DIESELKRAFTSTOFFEE UND IHRE MISCHUNGEN UNTEREINANDER

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Chemical - Physical - Research - Laboratory (CPVA)

of the Navy, Kiel

Diesel fuels and their mutual mixtures

CPVA B #5892-40

By letter "OKM BNr BBMV 27605-38 dated December 22, 1938 the CPVA was requested to investigate all diesel fuels which were available at home and abroad, to classify the oils according to their suitability for the operation of diesel engines and to convert unfit oils by blending insuitable ones. Approximately 100 diesel fuels were supplied from at home and abroad by the CPVA (see appendix #1). In addition to the diesel fuels also fuel oils were investigated which were furnished by the O.K.M. (High Command of the Navy). It should be determined whether the fuel oils were suitable for the operations of diesel engines. The main scope of the research work was a thorough going investigation of the oils and to improve unfit oils by blending them with highly ignitable ones. Following a request of the O.K.M. the RCH-diesel fuel (RCH = Ruhrchemie - Fischer-Tropsch plant "Ruhrchemie at Oberhausen-Holten) was chiefly used as an ignition promoting agent. Fuel oils which showed good ignition qualities but had a tendency to form coke-deposits were subjected to various testing methods in order to eliminate the components which are responsible for the coking altitude of the oils.

The following diesel-fuels have been investigated by the C.P.V.A.

A. Diesel fuels from petroleum oils.

Aa: Source: Germany
Ab: Source: Europe with the exception of Germany
Ac: Source: Asia
Ad: Source: America
Ae: Source: Unknown

B. Diesel fuels from lignite products
C. Diesel fuels from coal products
D. Hydrogenated naphthalenes
E. Synthetic diesel fuels
F. Diesel fuels from oil-shale products

Source of the oils classified as B, C, D, E, F: Germany

Appendix #2 represents the results of the analytical investigation of the diesel-fuels.

Appendix #3 comprehends remarks concerning the "Filter-Test" of Hagemann DIN method #1 (DIN = German Industry Standards) and DVM 3767 (German Society for testing materials)

Appendix #4 deals with the corroding properties of the oils DIN - Proposal, D.V.M. 3763

Appendix #5 gives further explanation of the experiments which were carried out to improve the properties of oils which showed coking tendencies.

Appendix #6 Tables and diagrams concerning the determination of the ignitability of diesel fuels in the laboratory.

Appendix #7 Valuation of the investigated oils with reference to their behavior in the motor based on the performed analyses and the ignition quality (cetane value) which was determined by the coincident-flash fixed delay method employing the H.W.A. - motor (motor developed by the Service Command).

Appendix #8 contains remarks and explanations covering the following items:
1. Determinations of the tendency to form mixtures according to Marder and Roelen.
2. Experiments to prevent the formation of precipitates of blended diesel fuels.
3. Experiments to improve the ignitability of diesel fuels.

Summary:

As soon as the described experiments have been completed the O.K.M. intends to carry out motor tests with the single oils and their mixtures. With reference to the motor tests the following remarks shall be made:

According to a publication of Koelbel (Brennstaffchemie (1939) 365-369) depending on the ignition quality of the diesel fuel approximately 40-55% RCH- diesel fuel must be admixed if the blended oil is supposed to have a cetane number of 65-85.

Since the RCH-diesel fuel is rather expensive the blending method for the improvement of diesel fuels seems to be uneconomical.

Many attempts were made in the previous years to decrease the ignition delay of a diesel fuel. In addition to the above described method so called "Promoters" have been tried out (amyl initrate). But due to the vaporizing promoter such mixtures are not stable. Another possibility to decrease the ignition delay consists in increasing the compression-ratio, but it must be clearly said that this method does not always succeed. Experiments must be mentioned in this connection which tried to solve the problem by admixing ignition oils to coal tar products.

According to information, which have been furnished by the "Dentsche Weeke" (German Works) at Kiel, not only the slowly ignitable diesel fuels from coal tar oils but also the "Welheim-oils" (extraction oils) could be used to operate the test-motor if approximately 10% highly ignitable petroleum-or RCH- diesel fuels were admixed serving as so called "ignition oils."

According to the engineers of the Dentsche Weeke it is not necessary to run motor tests with the coal tar based diesel fuels which were investigated by the CPVA because further knowledge will certainly not be obtained.

The publication of Panel (ATZ Automobiltechmische Zeitschrift, Stutragaut 1938, Heft 20) in worth while mentioning. Paul declares that the ignition delay can be greatly influenced by the application of a turbulent combustion. We were able to confirm his statement. The CPVA proposes to carry on the experiments as soon as the investigation of the oils have been finished.

It is necessary to determine the properties of the diesel fuels blended with RCH diesel-fuel, dekalin etc by running motor tests and to fix the percentage of ignitable agents which must be admixed in order to obtain diesel fuels which meet the specification of the Navy.

List of the samples

Number of the sample	Name of the agent	Received from	Mark of the oils	Source of the oil	Country	Remarks
C.	"Verkaufsvereingung" for tar products Essen	Gesellschaft für teerverwertung (Tar distilling Company) Duisburg-Meiderich	Coal tar oil Type IA	Coal	Germany	See publication of Dr Paul Autombbilte-chmische Zeitschrift Stuttgart 1938, Heft 20
B	German Gasoline Company Berlini Charlottenburg	A. Reibeck'sche Montanwerke, Halle-Saale, oil-distillation plant Weban	F.A.-diesel-fuel for vehicles	lignite	Germany	
B_2	" " "	" " " "	F. A. diesel-fuel for stationary engines	lignite	Germany	
Aa,	" " "	Dollbergen near Hannover	diesel fuel	petroleum oil	Germany	
B_3	Werschen-Weissenfelser lignite company	Koepsen factory	diesel-fuel	lignite	Germany	
B_4	Deutscher Braunkolen oel-vertrieb, Berlin	Carbonization Works - Weissandt-Goelzan	D.B.V. diesel-fuel	lignite	Germany	
B_5	Navy high Command B.B.M.5, Berlin W 30	Edeleanu Company Berlin Schoeneberg	diesel-oil from lignite tar	lignite	Germany	Results reported to High Command of the Navy with report C.P.V.A.#985-39
Aa_2	German-oil-refinery-	Oil-refinery	gas oil distillate	petroleum	Germany	
Aa_3	Denrag, Hannover Hindenburgstrasse 27-29	Misburg	cracked gas oil	"	"	
Aa_4			mixture of gas oil distillate and cracked gas oil	"	"	
Ac_1	Olex	Southern Tran Anglo-Tranian-Oil-Company	"B.P" diesel-fuel	"	Tran	
Ac_2	Hamburg 1	"	diesel-fuel	"	"	

List of the samples cont'd

Number of the sample	Name of the agent	Received from	Mark of the oils	Source of the oil	Country	Remarks
Ad_1 Ad_2	German-American Petroleum-Company Hamburg 36	D.A.P.G. Shipping-station Hamburg	Standard-diesel-fuel " " "	petroleum "	U.S.A "	Suitable for high-speed diesel-engines of ships
Aa_5	German-Mineral-oil distribution, Berlin	German petrol.Comp. Wieburg factory	bright gas-oil	petroleum	Germany	
C_2	Ruhroil Company	Bottrop	Welheim-middle oil	coal	Germany	
Ae_1 F_1	German Gasoline Company	Emmerich factory Messel factory of the Riebeck concern	Emmerich diesel-fuel Messel diesel fuel for vehicles	petroleum oil-shale	Abroad Germany	
F_2	Berlin-Charlottenburg 9	Messel near Darmstadt	" " " stationary motors	" "	"	
C_3	Tar products Company Frankfurt-Main	Chemical works Weyl, Marmheim	coal-tar-diesel-oil	coal	Germany	
C_4	Coal-mine (Rheinpraussen) Hamburg	Fuel work Rheinpreussen	diesel-fuel "R"	mixture of coal-tar-diesel-oil and synthetic diesel-fuel	Germany	
Ad_3	Navy High Command Letter #414 BBV IX January 13, 1939	Oil of Kiel-Moenkeberg	Aruba gas-oil storage tank #5	Petroleum	Aruba-Mexico	
Ad_4	Arsenal Kiel, letter #7396-39, VLV.-1 February 11, 1939	" " "	Aruba gas-oil storage tank #2	Petroleum	Aruba-Mexico	
Ad_5	" " "	" Kiel-Wik	fuel oil(diesel)	Petroleum	Mexico	

List of the samples cont'd.

Number of the sample	Name of the agent	Received from	Mark of the oils	Source of the oil	Country	Remarks
E	Ruhrbenzin Company Oberhausen Holten	RB Dept. B.V.A. Ldm-Op	RCH diesel-fuel	Fischer-Tropsch synthesis	Germany	
Ad_6	Rhenania-Ossag Mineral-oil Company Hamburg, Shellhouse	Shipped from New Petroleum-harbor	#71 Diesel-fuel	Petroleum	South America	
Ad_7	"	"	#72 gas oil	"	America	
Aa_6	Mineral oil products Company, Berlin W35	Wintershall A.G.Kassel Oil Refinery Salzbergen	diesel-fuel	petroleum	Germany	
C_5	Tar products Comp. Frankfurt -Main	Roechling's Iron- and steel works, Voelklingen	Coal-tar oil	coal	Germany	
Aa_7	Shell-Floridsdorfer mineral-oil-factory Vienna I	--	Floridsdorf-gas-oil	Petroleum	Austria	
B	Werschen-Weissenfelser Lignite company Halle	Koepsen-factory	kerosene	lignite	Germany	
B-6-7			"	"	"	
Ab_1	Navy high command, letter #414 BB V-IX, January 13, 1939) #10-arsenal 7396-39	Tank-ship "Nyholm" tank #2 Flemhude	Rumanian fuel-oil (diesel)	petroleum	Koustauza Rumanian	
Ae_2	Navy equipment department Sroinemnende	Motor ships "Samverstad"tank #576	gas oil	petroleum	unknown	
Ab_2	"Steana Romana" Vienna III	--	gas oil	petroleum	Rumania	
Ab_3	"Nova" oil and fuel company Vienna	oil refinery Schwechat	gas oil refined	petroleum	Rumania	

List of the samples cont'd

Number of the sample	Name of the agent	Received from	Mark of the oils	Source of the oil	Country	Remarks
Ad_8	Navy High Command, letter #414 BB-V-IX, January 13, 1939	Fat-refinery Brake i.o. tank 32 and 33	diesel-fuel-oil petrol	petroleum	Mexico	
C_6)	Ruhr-oil company Bottrop	--	Welheim fuel oil	coal	Germany	
C_7)			" " "	"	"	
Ab_4	Montan-Union Berlin W15	Refinery Concordia S.A. Bucurestic	gas oil	petroleum	Rumania	
Ae_3	Navy equipment department Sroinemende	Motor ship "Samverstad" tank #365	gas oil	petroleum	unknown	
Ae_4	Navy arsenal Kiel oil-H of Kiel-wik tank I	picked up at Hamburg	diesel fuel	petroleum	samples originate from the storage tanks of the Navy Arsenal, Oil hof Kiel-Wik	
Ae_5	" " tank IV	" " "	" "	"	" " "	
Ae_6	" " " VII	" " "	" "	"	" " "	
Ae_7	" " " VIII	" " "	" "	"	" " "	
Ae_8	" " " IX	" " "	" "	"	" " "	
Ad_9	Navy arsenal, Kiel	Oilhof Flemhude Tank II	" "	Petroleum	Mexico	
Ad_{10}	" " "	" " " III	" "	"	Mexico	
Ad_{11}	" " "	" " " IX	" "	"	"	
Ab_8	" " "	" Moenkeberg " I	" "	"	Russia	
Ad_{12}	" " "	" " " III	" "	"	Texas	
Ab_9	" " "	" " " IV	" "	"	Russia	
Ad_{13}	" " "	" " " V	" "	"	Aruba Mexico	
Ab_5	"Hamburg-America Line"	M.S."Duisburg" bunkered at Port Said	diesel fuel	"	Rumania	
Ad_{14}		M.S. "Dode" bunkered at Cristobal	diesel fuel	"	California	
Ac_3	Hamburg	M.S."Duisburg" bunkered at Miri	diesel fuel	"	Borneo	
Ad_{15}	Chemical Laboratory	bunkered at Los Palmas	diesel fuel	"		
		M.S."Cordillera" bunkered at Curacao		"	Curacao	

List of the samples cont'd

Number of the sample	Name of the agent	Received from	Mark of the oils	Source of the oil	Country	Remarks
Ad_{16}	German Mineral oil Company	German petrol co.	lignite diesel	petroleum	Venezuela	
B_8	Berlin - Schoneberg	Rositz factory	fuel	lignite	Germany	
B_9			diesel oil from lignite tar-hydrogenation	lignite	Germnay	
C_8	T. G. Farben	I. G. Farben	diesel fuel from coal hydrogenation	coal	"	
B_{10}	Ludwigshafen Zch.-P-Su-558	Ludwigshafen	middle oil from 1st step of lignite I-hydrogenation	lignite	"	cont. phenoles
B_{11}	March 16, 1939		" " "	"	"	without phenoles
B_{12}			middle oil from 1st step of lignite II-hydrogenation	"	"	
C_9			middle oil from 1st step of coal hydrogenation	coal	"	
C_{10}			heavy oil from coal hydrogenation	coal	"	
C_{11}			light heavy oil from coal hydrogenation (Uhde)	coal	"	
Aa_8	"Nova" oil and fuel comp. Vienna	Refinery Schwechat paraff. from Zistersdorf crude	Austriangas oil	petroleum	Austria	
Ac_4	Norddeutscher Lloyd Bremen	D.A.P.G	diesel oil bunkered at Bremerhaven by M.S. Duesseldorf" January 21, 1939	petroleum	West - Indies	
Ac_5	Fuel Department	"	diesel oil bunkered at Bremerhaven by S.S. Aachen January 24, 1939	petroleum		

List of the samples cont'd

Number of the sample	Name of the agent	Received from	Mark of the oils	Source of the oils	Country	Remarks
E_2	Ruhrbenzin Oberhausen-Holten	Ruhrbenzin	RCH-cetane for motor tests	Fischer-tropsch synthesis	Germany	
Ad_{111}	Navy High Command letter #414 BB-V-9 January 13, 1939	Bureau of ships "Oellager" Achim, V B-7-A-5, April 14, 1939	Aruba-fuel oil	petroleum	Aruba	
Ad_{18}	KMD, Hbg, 13. letter #V-2837-V-4, March 6, 1939	D.A.P.G. Hamburg	Aruba diesel-fuel	petroleum	Aruba	
Ad_{19}	" " " "	Rhenania-Ossag-mineral-oil-works	diesel-oil	petroleum	Aruba	
Ad_{20}	" " " "	A. G. Hbg.	gas-oil	petroleum	Venezuela	
Ac_6	" " " "	Olex, Hamburg 1	gas - oil	petroleum	Southern Iran oil fields of the Anglo-Iranian-oil company	
Ac_7			diesel oil	petroleum		
C_{12}	Krupp works	Krupp Works	Low temperature carbonization tar oil "Amalia" Hannover Mine	coal	Germany	Dephenolized
C_{13}	Mining department	Krupp Works	Low temperature carb. tar oil fuel work Krupp, Hannover Mine	coal	Germany	Asphalt cont.
C_{14}	Coal division Essen	" "	Hannover Mine	coal	Germany	without asphalts
Ab_6	Steana Romania Vienna 40	Steana Romana Bucuresti	gas oil	petroleum	Rumania	
Ad21	KMD, Hbg, 13. Letter #2837 v-4, May 6, 1939	European storage tank and transport comp.	diesel fuel	petroleum	America	

List of the samples cont'd

Number of the sample	Name of the agent	Received from	Mark of the oils	Source of the oils	Country	Remarks
Ad_{22}		Hamburg branch	gas oil	petroleum	America	
B_{13}	Navy High Command, Berlin BB-M-V	Edeleann Comp. Berlin-Tempelhof	Edeleanu diesel-fuel, A.S.W.-distillate	lignite	Germany	
B_{14}	Navy Yard, Kiel	German Petroleum Co. Rositzer lignite M.T.S "Nikolams Otto"	lignite gas-oil	lignite	Germany	
Ac_8	Norddentscher Lloyd Bremen	Standard Vacuum Oil Co. Port Said, bunkered February 20, 1939 by M.S. "Marburg"	diesel oil	petroleum	Port Said	
Ad_{23}	"	Lago Oil Comp. Aruba bunkered February 15, 1939 by M.S. "Düsseldorf"	diesel oil	petroleum	Aruba	
Ac_9	"	Union oil comp. of California bunkered March 27, 1939 by M.S. "Düsseldorf" at Colon	diesel oil	petroleum	Colon	
Ac_{10}	"	Socony-Vacuum Oil Col bunkered April 4, 1939 by M.S. "Marburg" at Singapore	diesel oil	petroleum	Singapore	

List of the samples cont'd.

Number of the sample	Name of the agent	Received from	Mark of the oils	Source of the oils	Country	Remarks
Aa_9	"Nitag" German fuel Comp.	"Nitag" Salzbergen Refinery	Nitag gas oil	petroleum	Germany	
Ab_7	Berlin-Charlottenburg	Nitag Import Rum. gas oil	Nitag gas oil "	petroleum	Rumania	
Ae_9		Eurotank product Hamburg	Nitag gas oil	petroleum	unknown	
B_{15}	German petroleum Comp. Demonstration plant Berlin-Mariendorf	Rositz-Mineral oil-	Power Oil I	lignite	Germany	
E_3	Ruhrbenzin Comp. Obernhausen	Ruhrbenzin Comp.	RCH-diesel-fuel (Kogasin II)	Synthetic gas oil (Fischer Tropsch)	Germany	
D_1	German Hydrogenation Works	German Hydrogenation	Dekalin	Completely hydrog. naphthalene	"	
D_2	Rottleben near Dessau	Works	Tetralin	partially hydrog. naphthalene	"	

Appendix #11

German diesel fuels from petroleum (Aa)

Number of the group	Aa1	Aa2	Aa3	Aa4	Aa5	Aa6	Aa7	Aa8	Aa9
Color (Ostwald)	3	1	6	5	1	1	2	1	1
Transparency	clear	clear	slightly cloudy	clear	clear	clear	clear	clear	clear
specific gravity 20°C	0.841.	0.860	0.888	0.878	0.848	0.840	0.861	0.842	0.840
Viscosity 20°C	1.4	1.6	1.04	1.2	1.3	1.35	1.4	1.7	1.3
" 10°C	1.5	1.95	1.10	1.3	1.4	1.50	1.6	2.05	1.45
" 50°C									
" 80°C									
" 100°C									
Water %	Aa1	Aa9	absent	absent	absent	absent	absent	absent	absent
Ash %	traces	0.01	0.014	0.004	0.003	traces	absent	absent	traces
organic acids calculated as % SO_3	0.02%	0.018	absent	0.008	0.005	0.01	0.052	0.008	0.096
Asphalt %	Aa1	Aa9	absent	absent	absent	absent	absent	absent	absent
Insoluble in alcohol-ether %	Aa1	Aa9	absent	absent	absent	absent	absent	absent	absent
Insoluble in xylol %	Aa1	Aa9	absent	absent	absent	absent	absent	absent	absent
Conradson carbon-residue %	0.017	0.01	0.15	0.06	0.005	0.004	0.003	traces	0.02
Flash point Pensky-Martens closed tester °C	72	135	86	93	76	70	86	127	71
Flash point (DVM) °C	95	142	101	108	96	78	100	134	92
Fire point by means of open cup °C	116	170	110	120	112	109	117	144	110
Pour point °C	-18°	-10°	-20°	below -20°	below -20°	-18°	below -20°	-3°	-16°
Filtering test according to Hagemann-Hammerich	5.2	9.8°	3.8	5.6	5.4	5.6"	4.6	6.2°	3.6
Creosot content %	absent	absent	absent	absent	below 1%	absent	absent	absent	absent
Initial boiling point °C	183°	256°	206	213°	185°	180°	205°	265°	185°
Boiling range:									
to 225°C are vaporized %	7.0		74.7			13.5			11.4
" 250 " " " "	25.0		-98.2	45.7	22.2	30.2	30.4		28.5
" 275 " " " "	42.0		291°			46.0			45.0
" 300 " " " "	62.5	48.2		84.2	88.6	60.0	77.6	29.6	60.0
" 325 " " " "	80.0			98.8	98.6	73.5			76.6
" 350 " " " "	89.0			320°	328°	84.0	94.8	87.6	84.0
" 375 " " " "	377°	98.0		320°	328°	92.5	96.6	98.2	98.6
End point °C	97.5	310°		320°	328°	98.0	96.6	98.2	98.6
						390°	352°	379°	381°

Appendix #11

German diesel fuels from petroleum (Aa) (Cont'd)

Number of the group	Aa1	Aa2	Aa3	Aa4	Aa5	Aa6	Aa7	Aa8	Aa9
Average boiling point according to Ostwald	288	294	235	260	271	285	273	316	287
Carbon %	84.9%	85.8	85.8	85.9	85.8	86.3	85.8	85.0	85.1
Hydrogen %	13.1	12.7	11.4	11.5	13.0	13.2	12.8	13.1	13.0
Sulfur %	0.2	0.4	1.6	1.1	0.5	0.2	0.2	0.1	0.4
End point	97.5	310°		320°	328°	98.0	96.6	98.2	98.6
						390°	352°	379°	381°
Average boiling point according to Ostwald	288	294	235	260	271	285	273	316	287
Carbon %	84.9%	85.8	85.8	85.9	85.8	86.3	85.8	85.0	85.1
Hydrogen %	13.1	12.7	11.4	11.5	13.0	13.2	12.8	13.1	13.0
Sulfur %	0.2	0.4	1.6	1.1	0.5	0.2	0.2	0.1	0.4
Thermal value kcal/kg	10875	10865	10405	10585	10865	10820	10800	10960	10840
Net calorific value kcal/kg	10190	10200	9810	9985	10185	10130	10130	10275	10160
Corrosion test according to Hammerich: losses mg	1.5	0.8	5.5	1.6	1.6	0.4	1.9	0.1	1.0
Figures according to Jentzsch: Flash point °C	70	77	80	92	80	73	77	116	70
Vaporization time in the dish sec.	35	40	25	40	30	35	30	35	45
Spontaneous ignition °C	266	263	274	270	256	262	262	254	255
Higher ignition value	530	510	530	540	510	520	510	520	490
Lower ignition value	16.6	17.5	7.0	9.3	10.2	11.4	10.5	31.9	11.6
R500%	0	0	0	0	0	0	0	0	0.2
R350 %	0.2	0	0.8	0.4	0	0.4	0.2	traces	0.3
Ignition delay sec.	1.7	1.8	1.9	1.9	1.7	1.5	1.8	1.2	1.3
Ignition value	16.5	16.5	6.6	9.3	10.1	11.2	9.9	33.3	10.7
Boiling figure	44	1	83	63	67	50	63	1	43
Tendency to age R 500 A	traces	0.4	0.9	0.6	0.4	0	traces	0.9	traces
Sludge level	1	2	16	7	1	2	2	traces	1
Jentzsch figure	81	79	44	54	59	62	57	100	61
Aniline point °C	67.8	68.5	25.7	44.5	62.1	67.3	64.0	81.6	67.3
Diesel index	56	50	21	33	50	56	47	64	56
Cetenenumber from specific gravity according to Marder	72	65	31	45	63	71	57	80	72
Cetene-number from Parachor according to Marder	69	65	26	42	59	68	54	77	67
Cetene - number, motor test H.W.A.-motor, coincident-flash fixed delay method	57.5	57.2	35.8	44.6	52.0	58.4	48.8	67.9	57.4

European diesel fuels from petroleum (A b)

