BERICHT ÜBER HEIZÖLE UND MISCHUNGSVERSUCHE MIT HEIZÖLEN

By Dr. Herman Meyer of Chemisch-Physikalische Versuchsanstalt der Marine, Kiel

Translation of Frames 70002 through 70058 of TOM Reel No. 175 (Navy Reel No. 5895-1) and comprising Item (A) of the TOM 175 index.

Navy Department
Bureau of Ships
15 January, 1947

Translation by
Dr. Walter Oppelt

Translation Accomplished under the Auspices of the Fuels and Lubricants Division of the Office of the Quartermaster General.

Chemical - Physical - Research - Station

of the Navy.

Report Concerning

Bunker-fuels and Miscibility of Tests

of Bunker-fuels.

Notice

The numbering of the frames does not correspond with the text of the experiments. The proper sequence of the frames is as listed below:

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The translation has been assembled in the proper sequence.

Report concerning bunker-fuels and miscibility tests of bunker-fuels.

The High Command of the Navy requested by letter No. 27605 K II b. dated December 12, 1937, the Navy Shipyard and the C.P.V.A. to investigate all bunker-fuels available. In addition such bunker-fuels should be also investigated which did not comply with the hitherto required specification of the navy. According to the Navy High Command's letter No. 2907 K II Es. dated February 2, 1938, all investigations should be made uniformly according to a schedule provided by the navy.

Miscibility tests should be performed with the bunker-fuels and especially the asphalt content of the mixtures should be determined.

The following bunker-fuels and their mixtures were investigated by the C.P.V.A.:

I. Bunker-fuels from coal:

1) Coal - tar - oil
2) Stinnes-bunker-fuel (Coal - bunker-fuel manufactured at Welheim)
3) V.f.T. - bunker-fuel (Mixture consisting of coal-tar-oil and Stinnes-bunker-fuel)
4) Low temperature - carbonization-oil (Krupp)
5) Uhde - bunker-fuel

II. Bunker-fuels from lignite:

1) Lignite - tar-oil furnished by the "Oil-Kontor"
2) Lignite - tar-oil furnished by the "Braunkohlenoel-vertrieb"

III. Shale-oil - bunker-fuels:

1) Estonian shale-oil

IV. Bunker-fuels from petroleum:

A. Bunker-fuels with a low asphalt-content

1) Ebano - bunker-fuel
2) Bunker-fuel from Nienhagen
3) Rumanian - bunker-fuel from Nordenham
4) Bunker-fuel of unknown origin (received from S.S. Potsdam)
5) Tranian bunker-fuel furnished by the Olex

B. Bunker-fuels with a higher asphalt content

1) Thin bunker-fuel from Aruba
2) Bunker-fuel of unknown origin (received from "Torpedo-boat "Luchs". Trial-oil of the D.P.A.G., Hamburg)
3) Bunker-fuel from California
4) Bunker-fuel of unknown origin (received from S.S. "Gneisenau")
5) Bunker-fuel "H38" furnished by Rhenania Ossag

C. Bunker-fuels with a high asphalt content

1) Pure Emrotank - bunker-fuel
2) Bunker-fuel received from Texas (furnished by the "HAPAG")
3) Bunker-fuel from Aruba (received fro "D.P.A.G.", Hamburg)
5) Bunker-fuel of unknown origin (received from SS "Bremen", bunkered in New York)
6) Bunker-fuel from Venezuela, "HAPAG"

Appendix I represents the results of the analyses of the bunker oils. It must be mentioned, that a correspondence was established between the Conradson carbon residue and the residue at 500°C (R500) determined in the Tentzsch apparatus. The ultimate analysis as well as the boiling range were not determined. The determination of the corrosivity against iron and copper are delivered subsequently because the metal sheets were but recently furnished by the Navy Yard.

Appendix II contains a compilation of the miscibility tests. Mostly such mixture were investigated which in the future can be employed for the operation of vehicles. In order to lower the viscosity high viscous strongly asphaltic oils were blended with fluid ones which are low in asphalt content. By mixing the latter precipitate asphaltic deposits from the former ones. Most of the deposits are dissolved if coal - bunker-oils (V.f.T - bunker-fuel) are added. In order to lower the viscosity farther more lignite diesel-fuel was added. The final mixture complied with the specifications of the navy (<10°E at 20°C).

Furthermore the influence of an admixture of petroleum bunker-fuel on the quality of the obtained product was investigated. A mixture consisting of equal volumes had favorable properties, i.e. the quality of the mixtures is improved compared with those of the components. Difficulties in the operation of the engines were observed (choking of the jets, spoiling of the filters) if an excess of petroleum gas-oil has been admixed to asphaltic bunker-fuels without having added bunker fuels (V.f.T. bunker-fuel) which are capable to dissolve the precipitations. Petroleum gas-oil in mixtures with other petroleum bunker-fuels acts like a fluid petroleum bunker-oil, which contains only small amounts of asphalts.

With respect to the results of the analyses of the bunker-fuel - mixtures the following remarks must be made:

The Conradson carbon residue content and the residue R500 of the mixtures can be computed from the figures of the components. Small deviations between the actual and the computed figures can be observed if deposits are present in the mixtures.

Appendix III shows the difference of the actual and the computed values of the Conradson carbon residue.

The ratio of the mixtures must be chosen in such a manner that the deposits are less than 0.5%.

Regarding mixtures which contain low or high asphaltic petroleum bunker oils the finished oil complies with the before mentioned requirement under the following conditions.

1. Not more than 50% petroleum bunker-fuel (calculated on the finished mixture) should be admixed.

2. It is advisable to add to the mixture 25% V.f.T. bunker-fuel. If several types of petroleum bunker oils are added simultaneously or if petroleum bunker oils and petroleum gas oils are employed either the volumes of asphaltic petroleum bunker fuels and the volumes of little asphalt containing petroleum bunker fuels or gas oils respectively must be equal or the latter must be present in smaller portions.

Remarks concerning the bunker-fuel - investigations.

1. With respect to the navy specifications (Tentzsch - figures) the 1st figure refers to Schulz-navy - boilers and the 2nd to high pressure - hot steam boilers if two figures are mentioned.

2. The ignition values of coal-based bunker oils were determined at 550°C.

3. A missing figure of the ignition delay (w) indicates that no ignition could be determined at the corresponding temperature; with the exception of the figures of the ignition delay (w) of coal - bunker-oils which was determined at 550°C.

4. The figures of Residue at 500° (R 500)
   " " " 350° (R 350) and
   of the tendency to age are listed in %.

5. The letters which are applied in the listing of R 350 indicate
   (k) = like coke
   (t) = like tar
   (a) = like asphalt

6. The precipitates which were formed after the "aging" test are suspensions if the test was performed with shale oil of the Estonian Rock - oil A.G., petroleum bunker-oil "H38" of Rhenania-Ossag and petroleum bunker oil from California (Hapag). The precipitates consisted of very fine grained, brownish black substances. It was impossible to determine any figures of the sludge level.

Summary: The investigations have clearly proved that strong - asphaltic and high viscous bunker-fuels (Compare Appendix I) can be utilized as mixing component for the production of oil mixtures which are suitable for the operation of engines if they are mixed in equal proportions with low asphaltic fluid petroleum bunker-fuels, V.f.T. bunker-fuel and lignite oils.

