FUEL RESEARCH INSTITUTE OF SOUTH AFRICA.

TECHNICAL MEMORANDUM NO. 10 OF 1957.

SECOND PROGRESS REPORT ON PETROL TESTS,
PERIOD: FEBRUARY TO APRIL 1957.

NOTE: (a) This second progress report is a continuation of Technical Memorandum No. 7 of 1957 and should be read in conjunction therewith.

(b) Correction to Technical Memorandum No. 7. On page 2 the calorific value of the reference fuel is given as 20,800 B.Th.U/lb., this should be 20,210 B.Th.U/lb.

1. NATURE AND PURPOSE OF TESTS.

This report deals with tests on Sasol/Satmar mixtures and Sasol/Alcohol mixtures.

In addition, the report contains some further evaluation of the test data (thermal efficiency and fuel consumption on a volumetric basis) which were not incorporated in Technical Memorandum No. 7

2. PERFORMANCE TESTS ON SASOL/SATMAR AND SASOL/ALCOHOL MIXTURES.

The apparatus used was generally as described in Technical Memorandum No. 7, with the exception that a Carter adjustable main jet carburettor was used to replace the model constructed at this Institute. The main reason for doing so was to use normal commercial apparatus, complete with the usual auxiliaries as choke and idling jet.

The adjustment of the jet was however, rather coarse and was replaced by a different arrangement, permitting of more gradual regulation of the air/fuel ratio. The

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instrument was also not so easily altered unintentionally after this alteration.

In addition, some improvements were made to the speed controlling and measuring devices. By means of a stroboscopic arrangement, the engine speed during a test run can now be controlled to within a fraction of one per cent.

Test runs were carried out at 2000 r.p.m., 25 H.P., and at 3000 r.p.m., full throttle. The test procedure followed was to adjust the carburettor to a given output by opening the throttle to a fixed position, upon which the combustion efficiency was set to the level desired on one of the test fuels. After completion of the test run, the fuel supply system was switched over to a tank containing another test fuel. After allowing some time to purge the system of the old fuel, a test run on the new fuel was made without altering either throttle opening or jet adjustment.

When all fuels had been tested, the jet adjustment was altered (but not the throttle) and the test series repeated at another level of combustion efficiency.

3. FUEL COMBINATIONS TESTED.

The present test series did comprise runs on Sasol/Satmar mixtures, blended at this Institute, in the following ratios: 50/50, 60/40 and 70/30. In addition, Sasol/Alcohol mixtures with 10%, 17.2% (Sasol as received) and 25% of Sasol's alcohol mixture were investigated on the test bed.

The 10% alcohol fuel was prepared by mixing 1 volume of alcohol with 9 volumes of alcohol-free Sasol petrol, the 25% alcohol mixture by combining 10.4 volumes of alcohol with 100 volumes of Sasol petrol containing 17.2% alcohol.

To these mixtures 0.24% of Corvus oil was added. Table No. 1.1 shows the properties of the various fuels. Unless otherwise indicated, specific gravities were determined by means

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of a Westphal balance, calorific values by a bomb test and alcohol contents by the water extraction method.

These figures agree well with those obtained by calculation.

4. DISCUSSION OF RESULTS.

(a) Further evaluation of test data contained in Technical Memorandum No. 7.

With the inclusion of thermal efficiency and specific consumption on a volumetric basis, as listed in tables No. 1A, 2A (superceding tables No. 1 and 2 of Technical Memorandum No. 7)and 3A (supplementing table No. 3 of Technical Memorandum No. 7), the available data may be considered to be fully used.

The thermal efficiency figures are primarily of theoretical interest. It is however, interesting that in nearly all cases where Sasol petrol and the hydro-carbon mixture has been used under identical conditions, the thermal efficiency when using Sasol is slightly higher than that attained with the hydro-carbon mixture. This is very clearly illustrated by table No. 3A, where both petrols were used at the same combustion efficiency and throttle position.

It will also be noted that at constant ignition advance, the combustion efficiency (as measured by the "Sun" Analyzer) and thermal efficiency vary in the same manner. This is also shown clearly by the data of table No. 2A.