Number of the group	Ab1	Ab2	Ab3	Ab4	Ab5	Ab6	Ab7	Ab8	Ab9
Color (Ostwald)	10	6	4	5	6	2	3	3	5
Transparency	opague	clear	clear	clear	clear	clear	clear	clear	clear
Specific gravity 20°C	0.912	0.851	0.865	0.856	0.855	0.833	0.834	0.859	0.851
Viscosity 20°C	12.5	1.5	1.5	1.4	1.3	1.4	1.27	1.35	1.35
Viscosity 10°C	25.4	1.7	1.65	1.5	1.3	1.65	1.40	1.65	1.50
Viscosity 50°C	3.8								
Viscosity 80°C									
Viscosity 100°C	1.4								
Water %	0.3	absent	absent	absent	absent	absent	absent	absent	absent
Ash %	0.06	traces	0.005	traces	0.005	absent	traces	0.001	0.23
Organic acids calculated as % SO_3	0.13	0.065	0.28	0.24	0.016	0.036	0.1	0.06	0.036
Asphalt %	1.18	absent	absent	absent	absent	absent	absent	absent	absent
Insoluble in alcohol ether %	4.1	absent	absent	absent	absent	absent	absent	absent	absent
Insoluble in xylol %	absent	absent	absent	absent	absent	absent	absent	absent	absent
Conradson-carbon residue %	4	0.02	0.017	0.034	0.047	0.02	0.009	0.017	0.045
Flash point Pensky-Marters closed tester °C	74	80	71	73	81	100	75	79	78
Flash point (DVM) °C	112	113	97	95	98	117	96	96	94
Fire point by means of open cup °C	138	125	116	111	112	132	114	113	108
Pour point °C	-20°	-18°	below -20°	below -20°	below -20°	-13°	-12°	-19°	below -20°
Filtering test according to Hagemann-Hammerich	4 Min.	5.2"	5.0"	4.2"	4.6"	4.2"	3.4"	5.4"	4.8"
Cresote content %	-	-	absent	6.0	absent	absent	absent	absent	absent
Initial boiling point °C	167°	195°	185°	193°	202°	210°	210°	183°	201°
Boiling range:									
to 225°C are vaporized %	8.3	5.5	14.0	12.5			12.0		
" 250 " " " "	16.3	18.5	34.8	34.0	23.4	3[illegible].2	23.3	17.6	27.4
" 275 " " " "	23.0	39.0	52.0	53.0			51.0		
" 300 " " " "	30.0	63.0	68.0	69.0	75.4	61.00	77.2	64.6	69.6
" 325 " " " "	48.0	76.0	78.0	83.0			90.2		
" 350 " " " "	89.8	86.0	86.2	89.0	94.2	93.2	98.3	91.4	91.6
" 375 " " " "	335°	93.0	97.0	94.0	98.2	98.4		97.8	98.8
End point °C	335°	96.8	368°	97.5	361°				
		380°		379°		378°	349°	378°	380°
Average boiling point according to Ostwald	304	292	279	278	277	294	275	288	280
Carbon %	85.7	85.9	85.9	86.7	86.4	86.0	86.0	85.6	85.1
Hydrogen %	11.9	13.2	13.1	12.0	12.8	13.2	13.3	12.9	12.8

European diesel fuels from petroleum (A b) (Cont'd)

Number of the group	Ab_1	Ab_2	Ab_3	Ab_4	Ab_5	Ab_6	Ab_7	Ab_8	Ab_9
End point °C	335°	96.8 380°	368°	97.5 379°	361°	378°	349°	378°	380°
Average boiling point according to Ostwald	304	292	279	278	277	294	275	288	280
Carbon %	85.7	85.9	85.9	86.7	86.4	86.0	86.0	85.6	85.7
Hydrogen %	11.9	13.2	13.1	12.0	12.8	13.2	13.3	12.9	12.8
Sulfur %	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.4
Thermal value kcal 1 kg	10535	10805	10715	10820	10780	10885	10920	10845	10840
Net calorific value kcal 1 kg	9915	10115	10030	10190	10110	10195	10225	10170	10165
Corrosion test according to Hammerich, losses mg	2.0	5.7	18.0	8.1	0.7	3.3	4.2	0.3	0.6
Figures according to Jentzsch:									
Flash point	82°	93°	72	73	88	108	72	87	86
Vaporization time in the dish - sec.	85	40	35	35	30	45	40	30	35
Spontaneous ignition	272	272	272	268	275	260	252	262	264
Higher ignition value	510	510	520	510	520	520	530	510	510
Lower ignition value	13	14.3	10.9	10.7	11.0	3.9	11.5	10.5	9.1
R 500 %	4.4	0	0	0	0	traces	traces	0	0
R 350 %	4.9	0.7	1.7	1.0	0.5	0.4	0.2	0.3	0.5
Ignition delay sec.	2.3	1.9	2	2.1	1.8	0.8	1.4	1.8	1.7
Ignition value	11.3	12.5	9.9	9.7	9.8	20	12.6	9.9	8.5
Boiling figure	7	2.8	39	38	33	25	68	30	35
Tendency to age									
R 500 A	6.9	1.0	1.0	0.5	0.8	0.7	0.3	0.5	1.1
Sludge level	24	2	7	4	3	1	2	2	2
Jentzsch figure	57	64	54	54	53	90	70	55	50
Aniline point °C	notcto be det.	68.8	57.4	60.0	63.2	76.6	69.7	64.8	63.5
Diesel index		53	43	47	49	64	59	48	50
Cetene number from specific gravity according to Marder	46	68	57	61	61	78	71	63	64
Cetene number from parachor according to Marder	39	66	53	60	57	74	67	60	61
Cetene number, motor test, HWA-motor, coincident-flash fixed-delay-method	44.6	56.3	46.2	49.6	51.3	65.9	59.3	50.4	50.7

Asiatic diesel fuels from petroleum (Ac)

Number of the group	Ac_1	Ac_2	Ac_3	Ac_4	Ac_5	Ac_6	Ac_7	Ac_8	Ac_9	Ac_{10}
Color (Ostwald)	1	10	10	10	2	1	10	10	10	9
Transparency	clear	opaque	opaque	opaque	clear	clear	opaque	opaque	opaque	opaque
Specific gravity 20°C	0.842	0.868	0.897	0.906	0.851	0.841	0.868	0.945	0.864	0.883
Viscosity 20°C	1.15	2.6	1.9	2.1	1.4	1.18	2.45	1.87	1.6	1.4
Viscosity 10°C	1.20	2.8	3.6	2.7	1.55	1.25	3.5	2.42	1.9	1.6
" " 50°C										
" " 80°C										
" " 100°C										
Water %	absent	absent	absent	traces	absent	absent	absent	absent	absent	traces
Ash %	absent	0.004	0.002	0.05	0.012	absent	0.009	0.082	0.031	0.002
Organic acids calculated as SO_3%	absent	traces	0.03	0.048	0.022	traces	0.004	0.024	0.036	absent
Asphalt %	absent	1.05	absent	0.04	absent	absent	0.45	0.022	0.1	0.11
Insoluble in alcohol-ether %	absent	absent	traces	0.07	absent	absent	1.40	0.82	0.655	0.665
Insoluble in xylol %	absent	traces	traces	traces	absent	absent	0.002	0.008	0.016	0.060
Conradson-carbon residue %	0.001	2.0	0.3	0.27	0.04	0.01	2.04	0.55	0.14	0.16
Flash point Pensky Marters closed tester °C	82	82	89	79	73	83	83	82	84	91
Flash point (DVM) °C	93	114	111	100	94	99	105	100	101	104
Fire point by means of open cup °C	108	129	132	116	110	109	120	118	116	129
Pour point °C	below -20°	-17.5	-17	below -20°	below -20°	below -20°	-11°	-19°	below -20°	-15°
Filtering test according to Hagemann-Hammerich	4.2"	25.6"	14.0"	13.2"	5.0"	3.8"	17.8"	6.6"	4.0"	3.8"
Creosote	absent	absent	absent	absent	absent	absent	absent	absent	absent	absent
Initial boiling point °C	204°	195°	220°	187°	189°	190°	197°	166°	202°	204°
Boiling range:										
to 225°C are vaporized %		4.5	15.6							
" 250°C " " "	75.5	11.7	39.0	35.4	22.0	46.2	11.2	9.0	16.2	9.6
" 275 " " " "		27.5	59.0							
" 300 " " " "	94.6	46.0	70.0	45.2	73.0	93.2	20.2	47.8	58.8	62.8
" 325 " " " "	98.1	57.5	79.6							
" 350 " " " "	314°	94.0		72.8	93.2	99.4	66.4	76.0	86.0	90.8
" 375 " " " "		345°		93.6	98.2		92.8	90.0	97.8	96.8
End point °			82.0 90.0 395°	378°	373°	350°	370°	372°	387°	362°
Average boiling point according to Ostwald	237	303	--	313	279	256	325	307	295	291
Carbon %	85.1	85.3	86.5	85.5	84.9	85.5	84.9	87.3	85.7	87.0

Asiatic diesel fuels from petroleum (Ac) (Cont'd)

Number of the group	Ac_1	Ac_2	Ac_3	Ac_4	Ac_5	Ac_6	Ac_7	Ac_8	Ac_9	Ac_{10}
Hydrogen %	13.0	12.9	12.2	12.2	13.1	12.9	12.9	11.6	12.3	11.6
Sulfur %	0.8	1.3	0.1	0.9	0.4	0.7	1.0	0.6	0.6	0.1
Thermal value kcal/kg	10800	10780	10645	10595	10810	10800	10700	10500	10835	10595
Net calorific value kcal/kg	10125	10105	10005	9960	10130	10125	10025	9895	10190	9950
Corrosion test according to Hammerich, losses mg	0.6	0.4	0.0	2.0	0.7	0.7	0.5	1.3	1.1	0.6
Figures according to Jentzsch:										
Flash point °C	86	85	96	90	130	85	85	78	89	93
Vaporization time in the dish sec.	25	60	45	50	35	30	65	55	45	40
Spontaneous ignition °C	264	265	277	270	258	252	264	272	260	271
Higher ignition value	530	510	510	510	520	550	510	500	490	530
Lower ignition value	7.1	15.6	9.0	10.8	8.9	6.3	16.5	9.7	9.3	8
R 500%	0	2.3	0.3	0	0	traces	2.5	0.5	0.1	traces
R 350%	0.1	20	8.1	7.7	traces	traces	21	6.4	1.4	0.7
Ignition delay sec.	1.6	1.6	2.9	2.8	1.6	1.3	1	2.6	2.0	2
Ignition value	7.2	14.4	7.5	9.6	9.0	755	15.4	8.1	8.2	7.6
Boiling figure	80	24	31	22	40	75	14	30	30	35
Tendency to age R 500 A	0	2	1.6	2.6	0.6	0.3	3.6	2.8	0.6	1.5
Sludge level	1	8	13	16	3	1	9	18	5	13
Jentzsch figure	48	72	43	52	53	51	75	46	49	45
Aniline point °C	56.8	not to be det.	55.0	not to be det.	67.5	57.3	not to be det.	not to be det.	not to be det.	51.1
Diesel index	48	--	34	"	53	49	"	"	"	35
Cetene number from specific gravity according to Marder	52	64	--	51	64	60	70	36	64	54
Cetene number from Parachor according to Marder	46	59	--	47	59	55	66	31	58	52
Cetene number motor test, HWA-motor, coincident-flash fixed delay method	50.0	57.6	40.1	35.3	50.6	50.2	58.7	38.3	46.7	44.8

American diesel fuels from petroleum (Ad)

Number of the group	Ad_1	Ad_2	Ad_3	Ad_4	Ad_5	Ad_6	Ad_7	Ad_8
Color (Ostwald)	10	2	2	3	10	10	3	10
Transparency	opaque	clear	clear	clear	opaque	opaque	clear	opaque
Specific gravity 20°C	0.901	0.850	0.860	0.854	0.918	0.905	0.848	0.901
Viscosity 20°C	2.1	1.35	1.65	1.4	13.7	1.95	1.2	12.6
" 10"	2.7	1.50	1.85	1.5	27.2	2.6	1.35	26.5
" 50°C								3.5
" 80°C								1.8
" 100°C								1.35
Water %	absent	absent	absent	absent	0.2	absent	absent	0.3
Ash %	traces	traces	traces	traces	0.08	absent	traces	0.017
Organic acids calculated as SO_3%	0.09	0.011	0.054	0.046	0.032	0.036	0.003	traces
Asphalt %	Traces	absent	absent	absent	0.22	traces	absent	1.45
Insoluble in alcohol ether %	absent	absent	absent	absent	3.08	0.52	asbent	4.3
Insoluble in xylol %	absent	absent	absent	absent	0.016	absent	absent	absent
Conradson carbon-residue %	0.15	traces	0.012	0.007	6.2	0.15	0.0035	4.9
Flash point Pensky-Marters closed tester °C	79	81	75	75	69	77	78	82
Flash point (DVM) °C	110	100	90	90	84	97	99	138
Fire point by means of open cup °C	134	115	115	113	95	118	118	150
Pour point °C	below -20°	below -20°	below -20°	below -20°	below -20°	below -20°	below -20°	-13.5
Filtering test according to Hagemann Hammerich	13.8"	5.2"	5.4"	4.2"	∞	13.2"	4.0"	not to be det.
Cresote content %	absent	absent	absent	absent	absent	absent	absent	
Initial boiling point °C	168°	198°	150°	188°	173°	190°	185°	180°
Boiling range:								
to 225°C are vaporized %	5.0	7.0	12.5	11.0	24.0		13.0	3.6
" 250°C " " "	15.2	2.0	28.0	33.0		13.0	42.0	7.0
" 275°C " " "	30.0	56.0	45.0	58.0	38.0		70.5	10.0
" 300°C " " "	47.0	77.0	65.4	77.0		46.2	86.5	16.0
" 325°C " " "	63.0	88.8	80.0	87.0	78.0		94.5	25.0
" 350°C " " "	76.0	94.0	90.0	93.5	345°	71.4	97.3	40.0
" 375°C " " "	91.0	98.0	98.0	98.0		95.2	340°	330
End point °C	368°	363°	378°	370°		388°		
Average boiling point according to Ostwald	304	275	307	309	286	310	260	335
Carbon %	86.4	86.1	85.6	85.9	84.2	86.6	85.5	85.1
Hydrogen %	11.9	13.1	12.9	12.9	11.8	12.0	12.9	11.7

American diesel fuels from petroleum (Ad) (Cont'd)

Number of the group	Ad_1	Ad_2	Ad_3	Ad_4	Ad_5	Ad_6	Ad_7	Ad_8
Sulfur %	0.7	0.2	0.2	0.4	1.9	0.7	0.3	2.0
Thermal value kcal/kg	10570	10880	10880	10835	10450	10590	10735	10430
Net calorific value kcal/kg	9950	10195	10205	10160	9835	9960	10060	9820
Corrosion test according to Hammerich, Losses mg	3.9	1.8	4.3	5.1	3.6	2.3	0.1	0.1
Figures according to Jentzsch:								
Flash point °C	87	82	75	74	79	85	78	92
Vaporization time in the dish sec.	40	25	30	30	80	40	25	110
Spontaneous ignition °C	270	268	268	268	270	267	268	262
Higher ignition value	490	520	520	530	520	500	530	510
Lower ignition value	10.8	11.2	10.3	10.3	10.8	9.2	4.7	7.1
R 500 %	traces	0	0	0	7.8	traces	traces	4.9
R 350 %	4.6	0.4	traces	traces	39	5.5	0.3	53
Ignition delay sec.	2.8	1.8	1.9	1.8	2.2	3.0	1.6	1.8
Ignition value	8.8	10.1	9.7	10.1	10	8.0	7.5	6.7
Boiling figure	27	60	63	63	25	27	74	3
Tendency to age R 500 A	2.4	0	traces	0.4	8.3	1.5	traces	6.5
Sludge level	18	1	2	3	80	19	2	70
Jentzsch figure	49	57	56	58	54	46	48	40
Aniline point °C	not to be det.	64.2	64.1	62.0	not to bet det.	not to be det.	58.9	not to be det.
Diesel index	"	51	48	48	"	"	48	"
Cetene number from specific gravity according to Marder	50	63	69	71	50	51	59	"
Cetene number from Parachor according to Marder	42	58	64	68	42	47	50	"
Cetene number HWA-motor, coincident Flash fixed-delay method	34.9	51.5	48.6	48.9	41.9	35.3	50.9	49.5

American diesel fuels from petroleum (cont'd)

Number of the group	Ad_9	Ad_{10}	Ad_{11}	Ad_{12}	Ad_{13}	Ad_{14}	Ad_{15}
Color (Ostwald)	3	5	5	3	4	10	7
Transparency	clear	clear	clear	clear	clear	opaque	clear
Specific gravity 20°C	0.853	0.848	0.860	0.851	0.851	0.862	0.874
Viscosity 20°C	1.4	1.4	1.45	1.35	1.35	1.5	1.5
" 10°C	1.5	1.6	1.7	1.5	1.35	1.8	1.7
" 50°C							
" 80°C							
" 100°C							
Water %	absent	absent	absent	absent	absent	absent	absent
Ash %	0.0025	0.05	0.02	0.001	0.001	0.015	traces
Organic acids calculated as SO_3%	0.003	0.13	0.08	0.012	0.016	0.05	0.1
Asphalt %	absent	absent	absent	absent	absent	absent	absent
Insoluble in alcohol-ether %	asbent	absent	absent	absent	absent	absent	absent
Insoluble in xylol %	absent	absent	absent	absent	absent	traces	absent
Conradson carbon residue %	0.004	0.09	0.094	0.012	0.014	0.1	0.03
Flash point Pensky-Marters closed tester °C	82	80	70	77	78	83	83
Flash point (DVM) °C	106	102	88	94	94	107	103
Fire point °C	128	121	103	110	109	123	125
Pour point °C	-18°	-18°	below -20°	below -20°	below -20°	below -20°	below -20°
Filtering test according to Hagemann-Hammerich	4.4"	4.6"	5.6"	4.6"	4.6"	6.6"	6.0"
Creosote content %			absent	absent	absent		
Initial boiling point °C	208°	200o	180°	189°	199°	210°	214°
Boiling range:							
to 225°C are vaporized %	4.0	5.8				3.0	4.0
" 250" " " "	19.0	23.0	27.0	28.6	23.0	18.5	20.0
" 275" " " "	44.8	42.2				41.0	50.4
" 300" " " "	68.5	66.0	59.0	68.8	66.4	60.0	77.0
" 325" " " "	84.5	82.2				74.5	89.0
" 350" " " "	93.0	90.0	81.6	92.4	91.8	84.0	95.0
" 375" " " "	96.0	98.0				91.0	98.5
End point °C	98.0		96.2	98.4	98.0		
	379°	365°	376°	376°	373°	372°	363°
Average boiling point according to Ostwald	285	284	289	279	284	295	280
Carbon %	85.5	85.5	84.8	86.0	86.5	85.8	85.8
Hydrogen %	13.1	13.1	12.7	13.1	13.2	12.9	12.0

American diesel fuels from petroleum (cont'd)

Number of the group	Ad_9	Ad_{10}	Ad_{11}	Ad_{12}	Ad_{13}	Ad_{14}	Ad_{15}
Sulfur %	0.9	0.4	0.9	0.1	0.1	0.5	0.8
Thermal value kcal/kg	10855	10815	10770	10890	10875	10785	10685
Net calorific value kcal/kg	10170	10130	10105	10205	10185	10110	10060
Corrosion test according to Hammerich, losses mg	0.3	8.2	0.6	0.3	0.5	0.2	6.0
Figures according to Jentzsch:							
Flash point °C	79	82	81	81	87	90	99
Vaporization time in the dish sec.	30	35	35	30	30	30	30
Spontaneous ignition °C	268	262	262	264	264	272	277
Higher ignition value	510	530	510	520	510	510	510
Lower ignition value	8.6	13.1	11.4	12.0	12.5	9.4	8.4
R 500 %	0.3	0	0	0	0	0	0
R 350 %	0.5	0.2	0.6	0.2	0.3	2.0	0.9
Ignition delay sec.	1.9	1.7	1.8	1.7	1.7	2.0	2.6
Ignition value	7.8	13.4	10.8	11.6	9.8	8.2	7.1
Boiling figure	42	32	23	39	35	33	37
Tendency to age R 500 A	1.1	traces	1.5	traces	0.7	1.1	1.4
Sludge level	2	1	3	"	3	4	8
Jentzsch figure	47	69	58	62	55	47	42
Aniline point °C	71.6	66.0	63.4	65.3	65.9	64.5	55.9
Diesel index	54	52	48	51	53	48	40
Cetene number from specific gravity according to Marder	65	67	63	63	66	63	54
Cetene number from parachor according to Marder	61	64	58	60	62	60	50
Cetene number HWA-motor, coincident flash fixed-delay method	61.4	54.9	48.8	50.8	52.2	48.5	40.9

American diesel fuels from petroleum (cont'd)

Number of the group	Ad_{16}	Ad_{17}	Ad_{18}	Ad_{19}	Ad_{20}	Ad_{21}	Ad_{22}	Ad_{23}
Color (Ostwald)	3	10	10	10	3	10	1	10
Transparency	clear	opaque	opaque	opaque	clear	opaque	clear	opaque
specific gravity 20°C	0.865	0.909	0.904	0.905	0.871	0.904	0.882	0.904
Viscosity 20°C	1.4	9.3	1.95	2.0	1.4	2.0	1.3	2.1
" 10"	1.58	117.5	2.60	2.7	1.6	2.7	1.5	2.9
" 50"		2.6						
" 80"		1.52						
" 100"		1.30						
Water %	absent	0.2	traces	absent	absent	0.1	absent	absent
Ash %	absent	0.064	absent	0.003	absent	0.006	absent	0.127
Organic acids calculated as SO_3 %	0.112	0.144	0.076	0.10	0.12	0.066	0.004	0.032
Asphalt %	absent	0.26	traces	traces	absent	0.073	absent	traces
Insoluble in alcohol ether %	absent	1.82	traces	traces	absent	0.059	absent	0.595
Insoluble in xylol %	absent	0.012	0.004	traces	absent	0.045	absent	0.009
Conradson carbon residue %	0.007	3.68	0.14	0.12	0.02	0.11	0.02	0.35
Flash point Pensky-Marters closed tester °C	81	96	77	94	79	72	75	83
Flash point (DVM) °C	99	114	93	113	91	92	93	98
Fire point °C	112	136	110		106	108	105	119
Pour point °C	below -20°	-15°	below -20°	below -20°	below -20°	below -20°	below -20°	below -20°
Filtering test according to Hagemann-Hammerich	5.4"	at +4° 82"	12.8"	12.2"	5.4"	10.0"	3.4"	9.4"
Cresote %	absent	absent			absent	absent	absent	absent
Initial boiling point °C	192°	210°	179°	184°	198°	188°	203°	186°
Boiling range: to 225°C are vaporized %								
" 250" " " "	23.0	6.0	12.2	12.0	20.6	12.6	30.4	9.8
" 275" " " "								
" 300" " " "	72.4	27.0	44.8	44.2	72.8	45.6	85.0	42.2
" 325" " " "								
" 350" " " "	92.0	78.0	76.4	73.0	94.8	75.8	98.2	71.2
" 375" " " "	98.6		93.8	92.6	98.2	87.8		92.4
End point °C	377°	340°	392°	97.0 418°	375°	383°	337°	382°
Average boiling point according to Ostwald	280	314	309	316	282		266	314
Carbon %	86.1	87.0	86.1	86.5	85.7	86.4	85.3	86.4
Hydrogen %	12.7	10.9	12.0	11.3	12.6	12.0	12.5	12.1

American diesel fuels from petroleum (cont'd)

Number of the group	Ad_{16}	Ad_{17}	Ad_{18}	Ad_{19}	Ad_{20}	Ad_{21}	Ad_{22}	Ad_{23}
Sulfur %	0.6	0.4	0.9	0.9	0.8	0.9	0.1	0.9
Thermal value kcal/kg	10765	10530	10635	10540	10715	10590	10735	10560
Net calorific value kcal/kg	10100	9960	10010	9950	10060	9965	10080	9925
Corrosion test according to Hammerich, losse mg	1.6	2.6	2.4	1.4	7.8	2.2	0.8	1.5
Figures according to Jentzsch:								
Flash point °C	87	103	80	80	80	77	80	78
Vaporization time in the dish sec.	30	125	55	50	40	50	35	55
Spontaneous ignition °C	267	268	272	265	258	279	276	269
Higher ignition value	520	520	510	500	530	490	510	490
Lower ignition value	8.6	14.1	9.4	9.8	8.3	12.1	8.1	9.6
R 500 %	0	4.7	traces	traces	traces	traces	traces	0.2
R 350 %	0.4	42	5.8	5.0	traces	5.3	traces	5.8
Ignition delay sec.	2.2	2.4	1.8	1.5	1.4	1.5	2	2.2
Ignition value	8.2	13.3	8.2	8.7	8.8	9.2	6.9	7.9
Boiling figure	35	4	25	23	57	16	68	22
Tendency to age R 500 A	0.6	6.3	1.9	1.8	traces	2.0	traces	2.9
Sludge level	4	18	13	14	"	14	1	18
Jentzsch figure	48	66	46	49	53	48	44	45
Aniline point °C	58.6	not to be det.	not to be det	Not to be det.	55.0	not to be det.	47.4	not to be det.
Diesel index	44	"	"	"	40.0	"	33	"
Cetene number from specific gravity according to Marder	58	50	51	52	56.0	"	46	52
Cetene number from Parachor according to Marder	54	47	47	48	52	"	41	48
Cetene number HWA- motor, coincident-flash fixed-delay method	43.6	46.1	34.8	33.9	41.3	35.4	33.3	36.0