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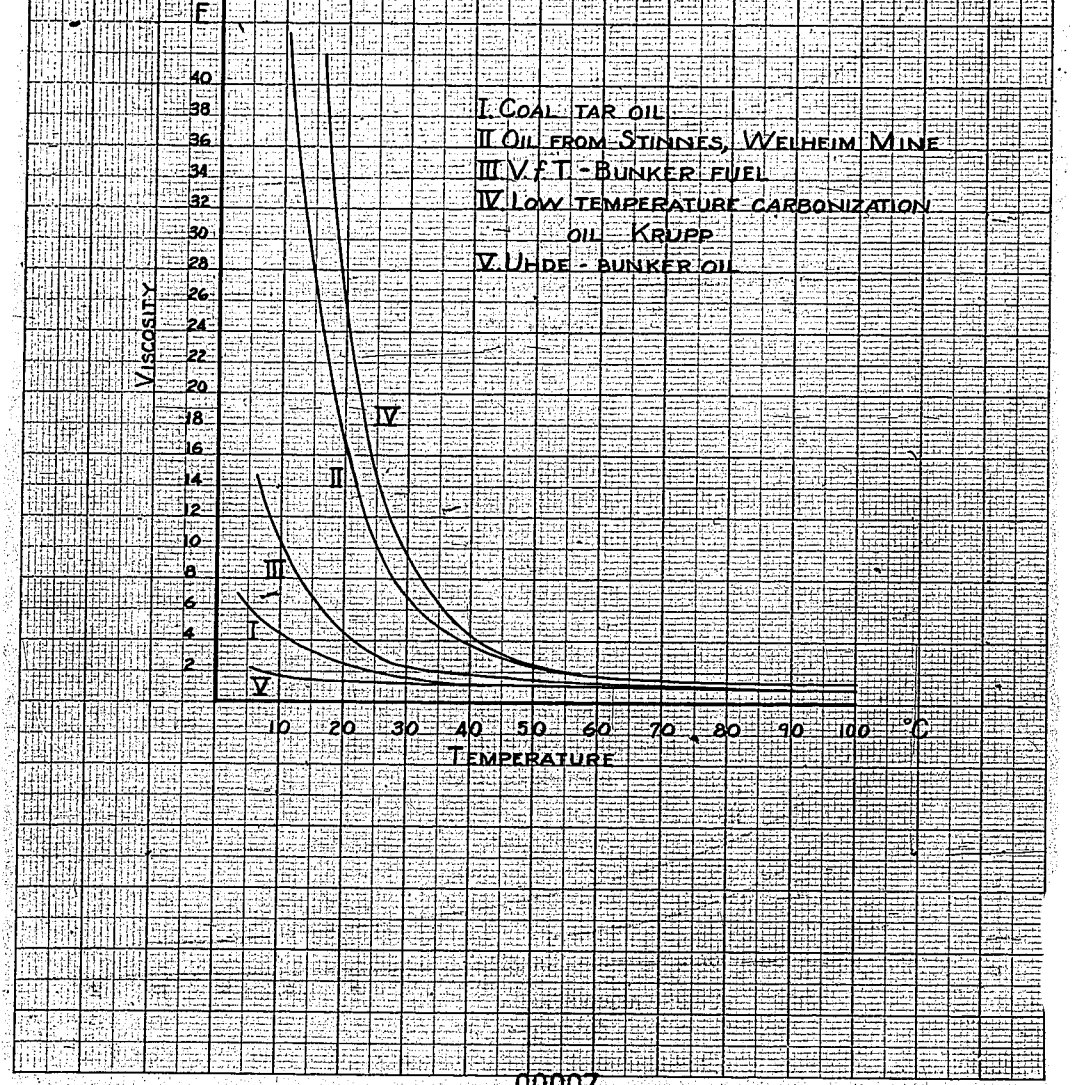
COAL TAR OILS



I. Coal tar oil
II. Oil from Stinnes, Welheim Mine
III. V.f.T. - Bunker fuel
IV. Low temperature carbonization oil Krupp
V. Uhde - bunker oil

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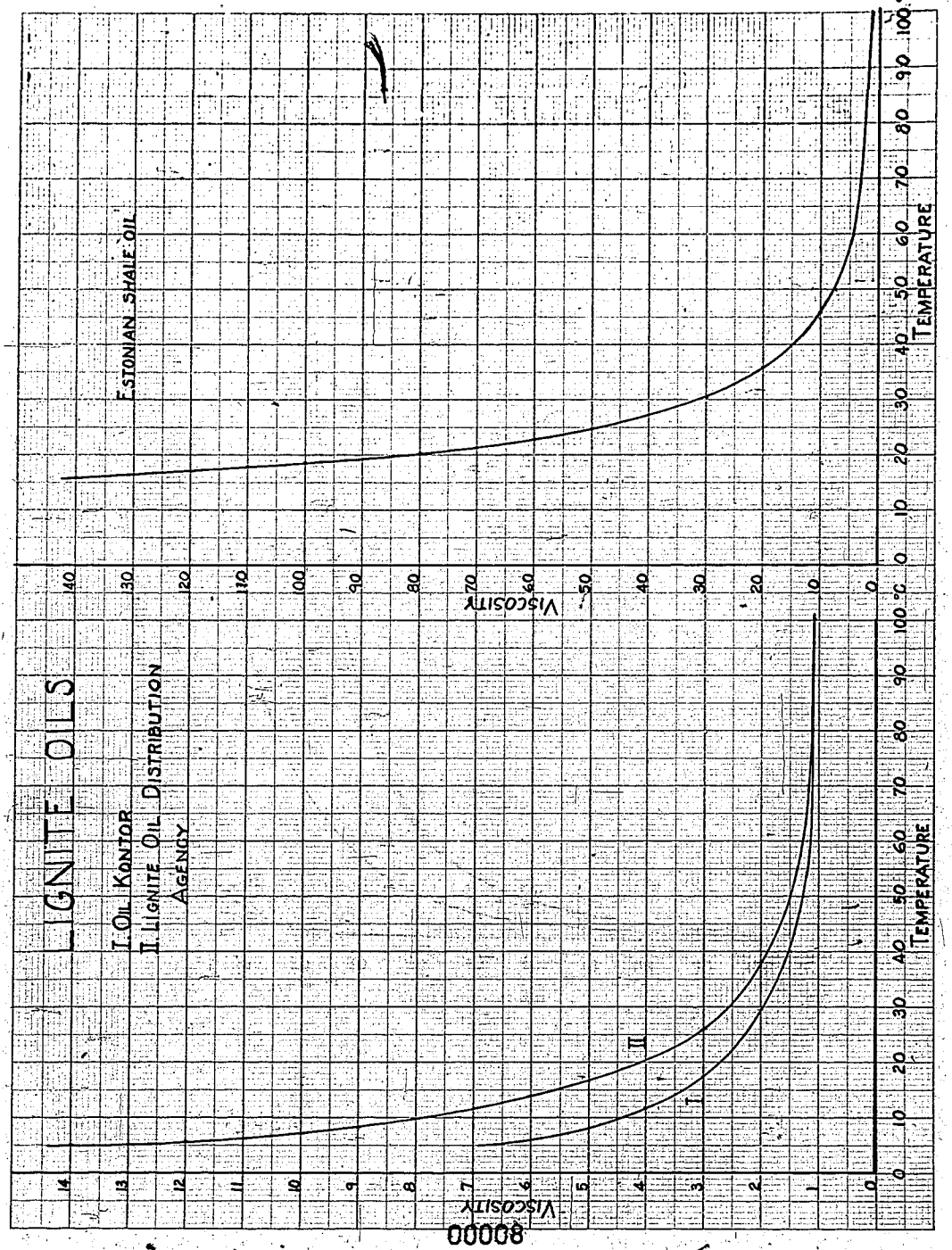

