Wallachs' Pta.,—20159

F.R. 5.

REPORT No. 7
OF 1941

RAPPORT No.
VAN

NAVORSINGS-INSTITUUT BRANDSTOF S. A. FUEL RESEARCH INSTITUTE

U1/E/1/4

FUEL RESEARCH INSTITUTE

OF SOUTH AFRICA.

BRANDSTOF-NAVORSINGS-INSTITUUT

VAN SUID-AFRIKA.

SUBJECT :
ONDERWERP: SOME FACTORS RELATING TO THE USE OF STANDARD ALCOHOL-PETROL BLENDS IN MOTOR-CARS.

DIVISION :
AFDELING :

NAME OF OFFICER :
NAAM VAN AMPTENAAR : REPORT PREPARED FOR THE LIQUID FUEL COMMITTEE BY DR. F.J. TROMP, ACTING DIRECTOR OF THE FUEL RESEARCH INSTITUTE OF SOUTH AFRICA.

SOME FACTORS RELATING TO THE USE OF STANDARD ALCOHOL-PETROL BLENDS IN MOTOR CARS.

REPORT PREPARED FOR THE LIQUID FUEL COMMITTEE BY DR. F.J. TROMP, ACTING DIRECTOR OF THE FUEL RESEARCH INSTITUTE OF SOUTH AFRICA.

The object of this paper is to examine the feasibility of making blends of alcohol with standard petrols which can be used alternatively with standard petrol in ordinary motor cars without making special engine adjustments.

It is extremely difficult to form a correct appreciation of the situation from the literature. This is mainly due to the fact that a very large percentage of authors are obviously biased in one or other direction, and in many cases, where such bias does not exist, the experiments are not sufficiently crucial or refined to decide the material points at issue.

However, from the evidence available, the following conclusions may reasonably be drawn.

Note : Alcohol denotes absolute alcohol unless otherwise stated.

(A) WHEN USED IN THE SAME PETROL ENGINE, WITH THE CARBURETTOR AND SPARK SET FOR MAXIMUM ECONOMY FOR PETROL, LITTLE DIFFERENCE IN POWER, ACCELERATION OR FUEL CONSUMPTION IS OBSERVED WITH BLENDS CONTAINING UP TO 20 PER CENT OF ALCOHOL, BUT THE GENERAL TENDENCY IS TOWARDS A REDUCED MILEAGE FOR A BLEND PREPARED FROM A STANDARD PETROL.

(1)

(a) According to Bridgeman, when used in the same engine, with carburettor and spark accurately adjusted to the optimum economy settings for each type of fuel, the same power and acceleration may be obtained at the expense of about 3.5 per cent greater consumption with a ten per cent blend, about double this difference with a 20 per cent blend, and still more with a 40 per cent blend.

(b) The U.S. Bureau of Standards (2) conducted a series of road tests with 15 cars over a course of 89 miles at an average speed of 31 miles per hour. Different carburettor settings were made and the fuels were compared on each of the settings. Standard petrol and a 10 per cent alcohol blend were tested. Four of the cars showed more than 1 per cent increased miles per gallon with the blend. Six of the cars showed more than 1 per cent decreased miles per gallon with the blend. The average fuel consumption was 15.91 miles per gallon for petrol and 15.85 miles per gallon for the blend. In another test with 4 cars, run at constant speed over a ten mile course under conditions approaching vapour lock, the Bureau obtained an average consumption of 16.54 miles per gallon for petrol and 16.02 miles per gallon for blend. A small loss in acceleration was observed with the blend.

(c) The Iowa State College, (3) as a result of road tests, conducted with 12 cars over a mile course, concluded that at speeds of 10 to 20 miles per hour a 4 per cent increase in miles per gallon was obtained with a 10 per cent alcohol-petrol blend. At speeds of 40-50 miles per hour equal mileages were obtained with petrol and blend. Improved acceleration was also obtained with the blend.

The following results were obtained with a Studebaker test car :-

CONSUMPTION - MILES PER GALLON.

