4340-1814A

A.I. 2(g).

AIR MINISTRY

[redacted]

11th December 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Samples Nos. AIR 407 and AIR 408 (received through War Office, S.T.2(d) - Ref.: BM.2480). Obtained in the European Theatre of Operations by the British Mobile Laboratories.

AIR 407 - "AVIATION FUEL C.3" ex Alliance Oil Installation, Vilvorde, Nr. Brussels. Container: 40-brl. Ref. No. 21 AGP/ENY 17.

AIR 408 - "AVIATION FUEL C.3" ex Alliance Oil Installation, Vilvorde, Nr. Brussels. Container: 40-brl. Ref. No. 21 AGP/ENY 18.

Analyses by The Petroleum Board, Vauxhall

FURTHER INFORMATION HAS BEEN RECEIVED SINCE RECEIPT OF THESE SAMPLES INDICATING THAT THEY ARE BLUE FUELS (B.4). THIS IS ALSO CONFIRMED BY THE FOLLOWING ANALYSES:

	AIR 407	AIR 408
Size of Sample .....Approx.	5-glns.	5-glns.
Specific Gravity	.7412	.7411
Colour	Blue	Blue
Distillation - I.B.P.	49°C	47°C
Recovery at 70°C	7%	8%
75°C	14%	15%
100°C	50%	50½%
105°C	58%	59%
140°C	93%	93%
150°C	96%	96½%
F.B.P.	158°C	158°C
Total Recovery	98%	98½%
Residue	1%	1%
T.E.L. Content	6.3 ml./I.G.	Present
Octane Number	91½	91½
Bromine Number	1.6	1.6
Odour	Normal	Normal
Hydrocarbon Analysis		
Aromatics	7.1%	7.0%
Unsaturateds	Nil	Nil

AIR 407 is a blue fuel of much lower aromatic content than usual for recent samples. The relatively high specific gravity, lead content and octane rating, and lower volatility are probably due to weathering.

AIR 408 is identically the same material.

C. Chilvers
Secretary
for Chairman, Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
Strand, W.C.2.

CONFIDENTIAL 13th December 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 409 - continued from 7th December 1944

Additional tests have been carried out on this sample with the following results:

Phenol Content	0.03%
Sulphur Content	0.88%

Evidently a high sulphur content fuel can be tolerated for this purpose and it seems probable that this fuel is entirely of shale origin, probably transported from Esthonia especially for the purpose.

C. Chilvers
Secretary
for Chairman, Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
Strand, W.C.2.

A.I. 2G.

AIR MINISTRY

CONFIDENTIAL 7th December 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 409 (received through War Office, S.T.2(d) - Ref.: BM.2480). Obtained in the European Theatre of Operations by the British Mobile Laboratories.

AVIATION FUEL ex Sinclair Oil Installation, Ghent. Ref.No. 1 CDN/ML/B/E/15

Analysis by The Petroleum Board, Vauxhall

Size of Sample .....Approx.	1 jerrican
Specific Gravity	.7508
Colour	Yellow
Distillation - I.B.P.	40°C
Recovery at 75°C	12%
100°C	32%
140°C	68%
150°C	78%
F.B.P.	197°C
Total Recovery	98%
Residue	1%
Lead	Nil
Octane Number	60½
Bromine Number	55.4
Aniline Point	32.8°C
Aniline Point after sulphonation	66.4°C
Odour	Resembles shale

Hydrocarbon Analysis

Aromatics	22.9%
Paraffins	35.2%
Naphthenes	10.4%
Unsaturateds	31.5%

It was later reported that this fuel was believed to be the material used in the propulsion of fly bombs. It will be seen that this is a highly unsaturated fuel of relatively low Octane rating and volatility. Judging from the odour it contains an appreciable amount of Gasoline of shale origin.

C.Chilvers
Secretary
for Chairman, Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
Strand, W.C.2.

CONFIDENTIAL 6th December 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 404 (received through Enemy Branch, Foreign Office and Ministry of Economic Warfare - Ref.: A0.220/5/Z)

AVIATION GASOLINE of orange colour taken from drum in a captured depot. First Vkrainsky Front.

Analysis by The Petroleum Board, Vauxhall

Size of Sample .....Approx.	1,700 ccs.
Specific Gravity	.8004
Colour	Yellow
Distillation - I.B.P.	58°C
Recovery at 70°C	29%
75°C	35%
100°C	60%
105°C	64%
140°C	81½%
145°C	84%
150°C	86½%
F.B.P.	194°C
Total Recovery	97½%
Residue	1%
Freezing Point	-5°C
Sulphur	0.42%
Existent Gum	(69 mg.
	(180 mg.Oil
Lead Content	Nil
Octane Number	77
Bromine Number	35 (water soluble free spirit)

Hydrocarbon Analysis (on water soluble free spirit)

Aromatics	52%
Paraffins	20.3%
Naphthenes	7.7%
Unsaturateds	20%
Water Solubles	5%
Iron Carbonyls	Nil

This fuel appears to consist of approximately 40% benzol, 5% alcohol and the balance gasoline, probably of low volatility and highly cracked. The existent gum content is high and no T.E.L. is incorporated.

It appears very doubtful whether this fuel was ever used as aviation gasoline on the Eastern Front (note freezing point as well as other properties). Although the octane rating is satisfactory it is unusual for the Germans to use a fuel of such high aromatic content and specific gravity even for motor gasoline.

C.Chilvers
Secretary
for Chairman, Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
Strand, W.C.2.

CONFIDENTIAL A [illegible] 27th October 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

157/16

Samples Nos. AIR 400 and AIR 401 (received through Enemy Branch, Foreign Office and Ministry of Economic Warfare - Ref.: AO 220/Z/229)

OIL received through the Norwegian Headquarters and taken from aircraft at Ilsvika (Trondheim).

AIR 400 - 1. For dynamoer og de finere mashin deler etc. (Oil for dynamos and other fine machinery).

AIR 401 - 2. Motor olje Grön spindel olje Arado 196. (Green spindle oil for Arado 196).

Analyses by Shell Marketing Co., Ltd., Fulham

	AIR 400	AIR 401
Size of Sample .....Approx.	15-ml.	15-ml.
Specific Gravity	0.913	0.879
Kinematic Viscosity @ 100°F, C.s..	237.3	15.7
210°F, "	18.64	3.65
Viscosity Index	-	-
Saponification Value (mg.KOH/gm.).	6.4	Less than 0.1
Saponifiable Matter	3.7% wt.	-

The properties of the saponifiable matter obtained from AIR 400 were as follows:

Refractive Index (60°C)	1.46½
Melting Point	44°C
Equivalent weight	374
Iodine Value	55

The material has not been identified by these properties and the small amount of sample precludes its further investigation.

AIR 400 appears to be a 100 grade aviation oil and contains about 3½% of unidentified fatty material.

AIR 401 is of normal quality and resembles previous samples of the same type.

C.Chilvers
Secretary
for Chairman, Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
Strand, W.C.2.

CONFIDENTIAL

AIR MINISTRY

WAR CABINET TECHNICAL SUB-COMMITTEE ON AXIS OIL

Report by the Enemy Oils and Fuels Sub-Committee
for period ended 30th June, 1944.

Since our last report examinations have been made on further samples of enemy fuels.

Three reports in regard to Diesel Fuels are attached as under:-

(i) Origins of Enemy Diesel Fuels as indicated by samples
(ii) Identification of Enemy Diesel Fuels.
(iii) Analysis of AIR. 368 - a K.1 Fuel.

The following are our comments on I. Aviation and Motor Gasolines, and II. Lubricants and Special Products.

I. AVIATION AND MOTOR GASOLINES.

(a) Aviation Gasoline (AIR Samples)

(1) C-3 Green Fuel.

The sample AIR.386 was a typical Green Aviation fuel of 96 octane number (RM) containing 5.62 mls/Imp. gallon TEL and containing an aromatic content of 40.6%. From the volatility the sample appeared to be slightly weathered, although this is not necessarily substantiated by the TEL content. It is of interest to note that the CFR octane research number of this sample was only 99.7 although this may possibly be accounted for by slight weathering. The sample was too small for a 3-C rich octane number determination but in view of the lower than usual CFR research number, it is possible that the 3-C value would also have been lower than usual.

AIR.367 was a very small sample of a Green Aviation fuel which from the few tests that could be carried out appeared to be a normal 3-C Green type.

AIR.345 was a sample of Green Aviation fuel which appeared to be slightly weathered. In addition, it contained appreciable quantities of a rubbery material which was responsible for the high existent gum figure of 278. Owing to the presence of this material in the sample no octane number was determined but in all other respects the fuel appeared to be normal.

(2) B-4 Blue Fuel.

Five samples of German Blue aviation gasoline have been received and these were all perfectly normal in properties having octane numbers of 91 and lead contents ranging from 5.44 to 5.65 mls. per I.G. One sample, AIR.383, had an aromatic content of 8.5% which is rather lower than usual; remaining samples had aromatic contents ranging from 13 to 16%. The aromatic content, however, of AIR.383 (8.5%) does not appear significant since aromatic contents lower than this have been obtained in the past. Inspections on samples of Blue and Green gasoline were received from Suez during the period under review and these inspections check fairly closely with our own inspections on similar materials.

(3) Miscellaneous Aviation Gasolines.

AIR.344 is a sample of aviation gasoline taken from the tank of a DH Moth flown from Denmark and the fuel appeared to be a typical pre-war unleaded aviation grade petrol of 77 octane number.

(b) /

(b) M.T. Gasoline (MECH. Samples)

Three samples of M.T. gasoline of widely differing types were tested.

MECH. 421 was a sample of German petrol used in France and is an alcohol blend containing 10% Ethyl Alcohol. The sample was too small for octane number determination to be carried out.

MECH. 420 was a sample of M.T. petrol from the Middle East and is a leaded gasoline of 73 octane number (M-) containing 1.33 mls. TEL/IG and represents a good average quality M.T. fuel.

MECH. 398, a sample taken from a German tank, was a highly aromatic leaded fuel with an octane number of 71, which is considerably lower than the octane requirements for British A.F.V's. The sample contained 40.7% aromatics (25% Benzol).

II. LUBRICANTS AND SPECIAL PRODUCTS

49 Samples are dealt with in this Summary.

Generally speaking the quality of the products has been well maintained, though one of the grease samples (MECH. 391) was of poor quality.

There are three developments to report. One of the Czech tank engine oils (MECH. 372) which was abnormally high in viscosity appeared to be compounded; a low viscosity gear oil from a Czech tank (MECH. 371) contained Voltol; and a compounded gear oil from a German tank (MECH. 417) may have contained a nitrogen compound. Otherwise no additives were found.

(a) Aero-Engine Oils and Fluids.

Seven enemy aero-engine oils have been received. All the oils were of the 100 grade and included one Voltol blend and an oil (from N. Africa) which appeared to contain synthetic oil. V.Is. were from 97 to 107 excepting the Voltol Oil which was 91.

A medium machine oil containing 50% rape oil from Italian sources was apparently a gun lubricant ("per Armi").

Three Italian aero hydraulic fluids, which were low cold test spindle oils of medium and low V.I. and a coolant, glycol plus water, from a Dornier, have also been received.

(b) Marine Oils.

Four Diesel engine oils of normal quality (70 V.I.) and one heavy oil of 94 V.I. possibly used for reduction gears, have been received. In addition there was a German medium torpedo oil from the Mediterranean, consisting of 25% fatty oil mixed with a spindle oil.

(c) General Lubricants (MECH. oils).

These consisted of 6 industrial oils and 8 oils from German fighting vehicles. The industrial oils were of medium quality. The A.F.V. oils include 6 gear oils varying widely in viscosity, and of these 4 appear to be compounded, one with Voltol, while another may have contained a nitrogen compound (anti-oxidation additive?). The 2 engine oils from tanks had the usual high V.Is. but were much higher in viscosity than previous samples (380-400" R.I. at 140°F. against 200") and one of them may have contained fatty oil (MECH. 372).

(d) Greases.