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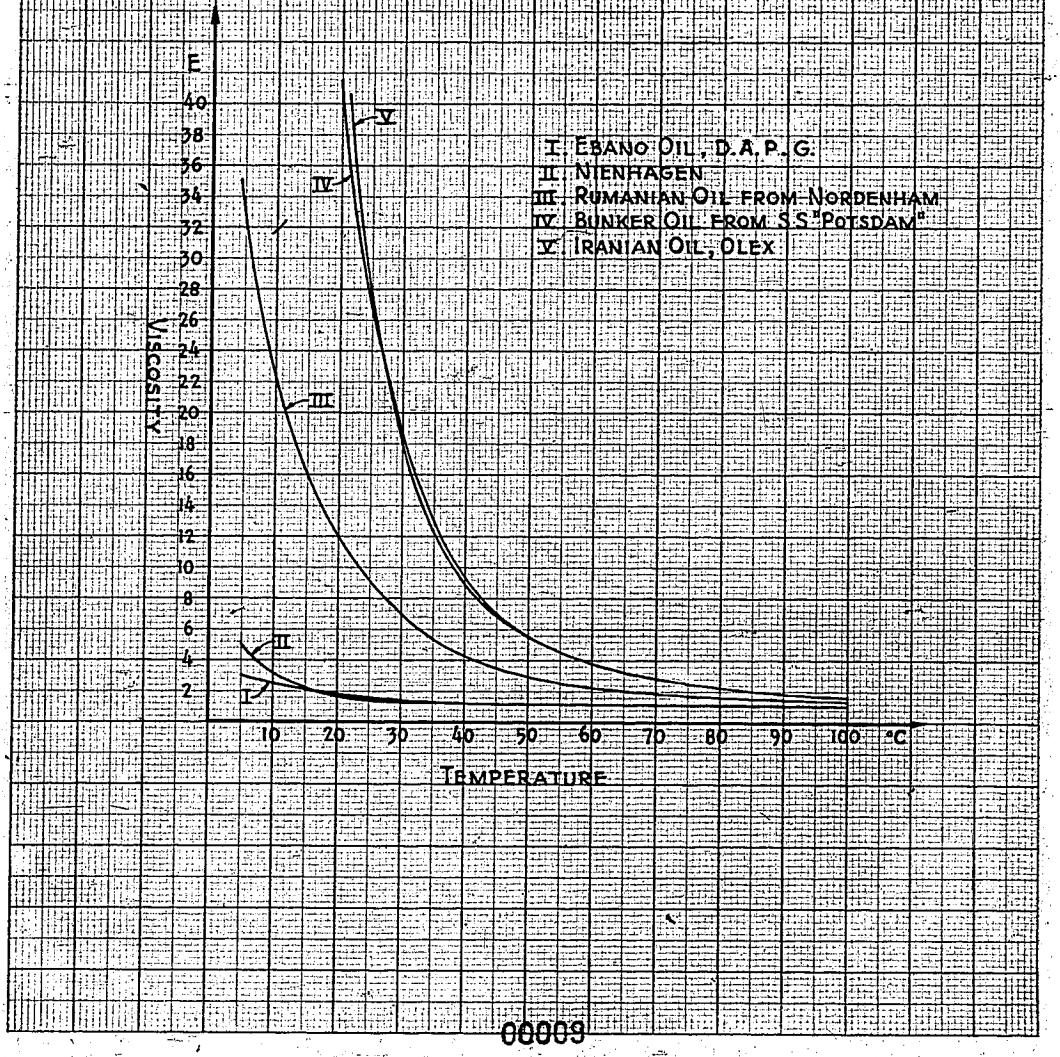
BY DATE

PETROLEUM BUNKER-FUELS

A. Low in Asphalt Content



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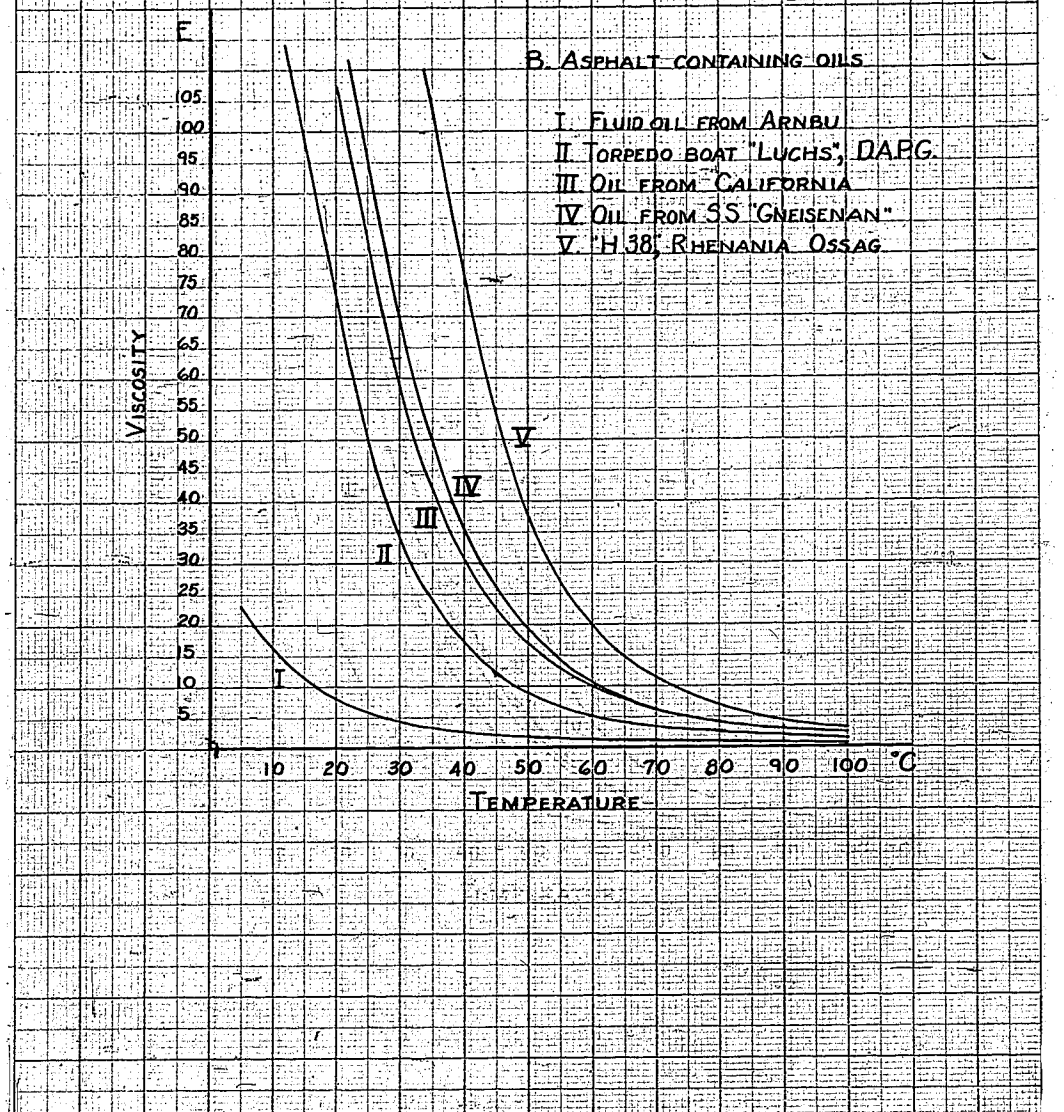
PETROLEUM BUNKER-FUELS



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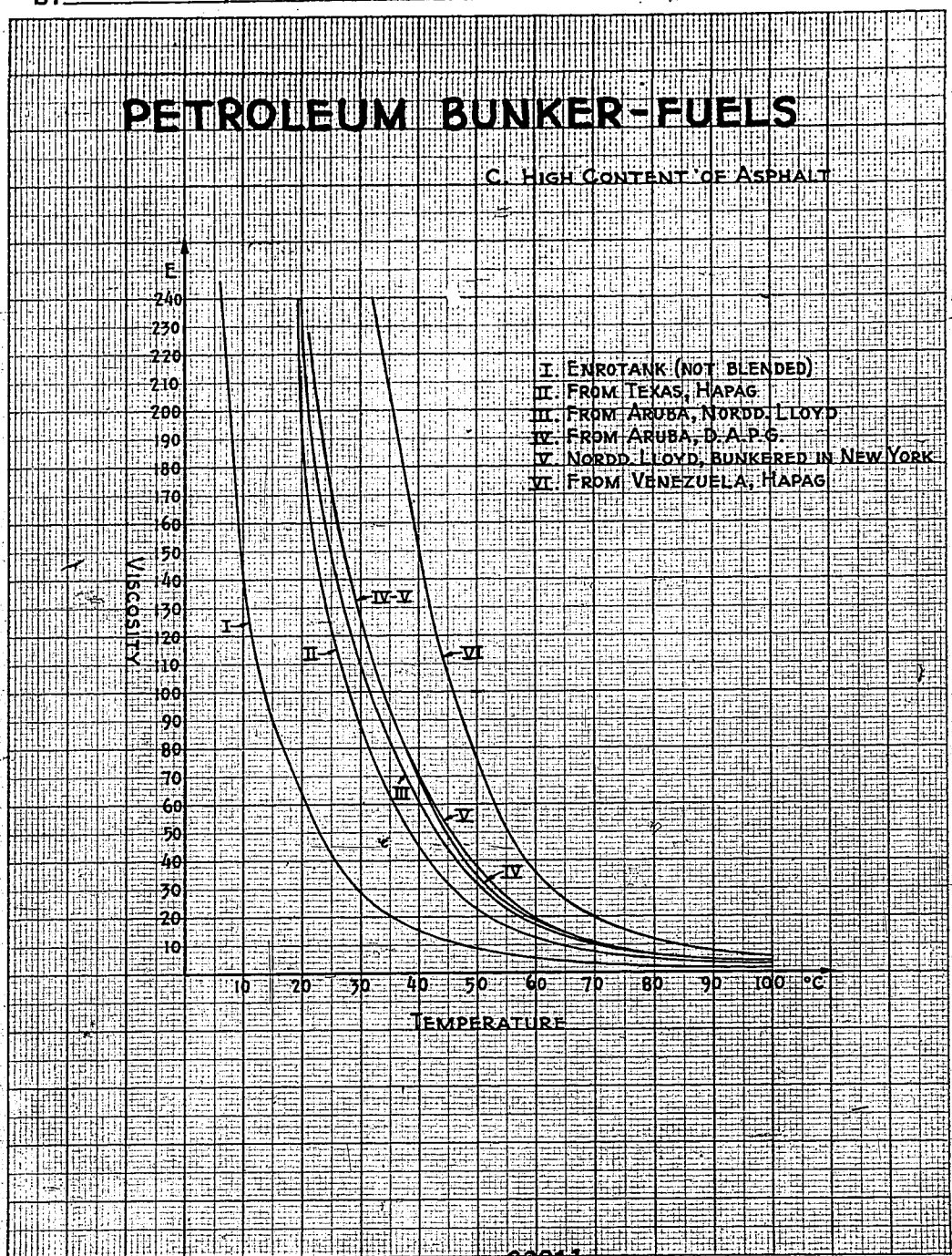
PETROLEUM BUNKER-FUELS

