C O N F I D E N T I A L

PETROLEUM ADMINISTRATION FOR WAR K-14392

Washington 3499 (F 913 C)

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Mr. Sidney Alexander
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Gentlemen:

For your information there is attached a copy of a statement prepared by certain industry consultants entitled "The Potential Supplies of Enemy Aviation Gasoline."

You will note that these gentlemen are strongly of the opinion that the main source of the German green combat fuel is from the hydrogenation plants. Several copies of this statement have been furnished to Mr. Barry for transmittal to London in order to obtain the comments of the experts there, who we understand do not share this view.

Sincerely yours,

/s/ E. M. BUTTERWORTH

E. M. Butterworth, Chairman,
European Axis Subcommittee.

Enclosure

THE POTENTIAL SUPPLIES OF ENEMY AVIATION GASOLINE

1. This is an estimate of the potential production of aviation gasoline by the enemy for 1943. The various sources and processes have been considered and the potential production set up in three degrees of probability in Table I.

ESTIMATE OF GERMAN POTENTIAL PRODUCTION OF AVIATION GASOLINE

Order of Probability	1	2	3
From Hydrogenation	1,380	1,230	800
Virgin Naphthas	125	541	140
Alkylates & Iso-octanes	62	180	150
Coal Tar Aromatics	37		-
Alkylated Benzol	-	-	500+
Total	1,604	1,951	1,590
Green Grade	824	Nil	
Blue Grade	780	1,951	

The main source of potential production is hydrogenation with a high probability that the Green or fighting grade is produced in the hydro plants that treat bituminous coal, tar or pitch and which are supplemented with hydro-forming plants. The Blue grade quality is assumed to be met when any hydro plant operates under aromatizing conditions. In any event there is very little virgin naphtha from the European crude that is of as high quality as hydrogasolines.

This view is not opposed to the thesis that the enemy is short of aviation fuel, but points rather to possible causes when the main thesis is supported on other grounds. A shortage of aviation gasoline could be explained on two points. First, the change from offensive warfare on a limited front to defensive on a very long front has immobilized a large amount of stocks, especially Green aviation gasoline. Secondly, there is required extra processing after hydrogenation to make aviation fuel and this extra processing (Hydrofining) may not have been adequately provided for.

2. Hydrogenation & Hydrofining

The Hydrogenation Process produces an aviation gasoline base stock of 70-74 O.N. (A.S.T.M.) which is highly naphthenic. The Hydrofining Process dehydrogenates cyclohexanes to aromatics while at the same time hydrogenating phenols and unsaturated compounds.

The Hydrofining Process was in operation in Germany in 1938, and the following are specifications of the product produced from hydrofining the crude naphtha from sump phase hydrogenation of bituminous pitch at 600 Ats.

HYDROFINED PRODUCT
FROM HYDROGENATED BITUMINOUS PITCH

% off at 100° C.	30-33
End Point ° C.	187
% Aromatics	60
Octane No. (research)	92-95
Octane No. (A.S.T.M.)	86-87
T.E.L. Response (1-3 cc)	Poor

This Hydrofining Process is used in America for producing toluene from petroleum, but it is less popular in petroleum work than the Hydroforming Process for producing aromatics--toluene. The difference is that the former is highly selective and only dehydrogenates cyclohexanes to produce aromatics while the latter converts a wide variety of compounds to aromatics but at the expense of substantial destruction to coke and fixed gas. In the absence of firm information on the percentage of cyclohexanes in the various hydrogasolines it is assumed that only those produced from bituminous coal, tar or pitch contain sufficient amounts to make Green grade aviation gasoline by hydrofining.

In the production of Blue grade aviation gasoline from hydrogasoline there are two alternatives; first, hydrofining of both bituminous coal and lignite hydrogasolines or second, the more destructive hydrogenation known as aromatizing. The latter is certainly an emergency process that will produce Blue grade gasoline from all hydro stocks.

The potential aviation gasoline from hydro plants is set up in three categories which are more or less arbitrary but detailed on Table II. The most probable production of aviation gasoline is shown in the first column and shows 824,000 metric tons of potential Green gasoline and 556,000 metric tons of Blue grade; a total of 1,380,000 metric tons. A lesser probability is that the indicated motor gasoline production would be converted to aviation with a shrinkage of from 1,585,000 tons of motor to 1,230,000 tons of Blue grade aviation gasoline. The sum of these two potentials is 3,555,000 tons of aviation gasoline. The further probability is that the diesel oil and heavier products would be converted to aviation gasoline with a shrinkage from 1,215,000 tons to 850,000 tons.

