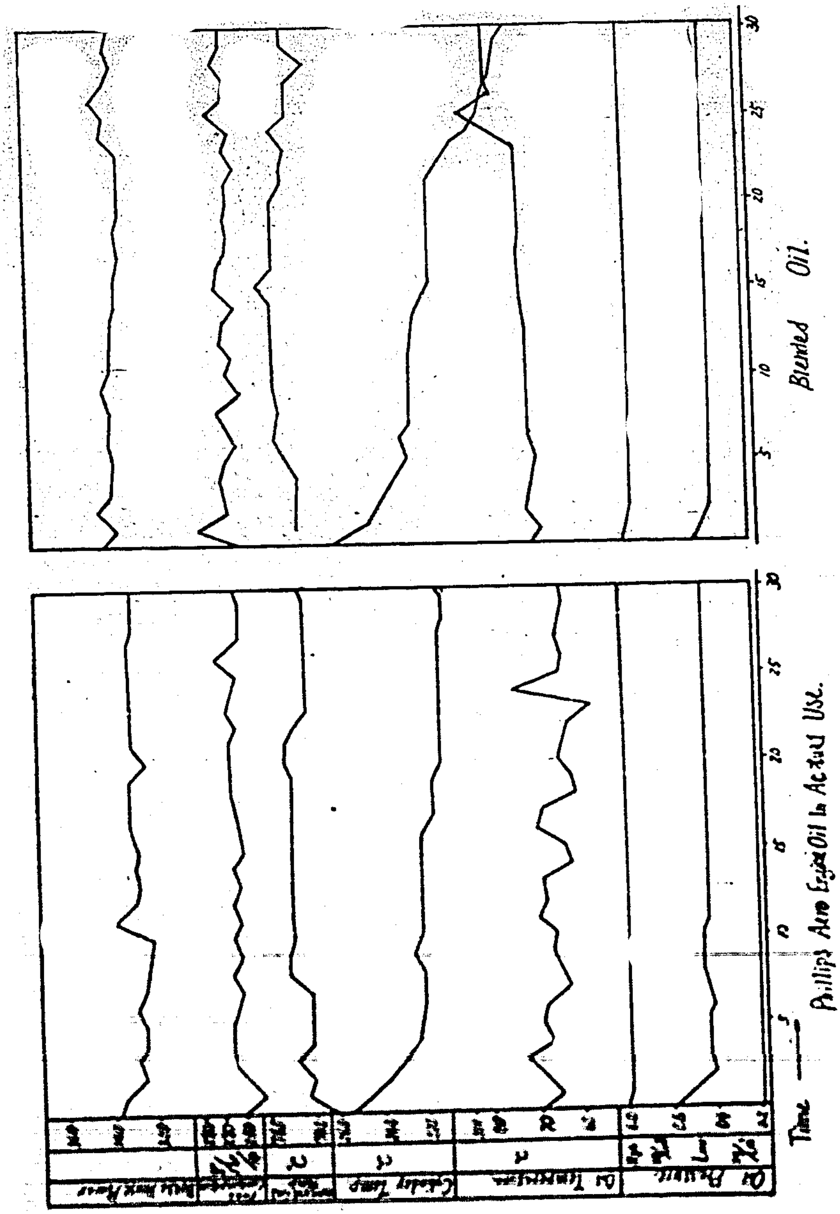

Figure 1(B)33
STATE OF FIRST RUNNING

ENCLOSURE (B)33

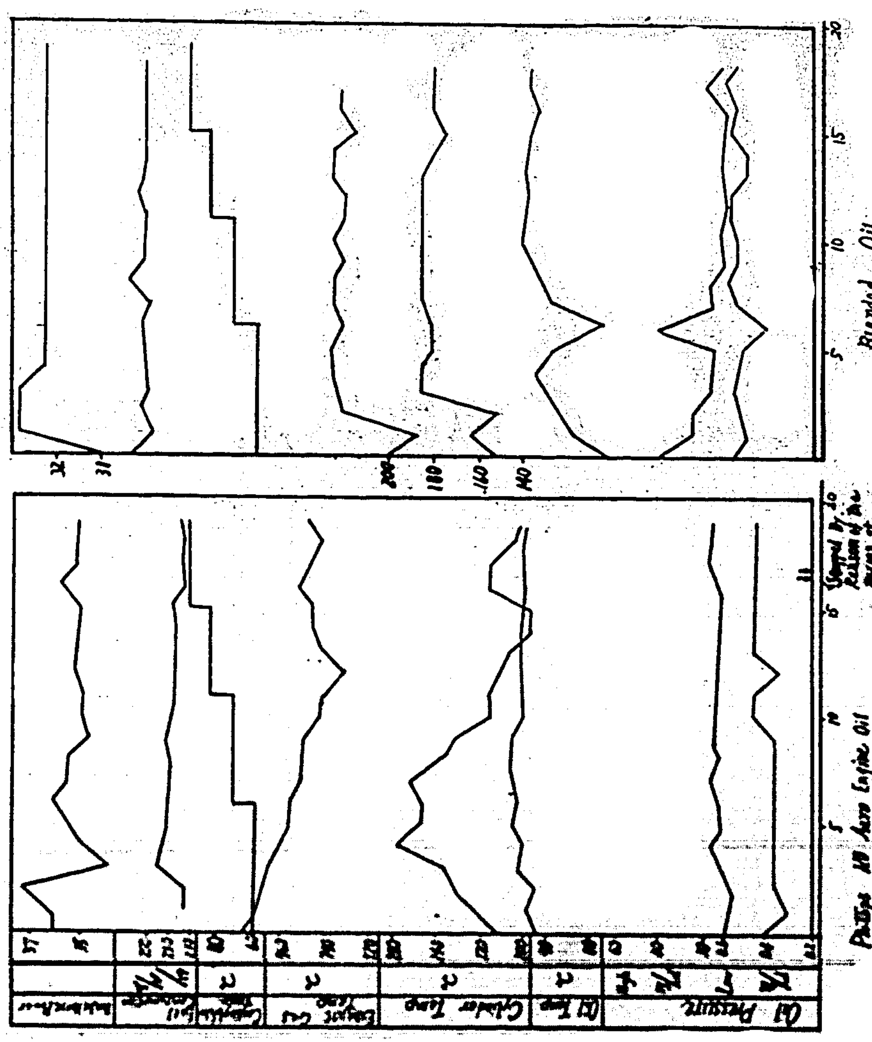

Figure 2(B)33
STATE OF SECOND RUNNING