C. High Content of Asphalt



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16—12123-1

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Bunker fuels (Technical qualities)

Type: Coal-tar-oil

Sample: Coal-tar-oil from Teerprodukten Verliniging des Ostens

Quality		Navy Spec.	Det. Value F	Tolerance
Color (Ostwald)			>10	
Transparency			opaque	
Spec. gravity (20°)		1.00-1.12	1.150	0.03
Viscosity 5°	E		6.4	
" 20"	E	1.5-3.0	2.6	
" 50"	E		1.25	
" 100"	E		1.0	
Thermal value	kcal/kg	~9300	9155	145
Net calorific value	kcal/kg	~9000	8807	193
Analysis: C	%		91.24	
H	%		6.96	
O	%			
N	%			
S	%	~0.8	0.76	
Creosote	%		4.0	
Chlorine	%			
Water content	%	Z 1	0.4	
Ash	%	<0.05	0.03	
Acids as SO_3	%		0.06	
Insoluble in light gasoline	%		0.44	
Insoluble in ether alcohol	%		28.0	
Insoluble in xylol	%		0.01	
Conradson carbon	%	≤3	1.2	
Flash-point (P.M.)	°C	>75°	104	
Flash-point (D.V.M.)	°C		123	
Fire point	°C		125	
Pour point	°C		<-25	

Quality	Navy Spec.	Det. Value F	Tolerance
Jentzsch figures			
Flash point (fp)°C	>-70	102	
Vaporization time in the dish (v)°C	< 60	45	
Spontaneous ignition (S_3p)°C	500-600	530	
Higher ignition value (Zo)	~650	>700	
Lower ignition value (Zu)			
Ignition value at 550°C		2.1	
Ignition delay (w) at 300°sec			
310" "			
320" "			
330" "			
340" "			
350" "			
550" "			
Boiling figure (Zk)			
Residue at 500°C (R 500)		0.8	
Residue at 350°C (R 350)		8.5 (k)	
Boiling figure (S_3)	>30	27	
Jentzsch figure			
Tendency to age (R 500 A)		6.5	
Sludge level		9	
Corrosivity against iron			
Corrosivity against copper			
Air consumption for			
Theoretical combustion nm^3			
CO_2 max %			

Adaptability for boilers

Miscibility: compare appendices

Remarks

X Temperature - viscosity diagram compare appendix

F Analyses performed by Chemical - Physical Research Station of the Navy Kiel

Bunker fuels (Technical qualities)

Type: Coal-tar oil Sample: "Welheim" coal-tar-oil from M. Stinnes

Quality		Navy Spec.	Det. Value F	Tolerance
Color (Ostwald)			>10	
Transparency			opaque	
Spec. gravity (20°)			1.096	
Viscosity 5°C	E	not more than 10E at 10°C	77.0	
" 20"	E		17.0	
" 50"	E		2.4	
" 100"	E		1.3	
Thermal value kcal/kg			9 578	
Net calorific value kcal/kg			9 245	
Analysis: C	%		91.37	
H	%		6.33	
O	%			
N	%			
S	%	below 1.5	0.58	0.92
Creosote	%		0	
Chlorine	%			
Water content	%	0.5	0.2	0.3
Ash	%	0.002	traces	
Acids as SO_3			0	
Insoluble in light gasoline	%		0.23	
Insoluble in ether alcohol	%		0.35	
Insoluble in xylol	%		0.22	
Conradson carbon	%	not more than 1.5	1.4	0.1
Flash-point (P.M.)	°C		136	
Flash-point (D.V.M.)	°C		145	
Fire point	°C		184	
Pour point	°C		<-20	

Quality	Navy Spec.	Det. Value F	Tolerance
Jentzsch figures			
Flash point (fp)°C		132	
Vaporization time in the dish (v)°C		70	
Spontaneous ignition (S_3p)°C		485	
Higher ignition value (Zo)		580	
Lower ignition value (Zu)			
Ignition value at 550°C		10.7	
Ignition delay (w) at 300°sec			
310" "			
320" "			
330" "			
340" "			
350" "			
550" "		0.9	
Boiling figure (Zk)			
Residue at 500°C (R 500)		2.2	
Residue at 350°C (R 350)		22 (t)	
Boiling figure (S_3)		1	
Jentzsch figure			
Tendency to age (R 500 A)		5	
Sludge level		10	
Corrosivity against iron			
Corrosivity against copper			
Air consumption for			
Theoretical combustion nm^3			
CO_2 max %			

Adaptability for boilers

Miscibility: compare appendices

Remarks

X Temperature - viscosity diagram compare appendix

f Analyses performed by Chemical - Physical Research Station of the Navy Kiel

Bunker fuels (Technical qualities)

Type: Coal tar oil

Sample: Coal tar oil from V.f.T. Essen

Quality	Navy Spec	Determined Value F*	Tolerance
Color (Ostwald)		> 10	
Transparency		opaque	
Spec. gravity (20°)	> 1.03	1.104	
Viscosity (x) 5° C E		16.3	
" 20 " E	≤ 10	4.3	
" 50 " E		1.5	
" 100 " E		1.05	
Thermal value kcal/kg.		9471	
Net calorific value "	≥ 9000	9120	
Analysis: C %		90.94	
H %		6.67	
O %			
N %			
S %	≤ 1.5	0.64	
Creosote %		4.0	
Chlorine %			
Water content %	≤ 0.5	0.15	
Ash %	≤ 0.025	0.02	
Acids as SO_3 %		0.04	
Insoluble in light gasoline %		0.85	
" " ether alcohol %		0.35	
" " xylene %		0.39	
Conradson Carbon %	≤ 2	1.5	
Flash-point (P.M.)		114	
Flash-point (D.V.M.)° C	> 80	130	
Fire point ° C		149	
Pour point ° C	≤ 10	≤ 20	

Quality	Navy Spec	Determined Value F*	Tolerance
Jentzsch figures			
Flash point (fp)° C	≥ 70	109	
Vaporization time in the dish (v)° C	< 60	55	
Spontaneous ignition (Szp° C)	500 - 600	485	15
Higher ignition value (Zo)	~650	680	
Lower ignition value (Zu)			
Ignition value at 550° C		4.0	
Ignition delay (w) at 300° sec			
310° "			
320° "			
330° "			
340° "			
350° "			
550° "		1.3	
Boiling figure (Zk)			
Residue at 500° C (R 500)		1.3	
Residue at 350° C (R 350)		1.8 (a)	
Boiling figure (Sz)	> 30	13.4	16.6
Jentzsch figure			
Tendency to age (R 500A)		5.7	
Sludge level		10	
Corrosivity against iron			
" " copper			
Air consumption for theoretical combustion nm^3			
CO_2 max. %			

Adaptability for boilers or in the engine respect.