TABLE II

Enemy Axis Hydrogenation Plants with Assumptions as to the Operating Schedules for 1943

	Aviation	Motor Gasoline	Diesel Fuel	Lubes, Wax or Heavy Fuel	Rated Capacity
Bituminous Coal, etc.					
Poelitz*	200	95	235	-	530
Ruhroel	78	-	-	100	200
Gelsenberg	156	200	-	-	400
Hibernia	156	200	-	-	400
Oberschlesische	234	200	-	-	500
Bethune	-	15	-	-	15
Levin	-	15	-	-	15
	824	725	235	100	2060
Low Temperature Tars					
Leuna	156	400	-	-	500
Brabag I, II & IV	200	-	200	170	600
Bruex	-	200	400	-	600
A.G. für Kraftstoff	-	50	50	-	100
	356	650	650	170	1800
Lignite Coal					
Union, Wesseling	-	150	-	-	150
Wintershall	100	-	-	-	125
	100	150	-	-	275
Crude Oil Refining*					
ANIC, Bari	100	-	-	-	120
ANIC, Leghorn	-	60	60	-	120
	100	60	60	-	240
Total	1380	1585	945	270	4375
	115	132			

*From 60-80% of Poelitz capacity may be operating on petroleum refining but its capacity is all listed together for convenience.

3. Crude Oil Naphthas

There is very little crude in Axis Europe that contains as satisfactory a base stock for aviation gasoline as that produced by hydrogenation. The estimate of virgin naphtha that might be used as base stocks for the Blue grade gasoline is shown below, and blending charts have been constructed to indicate the requirements of alkylates and aromatics that would be required for raising these stocks to Blue gasoline specifications.

TABLE III

	Wt. % Yield on Crude	Tons/Year	O.N. (A.S.T.M.)	F.B.P. °C.	R.V.P.	% of * Blending Agent to Make Blue Gasoline
Roumania						
Asphaltic Crude	17.	63,000	73	145	6.5	8
Intermed. "	12.5	62,000	67	126	7.5	30
Paraffinous "	11.0	541,000	62	135	7.5	40
Other Crudes	-	140,000	63	-	-	40
		806,000	63	140	7.3	

*For the purpose of this estimate it has been assumed that an alkylate and aromatic blending stocks are available of 92 O.N., A.S.T.M., and the final Blue grade gasoline will contain the indicated amounts (Vol.%) of blending agents. There is believed to be a high probability that the first two naphthas will be used for aviation gasoline with decreasing probability for the amounts indicated for the next two.

4. Blending Agents

There are two types of blending agents considered in this estimate; The paraffinous alkylates, hydrocodimers or iso-octanes which predominate in the lighter to middle boiling fraction of aviation gasoline and the aromatics that characterize the higher boiling fractions.

The processing used by the enemy to produce paraffinous blending agents is not critical in this estimate. There are known to be both hydrocodimer and alkylation plants, with the latter probably predominating in capacity. The estimated supplies are those from known plants and those from alkylating the butylenes from Fischer-Tropsch (including cracking) with the necessary isobutane from hydrogenation.

There is a large excess of butanes from hydrogenation that might be dehydrogenated to further increase either alkylate or hydrocodimer but this processing is not considered probable. The estimated production (potential) of paraffinous blending agents is as follows:

PARAFFINOUS BLENDING AGENTS
thousands of metric tons per day

Order of Probability	1	2	3
Alkylate from Roumania	60	-	-
Alkylate from Fischer-Tropsch Olefines	-	180	-
Hydrocodimer* Prewar Polymer Plants	2	-	150*
	62	180	150

*This capacity might also be used for alkylating benzol.

Consideration has been given to determining the source of paraffinous blending agents from the infra-red analysis of the octanes in captured enemy fuels. This analysis appears accurate and may be useful when a great deal more is known about the composition of base stocks made by various processes. British and American information is shown in Table IV on the analysis of octanes in paraffinous blending stocks. These results show wide differences in the ratios of iso-octanes for the same process. While the ratio of any two iso-octanes in enemy fuels may suggest either a hydrocodimer or alkylation process there is always a deficiency in the third isomer as, for example, the phosphoric acid selected polymers appear to be excluded from the enemy fuel because of the very low content of 2, 3, 4 trimethyl pentane, whereas the hot sulfuric acid hydrocodimers are questioned because of the low 2, 2, 3 trimethyl pentane.