Diesel fuels from petroleum (Unknown origin) Ae

Number of the group	Ae_1	Ae_2	Ae_3	Ae_4	Ae_5	Ae_6	Ae_7	Ae_8	Ae_9
Color (Ostwald)	1	2	2	4	4	4	4	4	1
Transparency	clear	clear	clear	clear	clear	clear	clear	clear	clear
Specific gravity 20°C	0.868	0.851	0.855	0.852	0.852	0.858	0.853	0.853	0.852'
Viscosity 20°C	1.25	1.41	1.42	1.4	1.35	1.4	1.4	1.5	1.65
" 10°C	1.48	1.55	1.60	1.5	1.50	1.55	1.5	1.75	2.04
" 50°C									
" 80°C									
" 100°C									
Water %	absent	absent	absent	absent	absent	absent	absent ab	absent	absent
Ash %	0.006	traces	traces	traces	0.04	0.04	0.015	0.13	traces
Organic acids calculated as SO_3 %	0.004	0.038	0.03	0.02	0.04	0.067	0.057	0.044	absent
Asphalt %	absent	absent	absent	absent	absent	absent	absent	absent	absent
Insoluble in alcohol-ether	absent	absent	absent	absent	absent	absent	absent	absent	absent
Insoluble in xylol %	absent	absent	absent	absent	absent	absent	absent	absent	absent
Conradson carbon residue %	0.02	0.02	0.002	0.02	0.045	0.07	0.02	0.05	0.009
Flash point Pensky-Marters closed tester °C	80	72	72	77	73	78	78	78	114
Flash point (DVM) °C	88	100	94	98	90	95	102	94	135
Fire point by means of open cup °C	109	116	108	114	113	118	121	113	165
Pour point °C	below -20°	below -20°	below -20°	below --20°	below -20°	below -20°	below -20°	below -20°	+20°: b.2°:
Filtering test according to Hagemann-Hammerich	5.8"	4.6"	5.0"	4.6"	4.6"	5.0"	5.2"	3.0"	7.1"
Creosote content %	absent								absent
Initial boiling point °C	188°	185°	190°	205°	198°	195°	198°	200°	240°
Boiling range									
to 225°C are vaporized %		10.3	11.9	9.8	10.0	7.0	9.5	8.0	
" 250 " " " "	37.4	30.0	33.0	30.5	29.0	27.0	29.3	30.0	0.6
" 275 " " " "		50.0	51.0	53.0	50.5	48.0	51.6	50.0	2.5
" 300 " " " "	83.6	68.0	65.0	70.5	71.2	66.6	70.0	68.5	22.0
" 325 " " " "		80.3	79.0	82.0	85.2	80.0	82.0	83.0	60.8
" 350 " " " "	98.2	90.0	88.0	91.0	93.0	90.2	91.0	92.0	84.4
" 375 " " " "		95.5	93.0	95.0	97.5	97.5	97.8	95.0	98.0

Diesel fuels from petroleum (Unknown origin) Ae (cont'd)

Number of the group	Ae_1	Ae_2	Ae_3	Ae_4	Ae_5	Ae_6	Ae_7	Ae_8	Ae_9
End point °C	320°	98.4 / 380°	97.5 / 385°	97.8 / 379°	375°	373°	375°	98.0 / 380°	372°
Average boiling point according to Ostwald	262	280	281	280	278	283	279	281	321
Carbon %	85.8	85.9	86.0	85.8	86.0	85.0	86.1	86.0	85.4
Hydrogen %	12.8	13.1	13.1	13.0	13.2	12.9	12.9	12.9	12.5
Sulfur %	0.9	0.3	0.4	0.4	0.4	0.5	0.4	0.5	1.1
Thermal value kcal/kg	10750	10865	10800	10825	10840	10840	10855	10840	10800
Net calorific value kcal/kg	10080	10180	10115	10145	10150	10165	10180	10165	10145
Corrosion test according to Hammerich, losses mg	0.6	0.2	0.5	0.4	0.2	0.9	0.4	0.3	1.0
Figures according to Jentzsch:									
Flash point °C	80	72	75	75	74	75	82	75	118
Vaporization time in the dish sec.	30	30	35	30	35	35	35	35	35
Spontaneous ignition °C	260	267	264	270	270	266	266	270	255
Higher ignition value	510	520	530	520	510	510	510	520	490
Lower ignition value	9	9.9	9.1	9.3	8.7	8.6	8.6	9.3	15.9
R 500 %	0	0	0	0	0	0	0	0	0.2
R 350 %	0	0.3	0.3	0.4	0.6	0.6	0.6	0.7	traces
Ignition delay sec.	1.8	1.9	2.0	1.9	1.8	1.8	1.8	1.8	1.2
Ignition value	8.6	9.4	9.2	8.1	7.7	7.9	7.9	8.6	14.7
Boiling figure	67	45	37	43	55	38	40	42	6
Tendency to age R 500 A	0.3	0.5	traces	0.42	0.9	0.8	0.7	0.8	0.5
Sludge level	2	2	0	2	2	2	2	2	2
Jentzsch figure	53	53	53	47	47	47	47	49	74
Aniline point °C	54.1	64.9	64.1	62.9	62.9	65.6	63.3	63.3	76.0
Diesel index	40	51	49	49	49	49	49	49	57
Cetene number from specific gravity according to Marder	50	64	63	64	63	62	63	64	76
Cetene number from parachor according to Marder	45	60	59	59	59	55	59	59	74
Cetane number HWA-motor coincident-flash fixed-delay method	39.1	47.5	45.7	49	48.1	46.6	48.1	49	63.4

Diesel-fuels from lignite (B)

Number of the group	B_1	B_2	B_3	B_4	B_5
Color (Ostwald)	7	9	7	8	8
Transparency	clear	opaque	clear	clear	clear
Specific gravity 20°C	0.875	0.895	0.875	0.886	0.903
Viscosity 20°C	1.1	1.3	1.25	1.25	3.5
" 10°C	1.2	1.5	1.30	1.4	3.6
" 50°C					
" 80°C					
" 100°C					
Water %	absent	absent	absent	absent	traces
Ash %	traces	0.015	0.0015	traces	0.010
Organic acids calculated as SO_3 %	0.003	0.008	0.003	absent	0.19
Asphalt %	absent	absent	absent	absent	absent
Insoluble in alcohol-ether %	absent	absent	absent	absent	absent
Insoluble in xylol %	absent	absent	absent	absent	absent
Conradson carbon residue %	0.05	0.08	0.035	0.08	0.19
Flash point Pensky-Marters closed tester °C	65	77	57	71	99
Flash point (DVM) °C	88	95	88	93	118
Fire point by means of open cup °C	102	110	105	109	131
Pour point °C	-18°	-16°	-17°	-15°	-18°
Filtering test according to Hagemann-Hammerich	4.0"	6.8"	8.2"	5.0"	---
Cresote content %	0.4	2.0	0.3	0.2	
Initial boiling point °C	185°	167°	150°	172°	
Boiling range					
to 225° are vaporized %	25.4	12.0	21.8		
" 250 " " "	48.2	26.4	39.5	34.6	
" 275 " " "	72.0	50.2	59.0		
" 300 " " "	86.0	72.6	67.5	79.0	
" 325 " " "	94.0	86.4	90.0		
" 350 " " "	98.3	94.4	94.0		
" 375 " " "		97.4	98.3	98.0	
End point °C	346°	355°	360°	342°	
Average boiling point according to Oswald	255	276	263	266	
Carbon %	85.9	84.8	84.7	85.6	86.2
Hydrogen %	11.6	11.2	11.3	11.5	12.2
Sulfur %	1.5	1.4	0.7	1.2	0.3
Thermal value kcal/kg	10375	10315	10445	10410	10515
Net calorific value kcal/kg	9770	9730	9855	9810	9875

Diesel - fuels from lignite (B) (Cont'd)

Number of the group	B_1	B_2	B_3	B_4	B_5
Corrosion test according to Hammerich, losses mg	3.0	2.9	3.0	1.5	18.0
Figures according to Jentzsch:					
Flash point °C	65	71	66	66	-
Vaporization time in the dish sec.	35	35	30	25	
Spontaneous ignition °C	278	286	280	277	
Higher ignition value	540	540	540	540	
Lower ignition value	6.8	8.2	7.6	9.6	
R 500 %	0	0	0	0	
R 350 %	0.5	0.9	0.2	1.2	
Ignition delay sec.	2.8 (300°/120B1)	3.4	2.9	3.0	
Ignition value	6.4	7.3	7.0	9.1	
Boiling figure	72	36	63	50	
Tendency to age R 500 A	0.8	2.5	0.7	3.0	
Sludge level	10	45	12	25	
Jentzsch figure	42	41	43	51	
Aniline point °C	30.2	34.4	31.6	31.8	36.3
Diesel index	26	24	26	25	24
Cetene number from specific gravity according to Marder	45	44	41	46	not to be det.
Cetene number from parachor according to Marder	41	38	36	44	" " " "
Cetene number HWA-motor, coincident flash fixed-delay method	41.5	41.5	39.4	39.0	

Diesel fuels from lignite (cont'd)

Number of the group	B_6	B_7	B_8	B_9	B_{10}
Color (Ostwald)	3	3	8	2	10
Transparency	clear	clear	clear	clear	opaque
Specific gravity at 20°C	0.856	0.869	0.864	0.860	0.950
Viscosity at 20°C	1.15	1.20	1.20	1.35	1.7
" " 10 "	1.18	1.25	1.25	1.45	2.0
" " 50 "					
" " 80 "					
" "100 "					
Water %	absent	absent	absent	absent	traces
Ash %	traces	traces	absent	absent	0.05
Organic acid calculated as SO_3 %	0.003	0.003	traces	0.006	absent
Asphalt %	absent	absent	absent	absent	0.9
Insoluble in alcohol	absent	absent	absent	absent	absent
Insoluble in xylol %	absent	absent	absent	absent	absent
Conradson carbon residue %	0.0025	0.002	0.010	0.001	0.65
Flash point Pensky-Marters closed tester °C	59	80	53	80	82
Flash point (DVM) °C	78	95	64	90	95
Fire point by means of open cup °C	83	105	75	104	112
Pour point °C	below -20°	below -20°	below -20°	below -20°	-20°
Filtering test according to Hagemann-Hammerich	2.4"	3.2"	3.6"	4.6"	9.0"
Creosote content %	0.7	0.5	absent	1.6	21.0
Initial boiling point °C	180°	190°	150°	186°	150°
Boiling range:					
to 225°C are vaporized %	60.0	21.2			25.6
" 250°C " " "	83.5	60.0	50.0	33.6	43.2
" 275°C " " "	94.6	72.0			62.8
" 300°C " " "	98.6	92.5	78.0	77.6	85.6
" 325°C " " "	295°	96.0			
" 350°C " " "		98.6	93.0	98.6	
" °C " " "	295°	328°	98.8	338°	303°
End point °C	295°		371°		308°
Average boiling point according to Ostwald	223	251	257	271	256
Carbon %	85.1	85.0	85.3	86.0	85.0
Hydrogen %	11.8	11.4	12.0	12.8	11.0
Sulfur %	1.0	0.8	1.1	0.2	1.0

Diesel fuels from lignite (Cont'd)

Number of the group	B_6	B_7	B_8	B_9	B_{10}
Thermal value kcal/kg	10490	10455	10440	10810	9725
Net calorific value kcal/kg	9875	9860	9815	10140	9150
Corrosion test according to Hammerich, losses mg	1.5	0.7	0.0	0.0	27.3
Figures according to Jentzsch:					
Flash point °C	61	83	61	82	76
Vaporization time in the dish sec.	20	25	30	30	30
Spontaneous ignition	284	273	277	267	309
Higher ignition value	530	530	530	510	590
Lower ignition value	5.8	6.7	6.8	8.6	1.7
R 500 %	traces	0	0	0	0.2
R 350 %	traces	0.3	0.7	0.6	1.6
Ignition delay sec.	2.5	2.5	2.4	2.3	15
Ignition value	5.0	6.3	6.8	7.8	1.7
Boiling figure	83	78	60	46	50
Tendency to age R 500 A	0.5	0.8	0.9	traces	4.2
Sludge level	12	11	9	2	7
Jentzsch figure	36	43	42	47	20
Aniline point °C	23.2	29.5	34.1	56.5	not to be det.
Diesel index	24	26	30	43	"
Cetene number from specific gravity according to Marder	36	45	50	57	19
Cetene number from parachor according to Marder	34	42	45	54	16
Cetene number HWA-motor, coincident flash fixed delay method	37.2	40.1	44.6	45.1	14.0

Diesel fuels from lignite (cont'd)

Number of the group	B_{11}	B_{12}	B_{13}	B_{14}	B_{15}
Color (Ostwald)	8	10	7	10	6
Transparency	clear	opaque	clear	opaque	clear
Specific gravity 20°C	0.889	0.982	0.873	0.903	0.862
Viscosity 20°C	1.2E	2.4E	1.4E	1.9E	1.2E
" 10"	1.25E	3.8E		2.5E	1.3E
" 50"					
" 80"					
" 100"					
Water %	absent	traces	absent	absent	absent
Ash %	0.005	traces	0.004%	0.018	absent
Organic acids calculated as SO_3%	0.008	absent	0.15	0.06	0.02
Asphalt %	0.075	1.0	absent	0.14	absent
Insoluble in alcohol-ether %	absent	absent	absent	0.11	absent
Insoluble in xylol %	absent	absent	0.04	0.0004	absent
Conradson carbon residue %	0.077	0.14		0.16	0.04
Flash point Pensky-Marters closed tester °C	68	85		80	54
Flash point (DVM) °C	84	97		101	69
Fire point by means of open cup °C	102	120		108	79
Pour point °C	below -20°	-16°		below -20°	-18°
Filtering test according to Hagemann-Hammerick	3.6"	33.2"		6.6"	3.0"
Creosote content %	traces	30		absent	0.6
Initial boiling point °C	168	190	208	184	146
Boiling range:					
to 225°C are vaporized %	28.0	16.4			
" 250°C " " "	52.0	34.0	25.6	12.0	42.0
" 275°C " " "	75.0	50.8			
" 300°C " " "	90.0	66.0	81.2	47.8	73.2
" 325°C " " "	98.8	80.0			
" 350°C " " "	318°	92.8	98.0	76.4	97.6
" °C " " "		350°	333°	88.4	348°
End point °C				376°	
Average boiling point according to Ostwald	250	277	273	--	267
Carbon %	85.9	84.9	85.0	87.5	86.0
Hydrogen %	11.1	9.5	13.6	11.5	12.0
Sulfur %	0.4	0.2	0.76	0.9	0.7
Thermal value kcal/kg	10415	9560	10600	10540	10530

Diesel - fuels from coal (C)

Number of the group	C_1	C_2	C_3	C_4	C_5
Color (Ostwald)	10	10	10	2	8
Transparency	opaque	opaque	opaque	clear	clear
Specific gravity 20°C	1.065	0.992	1.054	0.862	0.963
Viscosity 20°C	1.6	1.2	1.25	1.05	1.4
" 10 "	2.0	1.3	1.40	1.10	1.6
" 50 "					
" 80 "					
" 100 "					
Water %	0.1	absent	traces	absent	absent
Ash %	0.015	absent	0.028	absent	absent
Organic acids calcul. as SO_3 %	0.052	0.02	0.013	absent	0.006
Asphalt %	0.24	absent	0.36	absent	absent
Insoluble in alcohol-ether %	0.40	absent	absent	absent	absent
Insoluble in xylol %	0.010	absent	0.034	absent	absent
Conradson carbon residue %	0.36	0.02	0.33	0.002	0.04
Flash point Pensky-Marters closed tester °C	88	65°	102	60	74
Flash point (DVM) °C	104	97	108	80	89
Fire point by means of open cup °C	120	109	131	95	103
Pour point °C	-18°	below -20°	-16	-18	below -20°
Filtering test according to Hagemann-Hammerich	10.4"	6.2"	7.0"	4.0"	4.0"
Creosote content %	6.1	5.1	3.0	absent	1.0
Initial boiling point °C	199°	189°	221°	154°	182°
Boiling range:					
to 225°C are vaporized %					
" 250" " " "	43.1	68.7	38.9	56.0	51.0
" 275" " " "					
" 300" " " "	67.3		97.5	95.0	86.8
" 325" " " "					
" 350" " " "	89.5		98.6	99.2	98.8
" " " " "	95.5	99.2			
End point °C	356°	295°	305°	311°	338°
Average boiling point according to Ostwald	273	237	258	246	255
Carbon %	89.1	89.4	89.2	87.0	88.0
Hydrogen %	6.3	8.7	6.9	11.5	9.1
Sulfur %	0.8	0.1	0.4	0.3	0.5
Thermal value kcal/kg	9355	9840	9425	10585	9940

Diesel fuels from lignite (cont'd)

Number of the group	B_{11}	B_{12}	B_{13}	B_{14}	B_{15}
Net calorific value kcal/kg	9835	9060	9880	9940	9905
Corrosion test according to Hammerich, losses mg	0.1	42.9		3.2	1.2
Figures according to Jentzsch:					
Flash point °C	73	85	86	85	57
Vaporization time in the dish sec.	25	25	35	50	30
Spontaneous ignition °C	282	396	270	270	271
Higher ignition value	530	610	520	480	530
Lower ignition value	5.8	1.6	10	9.7	8.0
R 500 %	0	0	0	0.2	traces
R 350 %	0.5	1.2	0.5%	4.0	0.2
Ignition delay sec.	3.5	2.9	2.8	2	2.0
Ignition value	5.1	0.9	9.3	7.5	7.6
Tendency to age R500 A	1.2	2.7	2.5%	3.2	0.6
Boiling figure	70	37	54	30	53
Sludge level	8	5	38	23	9
Jentzsch figure	36	<20		44	46
Aniline point °C	26.7	not to be det.	not to be det.	not to be det.	39.4
Diesel index	21	"	"	"	33
Cetene number from specific gravity according to Marder	38	16	"	"	55
Cetene number from parachor according to Marder	32	not to be det.	"	"	49
Cetene number HWA-motor, coincident flash fixed-delay method	30.5	-10	-	35.5	43.3

Diesel fuels from coal (C) (Cont'd)

Number of the group	B_{11}	B_{12}	B_{13}	B_{14}	B_{15}
Net calorific value kcal/kg	9025	9385	9065	9985	9465
Corrosion test according to Hammerich, losses mg	3.5	0.8	2.7	0.3	0.1
Figures according to Jentzsch:					
Flash point °C	79	80	91	67	73
Vaporization time in the dish sec	35	25	30	30	30
Spontaneous ignition °C	510	460	512	268	296
Higher ignition value	650	600	670	560	590
Lower ignition value	2.1	3.0	2.5	7.2	1.8
R 500 %	traces	traces	traces	0	0
R 350 %	5.8	0.2	0.7	0	0.6
Ignition delay sec.	2.0 (550°/180B)	1.9	3.3	1.3	11
Ignition value	0.6	0.9	1.32	7.9	1.8
Boiling figure	53	81	77	73	70
Tendency to age R 500 A	5.8	0.4	4.7	traces	0.8
Sludge level	17	9	26	0	19
Jentzsch figure	<20	<20	<20	500	20
Aniline point °C	not to be det.	not to be det.	not to be det.	58.2	-3.6
Diesel index	"	"	"	44	4
Cetene number from specific gravity according to Marder	"	"	"	51	13
Cetene number from parachor according to Marder	"	2	"	43	not to be det.
Cetane number HWA-motor, coincident-flash fixed-delay method	0-	-11	-2.9	58.2	14.5

Diesel fuels from coal (C)(Cont'd)

Number of the group	C_6	C_7	C_8	C_9	C_{10}
Color (Ostwald)	10	10	4	10	10
Transparency	opaque	opaque	clear	opaque	opaque
Specific gravity 20°C	1.096	1.096	0.871	0.976	1.068
Viscosity 20°C	16	17	1.15	1.4	
" 10"			1.22	1.55	
" 50"	2.3	2.4			17.2
" 80"	1.2	1.4			2.8
" 100"	0.2	1.3			1.9
Water %	0.3	0.2	absent	0.4	1.0
Ash %	0.0075	traces	absent	0.001	0.07
Organic acids calculated as SO_3 %	absent	absent	0.006	0.012	0.016
Asphalt %	0.2	0.25	absent	0.17	6.76
Insoluble in alcohol-ether %	0.5	0.35	absent	traces	0.79
Insoluble in xylol %	traces	0.02	absent	traces	0.12
Conradson carbon residue %	1.06	1.3	0.001	0.010	2.49
Flash point Pensky-Marters closed tester °C	135	136	67	52	176
Flash point (DVM) °C	147	145	78	74	185
Fire point by means to open cup °C	187	184	86	90	214
Pour point °C	below -20°	below -20°	below -20°	below -20°	+4°C
Filtering test according to Hammerich	(+4°) ∞	not to be det.	3.4"	6.2"	not to be det.
Creosot %	2.0	absent	1.6	16.0	20.0
Initial boiling point °C	250°	250°	181°	151°	322°
Boiling range:					
to 225°C are vaporized %			75.4	50.8	
" 250" " " "	4.2	3.0			
" 275" " " "	11.0	10.6	96.0	79.2	
" 300" " " "	24.1	23.0	99.2	99.0	
" 325" " " "	40.0	39.6			
" 350" " " "	60.0	58.0			15.1
" 375" " " "	76.7	77.0			73.3
End point °C	388°	394°	308°	340°	380°
Average boiling point according to Ostwald	354	--	235	255	368
Carbon %	89.5	89.7	87.0	87.3	88.4
Hydrogen %	7.1	9.5	11.8	8.9	8.1
Sulfur %	0.3	0.3	0.05	0.3	0.2

Diesel fuels from coal (C) cont'd

Number of the group	C_6	C_7	C_8	C_9	C_{10}
Thermal value kcal /kg	9580	9575	10735	9705	9580
Net calorific value kcal/kg	9210	9080	10115	9235	9160
Corrosion test according to Hammerich, losses mg	0.1	0.0	0.6	1.7	0.1
Figures according to Jentzsch:					
Flash point °C	138	135	75	61	204
Vaporization time in the dish sec.	55	55	25	30	55
Spontaneous ignition °C	462	460	276	454	422
Higher ignition value	590	590	510	620	600
Lower ignition value	3.1	3.0	12.0	2.3	2.3
R 500 %	2.7	2.2	0	0	2.5
R 350 %	34	37	0.9	0.5	48
Ignition delay sec.	0.6	0.6	2.0	3.0	0.7
Ignition value	0.9	0.8	10.2	0.8	1.0
Boiling figure	1	1.0	80	60	1
Tendency to age R 500 A	5.9	5.4	traces	2.5	10.5
Sludge level	11	11	0	4	9
Zentzsch figure	<20	<20	58	<20	<20
Aniline point °C	not to be det.	not to be det.	43.7	not to be det.	not to be det.
Diesel index	"	"	33	"	"
Cetene number from specific gravity according to Marder	"	"	47	18	"
Cetene number from parachor according to Marder	"	"	45	9	"
Cetane number, HWA motor, coincident flash fixed-delay method	-1.8	-1.5	38.9	-6.5	-