Miscibility : compare appendices

Remarks

x Temperature - viscosity diagram compare appendix

*F Analyses performed by Chemical - Physical - Research - Station of the Navy, Kiel

Bunker fuels (Technical qualities)

Type: Low temperature carbonization coal tar oil. Sample: Low temperature carbonization coal tar oil "S" Krupp Company.

Quality	Navy Spec	Determined Value F*	Tolerance
Color (Ostwald)		≤ 10	
Transparency		opaque	
Spec. gravity (20°)		1.064	
Viscosity (x) 5° C E		110	
" 20 " E		26.5	
" 50 " E		2.7	
" 100 " E		1.15	
Thermal value kcal/kg		9 350	
Net calorific value "		8 910	
Analysis: C %		86.6	
H %		8.20	
O %			
N %			
S %		0.6	
Creosote %		13.0	
Chlorine %			
Water content %		1.4	
Ash %		0.03	
Acids as SO_3 %		0.02	
Insoluble in light gasoline %		18.6	
" " ether alcohol %		0.8	
" " xylene %		0.37	
Conradson Carbon %		7.4	
Flash-point (P.M.)		55	
Flash-point (D.V.M.) °C		74	
Fire point		104	
Pour point °C		- 20	

Quality	Navy Spec	Determined Value F*	Tolerance
Jentzsch figures			
Flash point (fp) °C		60	
Vaporization time in the dish (v) °C		120	
Spontaneous ignition (Szp °C)		478	
Higher ignition value (Zo)		640	
Lower ignition value (Zu)			
Ignition value at 550° C		4.7	
Ignition delay (w) at 300° Sec			
310° "			
320° "			
330° "			
340° "			
350° "			
550° "		1.9	
Boiling figure (Zk)			
Residue at 500° C (R 500)		7	
Residue at 350° C (R 350)		36 (a)	
Boiling figure (S_z)		27	
Jentzsch figure			
Tendency to age (R 500A)		14	
Sludge level		10	
Corrosivity against iron			
" " copper			
Air consumption for theoretical combustion nm^3			
CO_2 max. %			

Adaptability for boilers or in the engine respect.

Miscibility : compare appendices

Remarks

x Temperature - viscosity diagram compare appendix

*F Analyses performed by Chemical - Physical - Research - Station of the Navy, Kiel

Bunker fuels (Technical qualities)
Type: Coal tar oil

Sample: coal-tar oil from F. Uhde, Dortmund

Quality	Navy Spec.	Det. Value F	Tolerance
Color (Ostwald)		>10	
Transparency		opaque	
Spec. gravity (20°)		1.015	
Viscosity 5°C E		2.15	
" 20" E		1.5	
" 50" E		1.1	
" 100" E		1.0	
Thermal value kcal/kg		9752	
Net calorific value kcal/kg		9309	
Analysis: C %		89.45	
H %		8.42	
O %			
N %			
S %		0.34	
Creosote %		4.0	
Chlorine %			
Water content %		0.2	
Ash %		traces	
Acids as SO_3 %		0.024	
Insoluble in light gasoline %		0.02	
Insoluble in ether alcohol %		0.05	
Insoluble in xylol %		0.05	
Conradson carbon %		0.25	
Flash-point (P.M.) °C		95	
Flash-point (D.V.M.) °C		105	
Fire point °C		130	
Pour point °C		<-20	

Quality	Navy Spec.	Det.value F	Tolerance
Jentzsch figures			
Flash point (fp)°c		94	
Vaporization time in the dish (v)°C		30	
Spontaneous ignition(S_{zp})°C			
Higher ignition value (Zo)		411	
Lower ignition value (Zu)		600	
Ignition value at 550°C			
Ignition delay (w) at 300°sec		11.2	
310" "			
320" "			
330" "			
340" "			
350" "			
550" "			
Boiling figure (Zk)		2.5	
Residue at 500°C (R 500)			
Residue at 350°C (R 350)		traces	
Boiling figure (S_3)		0.6 (k)	
Jentzsch figure		48	
Tendency to age (R 500 A)			
Sludge level		2.3	
Corrosivity against iron		20	
Corrosivity against copper			
Air consumption for			
Theoretical combustion nm^3			
CO_2 max %			

Adaptability for boilers
Miscibility: compare appendices
Remarks
X Temperature--viscosity diagram compare appendix
f Analyses performed by Chemical - physical Research Station of the Navy Kiel

Bunker fuels (Technical qualities)
Type: Lignite tar oil

Sample: Lignite tar oil from Oilkontor

Quality		Navy Spec.	Det. value F	Tolerance
Color (Ostwald)			>10	
Transparency			opaque	
Spec. gravity (20°)	kg/l	0.950 0.940	0.947	0.07
Viscosity 5°C	E		6.5	
" 20"	E	≦ 4	2.7	
" 50"	E	≦ 2	1.30	
" 100"	E		1.05	
Thermal value kcal/kg			9912	
Net calorific value kcal/kg		≧ 9200	9375	
Analysis: C	%		85.71	
H	%		10.20	
O	%			
N	%			
S	%	≦ 1.5	0.66	
Cresobe	%	≦ 20	16.0	
Chlorine	%			
Water content	%	≦ 1	0.3	
Ash	%		0.005	
Acids as SO_3	%		0.28	
Insoluble in light gasoline	%		2.8	
Insoluble in ether-alcohol	%		0.8	
Insoluble in xylol	%		G.16	
Conradson carbon	%		0.7	
Flash point (P.M.)	°C	~75 ≧65	85	
Flash point (D.V.M.)	°C		110	
Fire point	°C		136	
Pour point	°C	< 0	-15	

Quality	Navy Spec.	Det. value F	Tolerance
Jentzsch figures:			
Flash point (fp) °C	≧65	89	
Vaporization time in the dish (v) °C	≦80	50	
Spontaneous ignition (S_{3p}) °C	≦ 300/280	298	
Higher ignition value (Z_o)		540	
Lower ignition value (Z_u)	≧ 3	4.9	
Ignition value at 550°C			
Ignition delay (w) at 300°sec	≦ 8/4		
310" "			
320" "			
330" "		11.3	
340" "		5.0	
350" "		2.2	
550" "		1.7	
Boiling figure (Zk)	≧3	3.6	
Residue at 500°C (R 500)		traces	
Residue at 350°C (R 350)		7.6(a)	
Boiling figure (S_3)	≧ 10/30	24	-6
Jentzsch figure		23	
Tendency to age (R 500 A)		5.2	
Sludge level		12	
Corrosivity against iron			
Corrosivity against copper			
Air consumption for Theoretical combustion m^3			
CO_2 max. %			

Adaptability for boilers
Miscibility: compare appendices
Remarks:
X temperature - viscosity diagram compare appendix
f Analyses performed by Chemical - Physical Research Station of the Navy Kiel

Bunker fuels (Technical qualities)
Type: Lignite tar oil Sample: Lignite tar oil from Deutschen Braunkohlen Vertrieb

Quality	Navy Spec.	Det. Value F	Tolerance
Color (Ostwald)		>10	
Transparency		opaque	
Spec. gravity(20°C)	0.965	0.936	0.029
Viscosity 5°C E		14.1	
" 20" E	≤ 3.8	3.9	0.1
" 50" E		1.5	
" 100" E		1.05	
Thermal value kcal/kg		9934	
Net calorific value kcal/kg	≥ 9200	9324	
Analysis: C %		83.72	
H %		11.59	
O %			
N %			
S %	≤ 1.5	1.15	
Creosote %	≤ 25	18.0	
Chlorine			
Water content %	≤ 1	0.5	
Ash %		0.01	
Acids as SO_3 %		0.18	
Insoluble in light gasoline %		1.36	
Insoluble in ether-alcohol %		1.6	
Insoluble in xylol %		0.16	
Conradson carbon %		2.5	
Flash - point (P.M.) °C	≥ 75	85	
Flash-point (D.V.M.) °C		108	
Fire point °C		127	
Pour point °C	≤ 0	16	