12 greases and 1 petroleum jelly have been received. The samples were generally of fair quality except a German grease from N. Africa (MECH.391, Einheitsfett) which, owing to its low soap content, had poor stability.

(e) Hydraulic Fluids.

In addition to the 3 Italian aero hydraulic fluids referred to above, 3 fluids from German tanks have been received. One of the fluids (MECH.406) contained fatty oil and another (MECH.412) was a low V.I. Oil (21).

September 1944.

QUARTERLY REPORT FOR ENEMY OILS AND FUELS COMMITTEE.

The Origins of Enemy Diesel Fuels as Indicated by Samples Received from October, 1943 to March, 1944.

Summary.

18 enemy diesel fuels samples have been received from October, 1943 to the end of March 1944, for 9 of which cetane number, mid-boiling point and diesel-index relationships are available. Generally these show the increased presence of non-petroleum oils, and are classified as follows:-

1. (a) 2 are normal petroleum products.

   (b) 2 are possibly normal petroleum products but they may contain shale oil distillate in appreciable proportions. It is recommended that iodine numbers are obtained for these samples.

   (c) 1 sample may be derived from low temperature bituminous tar, otherwise it is a petroleum product.

2. 4 contain brown coal tar distillate. Two of these samples possibly contain hydrogenated brown coal tar, while the remaining 2 are probably blends of brown coal tar distillate and a volatile Fischer-Tropsch oil.

Of the remaining 9, for which cetane numbers are not available, 2 are tentatively classed as petroleum and 5 as blends containing brown coal tar distillate.

The following classification of diesel oil samples is based on Figure 1 in "Identification of Enemy Diesel Fuels". It has been found satisfactory, subject to the limitation that, as yet, blended fuels which may contain shale oil distillate in appreciable proportions cannot be clearly differentiated from normal petroleum fuels. Iodine numbers should be available for such fuels.

The following fuels samples have been received between October, 1943 and March, 1944:-

MECH.394	MAR.230, 204, 214, 216, 207, 241	MISC.65	AIR.352
395	250, 231, 169, 215, 172, 171	T.D.789	332

Analytical data for these fuels are summarized in Table I; it will be noted that cetane numbers are available for 9 samples only. These have been plotted on the identification chart and conclusions drawn by the methods indicated in the report mentioned above. These conclusions are set down in Table I.

In particular, MAR.204, while possessing a cetane number corresponding to the cetane number for a similar petroleum oil, possesses a fairly high phenol content and a low sulphur content; hence bituminous coal is considered a possible source of supply for this sample. MECH.394 and 395, lying just above the '50' cetane line in Figure 1 of the report possess cetane numbers respectively less and greater than the limit of 5 cetane units which has been specified. While these two samples may correspond to oils of Roumanian origin, the fairly higher sulphur content and the somewhat anomalous cetane numbers may indicate the presence of shale oil distillate. Iodine values for these fuels evidently are required.

The high sulphur contents of the fuel samples AIR.352 and 332, preclude the possibility of the presence of hydrogenated brown coal tar distillate. It is considered probable that they are blends of volatile Fischer-Tropsch oil and brown coal tar distillate. The very anomalous cetane number does not indicate the presence of petroleum oils in appreciable proportions. These are K.1. fuels which will be the subject of a separate report.

Indications only are given as regards the origin of the 9 enemy fuels samples for which cetane numbers are not available. T.D.789 however, is almost certainly of the same class as AIR.352 and 332.

In Appendix I are set down the properties of some of the earliest enemy fuels samples, 1941 to 1942. If compared with Table I, the decrease in the use by the enemy of normal petroleum diesel oils is evident, 12 out of 14 samples being classified according to the scheme given in our first report as wholly or mainly petroleum products. The ignition quality of the latest oils has been fully maintained.

TABLE I.

Fuel Sample.	Diesel Index.	M.B.P. ° F.	Cetane No.	Cetane No. Calcd.	Phenol Content. %	Sulphur Content. %	Classification. *
MECH.394	56·8	521	55	50·5	0·02	0·35	1(b)
395	57·1	527	58	51·5	0·044	0·1	1(b)
MAR. 230	58·8	464	56	48	0·02	0·11	2
204	48·4	429	42	39·5	0·08	0·05	1(c)
214	52·3	350	38	38	0·03	0·05	1(a)
216	44·7	455	47	39	0·049	0·06	2
207	49·5	530	50	46·5	0·06	0·09	1(a)
AIR. 352	60·2	464	58	48·5	0·0015	0·55	2
332	60·5	459	57	48·5	0·005	0·61	2
T.D. 789	60	450	-	-	0·22	0·46	2
MAR. 231	51	532	-	-	0·024	0·35	2 ?
250	51	-	-	-	0·03	0·17	-
215	48·4	496	-	-	0·03	0·03	2 ?
109	58·2	428	-	-	0·019	0·12	1(a)
172	51·9	425	-	-	0·0011	0·097	2 ?
171	51·9	432	-	-	0·004	0·1	2 ?
241	56·7	-	-	-	-	-	-
MISC. 65	57·5	410	-	-	-	0·66	1(a)

* See summary.

APPENDIX I.

Fuel Sample.	Diesel Index.	M.B.P. ° F.	Cetane No.	Cetane No. Calcd.	Phenol Content. %	Sulphur Content. %	Classification. *
MECH. 113	52	428	39	41.5	-	0.04	1(a)
10	53	524	52	43	0.01	0.4	2
7	59.5	536	56	54	0.003	0.95	1(a)
MAR. 79	44.3	456	42	39	1.47	0.044	1(c)
41	60.3	468	52	49	-	0.34	1(a)
38	48.9	475	45	43	0.33	0.14	1(a)
23	42	543	44	42	-	0.92	1(a)
22	41	544	40	41	-	0.975	1(a)
21	56	525	54	50	-	0.745	1(a)
50	44	630	46	48	0.0005	0.07	1(a)
10	52	518	49	47	-	0.54	1(a)
1	53	525	45	49	0.0014	0.27	1(a)
15	54.3	527	53	49.5	0.0074	0.57	1(a)
3	58.5	543	54.5	54	0.0088	0.31	1(a)

* See Summary.

1st June, 1944.

DEPARTMENT OF OIL ENGINEERING AND REFINING.

UNIVERSITY OF BIRMINGHAM.

REPORT ON

IDENTIFICATION OF NAVY DIESEL FUELS.

F. H. Garner.

A. Winward.

Report No: E.F.3.

Copy No:

1st June, 1944.

SUMMARY.

Enemy diesel fuels may originate from:-

(a) Petroleum.

(b) Brown Coal Tar.

(c) Hydrogenated Brown Coal Tar.

(d) Bituminous Coal Tar (low temperature or hydrogenated).

(e) Shale Oil.

and (f) Fischer Tropsch Oils.

A chart has been constructed relating diesel-index, cetane number and mid-boiling point for diesel fuels of different origins, enabling classification to be made as

(1) Mainly or wholly of petroleum origin.

or (2) Either (b), (c), (d) or (e) are present in appreciable proportions.

Using this chart, 35 enemy diesel fuel samples from July, 1942 to April, 1944 have been classified as follows:-

1. (a) 14 are wholly or mainly of petroleum origin.

(b) 3 may be derived from bituminous coal tar - otherwise they are of petroleum origin.

(c) 5 contain petroleum and also indicate the presence of shale oil distillate or Fischer-Tropsch gas oil.

2. (a) 11 contain brown coal tar distillate, 7 of which may contain the hydrogenated product, while 2 probably consist of brown coal tar distillate blended with a volatile Fischer-Tropsch oil.

(b) 2 contain shale oil distillate or possibly Fischer-Tropsch oil.

Mobile and Base Laboratories.

The tests to be carried out by mobile and base laboratories are enumerated. A second chart is presented, to be used by mobile laboratories, based only on diesel-index and mid-boiling point measurements enabling a selection to be made of diesel fuel samples to be sent to base for cetane number determinations and classification. It is designed so that, whilst restricting the number of fuel samples to be sent to base, enough data will be accumulated to detect future variations in the origins of enemy diesel fuels.

CONSTRUCTION OF THE CHART.

This was based on an examination of test data from the literature for diesel fuels from petroleum (100), shale oil (12), low temperature tars (12) and brown coal tars (62).

Diesel Fuels from Petroleum.

Cloud gave the formula:-

$$\text{Cetane number} = \frac{\text{DI} \times \text{MBP}^{\circ}\text{F.}}{790} + 13, \text{ based on}$$

a wide range of petroleum diesel fuels. This served as a basis for the lines drawn on the chart (Figure 1) connecting diesel-index and mid-boiling point for cetane numbers 30 to 60. This relationship was taken as typical of petroleum fuels and was checked with a wide range of products, 100 in number. Examination of the deviation from actual values show the probable error given by this formula is about 4 cetane units. Further, 99 of the petroleum oils examined lay above the line BC - shown in Figure 1, so that enemy fuel samples falling below this line are not likely to be/of petroleum origin.
entirely

Diesel Fuels from Brown Coal Tar.

Data for 62 brown coal tar oils were obtained from Brennstoff-Chemie(1), all of which lay within a well-defined zone bounded by the lines DE and FG in Figure 1. Also it was found possible to drawn cetane lines for these products ranging from cetane numbers of 37·5 to 47·5 within this zone. The probable error is 2 cetane units; that is the cetane numbers for brown coal tar diesel fuels can, by these lines, be related more accurately to diesel-index and mid-boiling point than the cetane numbers for petroleum fuels using cetane lines based on Cloud's formula (above).

It is evident that oils which fall in the zone between BC and DE are probably blends of brown coal tar with petroleum or other fuels, but that blends of such products will also be found above BC. The cetane number may be used, as shown later, to effect a further differentiation.

Diesel Fuels from Hydrogenated Brown Coal Tar.

Relations between mid-boiling point, diesel index and cetane number were found for only 5 hydrogenated brown coal tar products and these lie on the curve HI (Figure 1). The cetane numbers of these fuels are higher than the corresponding petroleum fuels (as predicted by the Cloud formula) by 10 - 15 units.