SPEED M.P.H.	PETROL	10% ALCOHOL-BLEND	20% ALCOHOL-BLEND.
10	14	15.5	14.2
20	18.4	16.9	17.4
30	17.5	16.8	16.3
40	16.2	15.5	14.7
50	14.4	13.6	12.4
60	12.2	11.2	10.2

(d) The Contest Board of the American Automobile Association,[4] as a result of road tests with 4 cars over a 5 mile course at 45 miles per hour, concluded that a 10 per cent alcohol blend gave an average increased fuel consumption of 5 per cent compared with straight petrol. A number of different jets were used on each car.

(e) Christensen[5] states that with air-fuel ratios greater than that for maximum economy an alcohol blend gives an increased fuel consumption of about 3 per cent for each 10 per cent of alcohol present. With mixtures richer than that for maximum economy, alcohol blends containing up to 20 per cent of alcohol give lower fuel consumptions than petrol. These results will be obtained in standard cars without change of ignition or carburettor adjustment. In practice there is a tendency to set air-fuel mixtures on the rich side.

Christensen, referring to tests made by Gray and Sauve with tractors, concludes that a 10 per cent alcohol blend gave 3-6 per cent better fuel economy than petrol. No engine alterations were made.

(f) During February 1941 the Fuel Research Institute of South Africa conducted a series of road tests with a 1939 Ford V 8 Standard Sedan adjusted for maximum economy with petrol. This car carried three persons on all the trips and gave an exceptionally good performance with petrol as shown by the following :-

SPEED M.P.H.	25.7	34.2	43.4	53.3	62.5
M.P.G. WITH PETROL	28.8	27.3	25.3	23.2	20.9

A two mile course was taken and three runs were made in each direction. The runs on a given fuel were not made successively and the operators did not know the composition of the fuels which were being tested. The alcohol used in making up the blends was previously denatured by adding 5 volumes of benzol to every 100 volumes of alcohol.

The following results were obtained:

% Increase (+) or Decrease (-) Miles per Gallon with Petrol as Standard.

Mean Speed M.P.H.		25.7	34.2	43.4	53.3	62.5	Average	P
% Denatured	10	+2.4	-1.1	+0.4	+0.9	+1.4	+ 0.8	1.08
Alcohol by	15	-1.4	-2.2	-0.8	-2.2	+0.5	- 1.2	.92
Volume	20	+1.7	-0.7	-0.4	-0.9	-1.9	- 0.4	.98
	25	0.0	-1.8	-2.0	-1.7	-3.4	- 1.8	.94
	30	-1.4	-1.8	-3.6	-3.5	-5.7	- 3.2	.89
	40	-3.8	-6.2	-5.9	-7.3	-9.1	- 6.5	.84
	50	-8.7	-12.8	-15.4	-19.8	-14.8	-14.3	.72
	60	-12.5	-15.8	-15.4	-19.8	-19.1	-16.5	.73
	70	-11.1	-20.1	-25.3	-32.4	-25.8	-22.9	.68

For the interpretation of "P" see Section (B).

Very irregular running was obtained with blends containing 60 and 70 per cent of alcohol.

(6)

(g) Egloff and Morrell similarly conclude, "The many data presented indicate that the increased consumption of motor fuel employing a 10 per cent of alcohol-gasoline is approximately 4 per cent based on both road and block tests".

It is quite possible that alcohol petrol blends may give a better mileage than petrol if the petrol has an octane number which is too low for the engine. However, this problem is not considered here. Special high compression engines are also not considered.

No useful purpose will be served by referring to more tests since they substantially confirm the conclusion stated at the beginning of this section.

(B) SINCE AN AVERAGE REDUCTION IN MILES PER GALLON IS TO BE EXPECTED BY THE GENERAL USE OF ALCOHOL-PETROL BLENDS THE PRICE OF ALCOHOL WOULD HAVE TO BE LOWER THAN THAT OF STANDARD PETROL AND THE BLEND WOULD HAVE TO BE SOLD CHEAPER THAN STANDARD PETROL TO ENSURE THE SAME FUEL COSTS PER MILE WITH THE BLEND.