The specific consumption figure, expressed in gallons per horse power hour gives an expression for fuel economy in a form that is closely related to the customary "miles per gallon" yard stick.

At the 20 H.P. level, the best figure attainable is 0.095 gallons per H.P. hour. When generating 20 H.P., the average moderately heavy car will travel between 50 and 60 miles in one hour (assuming constant speed and a level road),

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and will then consume 20 x 0.095 = 1.9 gallons of petrol. The fuel consumption, expressed in miles per gallon is thus between 50 ÷ 1.9 = 26.5 and 60 ÷ 1.9 = 31.5, which is in fair agreement with figures obtained in road test. Under actual traffic conditions these figures may, of course, be substantially lower.

It is also interesting to note, that, when both carburettor and ignition timing are badly out of tune, the specific consumption may rise to 0.140 gallon/ H.P. hour (see table No. 3A, section C).

The petrol consumption then increases by a factor of nearly 1.5, or by 50%, which would reduce the theoretical figure for miles per gallon to a value between 18 and 21, and a still lower practical figure.

(b) Performance of Sasol/Satmar and Sasol/Alcohol Mixtures.

The data of table No. 1.2 and 1.3 clearly indicate that there is hardly any significant difference in what may be called the primary characteristics of the fuel - i.e. power generated and specific consumption. For instance, when comparing tests No. 1, 5 and 9 of table No. 1, which were carried out under identical carburettor adjustments, the difference in specific consumption is of the order of 1%.

The same remarks apply to table No. 1.4 which shows the effect of alcohol content, there are slight differences in power generated and in specific consumption. The former may be explained as follows:

In tests 5 and 6 - the 25% alcohol fuel, the mixture was obviously rather leaner than in runs 1 to 4, hence a slight drop in power resulted.

Comparing tests 7 and 8 with No. 9, it is clear that in all these cases the mixture is rich, but least so in test 9,

which/...

which therefore shows a slightly better power production and fuel economy.

Differences, both between the three Sasol/Satmar mixtures and between the various alcohol concentrations are however so slight that they do not affect the primary qualities.

The choice which blend to produce, has - as far as technical considerations are concerned - therefore to be based upon the secondary qualities of the fuel.

The most important of these are probably:

(a) Facility of starting and duration of warm-up period.

(b) Tendency towards vapour lock.

5. CONCLUSION.

The conclusion, resulting from this part of the investigation may thus be briefly formulated as follows:

As far as power generation and fuel economy are concerned, Sasol petrols of various alcohol concentrations and Sasol/Satmar mixtures compare well with hydro-carbon motor spirits.

The investigation has not dealt with starting properties, warm-up and vapour lock. It would appear however that in these respects alcohol blends are at a disadvantage compared with straight hydro-carbon petrols and this is thus a point requiring further investigation.

PRETORIA.
APRIL 1957.

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PRINCIPAL TECHNICAL OFFICER.

TABLE NO. 1A

COMPARISON OF PERFORMANCE OF SASOL AND IMPORTED HYDRO-CARBON PETROL IN A FIXED MAIN JET CARBURETTOR.

	JET		COMBUSTION EFFICIENCY %		THERMAL EFFIENCY %		SPECIFIC FUEL CONSUMPTION				POWER GENERATED HP	
							lbs/HP hour		gallons/HP hour			
TYPE	NO.	DIA. 0.001"	SASOL	MIX.	SASOL	MIX.	SASOL	MIX.	SASOL	MIX.	SASOL	MIX.
Chamfered	49	48.3	87.5	82	17.1	15.1	0.80	0.83	0.108	0.116	24.6	23.7
	50	49.9	84	78.5	14.8	13.3	0.92	0.945	0.125	0.132	21.9	21.35
	50	49.9	81	75	15.5	13.4	0.88	0.94	0.120	0.131	23.45	22.9
	51	51.4	82.5	74	15.6	12.2	0.875	1.03	0.119	0.144	24.3	22.85
	52	52.0	80	73.5	14.2	12.0	0.965	1.105	0.131	0.154	22.4	21.3
	53	53.0	78.5	71	13.1	11.9	1.04	1.06	0.141	0.148	21.1	20.8
	57	56.6	73	66	13.3	11.6	1.03	1.085	0.140	0.152	22.6	22.0
	57	56.9	72	64	12.9	11.5	1.06	1.09	0.144	0.152	23.1	22.3
Square	51	52.0	85	81	15.3	13.7	0.895	0.915	0.122	0.128	22.3	21.9
	56	56.9	74	67	13.9	12.1	0.985	1.04	0.134	0.145	23.2	21.9
	57	58.7	74	66.5	13.3	11.8	1.03	1.065	0.140	0.149	23.0	21.9
	58	58.7	68	63	12.3	10.5	1.11	1.20	0.157	0.168	21.9	20.7
	57	59.2	71.5	63	12.9	11.2	1.06	1.12	0.144	0.156	22.3	21.15