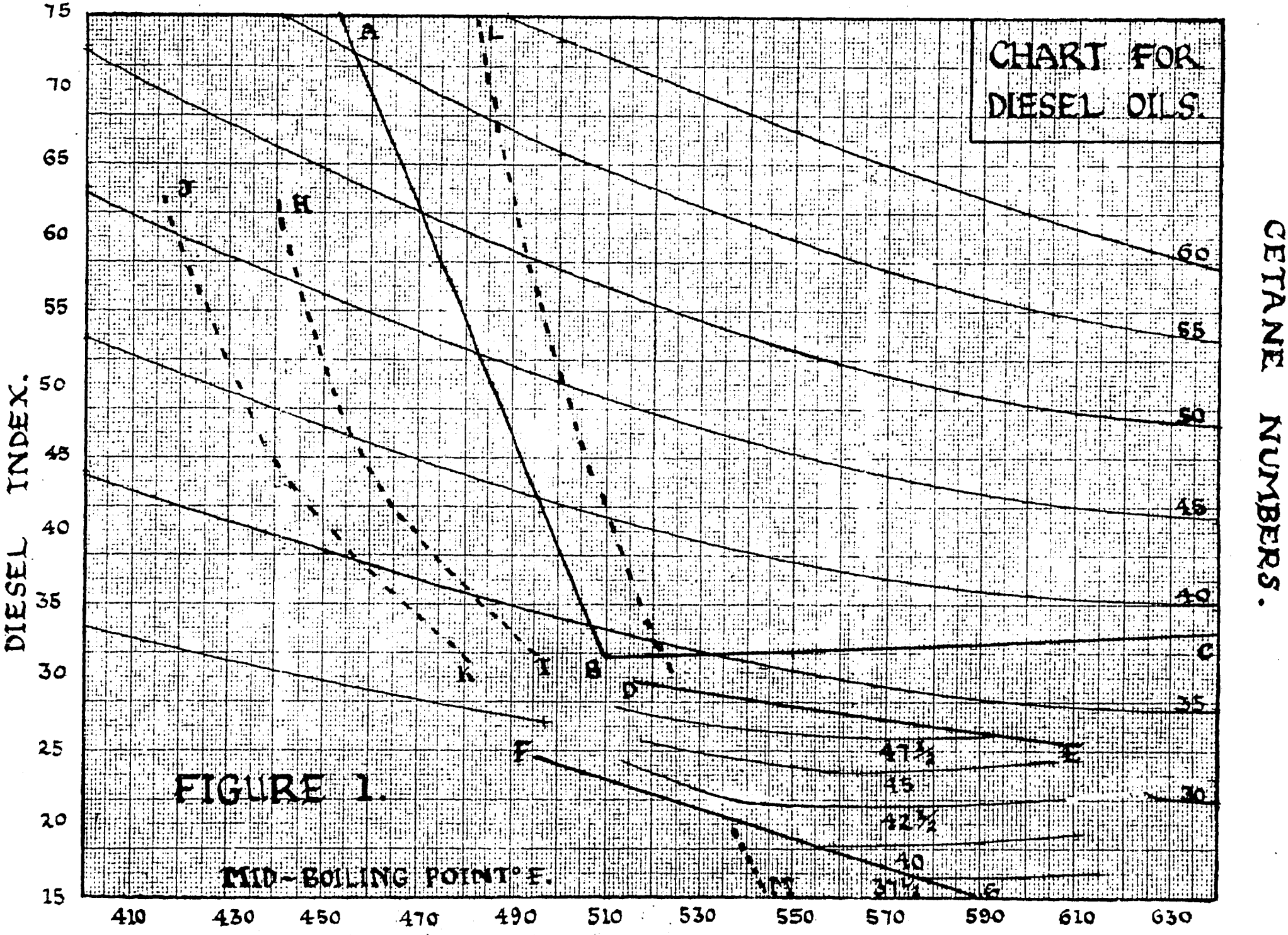


CHART FOR DIESEL OILS.
DIESEL INDEX.
CETANE NUMBERS.
MID-BOILING POINT° F.
A
B
C
D
E
F
H
J
K
L
60
55
50
45
40
35
30
47½
45
42½
40
37½
75
70
65
60
55
50
45
40
35
30
25
20
15
410
430
450
470
490
510
530
550
570
590
610
630

FIGURE 1.

Diesel Fuels from Low Temperature Bituminous Coal Tar.

A series of twelve values for the relevant properties of diesel fuel fractions from low temperature tars, hydrogenated and straight-run, were available(2,3,4). When plotted it was seen that the line JK in Figure 1 would represent a mean property curve. The cetane numbers for these products were similar to those for petroleum fuel, and the straight-run products would be distinguished from hydrogenated low temperature tars by high sulphur and phenol contents.

Note. (a) Cannel coals(5) were undistinguishable from the above.

(b) High temperature bituminous coal tar is of too poor ignition quality for diesel fuel without extensive treatment, so this source of enemy fuel has not been considered.

Diesel Fuels from Shale Oil.

Consideration of the properties of 12 fuel oils from shale(5,6), straight-run distillates and hydrogenated products, show that these lie in the neighbourhood of the line LM in Figure 1. Cetane numbers for these oils were consistently higher than the corresponding petroleum product - by about 9 cetane numbers, as ~~shown on the dotted cetane lines cutting LM.~~

The Line AB and the '50' Cetane Line.

The line AB in Figure 1, has been inserted in order to effect some classification of the oils with respect to coal or petroleum origin, as shown later. Importance is attached to the '50' cetane line - it is considered that only fuels lying below this line may contain brown coal tar distillate (straight-run).

Fischer-Tropsch Oils and Brown Coal Tar Distillate.

Data from German literature has shown that Fischer-Tropsch diesel fuels have much higher cetane numbers than predicted by the Cloud formula for petroleum fuels, and this forms a basis for detecting those fuels containing Fischer-Tropsch oils.

The most likely blends containing Fischer-Tropsch oils to be used by the enemy are those with brown coal tar distillates and these only are considered in the following.

Such blends are unlikely to have cetane numbers higher than 60 for, assuming (1) a Fischer-Tropsch gas oil of cetane number 95 and brown coal tar diesel fuel of cetane number 42, and (2) a linear relationship for cetane addition, these would have to be blended in proportions of 30% to 70% respectively to give a cetane number of 58. There is some evidence however that

Fischer-Tropsch gas oil of 95 cetane number behaves as though it had a blending cetane number higher than 95, so that proportions lower than 30% of these oils are likely to be used by the enemy in blends with brown coal tar distillate.

Assuming this figure of 30% of Fischer-Tropsch gas oil in the blend, it can be shown that the diesel index of such a blend would be 49. By reference to Figure 1 it will be seen that a diesel index of 49 with a mid-boiling point of about 530° F. would fall well below the 50 cetane line. Thus, even when Fischer-Tropsch oil is blended with brown coal distillate, the fuels will lie below the 50 cetane line as mentioned under the immediately preceding heading.

Note. It is apparent that possible blends of petroleum and brown coal tar oils would fall well below the 50 cetane line.

THE USE OF THE CHART.

Primarily the actual cetane number for a sample is compared with that predicted from the diesel index/mid-boiling point relationship by the cetane lines on the chart. It must be borne in mind, however, that the probable deviation from these lines for petroleum oils is about ± 4 cetane units, and we have taken ± 5 as the outside limits for petroleum oils; for shale oils the cetane numbers are 9 above and brown coal tar products 10 - 15 cetane numbers above those for petroleum oils.

Then by the use of this chart (Figure 1), if the sample lies,

(a) in the zone ABC, and is no greater than 5 cetane units away from the cetane line according to Cloud's formula, it is probably mainly or wholly a petroleum product.

(b) to the right of AB and possesses a cetane number of 5 of more above the approximate cetane line, the sample probably contains a brown coal tar distillate or shale oil. However, if, in addition, it falls above the 50 cetane line, the latter possibility has been shown to be more probable, and iodine values for such fuels would confirm this or indicate the presence of Fischer-Tropsch oil blended with a petroleum oil.

(c) to the left of AB and possesses a cetane number of about 10 above the corresponding cetane line, it is probably derived from hydrogenated brown coal tar. It may however be a blend of brown coal tar and a more volatile product derived from Fischer Tropsch or petroleum provided that the cetane number is 5 or more/than the corresponding cetane line.
greater

(d) if, however, the sample lies to the left of AB and does not possess an anomalous cetane number, the line JK may serve as an indication of bituminous tar derivation, or the sample may simply be a more volatile petroleum product. Further differentiation, on the basis of phenol or sulphur (especially thiophenic) content, is necessary.

CLASSIFICATION OF ENEMY FUEL SAMPLES

JUNE, 1942 - MARCH, 1944.

Diesel indices, mid-boiling points and cetane numbers were available for 35 enemy fuel samples from June, 1942 to March, 1944. Test data are given in Table I ~~and plotted in Figure 3,~~ and show that only one sample, MISC.13, possesses a cetane number lower than that calculated for petroleum. Thus, in view of the high cetane numbers of brown coal tar products and shale oils, it may (on a statistical basis) be concluded that enemy diesel fuels show strong indications of the presence of non-petroleum products in many cases.

Using the chart (Figure 1) as explained, the following 13 fuel samples possess cetane numbers above 5 units greater than those indicated by the cetane lines for petroleum:-

MAR.230, 181A, 181B, 216, 175, 176, 192.

MECH.395, 315, 219A.

MISC.30, AIR.352 and 332.

These fuels are not wholly of petroleum origin, but may contain proportions of petroleum oil up to about 40%. The following Group A, taken from these samples, lie to the left of the line AB in Figure 1.

Group A.	Phenol Content. %	Sulphur Content. %	Cetane No. minus Cetane No. calcd.
MAR.230	0·02	0·11	8
181A	0·04	0·065	8
181B	0·026	0·045	6
216	0·049	0·06	8
175 or 176	0·092	0·067	6·5
192	0·03	0·02	5·5
AIR.352	0·0015	0·55	10·5
332	0·005	0·61	9·5

According to the chart, these 9 fuels probably contain hydrogenated brown coal tar, subject to the proviso that they may

be blends of brown coal tar distillate and a more volatile oil - petroleum or Fischer-Tropsch. It will be noted that the phenol and sulphur contents of this group show a rough correlation except in the case of the K.I. fuels, namely AIR.352 and 332, where the high sulphur contents do not suggest the presence of hydrogenated products. Hence of these 9 fuels:-

MAR.230-192 - probably contain appreciable quantities of hydrogenated brown coal tar oil,

and AIR.352 with 332 - are probably blends of brown coal tar distillate with a volatile Fischer-Tropsch (or possibly petroleum) oil.

The remaining 4 fuel samples, Group B, lie to the right of the line AB, and hence may contain either shale oil or brown coal tar distillate. The possibility of blends of Fischer-Tropsch oils and petroleum must, however, be borne in mind, for such blends would also possess anomalous cetane numbers.

Group B.	Phenol Content. %	Sulphur Content. %	Cetane No. minus Cetane No. calcd.
MECH.395	0·044	0·1	6·5
315	0·011	0·05	7·5
219A	0·00015	0·05	5·5
MISC.30	0·005	0·03	12

MECH.395 and 315 lie above the 50 cetane line and probably do not contain brown coal tar distillate as explained previously. It seems likely that they contain shale oil distillate blended with a petroleum gas oil. Iodine values are to be obtained on these samples and may supply positive proof, otherwise appreciable quantities of Fischer-Tropsch oil are present.

MECH.219A and MISC.30 fall below the 50 cetane line and it is probable they are blends containing brown coal tar distillate or shale oil. However, the sulphur contents of these two samples are characteristic of brown coal tar distillate only, but so they have been classified as such. Iodine values would again afford additional confirmation.

The remaining 22 enemy fuel samples possess cetane numbers approximating within the limit of 5 cetane units to those predicted by Cloud's formula, and consequently it may be said that the majority of these samples are substantially, if not

wholly, of petroleum origin. However, the following samples, Group C, lying in the region JK of the chart, may, while not possessing anomalous cetane numbers, contain derivatives from bituminous coal tar.

Group C.	Phenol Content. %	Sulphur Content. %
MAR.204	0·08	0·05
MISC.10	-	0·08
MISC.42	0·37	1·70

Further, the following 5 samples, in Group D, possess cetane numbers 3·5 - 5 units greater than those calculated by Cloud's formula for petroleum products, and they all lie above the 50 cetane line in Figure 1.

Group. D.	Phenol Content. %	Sulphur Content. %	Cetane No. minus Cetane No. calcd.
MECH.394	0·02	0·35	4·5
361	0·008	0·11	4·5
219B	0·74	0·27	3
218	0·011	0·80	4·5
335	0·018	0·23	5

Consequently it is considered possible that these 5 fuels may be blends of petroleum gas oil with shale oil or Fischer-Tropsch gas oil. Iodine values would assist again in differentiating between these possibilities, and it will be noted that the sulphur contents of these fuels preclude the possibility of Roumanian origin, except in the case of MECH.361.

The chart then, has enabled the following classification for the enemy fuel samples:-

1. (a) 14 are wholly or mainly of petroleum origin.

   (b) 3 may be derived from bituminous coal tar - otherwise they are of petroleum origin.

   (c) 5 contain petroleum but possibly proportions of shale oil distillate or Fischer-Tropsch gas oil are present.