Assume that 1 - x gallons of petrol are mixed with x gallons of alcohol to give 1 gallon of blend. Actually there is a small, but negligible, expansion on mixing alcohol and petrol.

Suppose the petrol gives "p" miles per gallon, and the blend gives "b" miles per gallon. The petrol present in 1 gallon of blend would give (1 - x)p miles. Therefore, the x gallons of alcohol present in 1 gallon of blend could be considered as giving b - (1 - x)p miles. Therefore, 1 gallon of alcohol, when contained in a blend, could be considered as giving

$\frac{b - (1 - x)p}{x}$ miles

Let Ac = "alcohol contribution"

$= \frac{b - (1 - x)p}{x}$ miles per gallon of alcohol.

To give an idea of the magnitude of these effects the following table has been constructed, Arbitrary values have been given to p, b and x. Note 100 x is equal to the percentage by volume of alcohol in the blend. "P" is the justifiable price ratio, that is the ratio of the price per gallon of alcohol, including the costs of making the blend, to the price per gallon of petrol, which will ensure that fuel costs per mile are the same for the blend as for petrol, that is, if the selling prices of the fuels are in the ratio of their fuel consumptions in miles per gallon. It is clear that P = Ac/p.

Suppose petrol gives 20 miles per gallon, and a 10 per cent alcohol blend gives 19 miles per gallon. 1 Gallon of blend contains 0.9 gallon of petrol, which, by itself, would drive the car 18 miles. The 0.1 gallon of alcohol, contained in 1 gallon of blend, therefore drives the car 19-18 = 1 mile. Hence 1 gallon of alcohol, when in the form of a 10 per cent blend, will drive the car 10 miles. Therefore Ac is 10. If fuel costs, per mile, to the consumer have to be unaltered, then

$$\frac{\text{Cost per gallon of petrol}}{\text{Cost per gallon of blend}} = \frac{Cp}{Cb} = \frac{20}{19} = 1.0526$$

The cost per gallon of blend, in the above case,

$Cb = 0.9\,Cp + 0.1\,Ca$, where Ca is the cost per gallon of alcohol.

$$\therefore \frac{C \cdot b}{0.9Cp + 0.1\,Ca} = 1.0526$$

$$\therefore \frac{Ca}{Cp} = 0.5 = P.$$

p	b	% Alcohol	Ac	P
20	18	10	0	0
20	18.5	10	5	0.25
20	19	10	10	0.5
20	19.5	10	15	0.75
20	20	10	20	1.00
20	20 - 3.5%	10	13	0.65
20	16	20	0	0
20	17	20	5	0.25
20	18	20	10	0.5
20	19	20	15	0.75
20	20	20	20	1.00
20	20 - 7.0%	20	13	0.65

For values of "P" based upon road tests see the table under (B)(f). The latter figures show a definite decrease in "P" as the percentage of alcohol increases. It is clear that a small reduction in miles per gallon from a blend containing low percentages of alcohol will have a serious effect on P. With a mileage reduction from 20 to 18 for a 10 per cent blend, the alcohol has been entirely wasted and the position would have been better if only petrol was used, although 10 per cent less petrol was available.

This argument is of importance when considering the relative merits of alcohol versus petrol manufacture for supplementing our liquid fuel supplies from local materials. It also has a direct bearing upon the nature of the raw materials which could be used for alcohol manufacture.

(C). THE ADDITION OF 10 PER CENT ALCOHOL TO PETROL APPRECIABLY LOWERS THE TEMPERATURES WHICH CAN BE PERMITTED BEFORE VAPOUR LOCK OCCURS. REID VAPOUR PRESSURE MEASUREMENTS SUGGEST THAT THERE WOULD BE LITTLE DIFFERENCE BETWEEN A 20 PER CENT BLEND AND PETROL, AND THAT WITH A 40 PER CENT BLEND THE VAPOUR LOCKING TENDENCY SHOULD BE CONSIDERABLY LESS THAN WITH PETROL.