<u>Diesel fuels from coal</u> (C) cont'd

Number of the group	C_{11}	C_{12}	C_{13}	C_{14}
Color (Ostwald)	10	10	10	10
Transparency	opaque	opaque	opaque	opaque
Specific gravity 20°C	1.004	1.027	1.064	1.004
Viscosity 20°C	2.7	5.55	26.5	1.62
" 10"	4.1	11.70	97.6	2.2
" 50"		1.75		
" 80"				
" 100"				
Water %	0.3	traces	1.0	0.4
Ash %	traces	0.009	0.039	0.05
Organic acids calculated as SO_3 %	0.004	0.016	0.004	0.018
Asphalt %	0.57	0.33	24.9	1.65
Insoluble in ether-alcohol %	0.08	absent	0.74	traces
Insoluble in xylol %	0.006	absent	0.41	0.076
Conradson carbon residue %	0.05	3.6	9.9	1.6
Flash point Pensky-Marters closed tester °C	67	83	50	103
Flash point (DVM) °C	85	100	72	116
Fire point by means of open cup °C	102	114	78	130
Pour point °C	-18°	-20°	-18°	below -20°
Filtering test according to Hammerich	∞	-	not to be det.	11.2"
Cresote content %	14.6	3.2	21.0	19.6
Initial boiling point °C	163°	182°	118°	230°
to 225°C are vaporized %				
" 250" " " "	21.0	16.8	28.8	18.8
" 275" " " "				
" 300" " " "	39.2	34.4	39.6	
" 325" " " "				
" 350" " " "	73.6	53.2	54.0	
" " " " "	97.8	72.8	69.6	92.8
End point °C	383°	382°	364°	299°
Average boiling point according to Ostwald	308		310	271
Carbon %	87.0	87.5	85.0	85.5
Hydrogen %	8.5	8.3	7.5	9.3
Sulfur %	0.1	0.6	0.5	0.3
Thermal value kcal/kg	9770	9705	9135	9550

Diesel fuels from coal (C) cont'd

Number of the group	C_{11}	C_{12}	C_{13}	C_{14}
Net calorific value kcal/kg	9325	9270	8745	9065
Corrosion test according to Hammerich, losses mg	2.2	0.5	7.3	3.7
Figures according to Jentzsch:				
Flash point °C	80	77	52	103
Vaporization time in the dish sec.	30	70	75	35
Spontaneous ignition °C	404	305	462 (470)	473
Higher ignition value	640	610	650	660
Lower ignition value	1.7	2.5	2.7	2.7
R 500 %	0	3.2	8.5	0.5
R 350 %	2.5	32	37	3.3
Ignition delay sec	3.6	3	21.	2.8
Ignition value	1.0	2.5	1.1	1.5
Boiling figure	22	12	24	29
Tendency to age R 500 A	3.0	9.1	21	6.2
Sludge level	16	24	-	14
Jentzsch figure	<20	<20	<20	<20
Aniline point	not to be det.	not to be det.	not to be det.	not to be det.
Diesel index	"	"	"	"
Cetene number from specific gravity according to Marder	22	"	"	10
Cetene number from parachor according to Marder	21	"	"	not to be det.
Cetane number, HWA-motor, coincident flash fixed-delay method	-8	--	--	--

Diesel fuels from hydrogenated Naphthalene (D)

Number of the group	D_1	D_2
Color (Ostwald)	1	1
Transparency	clear	clear
Specific gravity 20°C	0.884	0.970
Viscosity 20°C	1.20	1.18
" 10"	1.22	1.20
" 50"		
" 80"		
" 100"		
Water %	absent	traces
Ash %	traces	traces
Organic acids calculated as SO_3	absent	absent
Asphalt %	absent	absent
Insoluble in ether-alcohol %	absent	absent
Insoluble in xylol %	absent	absent
Conradson carbon residue %	0.002	0.002
Flash point Pensky-Marters closed tester °C	60	74
Flash point (DVM) °C	67	88
Fire point by means of open cup °C	76	100
Pour point °C	below -20°	below --20°
Filtering test according to Hammerich	2.6"	2.6"
Cresote content %	absent	absent
Initial boiling point °C	172°	178°
to 225°C are vaporized %		to 200°C = 18%
" 250" " " "		
" 275" " " "		to 210°C = 98.4%
" 300" " " "		
" 325" " " "		
" 350" " " "		
" 194" " " "	98.4	
End point °C	194°	210°
Average boiling point according to Ostwald		
Carbon %	85.2	88.8
Hydrogen %	12.9	9.0
Sulfur %	0.05	0.05
Thermal value kcal/kg	10775	10110

Diesel fuels from hydrogenated Naphthalene (cont'd)

Number of the group	D_1	D_2
Net calorific value kcal/kg	10100	9640
Corrosion test according to Hammerich, losses mg	0.6	0.9
Figures according to Jentzsch:		
Flash point °C	60	66
Vaporization time in the dish sec.	15	20
Spontaneous ignition °C	282	316
Higher ignition value	510	510
Lower ignition value	40	1.5
R 500 %	0	0
R 350 %	0	0
Ignition delay sec	1.4	1.8
Ignition value	33	0.9
Boiling figure	88	87
Tendency to age R 500A	--	--
Sludge level	--	--
Jentzsch figure	>100	12
Aniline point °C	34.8	below -25°C
Cetane number, HWA-motor, coincident flash fixed-delay method	39.6	23.2

Synthetic diesel fuels (E)

Number of the group	E_1	E_2	E_3
Color (Ostwald)	1	1	1
Transparency	clear	clear	clear
Specific gravity 20°C	9.760	0.784	0.765
Viscosity 20°C	1.1	1.45	1.15
" 10"	1.1		
" 50"			1.20
" 80"			
" 100"			
Water %	absent	absent	absent
Ash %	absent	absent	traces
Organic acids calculated as SO_3 %	absent	absent	0.005
Asphalt %	absent	absent	absent
Insoluble in alcohol-ether %	absent	absent	absent
Insoluble in xylol %	absent	absent	absent
Conradson carbon residue %	0.001	traces	0.02
Flash point Pensky-Marters closed tester °C	59	135	82
Flash point (DVM) °C	77	154	90
Fire point °C	89	175	110
Pour point °C	-145	+14°	-13°
Filtering test according to Hagemann-Hammerich	3.0*	to17° to +-16°	<1
Cresote content %	absent	absent	absent
Initial boiling point °C	174°	252°	195°
Boiling range:			
to 225°C are vaporized %			25.4
" 250" " " "	66.8		65.0
" 275" " " "			84.8
" 300" " " "	93.6	14.0	95.0
" 325" " " "			
" 350" " " "	98.2	97.0	98.5
" " " " "	319°	317°	308°
End point °C			
Boiling point according to Ostwald	240	308	244
Carbon %	83.5	83.7	84.3
Hydrogen %	15.1	14.9	14.9
Sulfur %	0.05	0.05	0.0

Synthetic diesel fuels (E) cont'd

Number of the group	E_1	E_2	E_3
Thermal value kcal/kg	11250	11255	11250
Net calorific value kcal/kg	10460	10475	10675
Corrosion test according to Hammerich, losses mg	0.2	0.0	3.2
Figures according to Jentzsch:			
Flash point °C	64	147	74
Vaporization time in the dish sec	25	30	20
Spontaneous ignition °C	243	232	241
Higher ignition value	520	540	530
Lower ignition value	11.0	14.5	15
R 500 %	0	0	0
R 350 %	0	traces	0
Ignition delay sec	0.6	3.8	0.3
Ignition values	12.6	19.3	18
Boiling figure	80	1	73
Tendency to age R 500 A	0	traces	--
Sludge level	0	0	--
Jentzsch figure	72	>90	>90
Aniline point °C	84.6	99.3	86.0
Diesel index	99	102	99
Cetane number from specific gravity according to Marder	91	107	99
Cetene number from parachor according to Marder	93	-	92
Cetane number HWA-motor, coincident-flash fixed-delay method	95.3	100.6	14.8 Such a cetane number is impossible for Kagasin II must read either 94.8 or 114.8 (Translater)

Diesel fuel from oil-shale (F)

Number of the group	F_1	F_2
Color (Ostwald)	10	8
Transparency	opaque	clear
Specific gravity 20°C	0.885	0.843
Viscosity 20°C	1.9	1.15
" 10"	2.45	1.20
" 50"		
" 80"		
" 100"		
Water %	absent	absent
Ash %	absent	absent
Organic acids calculated as SO_3 %	absent	absent
Asphalt %	absent	absent
Insoluble in alcohol-ether %	absent	absent
Insoluble in xylol %	absent	absent
Conradson carbon residue %	0.15	0.08
Flash point Pensky-Marters closed tester °C	83	72
Flash point (DVM) %	105	88
Fire point by means of open cup °C	133	99
Pour point °C	-9°	-14°
Filter test according to Hagemann-Hammerich	17.4"	8.6"
Creosote content %	absent	
Initial boiling point °C	168°	182°
Boiling range:		
to 225°C are vaporized %		
" 250" " " "	7.6	44.6
" 275" " " "		
" 300" " " "	26.0	82.6
" 325" " " "		
" 350" " " "	61.0	97.2
" 400" " " "	91.2	345°
End point °C	97.8 409°	
Boiling point according to Ostwald	330	260
Carbon %	86.1	85.3
Hydrogen %	11.4	12.5
Sulfur %	0.5	0.4

Diesel fuel from oil-shale (F) cont'd

Number of the group	F_1	F_2
Thermal value kcal/kg	10595	10700
Net calorific value kcal/kg	10000	10050
Corrosion test according to Hammerich, losses mg	0.9	0.4
Jentzsch figures:		
Flash point °C	88	69
Vaporization time in the dish sec	40	35
Spontaneous ignition °C	278	268
Higher ignition value	520	520
Lower ignition value	16.3	11.7
R 500 %	0	0
R 350 %	7.5	1
Ignition delay	2.8	1.9
Ignition value	14.2	11
Boiling figure	10	63
Tendency to age R 500 A	3.5	0.8
Sludge level	21	8
Jentzsch figure	68	61
Aniline point °C	not to be det.	47.9
Diesel index	-	42
Cetene number from specific gravity according to Marder	64	62
Cetene number from parachor according to Marder	61	54
Cetane number HWA- motor, coincident flash fixed-delay method	51.3	52.2

Appendix # III

Comments regarding the filter test (Hammerich-method)

The filter tests according to Hammerich and Hagemann were carried out in comply with the DIN draft # 1 DVM 3766 (German Industrial Standards #1, German Society for testing Materials 3767. According to the technical specifications of the Navy diesel-fuels are not subjected to the above mentioned test. According to the Technical Specification of the Army Ordnance Department however the filter test is requested. According to the specification 200 ccm diesel fuel must pass through the filter in not more than 60 sec. at temperatures of -5°C. In his article "Testing of diesel fuels for high speed diesel engines". (Chemical Formal 1939, pages 577-578) Karl Sipmann mentions that, no commonly used values for the filtering properties, the pour point and the beginning of paraffin precipitation have been established than those of the Army and Navy specifications. According to Sipmann a pour point of up to + 5°C can be admitted for diesel fuels which are used for the propulsion of ships. Aviation and car-diesel fuels however require pour points of -20°C to -30°C. Since neither in land-nor in ships - bunkers lower temperatures than 0°C occur the Navy's demand, that at -10°C no paraffin precipitations should take place, seems highly exaggerated. If the demand would read: No paraffin precipitation at 0°C by for more diesel fuels would be available for the Navy.

The following of the tested diesel fuels comply with the Army Ordnance Department Specifications for diesel fuels for cars:

Aa_3, Aa_4, Aa_5, Aa_{11}, Aa_9

Ab_2, Ab_3, Ab_4, Ab_5, Ad_6, Ab_7, Ab_8, Ab_9

Ac_1, Ac_4, Ac_5, Ac_6, Ac_8, Ac_9, Ac_{10}

Ad_1, ad_2, Ad_3, Ad_4, Ad_6, Ad_7, Ad_9, Ad_{10}, Ad_{11}, Ad_{12}, Ad_{13}, Ad_{14}, Ad_{15}

Ad_{16}, Ad_{18}, Ad_{19}, Ad_{20}, Ad_{21}, Ad_{22}, Ad_{23}

Ae_1, Ae_2, Ae_3, Ae_4, Ae_5, Ae_6, Ae_7, Ae_8

B_1, B_3, B_4, B_9, B_{10}, B_{11}, B_6, B_{15}, B_7, B_8, B_{14}

C_2, C_3, C_4, C_5, C_8, C_9, C_{12}, C_{14}

D_1, D_2

E_1

The remaining gas oils do not comply with the specifications. If precipitations were present or occurred it will be listed with the respective oils.

The filter test should not be overemphasized with regard to Navy diesel fuels in order not to refuse otherwise suitable oils.

The CPVA proposes therefore to include in the specifications the following items:

Filter test according to DIN-I, DVM 3767:

200 ccm not more than 60 sec. at 0°C acting under cold;
No paraffin precipitation at 0°C.

Hagemann - Hammerich - Filter - test.
Temporary DIN I DVM 3767

German diesel fuels from petroleum

Oil No	+10°	+8°	+6°	+4°	+2°	+1°	±0°	-1.2°	-2°	-4°	-5°	-6°	-7.5°	-8°	-9°	-10°	-10.5°	-10.7°	-13.0°	-13.5°	-15°	Pour Point	Remarks
Aa1					4.8"		5.2"	51.4"	51.8"													-18°	
Aa 2					8.8"		9.8"		10.6"	13.8"	∞											-10°	
Aa 3					3.8"		3.8"		3.6"	3.6"		4.0"		4.0"	4.0"			6.0"	∞			below -20°	
Aa 4					5.2"		5.6"		5.8"	6.0"		6.0"	7.8"		∞							below -20°	
Aa 5					5.0"		5.4"		5.8"	5.8"		7.2"	∞									below -20°	
Aa6					5.4"		5.6"		6.0"	7.4"		∞										-18°C	
Aa7					4.4"		4.6"		5.4"	5.6"		5.8"		6.4"		8.4"	∞					below -20°	
Aa 8	5.6"	6.2"	6.4"	7.0"	29.0"	∞																-3°	If the test starts at +2°C the following figures were obtained: +2°: 29.2 sec, +0°C = ∞
Aa 9					3.6"		3.6"		3.6"	5.0"		6.2"		17.0"		26.4"				63.0"	∞	-16°C	

Table No. 2: European Diesel fuels from petroleum

1 No.	+ 2°	± 0°	-2°	- 4°	-5°	- 6°	- 7°	-8°	-10°	-11°	-12°	-13°	-14°	-15°	Pour Point	Remarks
Ab 1	236"	240													-20°	Oil is too viscous
Ab 2	5.0"	5.2"	5.6"	6.6"		8.0"		10.2"	∞						below -18	50% deposits are present at -10°C, it is impossible to filter 50 ccm.
Ab 3	4.6"	5.0"	5.2"	5.8"		6.2"		6.8"	∞						below -20°	
Ab 4	4.0"	4.2"	4.6"	5.0"		5.4"		7.2"	8.6"	∞					below -20°	
Ab 5	4.2"	4.6"	5.2"	5.2"		5.2"		5.9"	6.4"	∞					-13°	
Ab 6	4.0"	4.2"		4.6"		15.6"									-19°	Approximately 50% solid deposits at -6.5°, it is impossible to filter 50 ccm
Ab 7	3.0"	3.4"	3.6"			3.8"			4.0"		6.8"		14.0"	24.4"	-12°	Temperature stays constant at -15° much deposits after 30 min. a test performed after 30 minutes showed the figure: ∞
Ab 8	5.2"	5.4"	5.8"		6.3		7.0"	∞							-19°	
Ab 9	4.6"	4.8"	(-3°) (5.2")			5.8"		5.8"	6.4"		7.4"	∞			below -20°	

Table No. 3 Asiatic diesel fuels from petroleum

Oil No.	+15°	+12.5°	+10°	+8°	+6°	+4°	+2°	±0°	-2°	-2.5°	-3°	-4°	-5°	-6°	-8°	-10°	-12°	-14°	-15.5°	-16°	-17.5°	-18°	-19.5°	-20°	-20.5°	-22°	Pour Point
Ac 1							4.0"	4.2"	4.2"			4.2"		4.6"	5.2"	6.6"	7.2"	7.4"				8.0"				∞	below -20°
Ac 2						18.4"	20.4"	25.6"	30.8"	33.2"	34.6"																-17.5°
Temperature does not proceed below -3°C and ascends a little later, despite the freezing bath has a temperature at least 10° degree.																											
Ac 3			7.2"	8.6"		11.6"	13.6"	14.0"																			-17°
At -2°C more than 50% deposits. It is impossible to filter 50/ccm.																											
Ac 4	6.8"	7.8"	8.4"	8.6"	9.9"	10.8"	11.8"	13.2"		15.0"		16.2"		18.2"	19.8"	22.7"	25.0"	29.0"		59.6"							below -20°
Ac 5							4.8"	5.0"	5.4"			6.0"		6.4"	6.8"	7.6"	8.8"	9.4"		11.6		13.8"		35.8"	∞		below -20°
Ac 6							3.8"	3.8"	3.8"			3.8"		3.8"	4.0"	4.2"	4.6"	5.0"		5.2"		5.4"		5.8"		6.2"	below -20°
The temperature scale of the thermometer does not indicate temperatures below -24°C																											
Ac 7	8.0"	9.2"	10.2"	10.6"		13.4"	15.2"	17.8"	20.8"			25.2"	27.6"	-7° ∞													-11°
At -7° more than 50% deposits																											
Ac 8							6.2"	6.6"		7.0"			7.8"		9.4"	11.0"	13.4"	20.4"	51.0"								-19°
Temperature stays constant for sometime at 15.5° and ascends later, a new test showed = ∞																											
Ac 9							4.0"	4.0"	4.2"			4.6"		4.8"	4.8"	4.8"	5.4"	-15° 6.2"			10.4"		19.0"				below -20°
Temperature stays constant at -19.5°C, deposits increase. After 20 minutes a test showed at -19.5°C = ∞																											
Ac 10							3.8"	3.8"	5.0"			5.8"		12.6"													-15°
Temperature stays constant at -4°C for sometime, goes down to -6°C after 30 minutes more than 50% deposits are present																											

Table NO. 4 American diesel fuels from petroleum

Oil No.	+15°	+12.5°	+10°	+8°	+6°	+4°	+2°	±0°	-2°	-4°	-5.5°	-6°	-7°	-8°	-9°	-10°	-11°	-12°	-13°	-14°	-15°	-16°	-18°	-20°	-22°	-24°	Pour point
Ad 1							12.6"	(-0.5°) (13.8")	15.2	17.0		20.0"		(-8.5°) 24.6"		29.6"		40.8"		56.5"		∞					below -20°
Ad 2							4.8"	5.2"	5.3"	5.8"		5.8"		7.0"		∞											
Ad 3							5.2"	5.4"	5.8"	6.2"		6.8"		7.6"		8.2"	∞										
Ad 4							4.0"	4.2"	4.7"	5.0"		5.6"		14.2"	∞												
Ad 5	Due to high viscosity no tests could be made.																										
Ad 6							12. 12.2	13.2"	(-2.5°) (15.4")	17.0"		20.0"		27.8"		37.0"		∞									below -20°
Ad 7							(+1.5°) (4.0")	4.0"	4.2"	4.6"		4.4"		4.6"	8.6"	∞											below -20°
Ad 8	Due to high viscosity no tests could be made.																										
Ad 9							4.2"	4.4"	4.6"	5.0"		5.2"		6.6"	18.4"	∞											-18°
Ad 10							4.2"	4.6"	5.0"	5.4"		5.8"		6.7"	∞												-18°
Ad 11							5.4"	5.6"	6.2"	6.6"		7.2"		7.6"		43.8"	∞										below -20°
Ad 12							(+1.5°) (4.8")	4.6"	4.8"	(-4.5°) (5.2)		5.4"		6.0"		8.8"	∞										below -20°
Ad 13							4.4"	4.6"	5.1"			5.8"				7.0"		8.0"	43.0"	∞							below -20°
Ad 14							6.0"	6.6"	7.2"	8.0"	8.4"	(-6.5°) (9.4")															below - 20°
	Temperature does not proceed below -6.5°C. The freezing bath was kept at a temperature of -20°C for 2 hours.																										
Ad 15							5.6"	6.0"	6.2	(-4.5°) (7.2")			7.6"			8.4"		9.2"		18.8"	82.4"						"
Ad 16							5.2"	5.4"	(-2.5°) (5.8")	(-4.5°) (6.2")		6.2"		11.8"		18.4"	(-11.5") (∞)										"
Ad 17	19.5"	(+13°) (20.6")	25.5"	28.0"	33.1"	41.3"		82"																			"
Ad 18	6.6"	7.0"	8.0"	8.4"	9.4"	10.4"	11.4"	12.8"	14.2"	15.6"		17.6"		20.0"		21.4"		25.6"		(38.4") (-14.5°)		∞					-15°
Ad 19							(+1°) (11.2")	12.2"	13.4"	15.4"		16.8"		19.0"		(-10.8°) (24.2")		35.0"		∞							
Ad 20							5.2"	5.4"	5.8"	6.0"		6.8"		7.2"		7.8"		8.4"		9.0"		9.8"	11.2"	12.8"	14.8"	16.0"	below -20°
	Lowest degree of the thermometer scale = -24°C																										
Ad 21							9.6"	10.0"	(-2.5°) (11.0")	11.8"		13.4"		14.8"		17.0"		21.0"		38.2"	45.4"	∞					"
Ad 22	Oil becomes cloudy at -22.5°C						3.0"	3.4"	3.8"	3.8"		4.0"		4.2"		4.2"				4.6"	(-15.5°) (5.2")		6.0"	7.2"	(-22.5°) (9.5")		"
Ad 23							8.2"	9.4"	9.8"			12.6"		13.8"				21.0"		26.6"		45.0"	62.0"	(-19.5°) (∞)			"

Table 5 Diesel fuels from petroleum (Unknown origin)

Oil No.	+2°	±0°	-2°	-4°	-5.5°	-6°	-7°	-8°	-9°	-10°	-11°	-12°	-14°	-16°	Pour point
Ae 1	5.2"	5.8"	6.0"	6.3"		7.0"		12.0"	∞						below -20°
Ae 2	3.8"	4.6"	4.8"	5.0"		7.0"	(7.5°) (9.8")					18.4"	∞		below -20°
Mush deposits below -10°C															
Ae 3	4.4"	5.0"	5.4"	5.6"		5.8"		6.2"		6.6"		7.2"	7.8"	∞	below -20°
Ae 4	4.0"	4.6"	4.6"	5.0"		5.6"		∞							below -20°
Ae 5	4.2"	4.6"	4.8"	5.0"		5.4"		5.6"		10.4"	∞				below -20°
Ae 6	4.6"	5.0"	5.4"			6.0"	6.0"		∞						below -20°
Ae 7	5.2"	5.2"	5.4"	5.8"		6.2"		7.0"	∞						below -20°
Ae 8	2.8"	3.0"	3.2"	3.2"		3.6"		4.6"	∞						below -20°
Ae 9	4.4"	5.0"	5.4"	5.6"		5.8"		6.2"		6.6"		7.2"	7.8"	∞	below -20°

Table No. 6 Diesel fuels from lignite

Oil No.	+10°	+9°	+7°	+5°	+3°	+2°	+1.5°	± 0°	-1°	-2°	-3°	-4°	-5°	-6°	-7°	-8°	-9°	-10°	-11°	-12°	-13°	-14°	-15°	-17°	-19°	Pour Point
B 1						4.0"		4.2"		4.8"	5.2"	6.0"	49.8"													-18°
B 2						6.8"		7.0"		7.8"	(-2.2°) (32.8")	(-3°) (36.2°)	(-4°) (∞)													-16°
B 3						8.0"		8.2"		8.2"	8.8"	8.8"	8.8"	44.2"	∞											-17°
B 4						5.0"		5.0"		5.4"		5.6"			6.2"	7.2"	∞									-15°
B 5	No oil available																									-18°
B 6						2.4"		2.4"		2.6"				2.8"				3.0°		3.6"		4.8"	∞			below -20°
B 7						3.0"		3.2"		3.2"		3.6"		3.6"		3.8"				5.0"						
	Straight cooling to -13° resulted the following figures:																									
B 8						3.4"		3.6"		3.8"		3.8"		4.0"		4.0"	15.4"	∞								below -20°
B 9						4.2"		4.6"		5.0"		5.0"		5.3"		5.4"	∞									below -20°
B 10						8.0"		9.0"		10.2"		11.2"		12.6"		∞										-20°
B 11						3.4"		3.6"		3.8"		4.0"		4.0"		4.2"		8.0	∞							below -20°
B 12	15.6"	16.6"	17.6"	21.0"	22.2"	(41.5") (24.6")		33.2"	∞																	below -20°
B 13	No oil available																									-16°
B 14						5.6"		6.6"				7.8"		8.6"				11.0"			13.4"		16.4"	23.8"	28.8"	below -20°
B 15						3.0		3.0		3.4		11.6		15.4		24.8		∞								-18°

Remark to B 14: From -19° on quick temperature decrease to -21.5° followed by an increase to -19°, after awhile, continous increase of the temperature despite further freezing. Test at -14.5°C = 45.8", at -10°C = ∞

Remarks referring to B7: crystallization at -13°C, temperature increases to -3.5°. The thermometer bulb is enveloped by crystals which hamper the temperature reading. Filtering time 6" at -6.5°C.