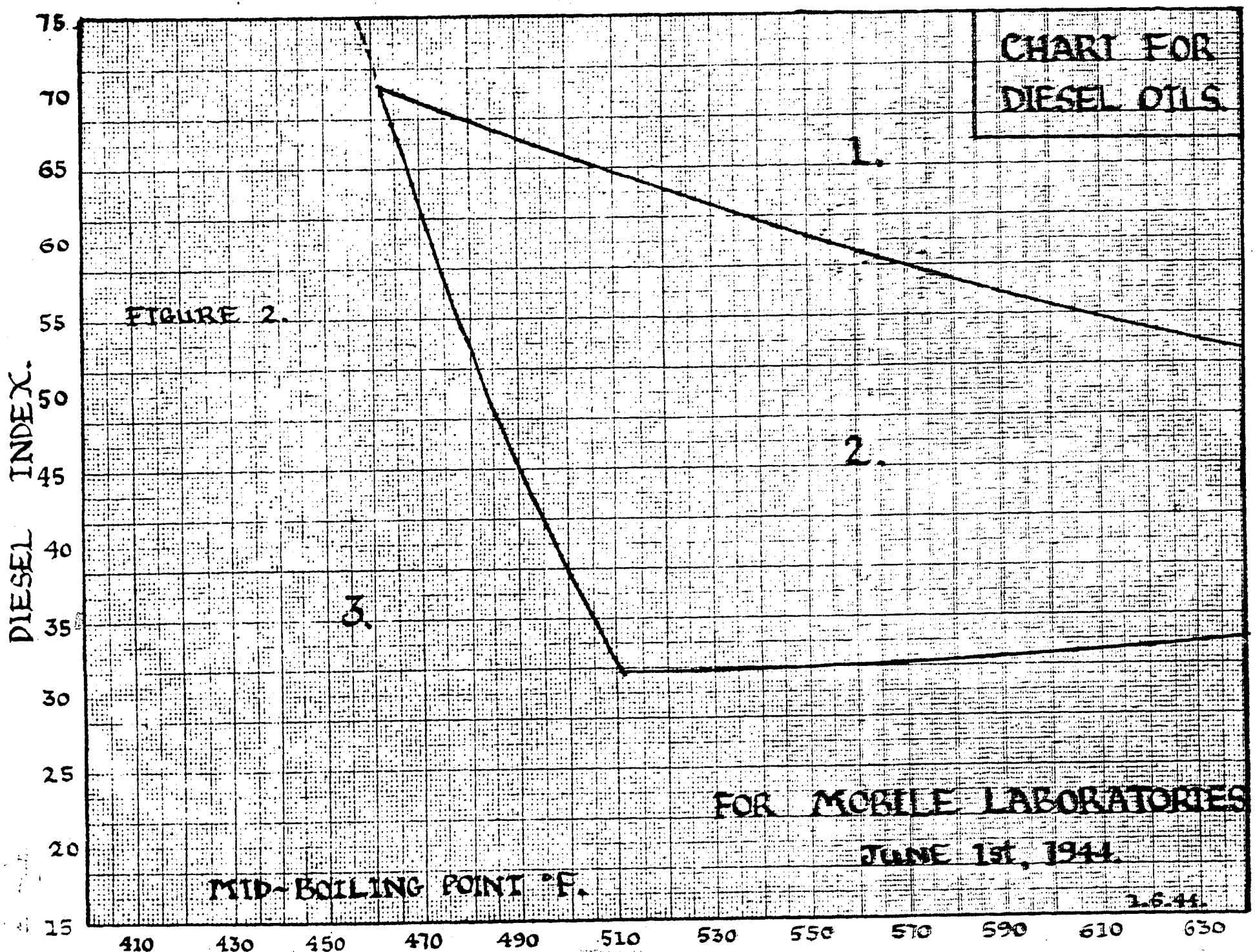


CHART FOR
DIESEL OILS.
1.
2.
3.
FIGURE 2.
DIESEL INDEX.
75
70
65
60
55
50
45
40
35
30
25
20
15
410
430
450
470
490
510
530
550
570
590
610
630
MID-BOILING POINT °F.
FOR MOBILE LABORATORIES
JUNE 1st, 1944.
2.6.44.

FOR MOBILE LABORATORIES.

The following list of tests probably represents the minimum which can be made in the mobile laboratories to characterise diesel fuels.

(a) Specific Gravity.

(b) Colour and Odour. By inspection only, i.e. colour whether light or dark, transparent or opaque, or odour, whether phenolic, etc.

(c) Aniline Point.

(d) Distillation Range.

(e) Diesel-Index obtained from (a) and (c)

All evidences of contamination and possible weathering should be noted for each sample tested. Diesel-index is then plotted on the simplified chart (Figure 2).

On Figure 2, three coloured zones are shown, red, blue and yellow. The following number of samples should be despatched for further examination at the base laboratory.

(1) Red zone - all samples.

(2) Blue zone - one sample in three.

(3) Yellow zone - all samples

These zones have been drawn to restrict the number of samples to be sent to base laboratories for further examination; most of the diesel fuel samples received to date have been in the blue zone and it is suggested that only one third of these are now required for further examination. Any future varieties with respect to origin of enemy diesel fuels should be brought to light by this chart, but the suggestion of one-third of the samples in the blue zone to be sent to base may require alteration as further samples are examined.

FOR BASE LABORATORIES.

The further tests required at base laboratories are:-

(1) Cetane Number.

(2) Sulphur Content.

(3) Phenol Content.

(4) Iodine Number (to detect shale and Fischer Tropsch oils).

(5) Cloud and Pour Points.

The above data for each fuel sample used in conjunction with Figure 1 will enable a satisfactory classification to be made with respect to origin. Rough distillation and examination of the various cuts may however be necessitated by certain possible blends before any definite conclusions can be drawn as to their nature.

TABLE I.

Fuel Sample.	Diesel Index.	M.B.P. ° F.	Cetane No.	Cetane No. Calcd.	Phenol Content. %	Sulphur Content. %	Classification. *
MECH.394	56·8	521	55	50·5	0·02	0·35	1(c)
395	57·1	527	58	51·5	0·044	0·1	2(b)
361	61·1	545	60	55·5	0·008	0·11	1(c)
353	47·0	556	48	46	0·01	0·12	1(a)
382	54·5	464	47	45	0·58	0·04	1(a)
335	57·8	540	58	53	0·018	0·23	1(c)
315	58·0	509	58	50·5	0·011	0·05	2(b)
285	49·5	543	48	47	0·0014	0·21	1(a)
238	51·8	480	48	44	0·25	0·064	1(a)
219B	57·7	543	56	53	0·74	0·27	1(c)
219A	50·3	545	53	47·5	0·00015	0·05	2(a)
218	61·4	545	60	55·5	0·011	0·80	1(c)
217	58·8	535	53	53	0·046	0·16	1(a)
MAR. 230	58·8	464	56	48	0·02	0·11	2(a)
204	48·4	429	42	39·5	0·08	0·05	1(b)
214	52·3	370	38	38	0·03	0·05	1(a)
216	44·7	455	47	39	0·049	0·06	2(a)
207	49·5	530	50	46·5	0·06	0·09	1(a)
190	44·3	433	42	37	0·11	0·01	1(a)
192	46·0	428	44	38·5	0·03	0·02	2(a)
209	50·6	467	47	43	0·03	0·06	1(a)
92	54·0	498	50	47	0·065	0·14	1(a)
181A	60·5	464	56	48·5	0·04	0·065	2(a)
181B	61·4	454	54	48	0·026	0·045	2(a)

* See Page 7.

Fuel Sample.	Diesel Index.	M.B.P. ° F.	Cetane No.	Cetane No. Calcd.	Phenol Content. %	Sulphur Content. %	Classification. *
MAR. 175	53·5	480	52	45·5	0·092	0·066	2(a)
176	53·6	480	52	45·5	0·092	0·067	2(a)
AIR. 352	60·2	464	58	48·5	0·0015	0·55	2(a)
332	60·5	459	57	48·5	0·005	0·61	2(a)
MISC. 42	33·0	452	34·5	32	0·37	1·7	1(b)
29	47·5	507	47	43·5	0·01	0·06	1(a)
30	49·5	513	57	45	0·003	0·03	2(a)
10	42·4	441	38·5	37		0·08	1(b)
11	50·5	543	47	47		0·06	1(a)
13	46·5	486	40	41·5		0·27	1(a)
15	46·4	461	42	40·5		0·07	1(a)

* See Page 7.

REFERENCES.

(1) Brennstoff-Chemie, 17, 442 (1936); 19, 87 (1938)

(2) Fuel Research Board Reports, March, 1939, Page 136.

(3) Fuel Research Board Reports, March, 1937, Pages 124-125.

(4) Brennstoff-Chemie, April 15, 1938, Pages 137-156

(5) Oil Shale and Cannel Coal, Page 402.

(6) Institute of Fuel XXIII, No: 1.

REPORT FOR ENEMY OILS AND FUELS COMMITTEE.

Analysis of AIR.368 - a K.1 Fuel.

Summary.

AIR.368, a K.1 fuel, contains about equal proportions of Fischer-Tropsch oil and brown coal tar distillate; the approximate boiling ranges (I.P.T.) being respectively 155° - 235° C., 235° - 355° C.

The use of these components has thus resulted in a high quality diesel fuel of low pour point suitable for low-temperature, high-altitude performance.

Routine Tests.

The results of routine tests on the sample are given in Table I.

Fractionation.

800 ccs. was roughly fractionated under 5 to 10 m.ms. mercury pressure into 10% fractions.

General Observations.

Burning tests were carried out on the 9 distillate fractions. The first four burned with a paraffinic flame, while the last four fractions gave a smoky, aromatic flame.

The characteristic odour of this K.1 fuel was mainly concentrated in the first cut, and was not removed by refluxing with 40% aqueous KOH solution for 30 minutes. The first cut decolourised potassium permanganate and bromine solutions immediately. The odour appears to be characteristic of Fischer-Tropsch products.

Analysis of Fractions.

The following tests were carried out on the 10% cuts.

(1) Cold test ° C.

(2) Aniline point ° C.

(3) Refractive index 20° C.

(4) Specific Gravity 30° C./20° C.

(5) Sulphur Content.

(6) Bromine and Iodine Values.

Refractive indices were determined by sodium light at 20° C. using a Pulfrich, sulphur contents by the lamp method, and bromine and iodine values by the methods of Francis and Hanus, respectively. Cold tests were made by cooling to the temperature at which a cloud appeared; with the first five fractions, fine crystals were formed.

The data obtained follow in Table II, and are plotted in Figure 1. Check determinations were carried out following two repeat fractionations.

The results show conclusively that the K.1 fuel AIR.368 is a blend of two oils of widely differing types. The bromine number of the more volatile part of the blend AIR.368, corresponds to 15% unsaturates; when this is considered in conjunction with the low sulphur content, i.e. 0·02%, and the low cold test, the possibility of it being a normal petroleum gas oil is precluded. The relatively high unsaturation precludes a hydrogenated product but is in accord with published information of Fischer-Tropsch oils. The physical properties, refractive index, specific gravity, aniline point and cold test are in accord with what would be expected from mixtures of n-paraffin and n-olefine hydrocarbons of the same boiling point. The odour lends support to this fraction being derived from Fischer-Tropsch synthesis. This fraction may have been dewaxed, although the setting point of undecane, B.P. 196° C., is -26° C. which is higher than that of the corresponding fraction of this boiling point for K.1. Thus the removal of paraffins by dewaxing might account for these low cold tests. The relatively high specific gravity and refractive index of the less volatile constituent show the presence of considerable proportions of cyclic hydrocarbons, while the cold tests are low for a petroleum product.

The following conclusion may thus be drawn as to the nature of the K.1. fuel of which AIR.368 is an example.

It is a blend of volatile fractions of Fischer-Tropsch oil with a less volatile fraction possibly of petroleum origin.

Since the above work was completed, a report of the examination of K.1 fuel by the Sinclair Refining Co. Engine Laboratory has been received, dated April 22nd, 1944.

The results confirm our examination, the conclusions reached in the Sinclair report being:-

(1) The fuel appears to be a 50/50 blend of high and low cetane material.

(2) No pour depressants or ignition quality improvers appear to be present.

(3) K.1 fuel is of excellent quality as measured by any U.S. diesel fuel specifications, and this fuel would be difficult to duplicate commercially by current methods of refining in the U.S. and in particular to duplicate the low pour point without pour depressants.

The cetane number of the 50% fraction is calculated as 61 from the Sinclair report, which is lower than that of the normal Fischer-Tropsch fuel, but this may be due to its higher volatility.

8th June, 1944.

Department of Oil Engineering
and Refining,
The University of Birmingham.

TABLE I.

Routine Tests Carried Out on AIR.368.