It is difficult to reconcile the considerable percentage of alkylates in the enemy fuel because of the low percentage of 2, 3, 3, trimethyl pentane. On the other hand, the alkylates are favored for the reason that the 2, 3, 3 trimethyl pentane might be excluded in the enemy product because it is the highest boiling iso-octane.

TABLE IV

OCTANES IN BLENDING AGENT

Boiling Points °C	Trimethyl Pentanes 2.2.4 99.3	2.2.3 110.7	2.3.4 116	2.3.3 118	Source
Alkylates	30	1	14	18	1AA 119
	30.7	1.6	9.0	14.5	S.O. of N.J.
	22.5	1.0	9.5	14.5	1AA 122
	22.4	1.5	14.8	10.5	Texaco
Hydrocodimers	12	18	28	28	AAOC (AZO4)
	9.9	9.2	43.9	8.6	S.O.Ind. (P_2O_5)
	30.	8.	36.	6	Heysham (P_2O_5?)
	30.2	18.3	14.2	7.4	Shell Hot Acid
Order of Performance					
Rich Mixture	4.	1	3	2	
Lean "	1.	2	4	3	

The Germans were the original inventors of phosphoric acid polymerization of gaseous olefins and there was in operation before the war a small capacity for this type of hydrocodimer. Since the war started, firm information indicates that the Germans put into operation in Roumania, during the summer of 1941, an alkylation plant with a rated capacity of 60,000 tons per year. This plant was assigned to utilize all of the butylenes available from the Roumanian refineries. There are large supplies of raw materials for alkylation in Germany, in particular the Fischer-Tropsch plants producing the necessary olefins while the hydrogenation plants, especially when operating for aviation gasoline, are long on iso-butane. It is estimated that the potential production of alkylates in Germany from these sources would be limited by the olefins available, which with the thermal cracking of Fischer-Tropsch synthetic crude would give a yield of the order of 180,000 tons of alkylate per year.

The aromatic constituents in enemy aviation fuel are characterized about as follows:

Total Aromatics	Blue 10-24	Green 40-45
% of aromatics as benzol	10-20	20-25
% of aromatics as toluene	30-38	30-35
% of aromatics as Higher	60-40	50-40

There is no dominant higher aromatic such as cumene that would suggest high quality from selective alkylation of benzol. On the contrary, the higher aromatics show no selectivity with respect to quality as indicated by the considerable amount of ortho xylene which is a distinctly inferior aromatic for aviation fuel purposes. It is concluded, therefore, that the production of aromatic blending agents has been done by "shot-gun" processes rather than selective alkylation of benzol. Among such processes are (1) hydrofining as discussed above, (2) Catalytic Cracking of either petroleum fractions or hydro middle oils, (3) hydroforming and (4) alkylation of benzol. Hydroforming is considered least likely, with catalytic cracking ranking with benzol alkylation as less likely than hydrofining of coal tar fractions and hydronaphthas as most probable.

The quantities of blending agents for the various other sources of aviation gasoline are estimated as shown in Table V.

TABLE V

BLENDING AGENTS REQUIRED

	% Base Stock	Alkylate	Aromatics
Bit. Coal Hydro after Hydro-fining -	100	-	-
Lignite Hydro after Hydrofining	100	-	-
Roumanian Naphthas			
from Asphaltic Crude	92	-	5,500
" Intermediate Crude	70	13,300	13,300
" Paraffinous Crude	60	180,000	180,000
Other Crudes	60	44,000	50,000
		237,300	248,800

Aromatics Total	248,800	say	250,000 T/Yr.
Benzol as such	50,000	-	62,000
Toluol	75,000		87,000
Higher	125,000		100,000

The benzol is readily available. There are, however, 187-200 thousand tons per year of alkylated benzol to be produced for the full utilization of the petroleum naphthas in aviation. These supplies are believed to be produced in the coking industry but it has been assumed that the toluene in coke oven naphthas would be required for explosives and other uses than fuel.

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