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No. 412

REPORT ON

THE EXAMINATION OF TWO OILS WITH SYNTHETIC
FATTY ADDITIVES FOR SUITABILITY FOR USE IN
AERO-ENGINES

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SECRET.

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R E P O R T

on

THE EXAMINATION OF TWO OILS WITH SYNTHETIC, FATTY
ADDITIVES FOR SUITABILITY FOR USE IN AERO-ENGINES.

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on

The Examination of Two Oils with Synthetic, Fatty
Additives for Suitability for use in Aero-Engines.

GENERAL

Two lubricating oils were examined in the BMW single-cylinder aero-engine in regard to their running qualities and behaviour in the wear machine.

The tests showed, that the different additives were quite effective.

OBJECT OF TESTS

Two oils from Louna - SS904 and SS 970, were examined with different additives as to their suitability as aero-engine lubricants. The oils had the following compositions.

- | | | | |
|------|-----------------|---|--|
| 1.) | SS 904a | = | SS 904 + 0.2% Inhibitor a |
| 2.) | " F | = | " + " " + 10% Ester F * |
| 3.) | SS 904a 2F | = | SS 904 + 0.2% " + 20% Ester F |
| 4.) | SS 904/06a 2F | = | SS 904 + SS 906 + 0.2% Inhibitor a + 20% Ester F |
| 5.) | SS 904 GD 153 | = | SS 904 + 0.7% Du Pont (U.S.A.) additive GD 153 |
| 6.) | SS 904 GD 410 | = | SS 904 + 0.7% " " " GD 410 |
| 7.) | SS 904 V 81a | = | SS 904 + 0.2% Inhibitor a + 10% Glycerine ester |
| 8.) | SS 904 HB 161a | = | SS 904 + 0.2% " " + 3.5% Glycolon " |
| | SS 970 | = | Mixture of equal parts by weight SS 906 and Gargoyle A |
| 9.) | SS 970 a | = | SS 970 + 0.2% Inhibitor a |
| 10.) | SS 970a F/2 | = | SS 970 + 0.2% Inhibitor a + 5% Ester |
| 11.) | SS 970a F | = | SS 970 + 0.2% " " + 10% " |
| 12.) | SS 970 F | = | SS 970 without Inhibitor a + 10% Ester |
| 13.) | SS 970 a 2F | = | SS 970 + 0.2% Inhibitor a + 20% Ester |
| 14.) | SS 970 a 2F Op. | = | SS 970 + 0.2% " " + " " + 1% Oppanol |

(* Ester F manufactured according patent application J 65 567 IV d/120)

Stanavo 100 and Rotring D, both commercial oils, were used for comparison.

Tables 1 and 2 give inspection data with running times.

TESTING

The oils were examined for ring sticking in the BMW single cylinder aero-engine type A. Testing conditions were the same as for Test series VIII in report No. 298g. For the determination of wear a machine was used as described in report No. 388.

TEST RESULTS

A classification of engine test results is given on plates 3 and 4.

SERIES SS904

SS904a, Test 470 showed a running period of 12 hrs. with one l. Ring sticking and is therefore about 50% better than the comparative oil Rotring D (Test 506) and with a consumption of 310g/h is lower than the normal consumption for Rotring, 400 g/h. The appearance of the piston after 12 hrs. was similar to that of a piston after 8 hrs. run with Rotring.

SS904aF, Test 518. With 23 hrs running time and only one ring half stuck shows the good effect of additive F. Considering the long running time, the appearance of the piston was good.

SS904a 2F, Test 524, has, according to the double quantity of additive, a corresponding longer running period of 27½ hrs. Even here the piston appearance is good considering the long running period.

SS904/06a 2F, Test 533. The more viscous SS906 was added to this oil until it had the same viscosity as SS904a. This resulted in a deterioration of the running period (22hrs. compared with 27½ hrs.) for the SS904a 2F which is of a substantially lower viscosity. Noteworthy, but not yet quite understood, is the greater consumption of the more viscous oil SS904/06a 2F of 520g/h to the 405 g/h of SS904a 2F. The piston appearance was normal.

The tests 470, 518 and 524 show that satisfactory lubrication is quite possible with oils of considerably lower viscosity than Rotring Oil (Vide Table 1). The viscosity of SS904a 2F is 15.1cst - 2.33°E, which is the viscosity of a summer automobile oil. The oil consumption was in the same range as with Rotring oil, but the running periods were three times as long.

SS904 GD 153, Test 515. With 12½ hrs. running time was not quite as good as the oil plus additive GD 410, the consumption of 335 g/h was also slightly higher.