Ignition Advance:
Adjusted to specific figure,
5° B.T.D.C. at 500 r.p.m.,
32° - 35° under load.

Engine Speed: 2550 r.p.m. ± 2%

TABLE 2A/...

TABLE NO. 2A

COMPARISON OF SASOL PETROL AND MIXTURE OF IMPORTED HYDRO-CARBON FUELS IN AN ADJUSTABLE MAIN JET CARBURETTOR.

	Engine Speed	Power Generated	Fuel Rate	Specific Fuel Consumption		Combus-tion Effiency	Thermal Effiency	Air/Fuel Ratio "Sun" Calculated		Exhaust Temp.
	r.p.m.	H.P	lbs/min.	lbs/hp. hr.	gal/hp. hr.	%	%			°C
SASOL	2003	22.3	0.263	0.707	0.096	89.5	19.3	14.8	13.1	541
	2023	23.2	0.274	0.709	0.096	87.0	19.3	14.5	12.6	539
	2057	23.9	0.288	0.724	0.099	84.5	18.9	13.9	12.0	526
	2036	23.7	0.294	0.743	0.101	83.0	18.4	13.8	11.8	528
	2078	24.0	0.305	0.763	0.104	81.0	17.9	13.4	11.3	511
	2068	24.3	0.314	0.777	0.106	79.5	17.6	13.2	11.0	502
	2028	23.5	0.324	0.826	0.112	77.5	16.5	12.9	10.7	493
	2019	23.5	0.336	0.858	0.117	74.5	15.9	12.5	10.3	484
	2019	22.9	0.349	0.914	0.124	72.5	14.9	12.2	9.9	475
	2024	22.8	0.361	0.948	0.129	70.5	14.4	11.9	9.6	464
	2021	22.5	0.376	1.001	0.136	68.0	13.6	11.6	9.2	456
	2006	22.1	0.389	1.056	0.144	66.0	12.9	11.3	8.9	448
H.C. MIXTURE	2013	18.2	0.220	0.726		87.0	17.3	14.4	15.6	545
	2000	21.6	0.240	0.666	0.093	86.5	18.9	14.4	14.3	538
	2006	22.5	0.255	0.679	0.095	85.0	18.5	14.0	13.5	532
	2018	22.6	0.272	0.721	0.101	82.0	17.4	13.7	12.6	520
	2000	22.6	0.286	0.760	0.106	79.0	16.5	13.2	12.0	500
	2015	22.3	0.303	0.817	0.114	73.5	15.4	12.65	11.3	488
	1998	21.9	0.312	0.853	0.119	73.0	14.7	12.3	10.8	474
	2008	21.6	0.323	0.897	0.125	70.5	14.0	11.9	10.4	462
	2020	20.7	0.337	0.976	0.136	67.5	12.9	11.5	10.0	454
	2024	20.2	0.361	1.071	0.150	64.5	11.7	11.0	9.3	440

All tests carried out at constant throttle opening. Ignition timing adjusted to 32.5° B.T.D.C. (identical to that obtained with standard carburettor under load - automatic vacuum advance disconnected. Jet adjustment varied between extremely lean and extremely rich positions for each fuel.

TABLE 3A/...

TABLE NO. 3A.

EFFECT OF IGNITION TIMING ON PERFORMANCE.