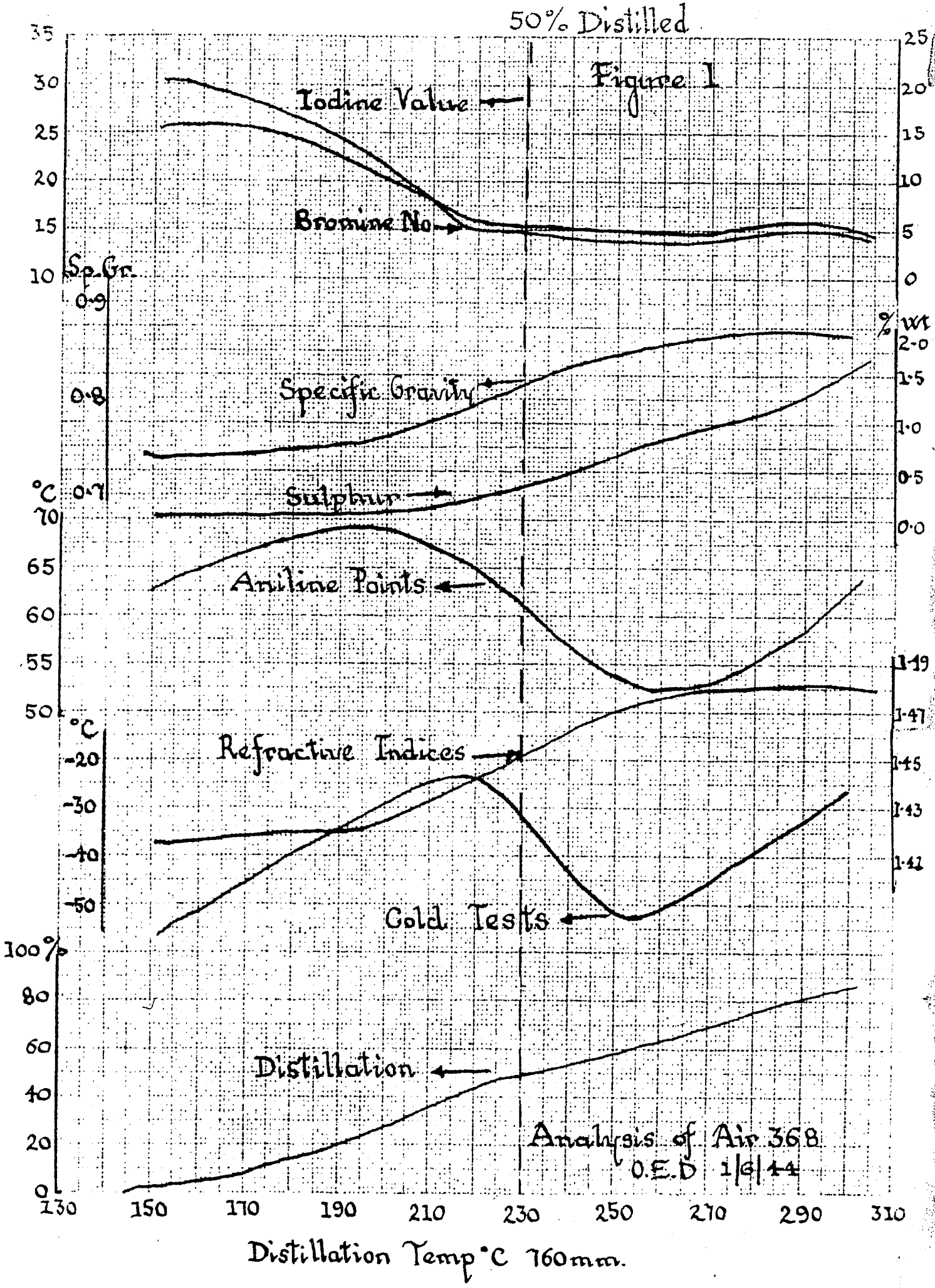
Specific Gravity/60° F.	0·8165
Cold Test.	-55° C.
Aniline Point.	63·2° C.
Sulphur Content.	0·57%
Bromine Number (Francis')	8·9
Distillation.	
Initial Boiling Point.	152° C.
160° C.	2%
180° C.	9%
200° C.	24%
220° C.	40%
240° C.	52%
260° C.	61%
280° C.	72%
300° C.	84%
320° C.	92%
340° C.	96%
Final Boiling Point.	354° C.
Recovery.	98·5%
Residue.	1·5%

TABLE II.

Cut.	Volume. cc.	I.B.P. corrd. to 760 mm. °C.	Cold Test. ° C.	Aniline Points. ° C.	Specific Gravity. 20° C.	Sulphur. %	Bromine No. *	Iodine Value.+	Refractive Index. n_D^{20}
1	80	144	-54	65·7	0·7380	0·024	15·8	30·3	1·4160
2	82	171	-40	68·6	0·7453	0·033	14·1	26·6	1·4185
3	80	189	-31	69·8	0·7548	0·055	11·6	22·5	1·4240
4	80	201	-29	69·7	0·7721	0·146	8·2	17·5	1·4318
5	80	214	-21	65·3	0·8005	0·273	5·5	15·3	1·4463
6	80	230	-44	57·5	0·8352	0·504	5·3	14·1	1·4643
7	80	249	-51	54·8	0·8559	0·83	4·2	14·3	1·4764
8	82	268	-40	55·4	0·8649	1·03	5·3	13·0	1·4819
9	80	312	-28	65·3	0·8657	1·81	5·5	14·3	1·4814
10	72	-	-	-	0·8925	1·1	8·3	15·3	-

* Francis.

\+ Hanus.


50% Distilled
Figure 1
Iodine Value
Bromine No
Sp. Gr.
0·9
0·8
0·7
Specific Gravity
% wt
2·0
1·5
1·0
0·5
0·0
Sulphur
°C
70
65
60
55
50
Aniline Points
1·49
1·47
1·45
1·43
1·41
°C
-20
-30
-40
-50
Refractive Indices
Cold Tests
100%
80
60
40
20
0
Distillation
Analysis of Air 368
O.E.D 1/6/44
130
150
170
190
210
230
250
270
290
310
Distillation Temp °C 760mm.

A.I. 2G.

AIR MINISTRY

CONFIDENTIAL 22nd September 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 402 (received through Ministry of Aircraft Production - Ref.: RDE/F/AB10A/EFC)

Stated to be M.T.FUEL (coloured red) captured in the Cherbourg Peninsula

Analysis by The Petroleum Board, Vauxhall

Appearance	Slightly cloudy
Specific Gravity	.7638
Colour	Pale greenish pink with a green bloom
Distillation - I.B.P.	46°C
Recovery at 70°C	8%
75°C	12%
100°C	43%
105°C	49½%
140°C	82%
150°C	87%
F.B.P.	179°C
Total Recovery	98%
Residue	1%
(Gum (I.P.)	1.0 mg.
(Oil	6.0 mg./100 mls.
Lead Content	5.91 mls.T.E.L./I.G.
Sulphur	0.03%
Octane Number	92 Octane
Sediment	Slight trace
Bromine Number	7.9

Hydrocarbon Analysis

Aromatics	33.5%
Paraffins	41.6%
Naphthenes	20.5%
Unsaturateds	4.4%

This differs from previous German Aviation Gasolines in respect of colour and aromatic content. The latter and the octane rating are intermediate between the blue and green fuels. Lead content is above the average.

S.J.M.Auld
Chairman,
for the Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House, W.C.2.

CONFIDENTIAL 22nd September 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 397 (received through Air Ministry, A.I.2.(g))

PETROL from a F.W.190 (BMW 801 engine) which crashed at Les Veys 12.7.44

Analysis by The Petroleum Board, Vauxhall

Size of Sample .....Approx.	4-glns.
Specific Gravity	.7740
Colour	Green
Distillation - I.B.P.	47°C
Recovery at 70°C	7%
75°C	10%
100°C	36%
105°C	41½%
140°C	78%
150°C	85%
F.B.P.	184°C
Total Recovery	98%
Residue	1%
Freezing Point	Below -50°C
Vapour Pressure (lb./sq.in.) ...	5.0
Total Sulphur	0.01%
Existent Gum (mg./100 mls.)	2.0
Lead Content (mls.T.E.L./I.G.)..	5.75
Octane Number	96
Octane Number of Base Fuel	84
Bromine Number	2.0
Hydrocarbon Analysis	
Aromatics	47.6%
Paraffins	43.2%
Naphthenes	9.2%
Unsaturateds	-
Individual Aromatics	
Benzene	4.0%
Toluene	12.5%
Xylenes	17.0%
Higher Aromatics	14.0%
Water Solubles	Nil
Phenols	Nil
Iron Carbonyls	Nil
Aromatic-Free and De-leaded Fuel	
Octane Number	72½
Aniline Point	66.0°C
Specific Gravity	.7070

This sample is similar to AIR 396. It has rather higher aromatics than previous German green C.3.fuels.

C.Chilvers
Secretary
for Chairman, Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
Strand, W.C.2.

A.I. 2G.

CONFIDENTIAL 15th September 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 396 (received through U.S.Embassy)

German AVIATION GASOLINE from USAAF in Normandy taken from an auxiliary jettisonable fuel tank dropped in the Carentan area. The tank was one of four which were damaged, all of which burst upon impact with the ground. Tanks of usual 75 U.S. gall. or 285 litres. Only 2½ galls. obtained.

Analysis by The Petroleum Board, Vauxhall

Specific Gravity .....Approx.	.7763
Colour	Green
Distillation - I.B.P.	50°C
Recovery at 70°C	6%
75°C	9%
100°C	35%
105°C	41½%
140°C	78%
150°C	85%
F.B.P.	177°C
Total Recovery	98%
Residue	1%
Sulphur	0.02%
Lead Content (mls.T.E.L./I.G.) ...	5.96
Bromine Number	1.2
Gum (mg./100 mls.)	1.4
Octane Number	95
Octane Number of Base Fuel (Lead free)	82
Octane Number (Lead and Aromatic free)	75

Hydrocarbon Analysis

Aromatics	47%
Paraffins	39.8%
Naphthenes	13.2%
Unsaturateds	Nil

Although generally similar to the German Green C.3 Fuel it has been noted that both the lead content and the content of aromatics are higher than usual.

S.J.M.Auld
Chairman,
for the Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
Strand, W.C.2.

CONFIDENTIAL 15th September 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 399

German AVIATION FUEL ex Me.109 G6/U4, DB 605A engine, crashed at T 627 627. Taken from main fuel tank. Date of sampling 31.7.44. Tank from which sample taken undamaged.

Analysis by The Petroleum Board, Vauxhall

Specific Gravity @ 60°F	0.7576
Colour	Blue
Distillation - I.B.P.	66°C
Recovery at 75°C	2½%
100°C	42½%
150°C	93½%
F.B.P.	162°C
Total Sulphur	0.01%
Lead Content	7.0 mls.T.E.L./I.G..
Octane Number	88
Octane Number of Base Fuel	68
Bromine Number	2.7
Hydrocarbon Analysis	
Aromatics	16.4%
Paraffins	21.4%
Naphthenes	62.2%
Aromatic Free and Deloaded Fuel	
Aniline Point	54.6°C
Octane Number	65

The tests are abnormal and the sample is undoubtedly weathered. It is to be noted that in any case there is a particularly high proportion of naphthenes - higher than any figure previously reported.

S.J.M.Auld
Chairman,
for the Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
W.C.2.

CONFIDENTIAL 10th August 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 395 (received through Air Ministry, A.I.2.(g) - Ref.: 2G/Gen.16/P)

LUBRICATING OIL taken from a Macchi 205 aircraft fitted with a DB.605A engine, which crashed at Bovinco airfield on 28.5.44.

Analysis by Shell Marketing Co., Ltd., Fulham

Size of Sample .....Approx.	½-pint
Appearance	Used oil - containing carbonaceous sediment and a little free water.
Dilution (gasoline)	1% vol.