Table 7 Diesel fuels from coal

Oil No.	+10°	+9°	+7°	+5°	+3°	+2°	+1.5°	+0°	-2°	-4°	-6°	-7°	-8°	-9°	-10°	-11°	-12°	-13°	Pour point
C 1						10.4"		11.8"	13.2"	16.6"	∞								-18°
C 2						6.2"		6.4"	7.0"	7.0"	7.4"		8.0"	8.8"	∞				-20°
C 3						7.0"		7.2"	7.8"	8.6"	9.4"		10.2"		11.5"		16.6"	∞	-16°
C 4						4.0"		4.0"	4.5"	4.5"	4.6"		4.8"		∞				-18°
C 5						4.0"		4.0"	4.2"	4.4"	4.6"		5.0"		7.8"	∞			below -20°
C 6				at +4° = ∞															
C 7	Due to hogh viscosity no tests could be made																		
C 8						3.4"		3.4"	3.6"	3.6"	3.6"		3.8"	∞					below -20°
C 9					(+4°) (6.0")	6.0"		6.2"	6.6"	7.5"	11.4"		∞						below -20°
C10	Due to high viscosity no tests could be made																		-4°
C 11	15.2"	(+8°) (16.4")	(+6°) (18.8")	(+4°) (24.8")		∞													-18°
C12	(+20°) (18.2")	(+7.5°) (21.8")	(+15°) (25.8")	(+12°) (31.2")	(+10°) (36.6")	(+8°) (46.0")	(+6°) (65.0")												below -20°
C 13	Due to high viscosity no tests could be made																		-18°
C 14						10.2"		11.2"	(-2.5°) (13.0")	14.6"	17.4"	∞							below -20°

Table 8. Diesel fuels from hydrogenated naphthalenes

Oil No.	+2°	±0°	-2°	-4°	-6°	-8°	-10°	-12°	-14°	-16°	-17.5	-18°	-20°	-22°	-23°	Pour point
D 1	2.6"	2.6"	2.8"	3.0"	3.0"	3.2"	3.4"	3.4"	3.6"	4.4"		5.0"	6.0"	10.8"		below -20°
D 2	2.6"	2.6"	2.6"	2.8"	2.8"	2.8"	3.0"	3.6"	4.4"		9.8"		5.6"		5.8"	below -20°

Table 9: Synthetic diesel fuels

	+22.5	+20°	+18°	+17°	+16.5°	+16.25	+2°	+0°	-2°	-4°	-6°	-8°	-10°	--10.75°	-11°	Pour point	Remarks
E 1							3.0"	3.0"	3.0"	3.0"	3.4"	3.6"	5.4"	∞		-14.5	
E 2	3.6"	3.8"	4.0"	7.0"	8.0"											+14°	At +17° foam like deposits
E 3													6.3"			-13°	Between +2° and -8° quick filtration, can not be measured, at -8° sudden cloudiness, at -11° more than 50% deposits

Table 10: Diesel oils from oil shale

	+2°	±0°	-1°	-2°	-3°	-4°	Pour point	Remarks
F 1	11.0"	17.4"	∞				-9°	Temperature increases from 0° to 0.5° despite freezing bath is -10°C cold, slow decrease to -1°C, foaming, formation of deposits at the wall of the container.
F 2	4.0"	8.6"		14.0"	38.5"	∞	-14°	

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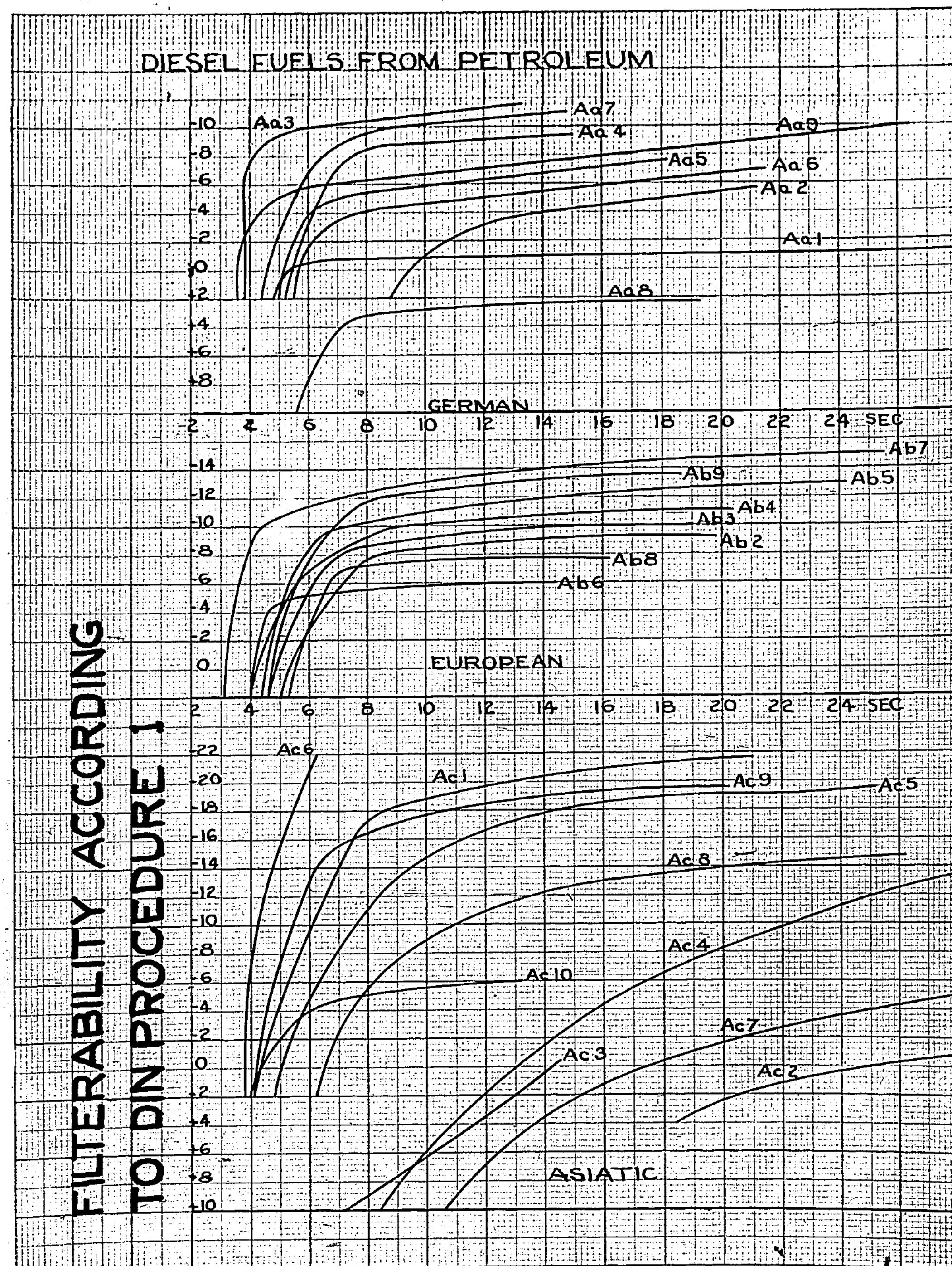

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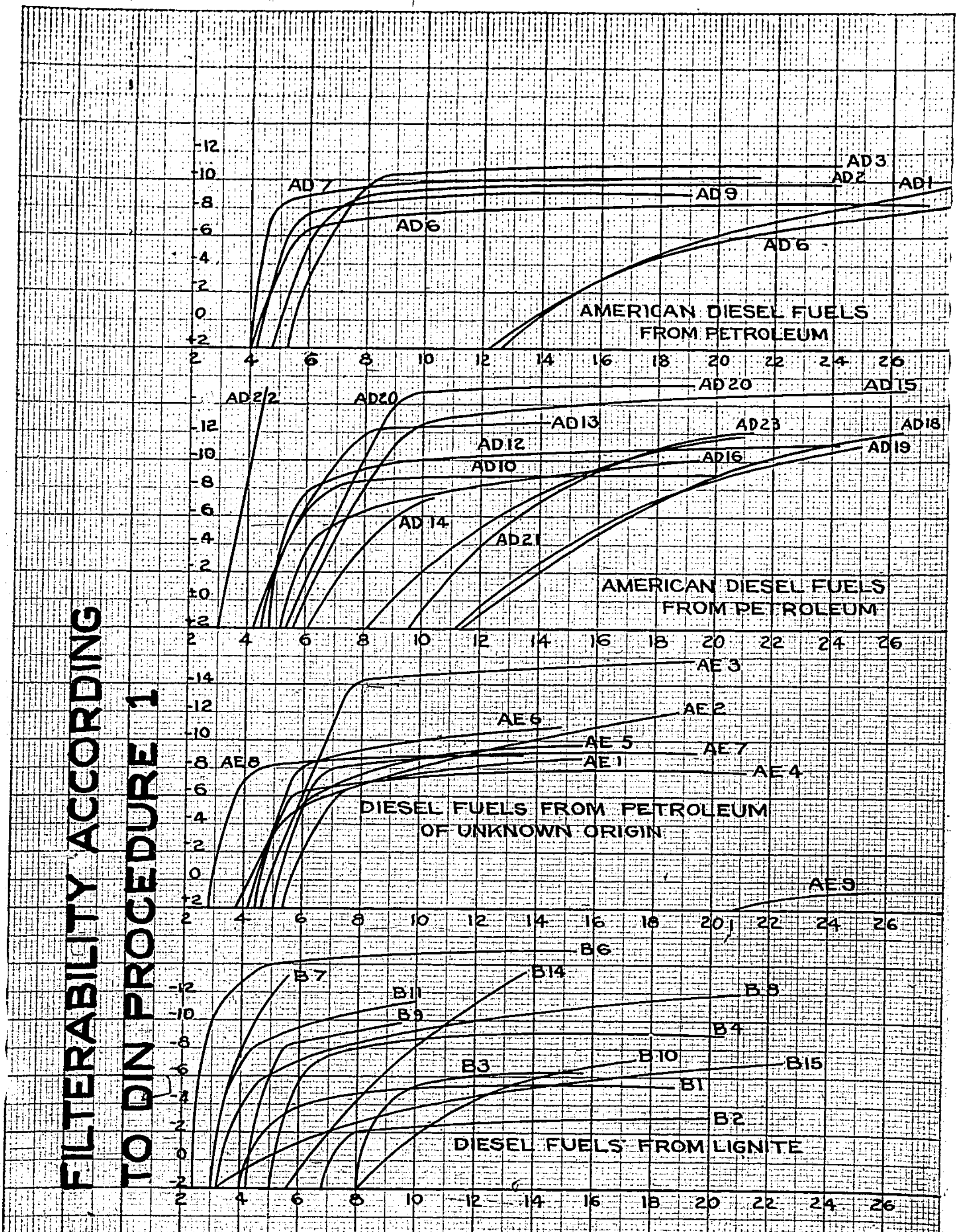

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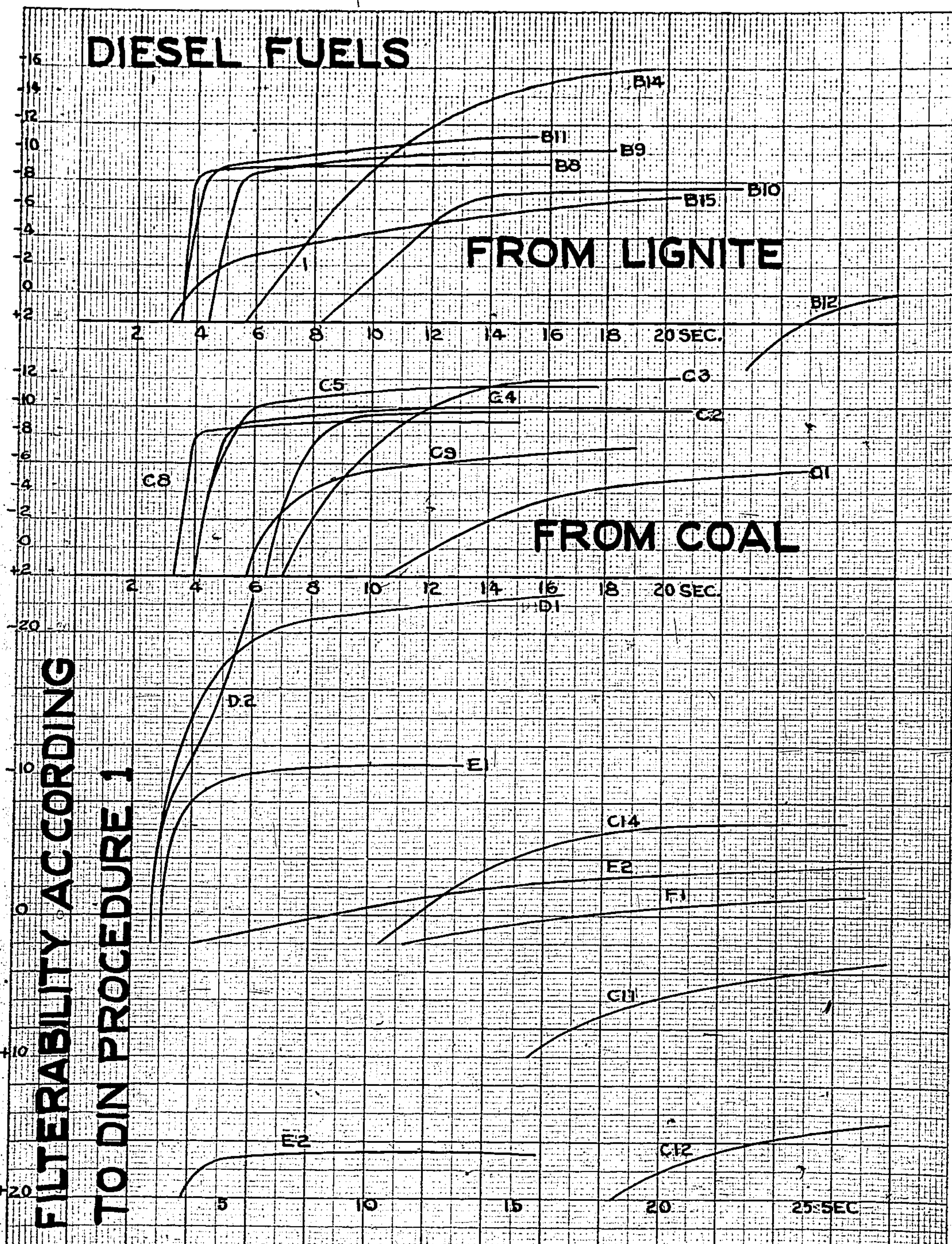

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Appendix IV

Remarks concerning corrosion caused by diesel fuels

Corrosion tests of the diesel fuels were performed according to DIN 1 DMV 3763. Heinze and Marder in an article "Requirements for modem diesel fuels" (Oil and coal, volume 14, number 41, November 1, 1938), mention that, according to the "Provisonal Specifications for diesel fuels for vehicles" published by the Army Ordnance Department, the losses of a zinc strip due to corrosion shall not exceed 1 mg, if the DIN method 1 DVM 3763 is applied. As shown by the figures of the performed corrosion tests not more than half of the total tested oils would comply with the specification. Hammerich is an Article "Corrosion by diesel-fuels" (Oil and coal, volume 14, number 26, July 8, 1938) proposes to accept diesel fuels which cause a corrosion losses of 4 mg. Moreover the reproducibility of the results is ± 1 mg.

According to Hammerich most of the samples are non-corrosive. The group of the corroding oils comprises the following fuels: petroleum diesel-fuels (Aa_3, Ab_3, Ab_4, Ab_7, Ad_3, Ad_4, Ad_{10}, Ad_{15}, Ad_{20}, and Ab_2, lignite diesel fuels B_5, B_{10}, B_{12}, coal diesel fuels C_{13}.

As show by the results of the tests of the petroleum oils the corrosivity of an oil depends on its acid content, it grows with an increasing acid content. But regarding the lignite and coal-diesel-fuels besides the acid content which is the main factor of corrosion, the presence of creosot influences the corrosive properties of an oil. The higher the creosot content, the higher are the weight losses of the employed zinc strips. The CPVA should admit weight losses of 4 mg (reproducibility ± 1 mg) employing DIN method 1 DVM 3763 for the determination of the corrosivity of a diesel fuel.

Appendix V

Improvement of diesel fuels or bunker fuels respectively which show an extremely high Conradson carbon residue.

Appendix A A number of the tested diesel fuels (compare appendix A) show a high conradson carbon residue. Various methods shall be described which are able to lower the conradson carbon residue. Not only diesel-fuels, but due to a request by the Navy High Command, also bunkers fuels were examined. The latter can be used as diesel fuels if it is possible to bring down the conradson carbon residue to 0.5%.

Four methods were employed to achieve an improvement of the oils.

I. The Frankenberg method which is owned by the Paul V. Frankenberg Company of Geising, district of Dresden and covered by the German Patent No. 664, 348. The process claims to be able to regenerate spent lubrication oils chiefly such of internal combustion engines. The spent oils are liberated from asphalt, coal particles and abraded metal particles by a treatment with alkali followed by settling.

The process was applied to bunker fuels which had a comparatively high conradson carbon residue with the aim to lower the conradson carbon residue by an alkaline treatment. But all the experiments failed as shown in the attached table if they were carried out in the laboratory as well as in a commercial scale by the company or the CPVA. (Compare appendix B)

Appendix B The following method was applied in the laboratory of the CPVA: The oils were heated to 70°C which temperature was maintained for a certain time. The oil were carefully decanted from the formed desposits. But a deposit could never be observed. The decanted oil was heated to 95°C and air was blown through the oil for 20 minutes whereby the same temperature was maintained. 4 parts of a 25% sodium hydroxide solution were added during 15 minutes under a constant introduction of air. Here upon 1.5 parts of water were admixed and the oil was allowed to settle for 2½ hours at 80°C and for another 3½ hours at normal temperatures.

Even now no deposits were observed. The water was perfectly separated from the oil. No results with respect to an improvement of the coke formation of the oils were obtained.

The following 3 oils were investigated in the laboratory:

Oil No. Ac_2 with 2.0% conradson carbon residue
Oil No. Ab_1 with 4.0% conradson carbon residue
Oil No. Ac_8 with 0.55% conradson carbon residue

As shown in the following table the conradson carbon residue was not lowered but increased.

Frankenberg Treatment n	Oil No. Ac_2	Oil No Ab_1	Oil No. Ac_8
	Conradson-Test	Conradson-Test	Conradson- test
Oil before treatment	2.0%	4.0%	0.55%
Oil after treatment	(0.002% SO_3 (2.5%	(0.09% NaOH (6.4 %	(0.074% NaOH (0.8 %

II. Another method, to treat the diesel fuels with fuller's earth failed also. The oils were subjected to a fuller's earth treatment at 80°C employing 3% fuller's earth and stirring during 3 hours.

Treatment with fuller's earth	Oil No Ac_2	Oil No Ab_1	Oil No Ac_8
	Conradson-Test	Conradson-Test	Conradson-Test
Oil before treatment	2.5%	4.0%	0.55 %
Oil after treatment	3.05%	5.07%	0.63%

III. As a 3rd method a treatment with sulfuric acid was employed, without being very effective. The oils have the tendency to form heavy emulsions during the following neutralization process with sodium hydroxide solutions. It must be further mentioned that comparatively high losses were observed when the laboratory tests performed. (Kind of treatment once or twice with sulfuric acid).

The oils were vigorously shaken with 3% of sulfuric acid during 20 minutes at 30°C.

After a settling time of 3 hours the liquid was liberated from the resin like substances. The treatment was repeated for a second time. The treated oil was rinsed with 1 part water + 1 part 10% sodium hydroxide solution. The following observations were made: The loss of oil substance depends on the height of the conradson carbon residue. It amounts to approximately 30-70%. During the water and alkali treatment emulsions are formed which can be broken by allowing the liquid to settle at elevated temperatures. The oils are brightened, the conradson carbon residue is lowered. The oil No Ac_8 acts peculiar. Despite its very low conradson carbon residue content it is less brightened than the rest of the oils.

Sulfuric acid treatment	Oil No. Ac_2	Oil No. Ab_1	Oil No. Ac_8
	Conradson Test	Conradson Test	Conradson Test
Oil before treatment	2.0%	4.0%	0.55%
Oil treated twic with sulfuric acid	0.61%	2.6%	0.62%
	losses approx. 40% color 7	losses approx. 50% color 9	losses approx. 35% color 9
Oil treated once with sulfuric acid			0.38 losses approx. 30% color 9

IV. A combined Frankenberg - sulfuric-acid treatment was tired. It was not superior to the sulfuric-acid treatment.

V. The treatment by distillation is worth while mentioning. According to the laboratory tests of the CPVA distillation is by for the most suitable method to improve oils which have a high conradson carbon residue. By distilling the oil No. Ab_1 its conradson carbon residue was lowered from 4 to 0.03%. The losses were approx. 10%. For this reason all oils which showed a high conradson carbon residue were distilled. The followingstables (appendix C and D) represent the obtained results.