The above conclusion is supported by Brigeman [1] and is generally accepted. Egloff and Morrell [6] give the following data:

% Alcohol in Blend	0	3	10	20	30	40
Temperature of Vapour Lock °F	118	110	112	114	116	118.

The fact that 10 percent blends have been employed extensively and that the fuel systems of standard cars have been designed to handle petrols of higher vapour pressure than are commonly sold in South Africa ought to eliminate any concern as to undue vapour locking tendency with blends prepared from standard petrols.

(D) 10 PER CENT BLENDS GIVE EASIER STARTING DOWN TO 0°F AND INFERIOR STARTING BELOW -10°F. COMPARED WITH PETROL IT IS NOT ANTICIPATED THAT STARTING DIFFICULTIES WILL BE EXPERIENCED, UNDER SOUTH AFRICAN CONDITIONS, WITH BLENDS CONTAINING UP TO 20 PER CENT OF ALCOHOL.

For a discussion see Bridgeman.[1] Egloff and Morrell[6] maintain that both cold and warm starting is more difficult with blends. Hubendick[7] states that many years of experience in the cold climate of Sweden has shown that "Lättbentyl", composed of 75 per cent of petrol and 25 per cent of "spirit" could be substituted for petrol without experiencing any difficulties which could not be easily remedied. Starting difficulties were experienced in many cases and several minutes running was necessary before full power was developed.

(E) WHEN STORING AND USING ALCOHOL BLENDS GREATER PRECAUTIONS TO EXCLUDE WATER ARE NECESSARY THAN WITH PETROL.

When sufficient water is added to a blend a portion of the alcohol separates out below. This layer will cause difficulties in starting and running. Bridgeman[1] gives the following water tolerances.

% Volume of Water necessary to cause Separation.

Temp. °F	10% Blend	20% Blend	40% Blend.
68	0.35	0.83	2.03
32	0.25	0.59	1.46
-4	0.18	0.40	1.00

Thus, the lower the percentage of alcohol in the blend, the lower is the water tolerance.

The low water tolerance of alcohol-petrol blends is one of the factors which favours the use of alcohol of over 99 per cent strength, instead of "spirit" of 93-95 per cent, for the manufacture of such blends.

Hubendick[7] states that no difficulty was experienced in Sweden on account of water separation from a 25 per cent alcohol blend.

(F) WHEN USING ALCOHOL BLENDS THERE IS GREATER LIABILITY TO CORROSION.

This is discussed by Hubendick,[7] who points out that the factors favouring corrosion are high alcohol content, rich gas-air mixtures, low temperature in cylinder, and impurities in the alcohol and denaturants.

(G) WHEN USING ALCOHOL BLENDS THERE IS A TENDENCY TOWARDS INCREASED CYLINDER WEAR.

According to Hubendick[7] this occurs particularly with blends of high alcohol content and rich gas-air mixtures when the cylinder temperatures are low.

(H) STRONG ALCOHOL BLENDS HAVE A SOLVENT ACTION ON GUMS DEPOSITED FROM PETROL IN THE FUEL TANK AND FEED LINES. PARTICLES OF GUM AND SCALE ARE THUS FREED AND WILL CHOKE CARBURETTOR JETS AND FILTER SCREENS.

According to Hubendick[7] this trouble is experienced by blends containing 25 per cent of alcohol. Once these particles have been removed no further trouble is experienced. According to Dietrick[8] similar precautions are necessary when using a 20 per cent blend.

BIBLIOGRAPHY.

1. Bridgeman. Ind. & Eng. Chem. Sept. 1936, 1102.

2. U.S. Bureau of Standards News Bulletin. No. 197. 1933.

3. Iowa State College, Progress Report No. VII, 1933.

4. Contest Board of the American Automobile Association. 1933.

5. Christensen. Ind. & Eng. Chem. 1936, 1089.

6. Egloff and Morrell. Ind. & Eng. Chem. 1936, 1080.

7. Hubendick, "Spiritusmotoren" 1930.

8. Dietrick, Zt. f. Spiritusindustrie Vo. 53, No. 51, 1930.