SS904 GD 410, Test 511. With 15 hrs. was slightly better than SS904a, showed approximately equal consumption and, considering the longer running time, a good piston appearance. In these tests two lubrication improvers for aero-engines marketed and produced by Du Pont de Nemours (USA) were investigated. The amount of additive taken was 0.7% by wt., this being the optimum amount as prescribed by the manufacturers; greater amounts are supposed to be harmful. Both products are phenolic esters of orthophosphoric

acid. Such esters are not stable thermally, but decompose easily with the formation of free phosphoric acid which in turn can be corrosive. As the test results obtained are not exactly outstanding, the further use of such products will for the time being be discontinued.

SS904 7 81a Test 535, also shows a favourable reaction to the ester additive and, with 21½ hrs. running time almost equals the SS904a F.

SS904a No 161, Test 536, is, in regard to running time and consumption (19 hrs. and 410 g/h), slightly below the standard of V61a.

Both additives do not attain the running time of additive F and they should not be tested further for the time being as there are also production difficulties.

SERIES SS970

SS970a, Test 473, with 9½ hrs. running time was only in the range of the corresponding Rotring oil (Test 464, 8½ hrs. and test 476, 11 hrs.) but it is to be considered that the Rotring test No. 476, because of its somewhat higher oil consumption 490 g/h, gave a little too long a running time. The strip showed somewhat less deposits than that of the corresponding Rotring tests.

SS970a F/2 Test 474. The piston had a normal appearance. The consumption of 310 g/h is to be regarded as low.

SS970a F, Test 472. With a running time of 14 hrs. and a consumption of 336 g/h shows again the good effect of additive F. Piston appearance normal.

SS970F, Test 475. An oil with F, but without "a" additive, gave a running time of 12½ hrs. against the 14 hrs. of SS970a F. One can assume therefore that the additive "a" also contributes considerably to the improvement of the running qualities. As the consumption with 400 g/h is slightly higher than the consumptions of oils with additive "a", it appears probable that "a" also influences the oil consumption.

SS970a 2F Test 580. Showed with 14 hrs. running time and 330 g/h oil consumption neither an improvement on SS970a F nor a deterioration, even though its viscosity at 100°C is only 16.5 c.st. It has to be considered that this test cannot be compared directly with the other runs of series 970, as a different cylinder had been used. Considering the long running period the piston appearance is good.

SS970a 2F, Test 582. The same oil as in previous test plus Oppanol additive had running period of 14-1/4 hrs. The Oppanol additive cannot be considered to have any effect on the oil as the running period was only increased by a fraction.

STANAVO 100, was used for comparative tests. It gave a running period of 8 hrs. 400 g/h consumption and the piston looked normal after the test.

ROTRING D, was also used for comparative tests. It had a running period of 8½ hrs. 400 g/h consumption and at the end of test the piston had its normal appearance.

This series of tests with the blended oil SS970 showed the favourable effects of the low viscosity additive F. The further development of this additive is at present being worked out.

MEASUREMENTS OF WEAR BY THE APPARATUS DESCRIBED IN REPORT No. 388

Because of the limited availability of the same testing apparatus not all the oils could be tested under identical testing conditions. The comparable values are bracketed in the table on Table 5.

These values corroborate the favourable influence of additive F on the SS904 Oil and also on the blended oil SS970.

The two Du Pont de Nemours products behaved quite unfavourably.

Plate 6 again shows the favourable action of additive F on wear, even though the viscosity of SS970a 2F is considerably lower than the viscosity of Rotring oil. Only direct comparable values are shown here. Depending on the running time, particularly so on the amount of additive F, a decrease in wear can be clearly seen.

Plate 7 shows, for comparison, a wear curve of the oil SS970a-2F taken from report No. 388. The actual wear measurements for different running times were taken after the oil had run in the BMW single cylinder engine. The greater stability against wear of SS970a 2F is shown by its low lying curve as compared with the Rotring D oil curve.

Attached: 5 Tables
2 Diagrams

For the chemical
work and its evaluation
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For the technical testing
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Techn. Testing Stand Op. 200.

Translators note:

We have tried to trace the Patent Application for the Ester F without success, but it is possibly similar to the Ester E515 which was produced at Laura. This is an Ester of adipic acid with C₉ C₁₀ alcohols.