Quality	Navy Spec.	Det. Value F	Tolerance
Jentzsch figures			
Flash point (fp) °C	≥ 65	86	
Vaporization time	≤ 80	50	
in the dish (v)°C			
Spontaneous ignition(S_{zp})°C	≤ 300/280	298	
Higher ignition value(Z_o)		550	
Lower ignition value (Zu)	≥ 3	4.6	
Ignition value at 550°C			
Ignition delay (w) at 300°sec	≤ 8/4		
310° "			
320° "		12	
330° "		5.3	
340° "		2.3	
350° "		1.9	
550° "			
Boiling figure (Zk)	≥ 3	3.4	
Residue at 500°C (R 500)		1.6	
Residue at 350°C (R 350)		9.4(k)	
Boiling figure (S_3)	≥ 10/30	34	
Jentzsch figure		24	
Tendency to age (R 500 A)		7.5	
Sludge level		12	
Corrosivity against iron			
Corrosivity against copper			
Air consumption for			
Theoretical combustion nm³			
CO_2 max. %			

Adaptability for boilers
Miscibility: compare appendices
Remarks
X Temperature -viscosity diagram compare appendix
f Analyses performed by chemical - physical Research Station of the Navy Kiel

Bunker fuels (Technical qualities)
Type: Shale oil

Sample: Shale Oil from Estonian Rock Oil Company

Quality	Navy Spec.	Det. Value F	Tolerance
Color (Ostwald)		>10	
Transparency		opague	
Spec. gravity (20°)	≦0.99-1.0	1.005	
Viscosity 5°C E		470	
" 20" E		82.0	
" 50" E	≦6-7.5	7.3	
" 100" E		1.5	
Thermal value kcal/kg	≧ 9400-9500	9460	
Net calorific value kcal/kg		8955	
Analysis: C %		87.07	
H %		9.61	
O %			
N %			
S %	≦ 1	0.86	
Cresolate %		26.0	
Chlorine %			
Water content %	≦ 1	1.0	
Ash %		0.01	
Acids as SO_3 %		0.1	
Insoluble in light gasoline %		7.8	
Insoluble in ether-alcohol %		0.5	
Insoluble in xylol %	≦1	0.76	
Conradson carbon %		4.1	
Flash point (P.M.)°C	≦ 70-90	94	
Flash point (D.V.M.)°C		118	
Fire point °C		146	
Pour point °C	≦ 18	15	

Quality	Navy Spec.	Det. value F	Tolerance
Jentzsch figures			
Flash point (fp)°C	≧65	96	
Vaporization time	≦80	90	10
in the dish (v)°C			
Spontaneous ignition(S_Zp)°C	≦300/280	304	4/20
Higher ignition value(Zo)		550	
Lower ignition value (Zu)	≧3	4.2	
Ignition value at 550°C			
Ignition delay (w) at 300°sec	≦ 8/4		
310°"			
320°"			
330°"			
340°"			
350°"			
550°"			
Boiling figure (Zk)	≧3	3.4	
Residue at 500°C (R 500)		3.6	
Residue at 350°C (R 350)		28(a)	
Boiling figure (S_Z)	≦10/30	7	3
Jentzsch figure		21	
Tendency to age (R 500 A)		9.8	
Sludge level			
Corrosivity against iron			
Corrosivity against copper			
Air consumption for			
Theoretical combustion nm^3			
CO_2 max. %			

Adaptability for boilers
Miscibility: compare appendices
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f Analyses performed by chemical - physical Research Station of the Navy Kiel

Hagemann - Hemmerich - 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	

Bunker fuels (Technical qualities)

Type: Petroleum bunker fuel

Sample: Petroleum bunker fuel from Nienhagen Mineral oil products Company

Quality	Navy Spec.	Det. Value F	Tolerance
Color (Ostwald)		>10	
Transparency		opaque	
Spec. gravity (20°)		0.916	
Viscosity 5°C E		4.8	
" 20" E	≤10	1.7	
" 50" E		1.25	
" 100" E		1.0	
Thermal value kcal/kg		10321	
Net Calorific value kcal/kg	≥9600	9781	
Analysis: C %		86.66	
H %		10.26	
O %			
N %			
S %	≤2	1.24	
Creosote %		0	
Chlorine %			
Water content %	≤1	0.20	
Ash %		0.02	
Acids as SO_3		0.03	
Insoluble in light gasoline %		0.17	
Insoluble in ether-alcohol %		traces	
Insoluble in xylol %		traces	
Conradson carbon %		0.6	
Flash point (P.M.) %	≥65	84	
Flash point (D.V.M.) °C		95	
Fire point °C		109	
Pour point °C	≤0	-20	

Quality	Navy Spec.	Det. Value F	Tolerance
Jentzsch figures			
Flash point (fp) °C	≥65	83	
Vaporization time	≤80	60	
in the dish (v) °C			
Spontaneous ignition (S_{zp}) °C	≤300/280	275	
Higher ignition value (Z_o)		500	
Lower ignition value (Z_u)	≥3	12	
Ignition value at 550°C			
Ignition delay (w) at 300°sec	≤8/4	4.5	
310°sec		2.8	
320° "		2.0	
330° "		1.5	
340° "		1.1	
350° "		0.7	
550° "			
Boiling figure (Zk)	≥3	9	
Residue at 500°C (R 500)/		traces	
Residue at 350°C (R 350)		25 (t)	
Boiling figure (S_z(	≥10/30	48	
Jentzsch figure		50	
Tendency to age (R 500 A)		1.3	
Sludge level		15	
Corrosivity against iron			
Corrosivity against copper			
Air consumption for			
Theoretical combustion nm^3			
CO_2 max %			

Adaptability for boilers

Miscibility: compare appendices

Remarks

X Temperature - viscosity diagram compare appendix

f Analyses performed by chemical - physical Research Station of the Navy Kiel

Bunker fuels (Technical qualities)

Type: Petroleum Bunker fuel

Sample: Rumanian bunker fuel from Nordenham

Quality	Navy Spec.	Det. Value F	Tolerance
Color (Ostwald)		>10	
Transparency		opaque	
Spec. gravity (20°) kg/l		0.918	
Viscosity 5°C E		32.8	
" 20" E	≤ 10	12.1	2.1
" 50" E		2.95	
" 100" E		1.4	
Thermal value kcal/kg		10 645	
Net calorific value kcal/kg	≥ 9600	10 059	
Analysis: C %		87.63	
H %		10.94	
O %			
N %			
S %	≤ 2	0.64	
Creosote %		0	
Chlorine %			
Water content %	≤ 1	0	
Ash %		0.03	
Acids as SO_3 %		0.096	
Insoluble in light gasoline %		0.40	
Insoluble in ether-alcohol %		3.2	
Insoluble in xyiol %		0	
Conradson carbon %		4.7	
Flash point (P.M.) %	≥ -65	89	
Flash point (D.V.M.) °C		110	
Fire point °C		132	
Pour point °C	≤ -0	<-20	

Quality	Navy spec.	Det.Value F	Tolerance
Jentzsch figures:			
Flash point (fp)°C	≥ 65	88	
Vaporization time in the dish (v)°C	≤ 80	140	80
Spontaneous ignition (S_{3p})°C	≤ 300/280	282	
Higher ignition value (Z_o)		510	
Lower ignition value (Z_u)	≥ 3	14.8	
Ignition value at 550°C			
Ignition delay (w) at 300°sec	≤ 8/4	4.7	
310" "		2.8	
320" "		1.6	
330" "		1.1	
340" "		0.8	
350" "		0.6	
550" "			
Boiling figure (Zk)	≥ -3	12	
Residue at 500°C (R 500)		5.9	
Residue at 350°C (R 350)		32	
Boiling figure (S_3)	≥ 10/30	18	
Jentzsch figure		59	
Tendency to age (R 500 A)		6.4	
Sludge level		80	
Corrosivity against iron			
Corrosivity against copper			
Air consumption for Theoretical combustion nm^3			
CO_2 max. %			

Adaptability for boilers

Miscibility: compare appendices

Remarks:

X Temperature - viscosity diagram compare appendix

f Analyses performed by chemical - physical Research Station of the Navy Kiel

Bunker fuels (Technical qualities)