Appendix A

No. 2	Conradson test of oil	Ac_2	2.0 %
No. 5	" " "	Ad_5	6.2 %
No. 1	" " "	Ab_1	4.0 %
No. 6	" " "	Ad_8	4.9 %
No. 9	" " "	C_6	1.06 %
No. 10	" " "	C_7	1.3 %
No. 8	" " "	B_{10}	0.65 %
No. 11	" " "	C_{10}	2.49 %
No. 7	" " "	Ad_{17}	3.68 %
No. 3	" " "	Ac_7	2.04 %
No. 12	" " "	C_{12}	3.6 %
No. 13	" " "	C_{13}	9.9 %
No. 14	" " "	C_{14}	1.6%
No. 4	" " "	Ac_8	0.55 %

Appendix V (cont'd)

Appendix B

Oil	Frankenberg drum III January 1939	Frankenberg Drum IV January 1939	Frankenberg Drum V January 1939
Bunker fuel	Eurotank-fuel oil	Eurotank-Ebano-fuel-mixture	Ebano-fuel-oil
Color (Ostwald)	10	10	10
Transparency	opaque	opaque	opaque
Spec. grav. 20°	0.977	0.927	0.898
Creosot content	absent	absent	absent
Water %	23.6 %	2.0 %	0.2 %
Ash %	2.16 %	0.31 %	0.055 %
Organic acids SO_3	absent	absent	absent
Na OH	0.66 %	0.02 %	0.04 %
Asphalts %	6.4 %	1.9 %	traces
Insoluble in alcohol ether %	5.6 %	2.9 %	0.11 %
Insoluble in xylol %	0.46 %	traces	traces
Conradson-carbon-residue %	10.7 %	4.7 %	0.49 %
Flash point Pensky-Marters °C	Due to foaming not to be determined	99°	85°
Flash point DVM °C		136°	101°
Fire point °C		-	-
Pour point °C	+ 7°C	below -20°	below -20°
Viscosity-curve		100° = 1.5 E	
		95° = 1.6 E	
		90° = 1.7 E	
		85° = 1.8 E	
		80° = 1.9 E	
		75° = 2.1 E	
	70° = 10.8 E	70° = 2.3 E	
	65° = 13.2 E	65° = 2.6 E	
	60° = 16.6 E	60° = 3.0 E	
	55° = 21.6 E	55° = 3.5 E	
	50° = 31.8 E	50° = 4.0 E	
	45° = 36.8 E	45° = 4.9 E	
	40° = 51.0 E	40° = 6.1 E	
	35° = 62.0 E	35° = 7.8 E	
	30° = 91.2 E	30° = 9.9 E	30° = 1.7 E
	27° = 110.0 E	25° = 12.9 E	25° = 1.85 E
		20° = 18.0 E	20° = 2.1 E
		15° = 24.0 E	15° = 2.45 E
		10° = 36.8 E	10° = 2.9 E
		5° = 56.4 E	5° = 3.55 E
Boiling rang			Beginning: 192°
			225° = 8.0 %
			250° = 15.0 %
			275° = 27.2 %
			300° = 40.0 %
			325° = 56.6 %
			332° = 74.0 %

Appendix V (cont'd)

Oil	Frankenberg drum III January 1939	Frankenberg drum IV January 1939	Frankenberg drum V January 1939
Spontaneous ignition °C			273
Lower ignition value			0.8
Higher ignition value			510
Ignition number			7.6
Ignition delay at 300°C 120 bubbles sec.			2.1
Boiling figure			9
Residue at 350°C %			17
Residue at 500°C %			traces
Vaporization time sec.			60
Flash point (Jentzsch) °C			81
Comparing figure			42
Residue at 350°C after " %			0.6
Sludge level			6
Hydrogen %	10.6	11.4	11.5
Carbon %	79.1	83.2	83.5
Sulfur %	2.4	2.5	3.0
Thermal value kcal/kg	9620	10350	10425
Net calorific value kcal/kg	9070	9755	9825

Appendix V (cont'd)

Appendix C

Oil No.	Oil before treatment conradson test %	Color	Distillate not yet washed conradson test %	color	Distillation losses %
Ac_2	2.0 %	10	0.005 %	3	6.0 %
Ad_5	6.2 %	10	0.03 %	3	22.0 %
Ab_1	4.0 %	10	0.05 %	5	10.2 %
Ad_8	4.9 %	10	0.04 %	3	60.0 %
C6	1.06 %	10	0.01 %	8	23.3 %
C_7	1.3 %	10	0.03 %	8	23 %
B_{10}	0.65 %	10	0.03 %	4	14 %
C_{10}	2.49 %	10	0.04 %	5	26.7 %
Ad_{17}	3.68 %	10	0.06 %	4	22.0 %
Ac_7	2.04 %	10	0.01 %	3	7.2 %
C_{12}	3.6 %	10	0.21 %	6	27.2 %
C_{13}	9.9 %	10	0.35 %	8	30.4 %
C_{14}	1.6 %	10	0.06 %	5	7.8 %
Ac_8	0.55 %	10	0.02 %	3	10.0 %

From the experiments the following conclusions may be drawn: All fuel oils which have a high conradson carbon dioxide residue can be transformed into diesel oils by a simple distillation process provided that they have suitable ignition properties.

Appendix VI

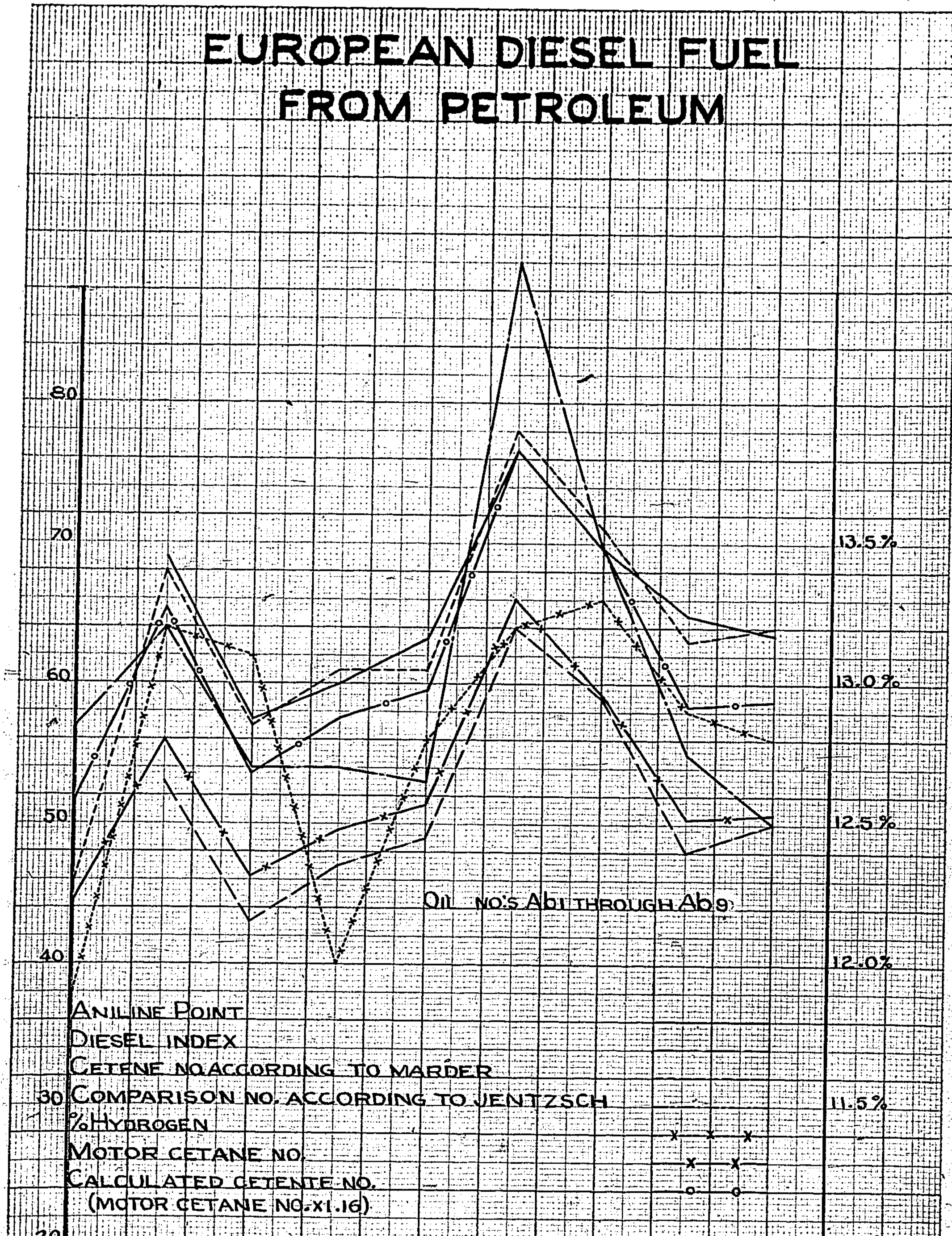
Table: Comparison of the ignitability of diesel-fuels determined in the laboratory and by the motor test respectively

Oil No.	Aniline point, °C	Diesel index	Cetene no. from spec. grav. accord. to Marder	Jentzsch figure	% Hydrogen	Cetane no. motor test HWA engine	Cetene number calculated from motor tested cetane number
			German diesel fuels from petroleum				
Aa_1	67.8	5.6	72	81	13.1	57.5	66.7
Aa_2	68.5	50	65	79	12.7	57.2	66.3
Aa_3	25.7	21	31	44	11.4	35.8	41.5
Aa_4	44.5	33	45	54	11.5	44.6	51.7
Aa_5	62.1	50	63	59	13.0	52.0	60.3
Aa_6	67.3	56	71	62	13.2	58.4	67.7
Aa_7	64.0	47	57	57	12.8	48.8	56.6
Aa_8	81.6	64	80	>100	13.1	67.9	78.8
Aa_9	67.3	56	72	61	13.0	57.4	66.6
			European diesel-fuels from petroleum				
Ab_1	not to be det.	not to be det.	46	57	10.9	44.6	51.7
Ab_2	68.8	53	68	64	13.2	56.3	65.3
Ab_3	57.4	43	57	54	13.1	46.2	53.6
Ab_4	60.0	47	61	54	12.0	49.6	56.5
Ab_5	63.2	49	61	53	12.8	51.3	59.5
Ab_6	76.6	64	78	>90	13.2	65.9	76.4
Ab_7	69.7	59	71	70	13.3	59.3	68.8
Ab_8	64.8	48	63	55	12.9	50.4	58.5
Ab_9	63.5	50	64	50	12.8	50.7	58.8
			Asiatic diesel fuels from petroleum				
Ac_1	56.8	48	52	48	13.0	50.0	58.0
Ac_2	not to be det.	not to be det.	64	72	12.9	57.6	66.8
Ac_3	55.0	34	--	43	12.2	40.1	46.5
Ac_4	not to be det.	not to be det.	51	52	12.2	35.3	40.9
Ac_5	67.5	53	64	53	13.1	50.6	58.7
Ac_6	57.3	49	60	51	12.9	50.2	58.2

Oil No.	Aniling point °C	Diesel index	Cetene no. from spec. grav. accord. to Marder	Jentzsch figure	% Hydrogen	Cetane No. motor test HWA engine	Cetene No. cal. from motor tested cetane No.
Ac_7	not to be det.	not to be det.	70	75	12.9	58.7	68.1
Ac_8	"	"	36	46	11.6	38.3	44.4
Ac_9	"	"	64	49	12.3	46.7	54.1
Ac_{10}	51.1	35	54	45	11.6	44.8	51.9
			American diesel fuels from petroleum				
Ad_1	not to be det.	not to be det.	50	49	11.9	34.9	40.5
Ad_2	64.2	51	63	57	13.1	51.5	59.7
Ad_3	64.1	48	69	56	12.9	48.6	56.3
Ad_4	62.0	48	71	58	12.9	48.9	56.7
Ad_5	not to be det.	not to be det.	50	54	11.8	41.9	48.6
Ad_6	"	"	51	46	12.0	35.3	40.9
Ad_7	58.9	48	59	48	12.9	50.9	59.0
Ad_8	not to be det.	not to be det.	not to be det.	40	11.7	49.5	57.4
Ad_9	71.6	54	65	47	13.1	61.4	71.2
Ad_{10}	66.0	52	67	69	13.1	54.9	63.7
Ad_{11}	63.4	48	63	58	12.7	48.8	56.5
Ad_{12}	65.3	51	63	62	13.1	50.8	58.9
Ad_{13}	65.9	53	66	55	13.2	52.2	60.5
Ad_{14}	64.5	48	63	47	12.9	48.5	56.2
Ad_{15}	55.9	40	54	42	12.0	40.9	47.4
Ad_{16}	58.6	44	58	48	12.7	43.6	50.6
Ad_{17}	not to be det.	not to be det.	50	66	10.9	46.1	53.4
Ad_{18}	"	"	51	46	12.0	34.8	40.3
Ad_{19}	"	"	52	49	11.3	33.9	39.3
Ad_{20}	55.0	40.0	56	53	12.6	41.3	47.9
Ad_{21}	not to be det.	not to be det.	not to be det.	48	12.0	35.4	41.0
Ad_{22}	47.4	33	46	44	12.5	33.3	38.6
Ad_{23}	not to be det.	not to be det.	52	45	12.1	36.0	41.8

Oil No.	Aniline point °C	Diesel index	Cetane No. from spec. grav. accord. to Marder	Jentzsch figure	% Hydrogen	Cetane No. motor test HWA engine	Cetene number cal. from motor tested cetane No.
			Diesel fuels from petroleum of unknown origin				
Ae_1	54.1	40	50	53	12.8	39.1	45.3
Ae_2	64.9	51	64	53	13.1	47.5	55.1
Ae_3	64.1	49	63	53	13.1	45.7	53.0
Ae_4	62.9	49	64	47	13.0	49.0	56.8
Ae_5	62.9	49	63	47	13.2	48.1	55.8
Ae_6	65.6	49	62	47	12.9	46.6	54.0
Ae_7	63.3	49	63	47	12.9	48.1	55.8
Ae_8	63.3	49	64	49	12.9	49.0	56.8
Ae_9	76.0	57	76	74	12.5	63.4	73.5
			Diesel fuels from lignite				
B_1	30.2	26	45	42	11.6	41.5	48.1
B_2	34.4	24	44	41	11.2	41.5	48.1
B_3	31.6	26	41	43	11.3	39.4	45.7
B_4	31.8	25	46	51	11.5	39.0	45.2
B_5	36.3	24	not to be det.	--	12.2	--	--
B_6	23.2	24	36	36	11.8	37.2	43.1
B_7	29.5	26	45	43	11.4	40.1	46.5
B_8	34.1	30	50	42	12.0	44.6	51.7
B_9	56.5	43	57	47	12.8	45.1	52.3
B_{10}	not to be det.	not to be det.	19	<20	11.0	14.0	16.2
B_{11}	26.7	21	38	36	11.1	30.5	35.4
B_{12}	not to be det.	not to be det.	16	<20	9.5	-10.0	-11.6
B_{13}	"	"	not to be det.	--	--	--	--
B_{14}	"	"	"	44	11.5	35.5	41.2

Oil No.	Aniline point °C	Diesel index	Cetene No. from spec. grav. accord. to Marder	Jentzsch figure	% Hydrogen	Cetane No. motor test HWA engine	Cetene No. cal. from motor tested cetane No.
			Diesel fuels from coal				
C_1	not to be det.	not to be det.	not to be det.	<20	6.3	0	--
C_2	"	"	"	<20	8.7	-11	-12.8
C_3	"	"	"	<20	6.9	-2.9	-3.4
C_4	58.2	44	51	50	11.5	58.2	67.5
C_5	-3.6	4	13	<20	9.1	14.5	16.8
C_6	not to be det.	not to be det.	not to be det.	<20	7.1	1.8	-2.1
C_7	"	"	"	<20	9.5	-1.5	-1.7
C_8	43.7	33	47	58	11.8	38.9	45.1
C_9	not to be det.	not to be det.	18	<20	8.9	-6.5	-7.5
C_{10}	"	"	not to be det.	<20	8.1	--	--
C_{11}	"	"	22	<20	8.5	-8	-9.3
C_{12}	"	"	not to be det.	<20	8.3	--	--
C_{13}	"	"	"	<20	7.5	--	--
C_{14}	"	"	10	<20	9.3	--	--
			Diesel fuels from hydrogenated naphthalenes				
D_1	34.8	--	--	>100	12.9	39.6	45.9
D_2	>-25	--	--	12	9.0	23.2	26.9
			Synthetic diesel fuels				
E_1	84.6	99	91	72	15.1	95.3	110.5
E_2	99.3	102	107	>90	14.9	100.6	116.6
E_3	86.0	99	99	>90	14.9	94.8	109.9
			Diesel fuels from oil - shale				
F_1	not to be det.	not to be det.	64	68	11.4	51.3	59.5
F_2	47	42	62	61	12.5	52.2	60.5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FROM PETROLEUM
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70
60
50
40
30
20
13.5%
13.0%
12.5%
12.0%
11.5%
11.0%
OIL NO'S Ab1 THROUGH Ab9
ANILINE POINT
DIESEL INDEX
CETENE NO ACCORDING TO MARDER
COMPARISON NO. ACCORDING TO JENTZSCH
% HYDROGEN
MOTOR CETANE NO.
CALCULATED CETENTE NO.
(MOTOR CETANE NO. X1.16)

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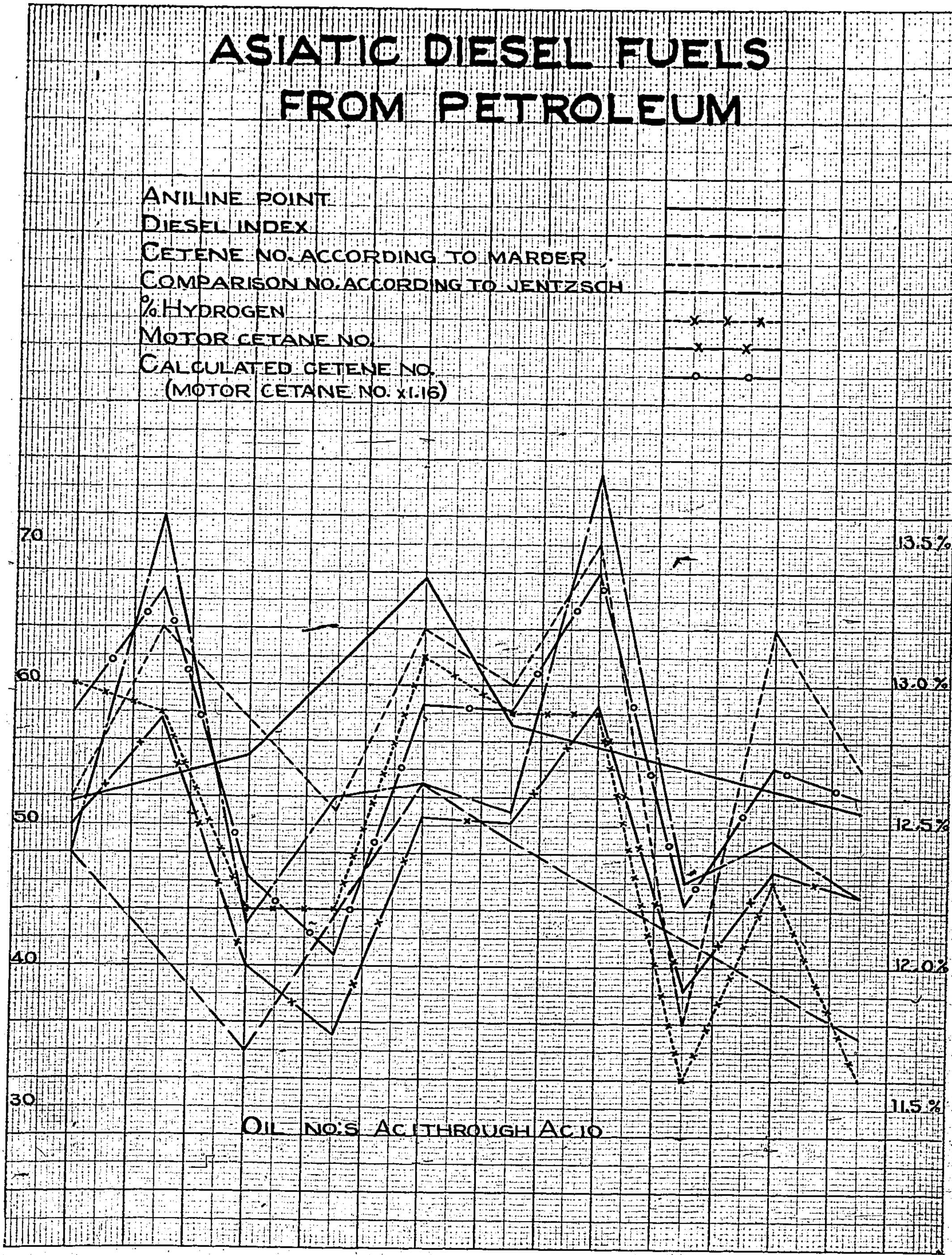

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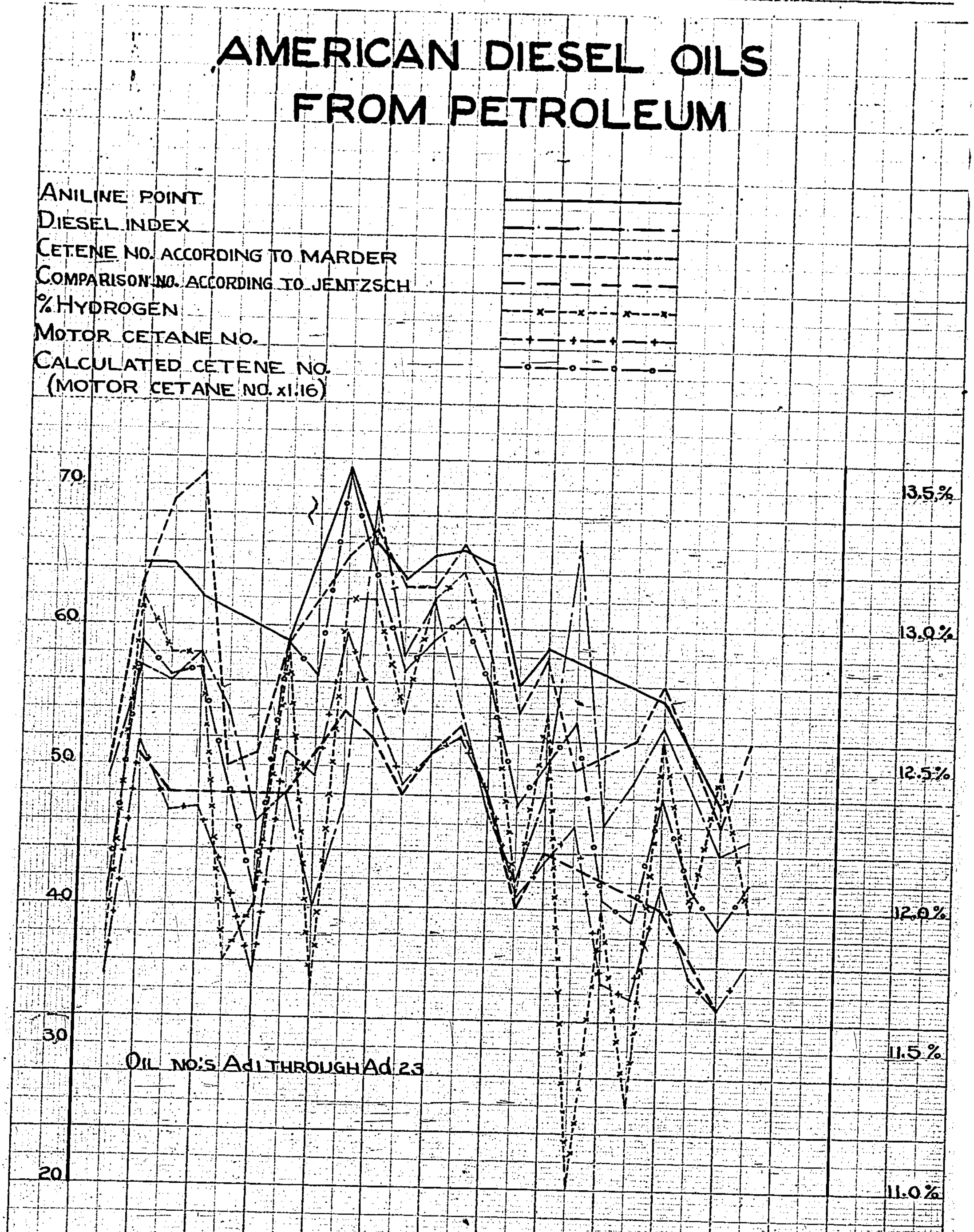

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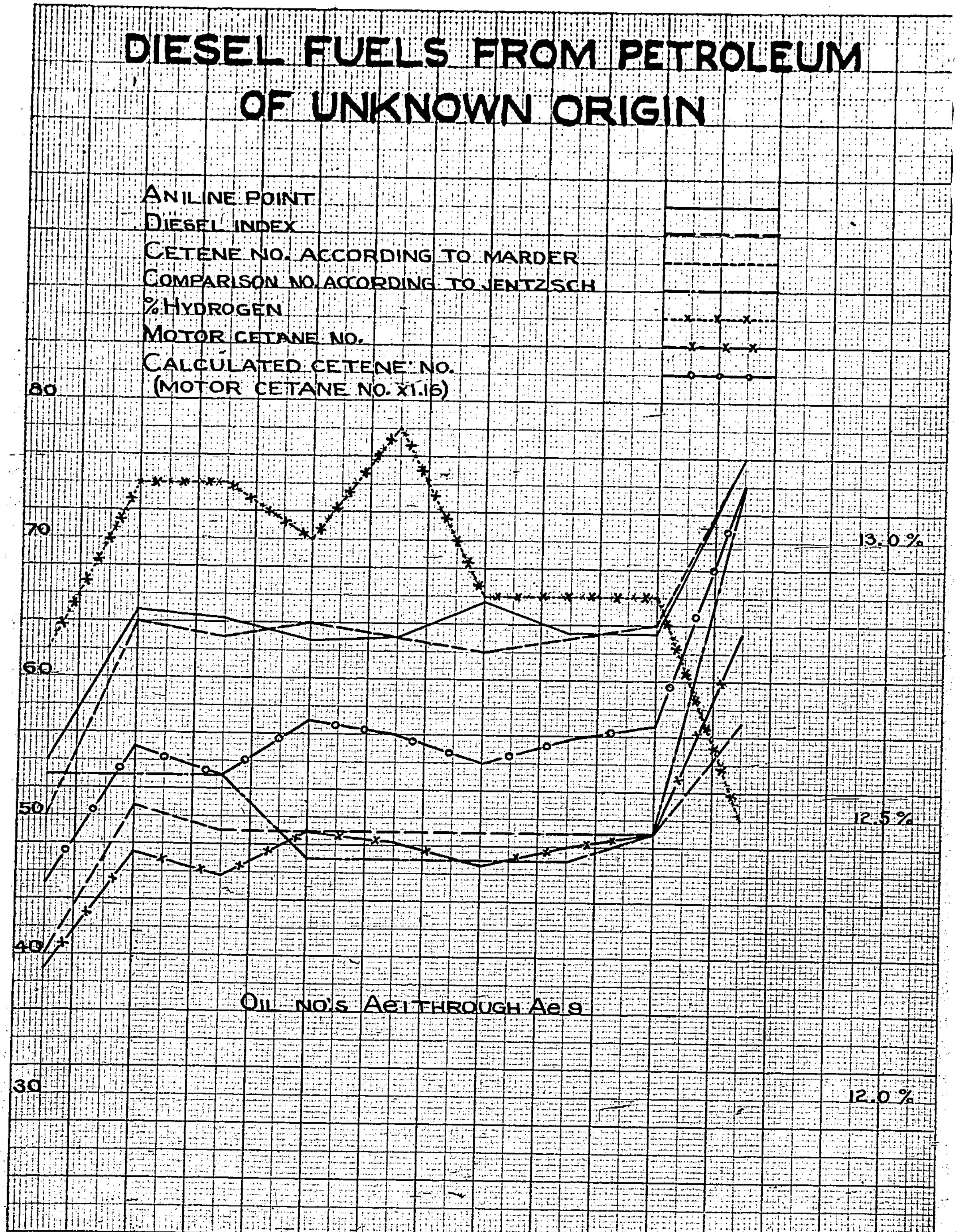