TABLE 2

Oil Type	Running Time Hrs.	Spec. Grav. @ 20°	Viscosity in c.st.			Thickening at 38° in %	Acidity	Sapon. No.	Coke No.	Asphalt %	Matter Insol. in Benzol	Ash	British Oxidation Test			
			38°C	99°C	V.I.									Visc. 38°	Acidity	Sap. No.
SS 904a	0	0.859	214	20.4	116		0.10	0.59	0.19	0	0	0	N ₂	421	0.09	0.57
Test 470	12	0.867	202	22.8	106	32	0.46	2.10	0.34	0.06	0.13	0.06	Air	896	3.77	12.20
SS 904 aF	0	0.865	181	17.6	111		0.13	24.20	0.16	0	0	0	N ₂	283	0.04	22.10
Test 518	23	0.870	253	21.8	110	40	0.76	13.60	0.54	0.04	0.12	0.09	Air	674	3.75	42.50
SS 904 a2F	0	0.874	150	15.1	109		0.21	43.10	0.12	0	0	0	N ₂	219	0.07	41.40
Test 524	27½	0.878	220	19.2	106	47	0.68	14.80	0.50	0.02	0.21	0.10	Air	513	3.64	58.20
SS 904/06 a2F	0	0.874	233	20.3	108		0.22	43.20	0.12	0	0	0	N ₂	366	0.07	39.80
Test 533	22	0.877	302	24.2	108	30	0.45	16.20	0.46	0.05	0.27	0.09	Air	642	3.56	58.00
SS 904 GD 153	0	0.867	229	21.0	116		0.04	1.80	0.13	0	0	0	N ₂	382	0.04	1.50
Test 515	12½	0.863	283	23.9	111	24	0.43	3.30	0.39	0.07	0.08	0.06	Air	1075	6.26	16.10
SS 904 GD 410	0	0.856	230	21.3	114		0.04	1.80	0.14	0	0	0	N ₂	404	0.05	1.40
Test 511	15	0.852	293	24.4	112	27	0.74	2.60	0.40	0.07	0.14	0.11	Air	777	4.11	14.50
SS 904 V81a	0	0.865	177	17.4	112		0.15	15.10	0.12	0	0	0	N ₂	280	0.05	14.70
Test 536	21½	0.870	240	22.1	110	36	0.42	13.10	0.54	0.06	0.20	0.08	Air	588	4.23	24.00
SS 904 H8 161a	0	0.869	201	15.2	113		0.09	10.10	0.13	0	0	0	N ₂	346	0.05	9.00
Test 538	19	0.864	202	23.0	111	31	0.46	8.30	0.48	0.01	0.25	0.08	Air	651	3.68	19.50

TABLE 2.

Oil Type	Running Time Hrs.	Spec. Grav. at 20°	Viscosity in c.st.			Thickening at 38° in %	Acid -ity	Sapena. No.	Coke No.	As-phalt %	Matter Ensol. in Benzol	Ash	British Oxidation Test.			
			38°C	99°C	V.I.									Visc. 38°	Acid -ity	Sap. No.
SS 970a Test 473	0 9½	0.878 0.880	305 332	24.0 24.7	110 103		0.08 0.42	0.35 1.40	0.18 0.41	0 0.02	0 0.14	0 0.04	N ₂ Air	400 836	0.09 2.86	0.46 11.00
SS 970a F/2 Test 474	0 10½	0.879 0.881	282 307	22.4 23.1	104 102		0.13 0.32	6.60 6.20	0.21 0.44	0 0.09	0 0.11	0 0.06	N ₂ Air	400 1780	0.05 4.78	5.60 13.50
SS 970a F Test 472	0 14	0.883 0.884	252 283	20.2 22.0	101 102		0.20 0.53	11.30 10.90	0.18 0.47	0 0.04	0 0.17	0 0.05	N ₂ Air	323 675	0.06 2.94	11.10 11.80
SS 970 F Test 475	0 12½	0.882 0.884	250 295	20.9 23.0	106 104		0.14 0.43	11.20 10.70	0.20 0.48	0 0.12	0 0.04	0 0.06	N ₂ Air	310 544	0.04 2.75	10.50 12.10
SS 970a 2F Test 580	0 14	0.890 0.892	188 231	16.5 19.2	100 102		0.22 0.54	41.60 26.30	0.19 0.54	0 0.08	0 0.25	0 0.05	N ₂ Air	244 432	0.09 2.91	38.90 51.00
SS 970a 2F0p Test 582	0 14½	0.890 0.892	266 301	22.5 23.7	110 106		0.29 0.63	42.40 26.80	0.21 0.58	0 0.05	0 0.25	0 0.06	N ₂ Air	342 630	0.11 3.15	39.70 52.50
Rotring Test 464	0 8½	0.889 0.891	265 282	19.4 20.6	90 94		0.03 0.26	0.13 1.30	0.26 0.46	0 0.07	0 0.14	0 0.06	N ₂ Air	273 380	0.03 2.10	0.24 8.10
Test 476	11	0.891	282	20.4	92		0.29	1.34	0.57	0.13	0.11	0.04				
Test 521	8½	0.891	284	20.4	92		0.33	2.50	0.58	0.04	0.18	0.05				
Test 534	8	0.891	281	20.5	93		0.19	2.40	0.34	0.06	0.30	0.05				

Table of results of ENGINE tests.