Type: Petroleum bunker fuel

Sample: Petroleum bunker fuel from SS "Potsdam

Quality	Navy Spec.	Det. Value F	Tolerance
Color (Ostwald)		> 10	
Transparency		opaque	
Spec. gravity (20°) kg/l		0.927	
Viscosity 5°C E		205	
" 20" E	≤ 10	42.4	32.4
" 50" E		5.7	
" 100" E		1.7	
Thermal value kcal/kg		10517	
Net calorific value kcal/kg	≥ 9600	9887	
Analysis: C %		85.68	
H %		11.96	
O %		<	
N %			
S %	≤ 2	1.54	
Creosote %		0	
Chlorine %			
Water content %	≤ 1	0	
Ash %		0.033	
Acids as SO_3 %		traces	
Insoluble in light gasoline %		0.98	
Insoluble in ether-alcohol %		5.5	
Insoluble in xylol %		0.14	
Conradson carbon %		7.1	
Flash point (P.M.) %	≥ 65	105	
Flash point (D.V.M.) °C		142	
Fire point °C		175	
Pour point °C	≤ 0	-11	

Quality	Navy Spec.	Det. Value F	Tolerance
Jentzsch figures:			
Flash point (fp)°C	≥ 65	1.08	
Vaporization time in the dish (v)°C	≤ 80	125	45
Spontaneous ignition (S_3p)°C	≤ 300/280	270	
Higher ignition value (^oZo)		510	
Lower ignition value (Zu)	≥ 3	6.9	
Ignition value at 550°C			
Ignition delay (w)at 300°sec	≤ 8/4	3.5	
310" "		1.9	
320" "		1.3	
330" "		1.0	
340" "		0.7	
350" "		0.6	
550" "			
Boiling figure (Zk)	≥ 3	6.2	
Residue at 500°C (R 500)		6.8	
Residue at 350°C (R 350)		45 (t)	
Boiling figure (S_3)	≥ 10/30	5	
Jentzsch figure		37	
Tendency to age (R 500 A)		9.8	
Sludge level		31	
Corrosivity against iron			
Corrosivity against copper			
Air consumption for			
Theoretical combustion nm^3			
CO_2 max. %			

Adaptability for boilers

Miscibility: compare appendices

Remarks:

X Temperature - viscosity diagram compare appendix

f Analyses performed by chemical - physical Research Station of the Navy Kiel

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Bunker fuels (Technical qualities)

Type: Petroleum bunker fuel

Sample: Iranian petroleum bunker fuel from Olex, Hamburg

Quality	Navy Spec.	Det. Value F	Tolerance	Quality	Navy Spec.	Det. value F	Tolerance
Color (Ostwald)		10		Jentzsch figures			
Transparency		opaque		Flash point (fp) °C	65	112	
Spec. gravity (20°)		0.923		Vaporization time in the dish (v) °C	80	160	80
Viscosity 5° E		210		Spontaneous ignition (S_zp) °C	300/280	265	
" 20" E	10	58.0	48	Higher ignition value (Zo)		500	
" 50" E		5.5		Lower ignition value (Zu)	6	6.2	
" 100" E		1.7		Ignition value at 550°C			
Thermal value kcal/kg		10325		Ignition delay (w) at 300° sec	8/4	3.5	
Net calorific value kcal/kg	9600	9744		310" "		2.1	
Analysis: C %		85.43		320" "		1.5	
H %		11.03		330" "		1.1	
O %				340" "		0.8	
N %				350" "		0.5	
S %	2	1.81		550" "			
Creosote %		0		Boiling figure (Zk)	3	5.5	
Chlorine %				Residue at 500°C (R 500)		5.5	
Water content %	1	0.10		Residue at 350°C (R 350)		61 (t)	
Ash %		0.06		Boiling figure (S_z)	10/30	1	9
Acids as SO_3 %		0.04		Jentzsch figure		35	
Insoluble in light gasoline %		0.65		Tendency to age (R 500 A)		9.7	
Insoluble in ether alcohol %		3.61		Sludge level		85	
Insoluble in xylol %		0.02		Corrosivity against iron			
Conradson carbon %		5.9		Corrosivity against copper			
Flash-point (P.M.) %	.65	110		Air consumption for			
Flash-point (D.V.M.) °C		141		Theoretical combustion mm^3			
Fire-point °C		186					
Pour point °C	0	1		CO_2 max %			

Adaptability for boilers

Miscibility: compare appendices

Remarks

x Temperature - viscosity diagram compare appendix

f Analyses performed by Chemical - physical Research Station of the Navy Kiel

Bunker fuels (Technical qualities)

Type: Petroleum bunker fuel

Sample: Petroleum bunker fuel from Arubor (low viscous)

Quality	Navy Spec.	Det. Value F	Tolerance
Color (Ostwald)		>10	
Transparency		opaque	
Spec. gravity (20°)		0.941	
Visdosity 5° E		23.0	
" 20" E	∠10	8.4	
" 50" E		2.2	
" 100" E		1.15	
Thermal value kcal/kg		10 473	
Net calorific value kcal/kg	≥9600	10 078	
Analysis: C %		86.47	
H %		7.51	
O %			
N %			
S %	≦2	1.18	
Creosote %		0	
Chlorine %			
Water content %	≦1	0.1	
Ash %		0.02	
Acids as SO_3 %		0.08	
Insoluble in light gasoline %		4.52	
Insoluble in ether alcohol %		4.69	
Insoluble in xylol %		0.89	
Conradson carbon %		7.3	
Flash-point (P.M.) °C	≥65	78	
Flash-point (D.V.M.) °C		108	
Fire point °C		126	
Pour point °C	≦0	∠-20	

Quality	Navy Spec.	Det. Value F	Tolerance
Jentzsch figures			
Flash point (fp) °C	≥65	82	
Vaporization time in the dish (v) °C	≦80	125	
Spontaneous ignition (S3p) °C	≦300/230	290	
Higher ignition value (Zo)		500	
Lower ignition value (Zu)	≥3	10	
Ignition value at 550°C			
Ignition delay (w) at 300° sec	≦8/4	5.2	
310" "		3.3	
320" "		2.0	
330" "		1.6	
340" "		1.0	
350" "		0.8	
550" "			
Boiling figure (Zk)	≥3	7.2	
Residue at 500°C (R 500)		7.0	
Residue at 350°C (R 350)		20(t)	
Boiling figure (S_3)	≥10/30	20	
Jentzsch figure		39	
Tendency to age (R 500 A)		8.9	
Sludge level		40	
Corrosivity against iron			
Corrosivity against copper			
Air consumption for			
Theoretical combustion nm^3			
CO_2 max %			

Adaptability for boilers

Miscibility: compare appendices

Remarks

X Temperature - viscosity diagram compare appendix

f Analysis performed by Chemical - Physical Research Station of the Navy Kiel

Bunker fuels (Technical qualities)

Type: Petroleum bunker fuel

Sample: Petroleum bunker fuel from Torpedo-boat "Luchs" D.A.P.G.

Quality	Navy Spec.	Det. Value F	Tolerance
Color (Ostwald)		>10	
Transparency		opague	
Spec. gravity (20°)		0.981	
Viscosity 5° E		305	
" 20" E'	≤10	72.5	62.5
" 50" E		9.0	
" 100" E		1.7	
Thermal value kcal/kg		10179	
Net calorific value kcal/kg	≥9600	9635	
Analysis: C %		86.21	
H %		10.34	
O %			
N %			
S %	<2	1.59	
Creosote %		2.0	
Chlorine %			
Water content %	≤1	0.5	
Ash %		0.03	
Acids as SO_3 %		0.06	
Insoluble in light gasoline %		7.2	
Insoluble in ether alcohol %		6.6	
Insoluble in xylol %		0.75	
Conradson carbon %		12.4	
Flash-point (P.M.) °C	≥65	83	
Flash-point (D.V.M.) °C		125	
Fire point °C		150	
Pour point °C	≤0	-21	

Quality	Navy Spec.	Det. Value F	Tolerance
Jentzsch figures			
Flash point (fp) °C	>65	68	
Vaporization time in the dish (v) °C	≤80	150	70
Spontaneous ignition (S_{zp}) °C	≤300/280	280	
Higher ignition value (Z_o)		51	
Lower ignition value (Z_u)	≥3	5.9	
Ignition value at 550°C			
Ignition delay (w) at 300° sec	≤8/4	12.5	
310" "		6.2	
320" "		3.6	
330" "			
340" "			
350" "			
550" "			
Boiling figure (Zk)	≥3	4.9	
Residue at 500°C (R 500)		12.1	
Residue at 350°C (R 350)		54(t)	
Boiling figure (S_z)	≥10/30	3.4	6.6
Jentzsch figure		30	
Tendency to age (R 500 A)		16	
Sludge level		15	
Corrosivity against iron			
Corrosivity against copper			
Air consumption for Theoretical combustion nm^3			
CO_2 max %			