Oil after removal of diluent and sediment

Appearance	Dark red oil with green bloom.
Specific Gravity	0.894
Kinematic Viscosity @ 100°F	261.6 c.s.
210°F	20.56 "
Viscosity Index	99
Saponification Value (mg.KOH/gm.)	Less than 0.1

AIR 395 is a used oil of the uncompounded, high V.I. type, and similar to many German aero oils previously examined.

S.J.M.Auld
Chairman,
for the Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
Strand, W.C.2.

1630

CONFIDENTIAL 4th August 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 398 (received through Air Ministry, A.I.2.(g))

FUEL from tank of FLYING BOMB crashed at Southborough 28.7.44

Analysis by The Petroleum Board, Vauxhall

Size of Sample .....Approx.	450-ml.
Specific Gravity	.7545
Colour	Yellowish Green
Distillation - I.B.P.	58°C
Recovery at 70°C	4%
75°C	6%
100°C	30%
105°C	37%
140°C	74%
150°C	82%
F.B.P.	182°C
Total Recovery	96½%
Residue	2½%
Freezing Point	-50°C
Vapour Pressure	-
Sulphur	0.34%
Existent Gum (mg./100 mls.)	32.6
Lead Content (mls.T.E.L./I.G.) ...	3.89
Octane Number	75
Bromine Number	26
Neutralization Value (mg.KOH/gm.).	0.037
Hydrocarbon Analysis	
Aromatics	18.5%
Paraffins	43.0%
Naphthenes	22.5%
Unsaturateds	16.0%

This petrol is a leaded fuel of the motor transport type though both the lead content and the octane number are higher than normal by comparison with previous German M.T.fuels. It is possible that the high lead content and octane number are due to partial weathering of a fuel of particularly high initial lead content. The usual lead content of German motor fuels is 1.5/2.0 ccs. per Imperial gallon, but figures as high as 2.5 ccs. have been obtained.

The abnormally high sulphur content may indicate the original presence of shale spirit and the high specific gravity tends to support this suggestion.

The high Existent Gum Content is to be noted and this suggests that the enemy is using up spirit unsuitable for normal use in ground equipment.

The tests on this sample are different from those reported indirectly through A.I.2.(g) on a sample obtained prior to the opening of the Flying Bomb attack on the U.K. An analysis of the latter sample was reported indirectly through A.I.2.(g), having been examined at the request of M.A.P. on 6th June 1944 by Esso European Laboratories. The analysis was as follows:

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ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 398 - continued

Specific Gravity	.745
Distillation - I.B.P.	59°C
Recovery at 70°C	1.5%
100°C	52.5%
150°C	96%
F.B.P.	156°C
Lead Content	3.12
Aniline Point before sulphonation	48.1
" " after sulphonation	52.9
Calorific Value - Gross	20,139
Net.	18,740

Hydrocarbon Analysis

Aromatics	5.3%
Unsaturateds	1.4%

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Chairman,
for the Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
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W.C.2.

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Sample No. AIR 382 (received through R.A.E., Farnborough - Ref.: Corres. EA/127, W.O. No.720, P.N.No.73)

GREASE from He.177 crashed at Yoxford, Suffolk, on 22/23 February 1944. The grease is used instead of oil as the energy absorbing medium in the undercarriage shock absorbers.

Analysis by Vacuum Oil Company, Ltd., Wandsworth

Size of Sample .....Approx.	½-lb.
Appearance	Soft unused grease. Bluish green tinge. Lime base.
Melting Point	87°C
Penetration (Worked) @ 77°F	225
Sodium Soap	-
Calcium Soap	16.8%
Mineral Oil and Unsaponifiables ..	380.5%
Free Fatty Acid	-
Impurities	-
Water Content	1.0%
Resistance to Heat	Poor
Characteristics of Mineral Oil	
Specific Gravity	0.865
Saybolt Universal Visc. @ 100°F ..	79.1"
130°F ..	-
210°F ..	37"
Cold Test	+30°F
Characteristics of Separated Fatty Acids	
Melting Point	110°F
Iodine Value	16.7
Refractive Index @ 70°C	1.430

This is a calcium base grease with a light viscosity oil and soap from fatty matter of fairly high saturation. It is dyed blue.

As a lubricating grease it would be of poor quality, but for its purpose as a shock-absorber filling is likely to be satisfactory.

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4th August 1944

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ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 382 (received through R.A.E., Farnborough - Ref.: Corres. EA/127, W.O. No.720, P.N.No. 73)

C O R R E C T I O N

For: Mineral Oil and Unsaponifiables .. 380.5%

Read: " " " " .. 80.5%

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1620

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Sample No. AIR 389 (received through Ministry of Economic Warfare - Ref.: AC 220)

German AVIATION SPIRIT as used at the Kastrup Aerodrome in Denmark

Analysis by The Petroleum Board, Vauxhall

Size of Sample ..... Approx.	11 mls.
Specific Gravity	.735
Colour	Blue
Distillation (on 5 mls.) - I.B.P..	45°C
20% recovered at	72°C
40% " "	92°C
60% " "	105°C
80% " "	126°C
End Point	140°C
Aniline Point	47.8°C
Bromine Number	1.6
Lead	Present

This appears to be a typical German blue fuel.

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Samples Nos. AIR 378, AIR 379, AIR 380, AIR 381.
AIR 384 (drawn by The Petroleum Board under instructions from R.A.F. 67 M.U., Taunton, April 1944.

AIR 378 - USED OIL from undamaged engine of Ju.88 A-4 Trop. PL.1214, Jumo 211 J-1, Eng.Nos.Port 4755, Starboard 1061302465, shot down at Bradwell Bay, Essex, 19.4.44. Tank from which sample taken undamaged.

AIR 379 - UNUSED OIL from Port Wing (Reserve) of Ju.88 A-4 Trop. PL.1214, Jumo 211 J-1, Eng.Nos.Port 4755, Starboard 1061302465, shot down at Bradwell Bay, Essex, 19.4.44. Tank from which sample taken undamaged.

AIR 380 - HYDRAULIC FLUID from Ju.88 A-4 Trop. ditto. ditto. Tank from which sample taken damaged.

AIR 381 - COOLANT from Ju.88 A-4 Trop. ditto. ditto. Tank from which sample taken damaged.

AIR 384 - ENGINE OIL ex Ju.88. (No further details received.)

Analyses by Shell Marketing Co., Ltd., Fulham

The Used Engine Oils (AIR 378 and AIR 384) are very similar in properties; their characteristics after removal of the diluent and sediment suggest that the oils are of the uncompounded, high V.I. type, probably solvent-extracted oils.

The Unused Engine Oil (AIR 379), although from the same aircraft as the Used oil (AIR 378), is of a different type. The oil contains a proportion of diluent apparently less volatile than a gasoline diluent and the diluent-free oil has a lower specific gravity, viscosity, coke number and pour point than those of the Used oil (AIR 378). The oil evidently contains no Bright Stock and its low specific gravity and other physical properties suggest the presence of synthetic lubricating oil.

AIR 380 is a light compounded Hydraulic Fluid similar to AIR 376, and AIR 381 (Engine Coolant), is an aqueous soluble oil emulsion containing approximately 4% vol. of oil, as judged from the small sample submitted (11 ml.).

	AIR 378	AIR 384	AIR 380
Size of Sample .....Approx.	2-glns.	2-glns.	3 qts.
Diluent (Gasoline)	2.0% vol.	1.7% vol.	-
Sediment insoluble in I.P.spirit	0.79% wt.	0.83% wt.	-
Ash (sulphated)	0.22% wt.	0.29% wt.	-
Nature of Ash	Chiefly lead sulphate, some iron compounds also present.		
	Tests on diluent- and sediment-free oils.		
Appearance	Dark red oil, dark green bloom.	Dark red oil, dull green bloom.	Cloudy light red oil, strong apple-green fluorescence.
Specific Gravity	0.892	0.889	0.862
Viscosity:			
Kinematic @ 32°F (C.s.)	-	-	17.5
100°F "	246.2	283.5	4.90
140°F "	-	-	3.08
210°F "	21.16	21.90	1.65
Saybolt Universal @ 100°F (Secs.)	1137	1310	-
210°F "	102.4	105.6	-
Viscosity Index	107	101	103 (approx.)
Pour Point	-5°F	-5°F	Flows @ -85°F
Saponification Value (mg.KOH/gm.)	1.2	0.8	5.0
Sulphur	0.30% wt.	0.20% wt.	-
Ramsbottom Coke No.	0.37	0.32	-

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ENEMY OILS AND FUELS COMMITTEE

Samples Nos. AIR 378, AIR 379, AIR 380, AIR 381 and AIR 384 - Continued

Additional tests on AIR 380

Neutralization Value (mg.KOH/gm.)	0.1
Flash Point, P.M., Closed	190°F
Open	230°F

The oil was tested for the presence of polymers with negative results.

The relatively low closed flash point indicates that the sample contains a small quantity of a more volatile fraction possibly due to contamination.

AIR 379 (Approximately 1 quart) - This sample was examined originally as a normal unused oil, but the figures did not correspond with these for the used oil from the same aircraft. It was therefore examined further for diluent (gasoline fuel), when 5.2% vol. was recovered. The diluent distilled over at a slower rate than is normal for gasoline diluent and when the sample was examined by a modified diesel diluent method, with a bath temperature of 120°C, the diluent was equivalent to 6.8% vol. and was recovered at a faster rate than is normal for diesel diluent.

It appears, therefore, that the sample contains approximately 7% vol. of a "diluent" intermediate in properties between those of a gasoline and a diesel fuel diluent.

The properties of the sample before and after removal of diluent by the modified diesel diluent method are tabulated below:

	AIR 379 As received	AIR 379 Diluent-free
Appearance	Red oil with medium green bloom, containing fine sediment as received.	
Specific Gravity	0.876	0.879
Flash Point, P.M., Closed	130°F	-
Open	230°F	-
Fire	350°F	-
Viscosity:		
Kinematic ..... @ 100°F (C.s.)	137.7	195.4
140°F "	49.4	66.3
210°F "	14.28	17.64
Redwood 1 ..... " 100°F (Secs.)	203	269
Saybolt Universal " 100°F "	636	903
210°F "	74	88
Viscosity Index	109	105
Ash (sulphated)	0.01% wt.	-
Pour Point	-30°F	-20°F
Saponification Value (mg.KOH/gm.)	0.8	-
Sulphur	0.20% wt.	0.20% wt.
Ramsbottom Coke No.	0.16	0.17

AIR 381 - The total volume of the sample was 11 ml. The sample had the appearance of a white, soluble oil emulsion with a small supernatant layer of dirty curd. It was diluted with water, and no further separation of material occurred, confirming that the sample represented an aqueous emulsion. The entire sample was demulsified in a Babcock bottle, and yielded 0.45 ml. of separated oil. The concentration of the emulsion was, therefore, approx. 4% vol.

Oil emulsions were frequently used in Germany as coolants prewar but for I.C.engines in road vehicles usually to the extent of not more than 1%, the oil being added as an anti-corrosive. It was the first indication of its use in coolants for aero engines.

S.J.M.Auld
Chairman,
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The Petroleum Board,
Shell-Mex House, W.C.2.

A.I. 2G. 1502

AIR MINISTRY

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ENEMY OILS AND FUELS COMMITTEE

Samples Nos. AIR 374 (Engine Oil), AIR 375 (Engine Coolant), and AIR 376 (Hydraulic Fluid) taken from Ju.88 shot down at Chigwell, Essex, 24.3.44.

Analyses by Shell Marketing Co., Ltd., Fulham

AIR 374 (Approximately 1½ litres ENGINE OIL) - This sample was used engine oil, dark in appearance, containing some coarse sediment, and with 1% of diluent. After removal of the diluent and sediment the oil had the following characteristics:-

Specific Gravity	0.886	
	S.U.	C.s.
Viscosity at 100°F	1145"	247.8
210°F	100"	20.78
Viscosity Index	105	
Pour Test	-10°F	
Saponification Value (mg.KOH/gm.)	0.8	
Sulphur Content	0.25% wt.	
Ramsbottom Coke No.	0.38	

The oil is therefore of the uncompounded high V.I. type generally met.