	S A S O L			MIXED H. C. FUEL.		
Ignition Advance °B.T.D.C.	Specific Consumption		Thermal Efficiency.	Specific Consumption		Thermal Efficiency.
	lbs/HP hour	gal/HP hour	%	lbs/HP hour	gal/HP hour	%
A	Combustion Efficiency at 85% Level. Fuel Rate 0.239 lbs/hour			Fuel Rate 0.266 lbs/hour		
20	0.853	0.116	16.0	0.859	0.120	14.6
25	0.790	0.107	17.3	0.743	0.104	16.9
30	0.756	0.103	18.1	0.706	0.099	17.8
35	0.735	0.100	18.6	0.689	0.096	18.2
40	0.732	0.100	18.7	0.686	0.096	18.3
45	0.746	0.101	18.3	0.693	0.097	18.1
50	0.753	0.102	18.1	0.710	0.099	17.7
B	Combustion Efficiency at 80% Level. Fuel Rate 0.293 lbs/hour			Fuel Rate 0.266 lbs/hour		
20	0.911	0.124	15.0	-	-	-
25	0.853	0.116	16.0	0.786	0.110	16.0
30	0.827	0.113	16.5	0.745	0.108	16.2
35	0.821	0.112	16.6	0.764	0.107	16.5
40	0.825	0.112	16.6	0.764	0.107	16.5
45	0.829	0.113	16.5	0.782	0.109	16.1
50	0.837	0.114	16.3	0.790	0.110	15.9
C	Combustion Efficiency at 76% Level. Fuel Rate 0.323 lbs/hour			Fuel Rate 0.294 lbs/hour		
20	1.031	0.140	13.2	0.975	0.136	12.9
25	0.959	0.130	14.2	0.889	0.124	14.1
30	0.932	0.127	14.7	0.860	0.120	14.6
35	0.910	0.124	15.0	0.848	0.118	14.8
40	0.936	0.127	14.6	0.856	0.120	14.7
45	0.950	0.129	14.4	0.865	0.121	14.5
50	0.955	0.130	14.3	0.882	0.123	14.2

All tests carried out at same throttle opening. Engine speed 2000 r.p.m. Jet adjustment constant in test series A, then adjusted to a new constant value for series B, and again re-adjusted to new constant value for series C.

TABLE 1.1/...

TABLE NO. 1.1

PROPERTIES OF FUELS USED IN TESTS REPORTED IN TECHNICAL MEMORANDUMS NO'S 7 AND 10, 1957.

Fuel No.	Type of Fuel	S.G. at 24°C.	Calorific Value		Alcohol Content
			B.Th.U/lb	Therms/gallon	%
1	Sasol (a) (used in tests reported in tables 1A, 2A, 3A, 1.2, 1.3).	0.735	18,600	1.37	
2	Sasol (b) (used in tests reported in table 1.4).	0.718	18,730		17.2*
3	Satmar	0.766			12.2*
4	Sasol/Satmar 70/30	0.735	19,030	1.40	15.7*
5	60/40	0.739	18,950	1.40	15.1*
6	50/50	0.742	18,870	1.40	14.8*
7	H.C. Reference Fuel	0.716	20,210	1.45	
8	Sasol/Alcohol 25%	0.7265	18,200		25.0
9	Sasol/Alcohol 10%	0.714	19,220		10.0
10	Sasol, Alcohol free	0.706	19,900	1.43	
11	Alcohol	0.789	13,090xx	1.01xx	

* Alcohol content determine experimentally by water extraction.

xx Calculated value.

Composition of Alcohol.

Ethanol	80.3%
Propanol	13.2
Butanol	1.0
Benzol	5.3
Alcohol fore runnings.	0.2

Composition of alcohol free Sasol petrol.

Hydro Carbon	97.7%
Benzol	2.3

TABLE 1.2/...

TABLE NO. 1.2

COMPARISON OF THREE SASOL/SATMAR MIXTURES (AT ABOUT 25 HP, 2000 R.P.M.)