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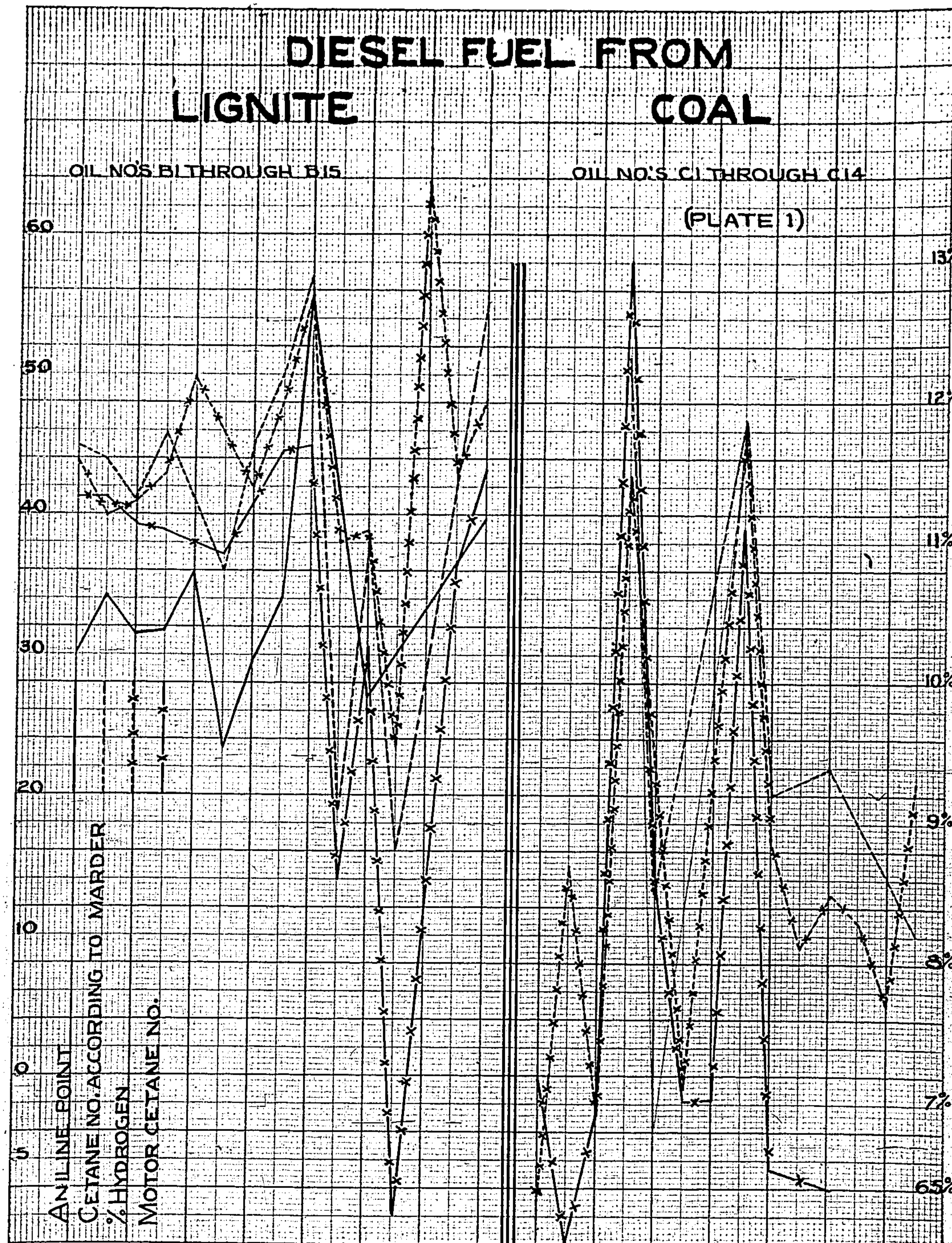

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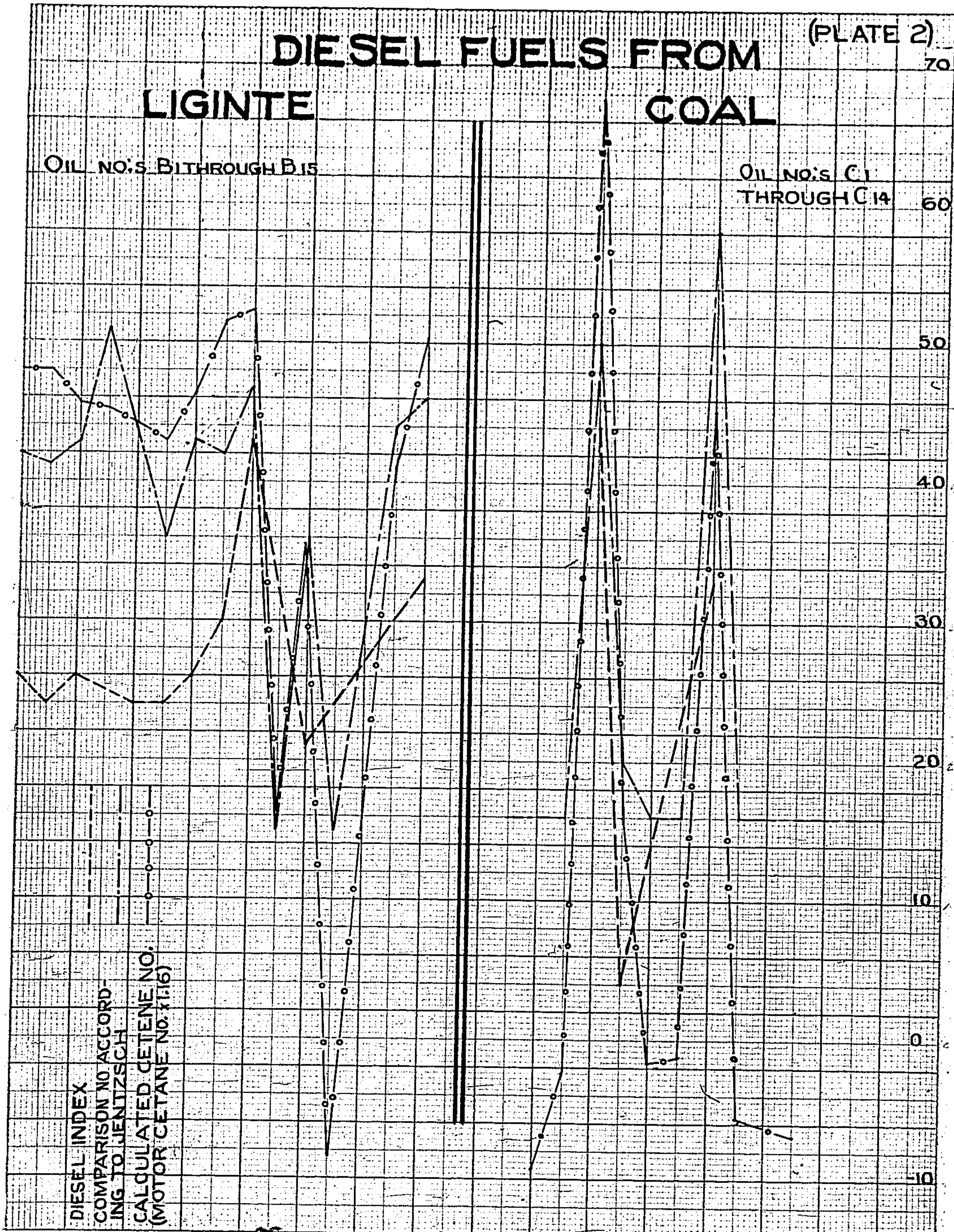

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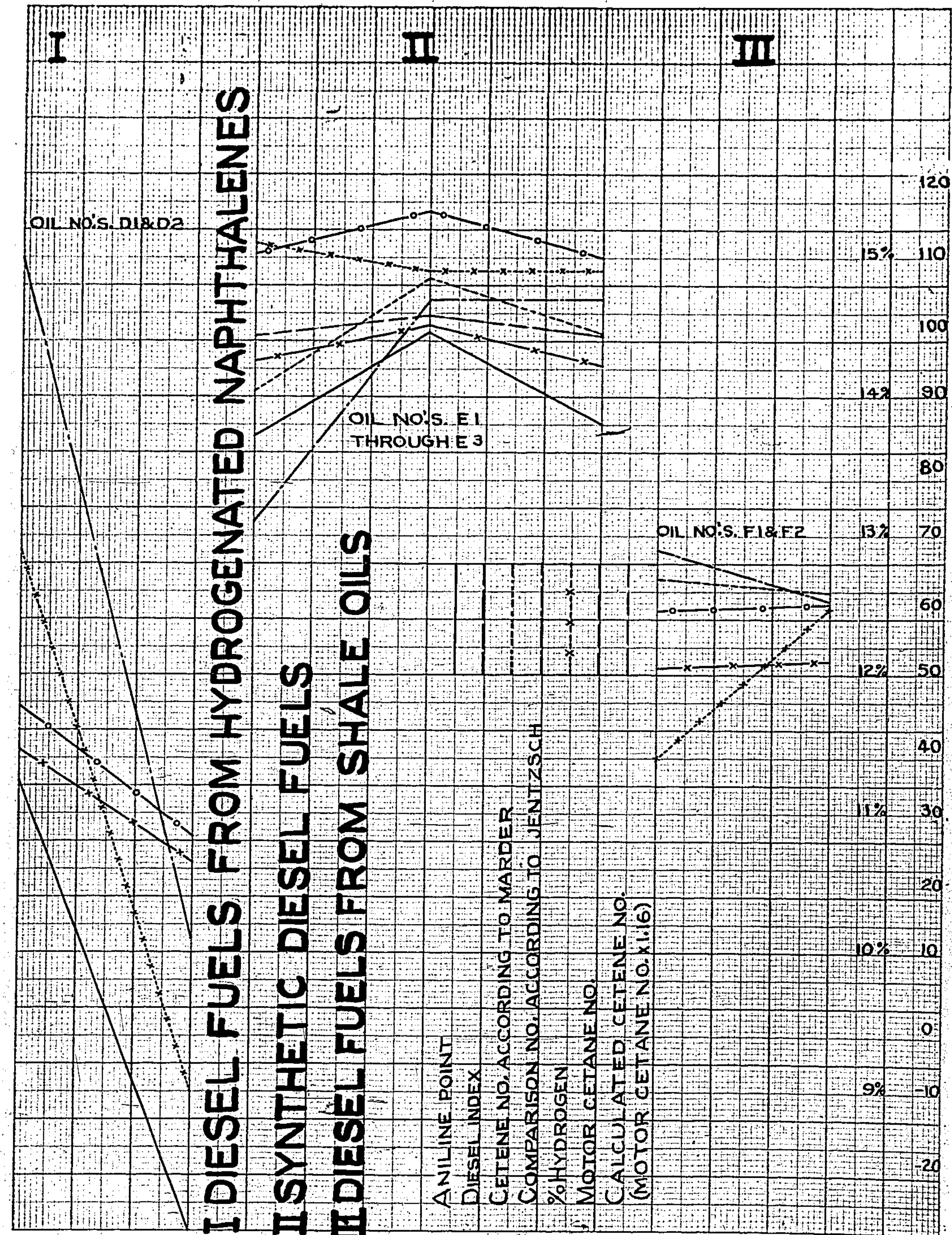

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Appendix VII

Classification of diesel fuels by means of motor test

A. Preface

In order to be able to compare the results of the motor tests with laboratory methods the CPVA requested the Rhenania-Ossag to test all samples by the HWA motor applying the coincident flash fixed-delay method. The cetane number of the best oils (cetane number 790) was determined by comparing them against a mixture of cetane-a-methyl naphthalene. Substandards (RCH-diesel fuel with a cetane number 88.4 and gas oil with a cetane number 36.5) were used for testing the normal oils. Oils of a lower ignitability were compared with a mixture which consisted of the above mentioned substandards, whereby the cetane number was calculated from the ration of the two ingredients in the mixture.

The ignitability of the samples C_{10}, C_{12}, C_{13}, C_{14}, was so low, that the motor could not be operated with the pure oils. Since it was impossible to obtain a homogenous mixture of the oils with gas oil and since difficulties in the operation of the pump and jet were to be expected, the cetane number of those oils was not determined.

In many cases it was possible to obtain a satisfactory reproducibility between the various testing methods. But a serious discrepancy was observed, when oil D1 (decalin) was tested. The Jentzsch figure (>100) is by far not in unison with the motor tested cetane number (39.6).

B. Classification of the diesel fuels

German diesel fuels from petroleum

Aa_1 has a high cetane number of 57.5 determined in the HWA motor and a very good ignitability. Regarding its specific gravity, its average boiling value and its high hydrogen content the fuel should be way suitable for the operation of high speed diesel engines.

Aa_2 Despite its low boiling figure the fuel should be very suitable for the operation of high speed diesel engines with respect to its excellent ignitability. With an initial boiling point of 256°C and only 48.2% boiling to 300° a low boiling figure according to Jentzsch must be expected. The remaining 50% are vaporized between 300 and 310°C. All properties comply with those of a good diesel fuel. The motor test showed a cetane number of 57.2.

Aa_3 has good boiling properties and a low vaporization time (v) but a lacking ignitability. With a boiling figure of 44 and a cetane number of 35.8 the oil is suitable for high speed engines. Its specific gravity is higher than requested by the Navy (0.880). The high boiling figure according to Jentzsch is in accord with the low Ostwald boiling figure. The net calorific value and the hydrogen content are a little low.

Aa_4 is suitable for high speed diesel engines. With respect to the boiling properties and its ignitability and the other determined data the oil is but of middle rank.

Aa_5 Due to a Jentzsch figure of 59, a cetane number of 52, its good ignitability and its boiling properties the oil is very suitable.

Aa_6 Due to the good ignitability and to normal analytical data both fuels are suitable for high speed engines.

Aa_7 Aa_6 cetane number 58.4, Aa_7 cetane number 48.8)

Aa_8 has an extremely good ignitability and a cetane number of 67.9. The low Jentzsch figure of 1 should not be two harmful. Favorable is the specific gravity, the hydrogen content and the thermal value. The low Jentzsch boiling figure can be explained by the fact, that the initial boiling point is as high as 265°C, that not more than 29.6% are vaporized till 300°C and 87.6% till 350°C, following a high Ostwald boiling figure (compare oil Aa_2). The oil is suitable for high speed engines.

Aa_9 With a Jentzsch figure of 61, a cetane number of 57.4 and other good analytical data the oil is supposed to be suitable for high speed engines.

European diesel fuels from petroleum

Ab_1 The sample represents a bunker fuel with the characteristics of a Mexican bunker fuel as commonly used by the Navy. Due to the high conradson carbon residue the original oil cannot be used as diesel fuel. The ignitability of the oil can be improved, and the conradson carbon residue content can be lowered according to appendix V.

Ab_2)
Ab_3)
Ab_4)
Ab_5) The oils have a good ignitability and are of high or middle rank.

Ab_2 cetane number 56.3
Ab_3 cetane number 46.2
Ab_4 cetane number 49.6
Ab_5 cetane number 51.3

Ab_7 has a high boiling figure (Jentzsch) and with a cetane number of 59.3 is a suitable fuel for high speed engines. Due to the determined analytical data the oil is supposed to be of an excellent quality.

Ab_8)
Ab_6) The performance of the motor test resulted a cetane number of 50.4 for oil Ab_8. Due to a cetane number of 65.9 the oil Ab_6 should be of a better quality. The comparatively low boiling figures (Jentzsch test) can be explained in the same manner, as it was done with the oils Aa_2 and Aa_8.

Ab_9 The Jentzsch figure of 50, the cetane number of 50.7 the specific gravity, the boiling figure (Ostwald), the hydrogen content indicates that the oil is very suitable for high speed engines.

Asiatic diesel fuels from petroleum

Ac_1 Despite its low Jentzsch figure (high speed engines require $\geq$ 8) the oil should be very suitable for high speed engines (compare Jentzsch boiling figure, boiling figure (Ostwald) hydrogen content). The cetane number is 50.0.

Ac_2 Due to a high conradson carbon residue and a unsatisfactory boiling range, despite it good ignitability the oil is suitable but for low speed engines. The conradson carbon residue content can be lowered according to appendix V. The sample has a cetane number of 51.6.

Ac_3 has a motor tested cetane number of 40.1. Due to its high high residue when heated to 350°C (R 350) the oil is supposed to choke the filter. Furthermore the specific gravity exceeds 0.880 and the boiling range is not favorable. Not more than 82% are varporized applying a temperature of 375°C. The oil is suitable for middle speed engines.

Ac_4 Due to the high value of R 350 and to the boiling range (not more than 94% distillate can be obtained) choking of the jet can be expected during continous operation of the engine. Despite a good ignitability the oil is supposed to be suitable but for middle speed engines. (cetane number 35.3)

Ac_5 A low vaporization time, a high Jentzsch boiling figure and the other
Ac_6 favorable analytical data make the oils suitable for high speed engines. Ac_5 has a cetane number of 50.6 and Ac_6 one of 50.2.

Ac_7 The oils have normal to excellent ignitability, despite their high amount
Ac_8 of conradson carbon residue and the unfavorable boiling range the should be used for the operation of high speed diesel engines. The cetane numbers are 58.7 for Ac_7, and 38.3 for Ac_8 respectively.

Ac_9 The oils have average ignitability, almost high values for R 350, which should not be harmful, because a favorable boiling figure (Ostwald) was observed. The specific gravity of sample Ac_{10} is just in accordance with the specifications. The following cetane numbers were determined: Ac_9 = 46.7, Ac_{10} = 44,8.

American diesel fuels from petroleum

Ad_1 and Ad_6

Ad_1 and Ad_6 are oils with average ignitability an cetane numbers of 34.9 for Ad_1 and 35.3 for Ad_6. Especially high is the specific gravity of 0.901 and 0.905 respectively. Corresponding with the low boiling figure (Jentzsch) the boiling figures (Ostwald) are comparatively high. The oils are not suitable for the operation of high speed engines because difficulties can be expected.

Ad_2 Ad_3 Ad_4 Ad_7

Due to good ignitability and to the determined analytical data the oils are suitable for high speed engines.

	Cetane numbers
Ad_2	51.5
Ad_3	48.6
Ad_4	48.9
Ad_7	50.9

Ad_5

The samples represent oils of the Mexican diesel oil type which are commonly used by the Navy. Due to the high conradson residue they can not be employed as diesel fuels. Since the ignition dator correspond with those of normal diesel oils the qualities of the oil can be improved according to the methods which have been described in Appendix No. V.

Ad_5 : Cetane-number 41.9
Ad_8 : " " 49.5

Ad_9 Ad_{10} Ad_{11} Ad_{12} Ad_{13} Ad_{14} Ad_{15} Ad_{16}

The oils have a satisfactory even a good ignitability. Despite the comparatively low boiling figures the oils are suitable for high speed engines because the boiling figures (Ostwald) are quite normal.

	Cetane number		Cetane number
Ad_9	- 61.4	Ad_{13}	- 52.2
Ad_{10}	- 54.9	Ad_{14}	- 48.2
Ad_{11}	- 48.8	Ad_{15}	- 40.9
Ad_{12}	- 50.8	Ad_{16}	- 43.6

Ad_{17}

With a conradson test of 3.68 and R 500 of 4.7 the oil is not suitable for the operation of diesel engines because it is quite similar to the oils Ad_5 and Ad_8.

Ad_{18} Ad_{19} Ad_{21} Ad_{23} With the exception of the high figures of R 350 the specific gravity exceeds 0.900. The thermal values are 10,000 kcal/kg and less. The oils do not seem suitable for a continous operation of high speed engines.

	Cetane Number		Cetane Number
Ad_{18}	34.8	Ad_{21}	35.4
Ad_{19}	33.9	Ad_{23}	36.0

Ad_{20} represents a diesel fuel with comparatively good analytical data. Suitable for continous operation of diesel engines. (Cetane number 41.3).

Ad_{22} Ignitdbility and specific gravity does not quite comply with the specifications. Despite the satisfactory boiling properties the oil is hardly suitable for high speed engines, because the motor tested cetane number is as low as 33.3.

Diesel fuels from petroleum of unknown origin

Ae_1 Ae_2 Ae_3 Ae_4 Ae_5 Ae_6 Ae_7 Ae_8 — The oils show an average ignitibility and other satisfactory analytical data. Suitable for high speed diesel engines.

	Cetane number		Cetane number
Ae_1	39.1	Ae_5	48.1
Ae_2	47.5	Ae_6	46.6
Ae_3	45.7	Ae_7	48.1
Ae_4	49.0	Ae_8	49.0

Ae_9 — has an excellent ignitability. The low Jentzsch boiling figure corresponds with the high. Ostwald boiling figure. The high cetane number of 63.4 indicates an oil of good quality.

Diesel fuels from lignite

B_1 - B_{15} The following oils have almost an identical ignitibility and average to good boiling figures. The hydrogen content and the net calorific value are sometimes lower than required.

	Cetane number		cetane number
B_1	41.5	B_7	40.1
B_2	41.5	B_8	44.6
B_3	39.4	B_9	45.1
B_4	39.0	B_{15}	43.3

There is no objection against their utilization for the operation of high speed diesel engines.

The oils B_6 and B_{11} however, which have a Jentzsch figure of 5 or 5.1 respectively despite their high boiling figures and their normal characteristics should be better used for the operation of middle speed diesel engines due to their unsatisfactory ignitibility.

	Cetane number
B_6	37.2
B_{11}	30.5

The oils B_{10} and B_{12} which have a very poor ignitibility cannot be utilized for the operation of diesel engines without being blended.

	Cetane number
B_{10}	14.0
B_{12}	-10

B_{14} Apart from the not normal boiling range, owing to a cetane number of 35.5 the oil is suitable for high speed engines.

Diesel fuels from coal

C_1-C_{15} Due to an unsatisfactory ignitibility and other data as for instance specific gravity, hydrogen content, net calorific value and high conradson carbon residue the oils C1, C_2, C_3, C_5, C_6, C_7, C_9, C_{10}, C_{11}, C_{12}, C_{13}, and C_{14} are not suitable for the operation of diesel engines.

	Cetane number		Cetane number
C_1	0	C_7	-1.5
C_2	-11	C_9	-6.5
C_3	29	C_{10}	-
C_5	14.5	C_{11}	-8
C_6	-1.8	C_{12}	-
		C_{13}	-
		C_{14}	-

The oils C_4 and C_8 are suitable for the operation of diesel engines.