AIR 375 (Approximately 500 ml. ENGINE COOLANT) - Although described as an Engine Coolant this is likely to be a De-icing Fluid. It consists of:

Ethyl Alcohol	70% vol.
Water	5% vol.
Ethylene Glycol	25% vol.

plus 1% wt. of a lithium soap, probably lithium ricinoleate.

The lithium ricinoleate is probably intended to act as a corrosion inhibitor, lithium being selected as the base due to increased solubility of the soaps at low temperatures.

AIR 376 (Approximately 1½ litres HYDRAULIC FLUID) - This is a Mineral Hydraulic Fluid of very low viscosity and containing approximately 4% of fatty oil. In appearance it is light red with strong green fluorescence. Its general characteristics are as follows:

Specific Gravity	0.858
Flash Point (P.M.), Closed	240°F
Open	255°F
Kinematic Viscosity @ 100°F	4.85 C.s.
210°F	1.65 "
Viscosity Index	107
Pour Test	Flowing at -60°F
Neutralization Value (mg.KOH/gm.)	0.1
Saponification Value (mg.KOH/gm.)	8

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The Petroleum Board,
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War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 391

K.1. DIESEL FUEL ex Mediterranean area

Analysis by The Petroleum Board, Vauxhall

Size of Sample .....Approx.	4-gln.Jerrican
Specific Gravity	.870
Colour	1 - 1½ N.P.A.
Distillation - I.B.P.	211°C
Recovery at 250°C	12%
300°C	62½%
350°C	94%
F.B.P.	369°C
Total Recovery	98½%
Residue	1%
Flash Point, Closed	208°F
Viscosity, Redwood 1, @ 100°F	37"
Pour Point	0°F
Cloud Point	16°F
Sulphur Content	0.08%
Conradson Carbon	Trace
Ash	Slight trace
Water	Nil
Nuetralization Value (mg.KOH/gm.).	0.006
Diesel Index	47
Cetane Number	47
Sediment	Nil
Aniline Point	65.8°C
Condition	Good - clear and bright
Phenols	0.002%

Hydrocarbon Analysis

Aromatics	19.5%
Paraffins	58.0%
Naphthenes	19.0%
Unsaturateds	3.5%

This is a diesel fuel of average ignition quality. It is probably of petroleum origin but may contain some synthetic material.

It would appear to be inaccurately designated as the tests are quite different from previous inspections of the K.1. fuel.

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Chairman,
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The Petroleum Board,
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War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Samples Nos. AIR 392 and AIR 393 (received via United States Petroleum Attache, London from A.F.H.Q.)

AIR 392 - No.991; Liquido avio I-R.A., Distillerie Italiane S.A., Milano.
AIR 393 - No.992; Liquido avio II, R.A. per amortizzatori.

NON-MINERAL HYDRAULIC FLUIDS

Analyses by Shell Marketing Co., Ltd., Fulham

	AIR 392	AIR 393
Size of Sample .....Approx.	2-litres	1-litre
Specific Gravity	0.955	0.958
Appearance	Clear, dark amber-coloured fluid.	Clear, pale amber-coloured fluid.
Odour	Of acetone or diacetone alcohol and castor oil.	
Kinematic Viscosity at 32°F	151 C.s.	555 C.s.
70°F	43.0 "	124 "
100°F	20.3 "	52.3 "
Pour Point, A.S.T.M. ..... max.	-55°F	-55°F
Neutralization Value (mg.KOH/gm.)	0.65	0.35
Saponification Value (mg.KOH/gm.)	85	131
Water Tolerance (approx.)	2% vol.	3% vol.
Distillation (A.S.T.M.) - I.B.P.	75°C	100°C
5% vol. recovered at	104°C	124°C
10% " " "	118°C	134°C
15% " " "	123°C	136°C
20% " " "	126°C	137°C
25% " " "	129°C	136°C
30% " " "	131°C	132°C
35% " " "	133°C	-
40% " " "	133°C	-
45% " " "	132°C	-
50% " " "	127°C	-
Total Recovery	52% vol.	31% vol.

Re-distillation

AIR 392					AIR 393				
Qnty.	Boiling Range	Spec. Grav. @ 20°/4°C	Refractive Index (20°C)	Nature	Qnty.	Boiling Range	Spec. Grav. @ 18°/4°C	Refractive Index (20°C)	Nature
55% vol.	55° - 59°C (58°C)	0.803	1.365	Acetone	40% vol.	56° - 64°C	0.811	1.360	Acetone
20% vol.	135° - 140°C (138°C)	-	1.392	Mixed distillate	10% vol.	65° - 120°C	-	1.372	Contains water.
25% vol.	150° - 165°C (160°C)	0.910	1.425	Di-acetone alcohol	50% vol.	150° - 170°C	0.918	1.423	Di-acetone alcohol.

Properties of Distillation Residue	AIR 392	AIR 393
Saponification Value (mg.KOH/gm.)	177	180
Iodine Value	83	85
Refractive Index at 20°C	1.476	1.476
Nature of Residue	Essentially castor oil	

The above analyses suggest that AIR 392 contains approximately 50% vol. of castor oil, and AIR 393 approximately 70% vol., both in diacetone alcohol.

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ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 394 (received via United States Petroleum Attache, London from A.F.H.Q.)

AIR 394 - No.997; Plain tinned can. No marking.

SOLUBLE CUTTING OIL

Analysis by Shell Marketing Co.Ld., Fulham

Size of Sample .....Approx.	1-gallon
Appearance	Clear dark red soluble oil. The oil produces a stable white slurry with water.
Water	2.0% wt. (approx.)
Alcohol (methyl)	3.0% wt. "
Free Acidity (mg.KOH/gm.)	4.0
Sulphur	2.25% wt.
Copper Strip Test	No stain
Sulphated Ash	2.94% wt. Essentially sodium sulphate
Unsaponifiable Matter	73.8% wt.

Properties of Unsaponifiable Matter

Appearance	Clear dark red spindle oil.
Specific Gravity	0.9095
Kinematic Viscosity @ 100°F	15.23 C.s.
210°F	3.03 "
Viscosity Index	37
Sulphur	1.15% wt.
Copper Strip Test	No stain

Total Free & Combined Fatty Acids 14.7% wt.

Properties of Fatty Acids

Melting Point	Viscous liquid at room temperature
Iodine Value	15
Mean Molecular Weight	365
Refractive Index nD 60°C	1.498
Sulphur	Present
Copper Strip Test	Slight stain
Nature of fatty acids	Probably naphthasulphonic acids

The values reported above for unsaponifiables and total acids are probably low due to the volatility of the spindle oil in the first case and to the solubility in water of the sulphonic acids in the latter case.

The above analysis indicates the following probable composition for the soluble oil:

Light Spindle Oil	75.0% wt.
Sodium naphthasulphonates	17.5% wt.
Free Fatty Acid	2.5% wt.
Methanol	3.0% wt.
Water	2.0% wt.

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ENEMY OILS AND FUELS COMMITTEE

Samples Nos. AIR 385 and AIR 386 (received through U.S. Embassy from A.F.H.Q., Petroleum Section by Air from Algiers

AIR 385 - Blue B-4 AVIATION GASOLINE
AIR 386 - Green C-3 AVIATION GASOLINE

Analyses by The Petroleum Board, Vauxhall

	AIR 385	AIR 386
Size of Sample .....approx.	1½-glns.	3-glns.
Specific Gravity	.734	.7755
Colour	Blue	Green
Distillation - I.B.P.	49°C	56°C
Recovery at 75°C	31%	7%
100°C	71%	37%
105°C	76%	46%
150°C	97%	86%
End Point	151°C	178°C
Total Recovery	98%	98%
Residue	1%	1%
Freezing Point	Below -60°C	Below -60°C
Vapour Pressure (lb./sq.in.)	5.7	3.5
Total Sulphur	0.01%	0.01%
Existent Gum (mg./100 mls.)	8	8
Lead Content (mls.T.E.L/I.G.).	5.65	5.62
Octane Number	91	96
Octane Number of Base Fuel	74	82
Octane Number by Research Method	93.5	99.7
Bromine Number	0.9	0.9
Hydrocarbon Analysis		
Aromatics	14.0%	40.6%
Paraffins	52.5%	36.8%
Naphthenes	33.5%	22.6%
Unsaturateds	Nil	Nil
Individual Aromatics		
Benzene	7.4%	5.8%
Toluene	4.8%	12.4%
Xylenes	1.8%	12.4%
Higher Aromatics	-	9.3%
Water Solubles	Nil	Nil
Phenols	0.0002%	0.0007%
Iron Carbonyls	Nil	Nil
Aromatic Free and De-leaded Fuel		
Specific Gravity	7173	.723
Aniline Point	56°C	61°C
Octane Number	70	76

Previous small samples of these two fuels (AIR 355 and AIR 356 respectively) had been received in February through the U.S.Embassy from A.F.H.Q.Petroleum Section. They were too small for anything but preliminary examination.

As a result of previous reports from Mobile Laboratory, the present larger samples were obtained. The analyses show rather lower C.F.R.Octane Numbers than obtained by the Mobile Laboratory, but most of the other figures are of the same order except that the gum content of both samples, and the lead content of the B-4 sample, are higher than those obtained by the Mobile Laboratory.

The samples are typical of Blue and Green German Aviation Fuels respectively.

The Petroleum Board,
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for the Enemy Oils & Fuels Committee

A.I.2B. 1500

AIR MINISTRY

SECRET 31st March 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Samples Nos. AIR 353 and AIR 354 (received through Ministry of Economic Warfare - Ref.: AO 220/Z/210)

AIR 353 - Echantillon Huile Synthétique. Nature inconnue. TARTANE. Obtained in France and said to be German Aviation Oil.

AIR 354 - Echantillon Huile Synthétique, Fleurs de Soufre, Poussière Charbon. TARTAN. Obtained in France and said to be German Aviation Oil.

Analyses by Shell Marketing Co., Ltd., Fulham

	AIR 353	AIR 354	
Size of Sample .... Approx.	50 mls.	50 mls.	
Appearance	Slightly opaque red oil with a medium blue-green bloom. Odour of essential oil due to bottle contamination.	Used oil, without bloom, containing carbonaceous material. Burnt odour partially masked by essential oil due to bottle contamination.	
		On oil as received	On diluent and sediment free oil
Specific Gravity	0.890	-	0.891
Kinematic Viscosity @ 100°F	257 C.s.	-	301.2 C.s.
140°F	80.0 "	90.8 C.s.	92.0 "
210°F	19.82 "	-	22.28
Viscosity Index	97	-	98
Diluent	-	No dilution	-
Sediment insoluble in I.P. Spirit	-	1.45%	-
Ash (sulphated)	0.01%	0.88%	-
Nature of Ash	-	Chiefly lead sulphate with sulphates of iron and tin.	-
Pour Test - A.S.T.M.	Minus 5°F	0°F	-
Saponification Value (mg.KOH/gm.)	0.8	-	2.6
Sulphur Content	-	0.25%	-
Copper Strip Test	-	-	Slight grey stain

AIR 353 appears to be a typical medium aircraft engine lubricating oil of the low specific gravity, high V.I. type.

AIR 354 appears to represent a used oil as judged by the high ash content and its nature. The high carbonaceous sediment may contribute to the "Poussière Charbon" (compare the description of the oil) but no evidence was obtained of the presence of the "Fleurs de Soufre."

S.J.M.Auld
Chairman,
for the Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
Strand, W.C.2.

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30th April 1944

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ENEMY OILS AND FUELS COMMITTEE

Samples Nos. AIR 363A, AIR 363B and AIR 366

Sample No. MAR.240 (received through Admiralty - Ref.: NID.01703/44)

AIR 363A and AIR 363B - Used ENGINE OIL ex Do.217M, 56051, U5 + DK, DB 603 A1, Engine Nos. Port 17192, Starboard 17194, shot down 11.5 p.m. Enfield 23.2.44 and landed without crew on Union Lane Allotments, Milton Road, Cambridge. Tank from which samples taken undamaged.