Test No.	Fuel	Speed	Power	Fuel Rate	Specific Consumption	Specific Consumption	Thermal Efficiency	Combustion Efficiency	Exhaust Temp.	Alcohol Content
		r.p.m.	H.P.	lbs/min.	lbs/HP.hr	gal/HP hr.	%	%	°C	%
1	A	2004	25.29	0.297	0.705	0.095	19.1	86.0	550	14.8
2		2009	25.73	0.321	0.75	0.101	18.0	80.7	528	
3		2008	25.55	0.340	0.80	0.108	16.8	78.0	514	
4		2007	25.11	0.366	0.87	0.117	15.5	73.0	492	
5	B	1999	25.14	0.299	0.715	0.097	18.7	86.2	550	15.1
6		2007	25.70	0.319	0.74	0.100	18.1	80.7	528	
7		2003	25.46	0.338	0.80	0.108	16.8	77.8	513	
8		2004	25.05	0.365	0.87	0.118	15.4	71.8	492	
9	C	2005	25.22	0.296	0.70	0.095	19.1	85.5	550	15.7
10		2006	25.75	0.319	0.74	0.101	18.0	81.0	528	
11		2005	25.51	0.336	0.79	0.107	16.9	78.0	512	
12		2005	25.17	0.366	0.87	0.118	15.3	72.0	493	
		All tests above carried out at constant throttle opening and at 4 different jet adjustments for each fuel. Ignition timing as specified : 5° B.T.D.C. at 500 r.p.m. Automatic advance operative.								
13	A	2014	27.53	0.351	0.765	0.103	17.6	77	512	
14	B	1996	27.34	0.351	0.770	0.104	17.4	77	512	
15	C	2007	27.44	0.347	0.759	0.103	17.6	77	508	
		Three test runs on all three fuels at same jet and throttle setting.								

TABLE NO. 1.3/...

TABLE NO. 1.3

COMPARISON OF THREE SASOL/SATMAR MIXTURES (FULL LOAD ± 3000 R.P.M.)

Fuel	Speed	Power	Fuel Rate	Specific Consumption	Specific Consumption	Thermal Efficiency	Consumption Efficiency	Alcohol Content
	r.p.m.	H.P.	Lbs/Min.	Lbs/HP hr.	Gals/HP hr.	%	%	%
A	3005	62.57	0.700	0.671	0.090	20.1	87.5	14.8
50:50	3008	65.75	0.802	0.732	0.099	18.4	81.5	
B	3000	62.19	0.691	0.667	0.090	20.1	87.5	15.1
60:40	3026	66.57	0.783	0.706	0.096	19.0	81.5	
C	2995	61.83	0.685	0.665	0.090	20.1	87.5	15.7
70:30	3017	66.37	0.786	0.711	0.097	18.8	81.5	

Ignition Timing : As specified, 5° B.T.D.C. at 500 r.p.m.
Automatic advance operative.

Throttle : Fully opened, same jet adjustment for all tests.

TABLE 1.4/...

TABLE NO. 1.4

EFFECT OF ALCOHOL CONTENT.

Test No.	Alcohol	Speed	Power Generated	Fuel Rate	Specific Consumption	Specific Consumption	Exhaust Temp.	Compustion Efficiency	Thermal	
	%	r.p.m.	H.P.	lbs/min.	lbs/HP hr.	gal/HP hr.	^{o}C	%	Effien-cy	
1	10	2007	27.72	0.309	0.669	0.094	542	83.0	19.8	)
2		2004	27.68	0.312	0.676	0.095	542	83.0	19.6	)
3	17.2	2007	27.75	0.303	0.655	0.091	552	84.2	20.7	)
4		2011	27.80	0.308	0.665	0.093	555	84.3	20.4	) A
5	25	2005	27.07	0.317	0.703	0.097	560	86.6	19.9	)
6		1998	27.06	0.311	0.690	0.095	560	86.6	20.2	)
7	10	2014	27.59	0.342	0.744	0.104	518	74.7	17.8	)
8	17.2	2009	27.69	0.343	0.743	0.103	518	76.0	18.2	) B
9	25	2014	27.76	0.340	0.735	0.101	518	77.3	19.0	)

Ignition Timing : 5^{o} B.T.D.C. at 500 r.p.m., automatic advance operative.

Throttle Position: Same in all tests A.
Same in all tests B.
Setting A nearly, but not necessarily exactly, equal to setting B.