Test No.	Oil Grade	Cylinder Piston	Running time hrs.	Consumption g.	Sticking parts		Piston crown	Piston rings
					1. Ring	2. Ring		
470	SS 904 a	Y/Y1	12	310	$\frac{1}{2}$	-	dark, brown	slightly coked
506	Rotring	U/U1	8	400	$\frac{1}{2}$	$\frac{1}{8}$	dark, grey	" "
511	SS 904 GD 410	U/U1	15	300	$\frac{1}{2}$	$\frac{1}{4}$	" "	" "
515	SS 904 GD 153	U/U1	$12\frac{1}{2}$	355	$\frac{1}{2}$	$\frac{1}{2}$	" "	" "
518	SS 904 a F	U/U1	23	400	$\frac{1}{2}$	-	dark, brown	medium coked
521	Rotring	U/U1	$8\frac{3}{4}$	400	$\frac{1}{2}$	$\frac{1}{2}$	dark, grey	" "
524	SS 904 a 2F	U/U1	$27\frac{1}{2}$	405	$\frac{1}{2}$	-	grey brown	" "
531	Rotring	W/W2	$7\frac{1}{2}$	-	$\frac{1}{2}$	-	medium	" "
533	SS 904/06a 2F	W/W2	22	520	$\frac{1}{2}$	-	dark, grey	" "
534	Rotring	W/W2	6	400	$\frac{1}{2}$	$\frac{1}{4}$	" "	slightly coked
535	SS 904 V 81a	W/W2	$21\frac{1}{2}$	540	$\frac{1}{2}$	$\frac{1}{2}$	" "	" "
536	SS 904 H5 161a	W/W2	19	410	$\frac{1}{2}$	$\frac{1}{2}$	" "	" "

Table of results of motor tests.

Test No.	Oil	Cylinder piston	Running time hrs.	Consumption g.	Sticking parts		Piston bottom	Piston rings
					1. Ring	2. Ring		
464	Rotring D	Y/V1	8 $\frac{1}{2}$	400	$\frac{1}{4}$	$\frac{1}{4}$	dark, grey layer	slightly ooked
472	SS 970 a 1	Y/V1	14	385	$\frac{1}{4}$	$\frac{1}{4}$	dark, brown layer	" "
473	SS 970 a	Y/V1	9 $\frac{1}{2}$	335	$\frac{1}{3}$	$\frac{1}{3}$	dark, grey layer	" "
474	SS 970 a 1/2	Y/V1	10 $\frac{1}{2}$	310	$\frac{1}{3}$	-	"	" "
475	SS 970 F	Y/V1	12 $\frac{1}{2}$	400	$\frac{1}{2}$	-	"	" "
476	Rotring	Y/V1	11	490	$\frac{1}{3}$	$\frac{1}{3}$	"	no cooke
478	Stanavo 100	Y/V1	8	400	$\frac{1}{2}$	$\frac{1}{3}$	grey layer	" "
580	SS 970 a 2F	S/S2	14	330	$\frac{1}{4}$	-	dark, grey layer	" "
582	SS 970 a 2F Op	S/S2	14 $\frac{1}{4}$	520	$\frac{1}{3}$	$\frac{1}{4}$	"	" "

Table 5.

TABLE

Running times and wear with different additives.

Test No.	Oil	Running time/hrs.	Wear
506	Rotring	8	0,1160)
470	SS 904a	12	0,0975)
511	SS 904 GD 410	18	0,3249)
533	SS 904/06a 2 F	22	0,0056)
321	Rotring	$8\frac{3}{4}$	0,1591)
518	SS 904a F	23	0,0121)
524	SS 904a 2 F	$27\frac{1}{2}$	0,0139)
534	Rotring	8	0,3022)
515	SS 904 DG 153	$12\frac{1}{2}$	0,2675)
535	SS 904a V 81	$21\frac{1}{2}$	0,0077)
538	SS 904a HB 161	19	0,0088)
464	Rotring	$8\frac{1}{2}$	0,1150)
478	Stanavo 100	8	0,2412)
475	SS 970a	$9\frac{1}{2}$	0,1520)
474	SS 970a F/2	$10\frac{1}{2}$	0,0484)
472	SS 970a F	14	0,0316)
475	SS 970 F	$12\frac{1}{2}$	0,0285)
580	SS 970a 2 F	14	0,0071)

*) Groups I and IV can directly be compared.

Wear, Consumption and Running Time with different Additives.

Plate 8



Plate 7

Relation of Wear and Running Time
Oil Temperature 100°C