AIR 366 - Used ENGINE OIL ex Do.217M, U5 + EL, DB 603 A2, Engine Nos. Port 01600019, Starboard 01600361, shot down Westcott, Nr.Dorking, 24.2.44. Bombing attack.

MAR.240 - German LUBRICATING OIL obtained from a small Dutch coaster in the Baltic.

Analyses by Shell Marketing Co., Ltd., Fulham

	AIR 363A	AIR 363B	AIR 366	MAR.240
Size of Sample ..... Approx.	2-galls.	2-galls.	2-galls.	10-mls.
Specific Gravity	0.896	0.896	-	-
Kinematic Viscosity @ 140°F, Cs.	89.3	84.3	-	-
Diluent (Gasoline)	3.2%	3.2%	4.8%	-
Sediment insoluble in I.P.Spirit	1.87%	1.81%	1.66%	-
Ash (sulphated)	0.58%	0.52%	0.50%	-
Nature	Essentially lead sulphate with some iron oxide and a little nickel oxide.			-
	Tests on used oils after removal of diluent and filtration			Original sample
Appearance	:-------- Dark red oils with a green bloom ----:			
Specific Gravity	0.891		0.891	0.924
Viscosity:				
Kinematic ..... @ 100°F..Cs.	286.4		286.8	177.3
" 140°F.. "	90		90	53
" 210°F.. "	22.10		21.90	13.34
Redwood 1 ..... " 140°F,Secs.	365		365	217
Saybolt Universal " 100°F, "	1322		1325	819
" 210°F, "	106		106	70
Viscosity Index	101		100	69
Pour Point	-5°F		-10°F	-
Saponification Value (mg.KOH/gm.)	0.6		1.2	0.6
Ramsbottom Coke No.	0.33		0.34	-

AIR 363A, AIR 363B and AIR 366 are used aircraft oils in very similar condition. Analysis indicates that they are of the same grade and type and are similar to AIR 324 (Cf. Report 16.9.43).

MAR.240 is an uncompounded engine oil of the medium V.I. type.

S.J.M.Auld
Chairman,
for the Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House, W.C.2.

CONFIDENTIAL 30th April 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 364

COOLANT ex Do.217M, 56051, U5 + DK, DB 603 Al, Engine Nos. Port 17192, Starboard 17194, shot down 11.5 p.m. Enfield 23.2.44 and landed without crew on Union Lane Allotments, Milton Road, Cambridge. Tank from which sample taken undamaged.

Analysis by Shell Marketing Co., Ltd., Fulham

Size of Sample .....Approx.	2-galls.
Appearance	Cloudy, aqueous liquid with some oil scum on surface.
Odour	Slightly of gasoline.

The supernatant oily layer was separated off, the coolant filtered and examined further as follows:

Specific Gravity @ 60/60°F	1.061
Distillation (A.S.T.M.) - I.B.P.	101°C
Recovery 5% vol. at	102°C
10	104
20	105
30	107
40	109
50	118
60	151
70	192
80	192
90	192
95	193
Total Recovery at 193°C	96.5% vol.

A portion of the fraction boiling above 118°C (approx.upper 50% vol.) was re-distilled and found to fractionate approximately as follows:

50% vol.	Essentially water.	B.P. 102°C, R.I. at 21°C	1.3433
50 "	" glycol.	" 196°C, R.I. " 21°C	1.4265

Ash (sulphated)	0.07% wt.
Nature	Essentially lead sulphate.

This engine coolant is a solution of 40% vol. ethylene glycol in water. The sample is contaminated with gasoline.

S.J.M.Auld
Chairman,
for the Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House, W.C.2.

SECRET 1st May 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

OIL Sample No. AIR 349 (received through U.S.Embassy from A.F.H.Q., Petroleum Section - Compare Analysis L.82 of No.1 Mobile Petroleum Laboratory, R.A.S.C.)

Fl-Oel Aero Shell Mittel
a L a
Flug - Schmierstoff

Analysis by Shell Marketing Co., Ltd., Fulham

Size of Sample .....Approx.	2 litres	
Appearance	Slightly cloudy red oil with green bloom	
Saponification Value (mg.KOH/gm.).	7	
Unsaponifiable Matter	92.7%	
	Original Oil	Unsaponifiable Material
Viscosity		
Kinematic Viscosity @ 100°F (Cs.)	295.7	225.9
210°F "	20.83	15.38
Viscosity Index	91	67

This unused lubricating oil contains a small proportion of fatty material. The increase in the V.I. of the oil brought about by this small proportion of fatty material suggests that the latter is a Voltol.

S.J.M.Auld
Chairman,
for the Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
Strand, W.C.2.

157/16/INT A.I. 2G. 1521

AIR MINISTRY

SECRET 17th April 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 367 (received through Air Ministry, A.I.2.(g))

Petrol taken from remains of broken tank of Ju.188 which crashed near Chelmsford 14.3.44

Analysis by The Petroleum Board, Vauxhall

Specific Gravity	.7769
Distillation - I.B.P.	60°C
Recovery at 75°C	5%
100°C	39%
105°C	46%
150°C	88%
End Point	178°C
Total Recovery.....	98%
Residue	1%
Colour	Green
Aniline Point	19.8°C

Only a small sample was available. It is apparently a typical green fuel.

S.J.M.Auld
Chairman,
for the Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
Strand, W.C.2.

SECRET 25th March 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 345

Petrol ex Ju. 188 E-1,3E + AF, BMW 801 G.2, Engine Nos. Port 303208, Starboard 306048 shot down at Hungerford, Berks. 1.11.43. Tank from which sample taken damaged.

Analysis by The Petroleum Board, Vauxhall

Specific Gravity	.7748
Colour	Green, cloudy
Distillation - I.B.P.	52°C
Recovery at 70°C	4%
75°C	9%
100°C	39%
105°C	45%
140°C	81%
150°C	86½%
F.B.P.	175°C
Total Recovery	97%
Residue	2% (partly solid due to presence of rubber)
Freezing Point	Below -60°C
Vapour Pressure (lb./sq.in.)	2.3
Existent Gum (mg./100 mls.)	278 (rubbery material)
Total Sulphur	0.02%
Lead Content (mls. T.E.L./I.G.)	5.83
Octane Number	Owing to presence of rubber Octane No. was not determined.
Octane Number of Base Fuel	83½
Iodine Number	1.7
Bromine Number	1.0

Hydrocarbon Analysis

Aromatics	46.4%	on rubber-free material
Paraffins	41.8%	
Naphthenes	11.8%	
Unsaturateds	Nil	

Individual Aromatics

Benzene	4.9%	on rubber-free material
Toluene	14.0%	
Xylenes	15.0%	
Higher Aromatics	12.5%	

Phenols	Nil
Iron Carbonyls	Nil
Water Solubles	Nil

Doleaded and Aromatic Free Fuel

Specific Gravity	.7062	on rubber-free material
Aniline Point	66.4°C	
Octane No.	77½	

This appears to be a weathered sample of green fuel.

S.J.M.Auld
Chairman,
for the Enemy Oils and Fuels Committee

The Petroleum Board,
Sholl-Mex House,
W.C.2.

CONFIDENTIAL 25th February 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 340 (received through Allied Force Headquarters, Petroleum Section, from North Africa)

Flug Schmierstoff in Jerrican

Analysis by Vacuum Oil Co., Ltd., Wandsworth

Size of Sample .....Approx.	4-galls.
Specific Gravity	.8704
Colour (Lovibond).....	60
Flash Point, Open	420°F
Pour Point	+15°F
Diluent	Nil

	S.U.	Red.1	C.s.
Viscosity @ 100°F	1180"	-	255.4
130°F	493"	-	106.7
140°F	-	343"	84
210°F	105"	-	21.6

Viscosity Index	107
Neutralization Value (mg.KOH/gm.)	0.056
Saponification Value (mg.KOH/gm.)	0.67
Ash	0.01%
Sulphur	0.30%
Chlorine	0.08%
Phosphorus	Nil
Ramsbottom Coke No.	0.34
Condition	Clean and dry

It is likely that this oil contains an appreciable proportion of synthetic material, the sulphur content being due to the nature of the natural petroleum component. The presence of a small quantity of chlorine is to be noted but this may have been due to the use of chloride catalyst in the synthetic production and not to deliberate addition. The quantity would be small to have any effect as an additive.

The pour point is higher than that of previous samples believed to contain synthetic material.

S.J.M.Auld
Chairman,
for the Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
W.C.2.

CONFIDENTIAL 24th February 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

General Report on a number of samples of Italian Greases received via United States Petroleum Attache, London, from A.F.H.Q.

Sample No. AIR 357 - No.985; Grasso Consistente Avic R.A.
" " AIR 358 - " 986; " " " "
" " AIR 359 - " 987; Grasso Avio Per Eliche Fiat-Hamilton.
" " AIR 360 - " 988; Grasso Petrolato R.A., per Protezione Esterna, etc.
" " AIR 361 - " 989; Grasso Petrolato R.A., per Protezione Esterna, etc.

Analyses by Vacuum Oil Co., Ltd., Wandsworth - Samples received 13.1.44

These samples appear by their labelling to be all products used for aviation purposes. They have been given visual and general examination only as they all belong to classes of material readily defined and of which the standard can be well appraised.

They fall into three types:

1. Petrolatum.
2. High Melting Point grease somewhat similar to D.T.D.419.
3. One sample of an aluminium soap-thickened oil similar to products used in this country for the lubrication of variable pitch propellers and stated by its description as being employed for the same purpose.

The products are all in reasonable condition and those employed for operative purposes may be expected from their condition and general characteristics to be suitable for the purposes for which they are designated.

AIR 357 - The material in general is practically identical with AIR 358 but slightly lighter in colour and stiffer in consistency. Melting Point 143°C, Unworked Penetration 190, Worked Penetration 235.

AIR 358 is a light brown soft, short-fibred soda base grease of an oily appearance and slightly granular. No free oil. Melting Point 138°C, Unworked Penetration 260, Worked Penetration 305.

AIR 359 is a dark brown coloured stringy fluid grease. It is compounded with a fairly heavy oil and thickened with aluminium soap.

AIR 360 is a dark green Petroleum Jelly with a Melting Point of 57°C, Unworked Penetration 85, Worked Penetration 125.

AIR 361 is a dark green Petroleum Jelly with a Melting Point of 48°C, Unworked Penetration 85, Worked Penetration 205.

AIR 360 and AIR 361 are in general similar to samples which we have previously examined, one apparently representing a softer variant.

S.J.M.Auld
Chairman,
for the Enemy Oils and Fuels Committee

The Petroleum Board,
Shell-Mex House,
W.C.2.

CONFIDENTIAL 25th February 1944

War Cabinet Technical Sub-Committee on Axis Oil

ENEMY OILS AND FUELS COMMITTEE

Sample No. AIR 340 (received through Allied Force Headquarters, Petroleum Section, from North Africa)

Flug Schmierstoff in Jerrican

Analysis by Vacuum Oil Co., Ltd., Wandsworth

Size of Sample .....Approx.	4-galls.		
Specific Gravity	.8704		
Colour (Lovibond).....	60		
Flash Point, Open	420°F		
Pour Point	+15°F		
Diluent	Nil		
	S.U.	Red.1	C.s.
Viscosity @ 100°F	1180"	-	255.4
130°F	493"	-	106.7
140°F	-	343"	84
210°F	105"	-	21.6
Viscosity Index	107		
Neutralization Value (mg.KOH/gm.)	0.056		
Saponification Value (mg.KOH/gm.)	0.67		
Ash	0.01%		
Sulphur	0.30%		
Chlorine	0.08%		
Phosphorus	Nil		
Ramsbottom Coke No.	0.34		
Condition	Clean and dry		

It is likely that this oil contains an appreciable proportion of synthetic material, the sulphur content being due to the nature of the natural petroleum component. The presence of a small quantity of chlorine is to be noted but this may have been due to the use of chloride catalyst in the synthetic production and not to deliberate addition. The quantity would be small to have any effect as an additive.

The pour point is higher than that of previous samples believed to contain synthetic material.

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