	Cetane number
C_4	58.2
C_8	38.9

Diesel fuels from hydrogenated naphthalenes

D_1 The completely hydrogenated naphthalene (dekalin) has excellent ignition values but the motor tested cetane number is 39.6. The great difference between the motor tested cetane number and the Jentzsch figure which is higher than 100 is worth while mentioning. The dekalin is suitable for the operation of high speed diesel engines.

D_2 The partly hydrogenated naphthalene (tetralin) has an unsatisfactory ignitibility, (Jentzsch figure 0.9) and should not be applied for high speed diesel engines. Its motor tested cetane number is 23.2.

Synthetic diesel fuels

The oils are the most valuable synthetic diesel fuels which, being admixed to oils of a low ignitibility, improvethe quality of the unsatisfactory oils.

	Cetane number
E_1	95.3
E_2	100.6
E_3	94.8

Diesel fuels from oil-shale

F_1 The motor tested cetane number is high. Due to the analytical data and their ignitability the oils are of good quality.

Appendix VIII

The miscibility of diesel fuels, the removal of sludge deposits from their mixtures and methods for the improvement of the ignitibility of diesel oils

Another scope of the investigations was to determine the influence of an admixture of RCH- diesel fuels and dekalin or of mixtures of dekalin and tetralin respectively to unsatisfactory diesel-fuels with respect to the formation of sludge deposits and of their ignitibility.

I. Determination of the ignitability of diesel fuels according to Marder and Roelen.

According to Marder (Oil and coal, volume 13 pages 1162-1166) diesel fuels of every origin can be safely stored, if they are sufficiently refined.

But, if diesel fuels of various origin which can be safely stored, are mixed the formation of asphalt deposits can be often observed, despite before mixing almost no asphalt could be determined in the single oils by means of benzine.

Considering diesel fuels of uniform origin their adaptibility for storage and their miscibility can be easily determined. The determination of their asphalt content by means of benzine makes it feasible to answer the above mentioned questions.

If mixtures of diesel fuels of various origin had to be tested the maximum precipitation value was determined applying the Marder method. With a figure of zero obtained the fuel is completely miscible and fit for storage according to Marder; 0.3% asphalt deposits are just admittable for technical consumption. Contrary to this opinion Roelen (Oil and coal, volume 14, pages 1077 - 1078) states that deposits can be formed from mixtures of diesel fuels and synthetic fuels sooner or later even if the oils were treated for 24 hours according to Marder with forming any deposits.

Appendix I

Appendix I shows the results of tests when coal-lignite or shale-diesel fuels were investigated in mixtures with RCH- diesel fuels. The tests were carried out according to prescriptions of Marder and Roelen. As shown in the table, all oils which show a maximum precipitation figure of zero or slightly above zero (Marder method) can be regarded as miscible (Roelen method) if the admittable asphalt content is supposed to be as high as 0.5%.

Consequently the diesel fuels B_{10}, B_{12}, C_1, C_3, C_6, C_7, C_9, C_{10}, C_{11}, C_{12}, C_{13}, and C_{14} can not be mixed with the RCH-diesel-fuel, whereas the remaining diesel fuels are "miscible".

The deposits are supposed to be high-molecular, oxygen containing compounds. In accordance with the results (Roelen-method) the composition of the deposits is not uniform. This can be easily recognized, because the deposits are of different color (white, light - or dark-brown, even black and tar like). It is impossible to make any specific statement with respect to their chemical composition, they can be summarized under the general term "asphaltic substances".

As shown by the presented figures the Roelen-method makes higher demands concerning the adaptibility of an oil than the Marder-method. Therefore the C.P.V.A. proposes to adopt the Roelen method if the miscibility and suitability for storing of diesel fuels of various origin must be tested.

II. Experiments for the removal of deposits from diesel-fuel-mixtures.

Furthermore experiments were carried out to prevent the formation of deposits by the application of specific agents if diesel fuels from various origin are mixed or to influence the course of the formation in such a manner that only small amounts of deposits are formed. Such diesel fuels were investigated which were unsatisfactory with reference to the formation of asphalts when mixed with RCH diesel fuels.

Appendix 2

Reviewing the numerous experiments (compare appendix 2) it was clearly to be seen that a couple of methods were successful. Treating the oils in mixture with RCH-diesel-fuel (proportion 1:1) with fuller's earth under boiling must be mentioned. With a decreasing admixture of RCH-diesel fuel, with the application of normal temperatures for the earth treatment or boiling for a short time not only the amount of the substances which are insoluble in the RCH-diesel-fuel increase but also the conradson carbon residue. Regarding a commercial scale operation the yields can be improved by the application of filter presses. Oxidizing agents such as barium-per-oxide, manganese-di-oxide were likewise successful. A treatment with fuming sulfuric acid (olenm) in the presence of fuller's earth is recommendable. Experience has shown that coal-or lignite-diesel fuels which contain high amounts of creosote are also high in the content of substances which are insoluble in benzine or RCH diesel-fuel. As soon as the creosotes are removed the amount of substances which are insoluble in benzine or RCH-diesel - fuel decreases sharply or even disappears.

Additional experiments were carried out by subjecting the diesel-fuels to a distillation process or to a treatment with concentrated sulfuric acid. The obtained results were not too successful. The substances which are insoluble in benzine or RCH-diesel-fuel and which are formed by mixing diesel fuel of various oxygen origin are mostly of the "soft asphalt" type due to their solubility in alcohol. A few experiments were carried out in such a manner that alcohol was admixed to the diesel - fuel - mixtures in the presence of fuller's earth. But those experiments were only partly successful.

III Experiments with the aim to improve the ignitibility of diesel fuels

Special experiments were carried out in order to improve the ignitibility of diesel fuels by admixing high grade fuels to low grade ones. The experiments were carried out on fuels with good and unsatisfactory ignitibility.

Appendix III

Experiments which are listed in appendix III were carried out in order to find out which diesel fuel with a good ignitability offers the best improvement in its mixtures with low grade fuels. As expected the RCH-diesel fuel is superior to the other tested fuels. The ignitibility was determined by the spontaneous ignition point (Jentzsch method).

Appendix IV

Appendix IV represents the ignitability of mixtures of diesel fuel C_1, with other diesel fuels (various mixing proportions). The presented figures show how low grade diesel fuels can be substantially improved by an admixture of highly ignitable oils. The increase of the ignitibility depends on the applied mixing proportions.

Appendix V

In order to perform an exhaustive study of the possibilities to improve the ignitibility of diesel-fuels numerous mixtures consisting of the highly ignitable RCH-diesel-fuel and dekalin were investigated. The mixing proportions of the mixtures were roughly determined. The already mentioned discepancy between the motor'tested cetane number of the dekalin and its analytical determined ignitibility must be stated.

Appendix VI

Appendix VI contains the results which were obtained from mixtures consisting of diesel-fuels and for dekalin and tetralin respectively. Experiments with tetralin admixture were carried out in order to comply with requests for saving tetralin. The results confirm the deterioriating influence of the tetralin.

Tetralin should not be employed as admixture to dekalin, because it lowers the improving effect of the latter. It is perhaps suitable as a diluting agent of high grade diesel-fuels.

Appendix VIII

Appendix I

Comparison of the amount of substances which are insoluble in-benzine with those which are insoluble in RCH-diesel fuel

Oil No.	Substance insoluble in benzine extracted with alcohol	Substances insoluble in benzine not extracted with alcohol	Substances insoluble in RCH-diesel fuel at normal temperatures	Substances insoluble in RCH-diesel fuel heated at 180°C during 1 hour	Color of the deposits
B_1	absent	absent	absent	traces	after heating to 180°C white.
B_2	absent	absent	absent	0.21%	after heating to 180°C light brown
B_3	absent	absent	absent	traces	after heating to 180°C white
B_4	"	"	"	"	" " " "
B_6	"	"	"	"	" " " "
B_8	"	"	"	"	" " " "
B_9	"	"	"	"	" " " "
B_{10}	~~0.9%~~	5.5%	1.94%	0.58%	black and tar-like
B_{11}	0.075%	0.10%	absent	0.16%	light brown
B_{12}	1.0%	2.8%	2.32%	0.90%	red-brown
B_{14}	0.14%	0.15%	traces	0.20%	" "
B_{15}	absent	absent	absent	absent	---
C_1	0.24%	1.54%	1.04%	0.36%	red brown
C_2	absent	absent	absent	0.20%	after heating to 180°C light brown
C_3	0.36%	1.07%	1.15%	0.20%	red brown
C_4	absent	absent	absent	traces	--
C_5	"	"	"	0.21%	after heating to 180°C light brown
C_6	0.20%	0.79%	0.70%	0.62%	red brown
C_7	0.25%	0.80%	0.53%	0.34%	" "
C_8	absent	absent	absent	0.07%	light brown
C_9	0.17%	0.85%	0.034%	0.15%	" "
C_{10}	6.76%	7.1%	6.75%	1.72%	black and tar-like
C_{11}	0.57%	0.95%	0.86%	0.40%	" " " "
C_{12}	0.33%	0.99%	0.51%	0.56%	red brown
C_{13}	24.9%	33.7%	29.5%	0.76%	black and tar-like
C_{14}	1.65%	2.80%	3.83%	0.20%	black brown
F_1	absent	absent	absent	0.08%	after heating to 180°C light brown
F_2	absent	absent	absent	0.14%	" " "

Analytical method according to Marder and Roelen

200 ccm RCH-diesel-fuel were admixed to 5 g oil and allowed to react for 24 hours at normal temperature in darkness. In case no deposits were observed the mixture was heated to 180°C for 1 hour. Deposits were removed by filtering employing a 1 G-4 filter crucible. The filtrate was heated to 180°C for 1 hour. The deposits were rinsed twice with light gasoline and dried at 130°C. For the determination of the substances which are insoluble in benzine 4g oil were diluted with 160 ccm light gasoline and allowed to react at normal temperatures for 24 hours in darkness. The deposits were treated as mentioned above and after rinsing with light gasoline extracted with alcohol.

Appendix VIII

Appendix III

Sample C 1	80 % + 20 % Sample Aa 1		Spontaneous ignition	478
" "	50 % + 50 % " "		" "	284
" "	20 % + 80 % " "		" "	265
Sample C 1	20 % + 80 % Sample E 3	(RCH-	" "	255
" "	50 % + 50 % " "	Diesel-	" "	280
" "	80 % + 20 % " "	fuel	" "	300
Sample C 1	50 % + 50 % Sample E 2		" "	275
" "	20 % + 80 % " "		" "	260
" "	80 % + 20 % " "		" "	294
Sample C 1	80 % + 20 % Sample D 1		" "	470
" "	50 % + 50 % " "		" "	291
" "	20 % + 80 % " "		" "	286
Sample C 1	20 % + 80 % Sample Ad12		" "	270
" "	50 % + 50 % " "		" "	290
" "	80 % + 20 % " "		" "	468
Sample C 1	80 % + 20 % Sample Aa 8		" "	440
" "	50 % + 50 % " "		" "	282
" "	20 % + 80 % " "		" "	270
Sample C 1	20 % + 80 % Sample E 1		" "	260
" "	50 % + 50 % " "		" "	280
" "	80 % + 20 % " "		" "	303

Appendix VIII

Appendix IV

	R 500	V	R 350	S_z	S_{zp}	K_z	Z_o
20% C_1 + 8ö	0%	30 sec.	1.9%	28	275°C	8.6	540
20% C_1 + 80	0 %	25 "	1.0%	20	280	6.1	560
80% C_1 + 20	0.6%	25 "	4.6%	20	305	1.2	610
20% C_1 + 80	0 %	25 "	1.1%	13	270	6.5	530
80% C_1 + 20	0.5 %	30 "	5 % k	20	312	1	610
20% C_1 + 80	0.3 %	25 "	2 %	20	290	5.6	530
80% C_1 + 20	traces	25 "	4.2 % k	17	305	2.1	610
80% C_1 + 20	0 %	25 "	1.7 %	30	280	4.9	550
20% C_1 + 80	0 %	30 "	5.8 %	3	280	6.7	540
20% C_1 + 80	0 %	25 "	2.7 %	13	287	3.4	500
80% C_1 + 20	0 %	25 "	4.4 %	10	462	1	620
80% C_1 + 20	0.6 %	25 "	6 % k	10	447	1	620
80% C_1 + 20	0.4 %	30 "	5 % k	10	478	1	620

R 500 Residue

V Vaporization time in sec.

R 350 Residue

S_z Boiling figure

S_{zp} Spontaneous ignition

K_z Jentzsch figure indicating ignitibility

Zo Higher ignition value.

1. Experiment

Oil C_3 (coal-diesel-fuel from the Weyl Company, Chemical Works at Ludwigshafen) was mixed with 10% fuller's earth. The mixture was heated to the boiling point and allowed to boil for 3 hours applying a reflux condenser.

The cooled mixture was filtered and the substances which are insoluble in benzine were determined by a qualitative test.

Conradson carbon residue	0.38%
Insoluble in RCH-diesel-fuel	0.5 %
Orig. oil insoluble in RCH diesel fuel	1.15%

2. Experiment

The oil C_3 was mixed with RCH-diesel-oil in the proportion 1:1, 10% fuller's earth was added and the mixture was treated in the same manner as described above.

Insoluble in benzine:	traces
Conradson carbon residue	0.10 %
Insoluble in RCH-diesel fuel	0.08 %
Orig. oil insoluble in RCH-diesel fuel	1.15 %

3. Experiment

20% RCH-diesel-fuel and 5% fuller's earth were admixed to the oil C_3. The mixture was boiled for 1 hour and filtered after cooling.

Insoluble in benzine: deposits present.

The results were not changed after boiling for another hour.

4. Experiment

The oil C_3 was mixed with 35% RCH-diesel-fuel and 5% fuller's earth and treated as described under experiment 3.

Insoluble in benzine:	deposits present
Conradson carbon residue	0.5%
Insoluble in RCH-diesel-fuel	0.22%
Orig. oil insoluble in RCH-diesel-fuel	1.15%

5. Experiment

The oil C_3 was mixed with RCH diesel-fuel in the proportion 1:1, 7.5% fuller's earth were added and after vigorously shaking the mixture was allowed to react for 24 hours applying normal temperature. After filtering the oil had the following quality:

Conradson carbon residue	0.16%
Insoluble in RCH diesel fuel	0.66%
Orig. oil insoluble in RCH diesel fuel	1.15%
Insoluble in benzine	0.37%
Deposits extracted with alcohol	0.04%

Remarks: Since the deposits are almost soluble in alcohol, they are of the "soft asphalt" type.

6. Experiment

The diesel fuel C_{13} was distilled: losses 30%

(a) Distillate not extracted	: insoluble in benzine	: traces
(b) " extracted	: " " "	absent

	distillation losses:	30 %
Treating	extraction " "	35 %
	total yield	35 %

7. Experiment

The diesel fuel C_{14} was distilled : losses 8%

(a) distillate not extracted	: insoluble in benzine	: traces
(b) " extracted	" " "	: absent

distillation losses	8%
extraction losses	27%
Total yield	65%

Appendix VIII

8. Experiment

The diesel fuel B_{10} was treated with 10% concentrated sulfuric acid: treating losses 49%.

Insoluble in benzine : absent

Appendix VIII (cont'd)

Distillation | Treated with 3% sulfuric acid

	B_{10}	B_{12}	C_{13}	C_{14}	B_{10}	B_{12}	C_{13}	C_{14}
Insoluble in benzine	0.63%	0.5%	1.48%	0.17%	0.24%	2.96%	8.48%	0.72%
color of the insoluble substances	brown	brown	dark brown	brownish	red brown	dark brown	dark green	brown
The insoluble substances are soluble in alcohol	entirely	entirely	entirely	entirely	entirely	entirely	7%	entirely
Insoluble in RCH-diesel-fuel at normal temperatures	1.2%	0.48%	4.3%	0.4%	0.17%	24%	4.72%	0.60%
Color of the insoluble substances	red-brown	red brown	dark brown	brown	brown	brown	grey	grey
The insoluble substances are soluble in alcohol	entirely	entirely	entirely	entirely	entirely	entirely	3.76%	0.04%
Insoluble in RCH-diesel fuel after heating at 180°C for 1 hour	1.0%	1.6%	0.76%	0.26%	0%	0.14%	0.18%	0.14%
Color of the insoluble substances	red brown	red brown	brown	grey	-	grey	dark green	grey
From the insoluble substances are dissolved by alcohol	0.78%	entirely	0.69%	entirely	-	entirely	0.13%	0.08%
Yield	96%	97.4%	76.7%	96%	73%	68%	30%	56%
Spontaneous ignition °C	307	390	474	479	298	310	392	432
Lower ignition value	2.1	1.4	1.7	2	2.6	1.8	1.5	1.6
Higher ignition value	610	620	650	670	600	610	680	670
Jentzsch ignition value	2.1	0.8	9.6	0.8	2.7	1.8	1.1	0.9
Boiling figure	60	40	47	18	38	28	-	13
Jentzsch figure	20	<14	<14	<14	21	16	-	<14

Remarks: The differences between the yields which are obtained by the boiling analysis or by the above mentioned refining distillation are caused by a not so careful applied heating method. A temperature drop at the end of the distillation was not considered.

B-C-and F-oils mixed with RCH-diesel-fuel in the proportion 1:1, 10% fuller's earth added and boiled for 3 hours.

Mark of the oil	Yield	Color according to Ostwald	Insoluble in benzine absent	Color of the insoluble substances	From the insoluble substances are dissolved by alcohol	Insoluble in benzine oil before treating (extracted with alcohol)
B_1	87.1%	5	absent	-	-	absent
B_2	85.0%	6	"	-	-	"
B_3	85.0%	3	"	-	-	"
B_4	88.2%	5	"	-	-	"
B_6	91.2%	3	"	-	-	"
B_8	84.5%	4	"	-	-	"
B_9	86.7%	1	"	-	-	"
B_{10}	86.3%	10	0.83%	brownish	0%	0.9%
B_{11}	86.0%	5	absent	-	-	0.08%
B_{12}	84.0%	9	0.50%	brownish	0%	1.0%
C_{10} +)	83.3%	10	1.02%	greenish	0.06%	6.76%
B_{14}	86.1%	6	absent	-	-	0.14%
B_{15}	86.2%	4	"	-	-	absent
C_1	85.0%	10	0.05%	brown	0%	0.24%
C_2	85.0%	8	absent	-	-	absent
C_3	85.0%	9	0.07%	brown	0%	0.36%
C_4	86.7%	3	absent	-	-	absent
C_5	86.7%	6	"	-	-	"
C_6	85.0%	10	0.13%	brown	0.05%	0.2%
C_7	83.4%	10	0.07%	brown	0.010%	0.25%
C_8	90.4%	2	absent	-	-	absent
C_9	85.1%	8	traces	red brown	0%	0.17%
C_{10}	80.7%	10	1.06%	dark brown	0.09%	6.76%
C_{11}	84.5%	10	0.24%	red brown	0.11%	0.57%
C_{12}	74.5%	10	0.49%	red brown	0.03%	0.33%
C_{13}	85.0%	10	0.07%	red brown	0.05%	24.9%
C_{14}	85.6%	10	0.19%	red brown	0%	1.65%
C_{15}	85.0%	3	absent	-	-	absent
F_1	86.7%	4	"	-	-	"
F_2	85.6%	7	"	-	-	"

Procedure: The oils were mixed with RCH-diesel-fuel in the proportion 1:1, 10% fuller's earth were added and the mixture was boiled for 3 hours employing a reflux condenser.

Remarks: The yields can be improved by the application of a filter-press.

+) C_{10} was mixed with 20% RCH-diesel-fuel and allowed to react from April 9, 1940 to May 31, 1940; the mixture was diluted with RCH-diesel fuel until the proportion of the original oil to RCH-diesel-fuel was 1:1. The further treatment was accomplished as described above.

Mixing proportions	Method of treatment	Insoluble in benzine not extracted with alcohol	Insoluble in benzine extracted with alcohol
70% B_{10} + 30% RCH-diesel fuel + 5% fuller's earth + 5% BaO_2	boiled for one hour	0.080%	absent
70% B_{10} + 30% RCH-diesel fuel + 5% fuller's earth + 5% MnO_2	boiled for one hour	1.07%	0.10%
B_{10} + RCH-diesel fuel 1:1 + 5% fuller's earth + 10% alcohol	shaken at normal temperature for 15 minutes	1.08%	absent
B_{10} + RCH-diesel fuel 1:1 + 5% fuller's earth + 10% alcohol	boiled for two hours	0.65%	absent
B_{10} + RCH-diesel fuel 1:1 + 10% fuller's earth	heated to 150°C for two hours under introduction of air	0.65%	0.02% Due to escaping oil-vapors the mixture becomes more viscous and yields only 60%.
70% B_{10} + 30% RCH diesel fuel + 5% fuller's earth + 5% H_2SO_4 with a SO_3 content of 20%	Shaken at normal temperature for 5 minutes, afterwards the acid removed by treating with water	0.85%	0.02% Due to the high phenol content an admixture of light gasoline produces a red deposit. With the phenols extracted before no deposit was observed by admixture of light gasoline.
C_{11} + RCH diesel fuel 1:1 + 5% fuller's earth + 10% alcohol	Shaken at normal temperature for 15 minutes	1.03%	0.08%
C_{11} + RCH diesel fuel 1:1 + 5% fuller's earth + 10% alcohol	boiled for two hours	0.05%	absent

Mixing proportions	Method of treatment	Yield	Insoluble in light gasoline not extracted with alcohol	Appearance of the substances which are insoluble in light gasoline
1 part B_{10} + 10% alcohol + 1 part RCH diesel fuel			0.6%	reddish
1 part B_{10} + 20% alcohol + 1 part RCH diesel-fuel			0.28%	brown
1 part B_{10} + 1 part RCH diesel fuel + 5% BaO_2 + 10% fuller's earth	boiled for 3 hours	83.4%	0.07	red-brown
1 part B_{10} + 1 part RCH diesel fuel + 5% MnO_2 + 10% fuller's earth	boiled for 3 hours	83.4%	0.19	red-brown
1 part B_{10} + 1 part RCH diesel fuel + 3% fuming H_2SO_4 containing 20% SO_3 + 10% fuller's earth	treated at normal temperature not treated with water and NaOH after refining	85.0%	absent	--
1 part C_{11} + 10% alcohol + 1 part RCH diesel fuel			0.54	reddish adhering to the bottom
1 part C_{11} + 20% alcohol + 1 part RCH-diesel fuel			0.12	gray-brown
1 part C_{11} + 1 part RCH diesel fuel + 2% fuming H_2SO_4 cont. 20% SO_3 + 10% fuller's earth	boiled for 3 hours (a) not treated after refining (b) treated with H_2O + NaOH	83.9 73.9	0.50 0.03	reddish, adhering to the bottom brown
1 part C_{12} + 10% alcohol + 1 part RCH diesel fuel			0.29	brown
1 part C_{12} + 20% alcohol + 1 part RCH Diesel fuel			0.14	brown

Appendix VI

B - and C - oils + admixture of a dekalin - tetralin - mixture

% Oil	Admixture consist. of 20% tetralin +80% dekalin	Spec. grav. at 20°C	Insoluble in light gasoline	Deposits	Szp	Zu	Zo	Zk	Sz	Vz
90% B_6	10%	0.861	absent	absent	283	7.3	550	6.8	82	43
90% B_{14}	10%	0.901	0.35%	"	278	12.1	500	9.7	25	51
50% C_7	50%	0.996	0.39%	traces	296	9.5	540	7.9	55	43
65% C_{10}	35%	1.008	0.65%	small amounts	298	10.3	520	7.9	30	41
50% C_{13}	50%	0.980	2.0%	large amounts	301	3.9	530	3	42	22
	Admixture consisting of 40% tetralin and 60% dekalin									
90% B_6	10%	0.863	absent	absent	277	7.5	550	7.4	83	47
90% B_{14}	10%	0.903	0.40%	"	278	11.1	500	8.9	23	48
50% C_7	50%	1.006	0.45%	traces	295	5.4	520	4.1	43	27
65% C_{10}	35%	1.016	0.62%	small amounts	306	6.2	530	4.6	30	28
50% C_{13}	50%	0.991	1.9%	large amounts	307	3.7	530	2.7	57	22

Legend of the heading:

S_{zp} = point of spontaneous ignition
Zu = lower ignition value
Zo = lower ignition value

Zk = Jentzsch figure
S_z = Jentzsch boiling figure
V_z = Jentzsch figure