Adaptability for boilers

Miscibility: compare appendices

Remarks:

X Temperature -- viscosity diagram compare appendix

f Analyses performed by Chemical - Physical Research Station of the Navy Kiel

Bunker fuels (Technical qualities)

Type: Petroleum bunker fuel

Sample: Petroleum bunker fuel from California HAPAG

Quality		Navy Spec.	Det. Value F	Tolerance
Color (Ostwald)			>10	
Transparency			opague	
Spec. gravity (20°)			0.958	
Viscosity 5°	E		375	
" 20"	E	≤ 10	106	96
" 50"	E		16.6	
" 100"	E		3.0	
Thermal value kcal/kg			10300	
Net calorific value kcal/kg		≥ 9600	9765	
Analysis: C	%		86.61	
H	%		11.30	
O	%			
N	%			
S	%	≤ 2	1.61	
Creosote	%		0	
Chlorine	%			
Water content	%	≤ 1	0.25	
Ash	%		0.09	
Acids as SO_3	%		0.024	
Insoluble in light gasoline	%		4.96	
Insoluble in ether alcohol	%		7.15	
Insoluble in xylol	%		traces	
Conradson carbon	%		10.6	
Flash-point (P.M.)	%	≥ 65	90	
Flash-point (D.V.M.)	°C		109	
Fire point	°C		143	
Pour point	°C	≤ 0	-10	

Quality	Navy Spec.	Det. Value F	Tolerance
Jentzsch figures			
Flash point (fp) °C	≥ 65	92	
Vaporization time in the dish (v) °C	≤ 80	140	60
Spontaneous ignition (S_{3p}) °C	≤ 300/280	280	
Higher ignition value (Z_o)		510	
Lower ignition value (Z_u)	≥ 3	4.7	
Ignition value at 550°C			
Ignition delay (w) at 300° sec	≤ 8/4	5.3	
310" "		3.4	
320" "		2.7	
330" "		2.0	
340" "		1.6	
350" "			
550" "			
Boiling figure (Zk)	≥ 3	3.9	
Residue at 500°C (R 500)		10	
Residue at 350°C (R 350)		53 (t)	
Boiling figure (S_3)	≥ 10/30	2	8
Jentzsch figure		26	
Tendency to age (R 500 A)		12.8	
Sludge level			
Corrosivity against iron			
Corrosivity against copper			
Air consumption for			
Theoretical combustion nm^3			
CO_2 max %			

Adaptability for boilers

Miscibility: compare appendices

Remarks

X Temperature - viscosity diagram compare appendix

f Analyses performed by Chemical - Physical Research Station of the Navy Kiel

Bunker fuels (Technical qualities)
Type: Petroleum bunker fuel

Sample: Petroleum bunker fuel from SS "Gneisenau"

Quality	Navy Spec.	Det.Value F	Tolerance
Color (Ostwald)		10	
Transparency		opague	
Spec. gravity (20°)		0.968	
Viscosity 5° E		498	
" 20" E	≤ 10	131	
" 50" E		18.1	
" 100" E		3.0	
Thermal value kcal/kg		10182	
Net calorific value kcal/kg	≥ 9600	9602	
Anaysis: C %		85.57	
H %		11.01	
O %		1.8,	
N %			
S %	≤ 2	1.81	
Creosote %		0	
Chlorine %			
Water content %	≤ 1	0.2	
Ash %		0.06	
Acids as SO_3 %		0.01	
Insoluble in light gasoline %		4.9	
Insoluble in ether alcohol %		36.0	
Insoluble in xylol %		0.9	
Conradson carbon %		10.3	
Flash-point (P.M.) %	≥ 63	100	
Flash-point (D.V.M.) °C		154	
Fire point °C		169	
Pour point °C	≤ 0	-10	

Quality	Navy Spec.	Det.Value F	Tolerance
Jentzsch figures			
Flash point (fp)°C	≥ 65	106	
Vaporization time in the dish (v) °C	≤ 80	160	80
Spontaneous ignition (S_3p)°C	≤ 300/260	275	
Higher ignition value (Zo)		510	
Lower ignition value (Zu)	≤ 3	4.3	
Ignition value at 550°C			
Ignition delay (w) at 300°sec	≤ 8/4	4.3	
310" "		2.9	
320" "		2.3	
330" "		1.8	
340" "			
350" "			
550" "			
Boiling figure (Zk)	≥ 3	3.7	
Residue at 500°C (R 500)		10.4	7.4
Residue at 350°C (R 350)		60 (t)	57
Boiling figure (S_3)	≥ 10/30	1	9
Jentzsch figure		26	
Tendency to age (R 500 A)		13	
Sludge level		>100	
Corrosivity against iron			
Corrosivity against copper			
Air consumption for Theoretical combustion nm^3			
CO_2 max %			

Adaptability for boilers
Miscibility: compare appendices
Remarks
X Temperature - viscosity diagram compare appendix
f Analyses performed by Chemical - Physical Research Station of the Navy Kiel

Bunker fuels (Technical qualities)

Type: Petroleum bunker fuel

Sample: Petroleum bunker fuel "H38" Rhenania Ossag

Quality	Navy Spec.	Det.Value F	Tolerance
Color (Ostwald)		10	
Transparency		opaque	
Spec. gravity (20°)		1.010	
Viscosity 5° E		2550	
" 20" E	≦ 10	430	420
" 50" E		36.2	
" 100" E		3.6	
Thermal value kcal/kg		10153	
Net calorific value kcal/kg	≧ 9600	9604	
Analysis: C %		85.63	
H %		10.43	
O %			
N %			
S %	≦ 2	1.88	
Creosote %		0	
Chlorine %			
Water content %	≦ 1	0.3	
Ash %		0.06	
Acids as SO_3 %		0.06	
Insoluble in light gasoline %		5.03	
Insoluble in ether alcohol %		7.3	
Insoluble in xylol %		traces	
Conradson carbon %		11.3	
Flash-point (P.M.) °C	≧ 65	102	
Flash-point (D.V.M.) °C		157	
Fire point °C		221	
Pour point °C	≦ 0	-16	

Quality	Navy Spec.	Det.Value F	Tolerance
Jentzsch figures			
Flash point (fp)°C	≧ 65	110	
Vaporization time in the dish (v)°C	≦ 80	200	120
Spontaneous ignition (S_zp)°C	≦ 300/280	270	
Higher ignition value (Z_o)		510	
Lower ignition value (Zu)	≧ 3	3.7	
Ignition value at 550°C			
Ignition delay (w) at 300° sec	≦ 8/4	5.7	
310° "		3.1	
320° "		2.4	
330° "			
340° "			
350° "			
550° "			
Boiling figure (Zk)	≧ 3	3.3	
Residue at 500°C (R 500)		9.2	
Residue at 350°C (R 350)		69 E	
Boiling figure (S_3)	≧ 10/30	1	9
Jentzsch figure		26	
Tendency to age (R 500 A)		12.1	
Sludge level			
Corrosivity against iron			
Corrosivity against copper			
Air consumption for Theoretical combustion nm^3			
CO_2 max %			

Adaptability for boilers

Miscibility: compare appendices

Remarks:

X Temperature - viscosity diagram compare appendix

f Analyses performed by Chemical - Physical Research Station of the Navy Kiel

Bunker fuels (Technical qualities)

Type: Petroleum bunker-fuel

Sample: Eurotank Petroleum bunker-fuel from The European Storage and Transport A. G.

Quality	Navy Spec.	Determined Value F*	Tolerance
Color (Ostwald)		10	
Transparency		opaque	
Spec. gravity (20°)		0.991	
Viscosity (x) 5° C E		260	
" 20 " E	≤ 10	64.0	54
" 50 " E		8.5	
" 100 " E		1.9	
Thermal value kcal/kg		10213	
Net calorific value "	≥ 9600	9697	
Analysis: C %		88.23	
H %		9.8	
O %			
N %			
S %	≤ 2.5	0.6	
Creosote %		0	
Chlorine %			
Water content %	≤ 1	0.4	
Ash %		0.3	
Acids as SO_3 %		0.006	
Insoluble in light gasoline %		19.4	
Insoluble in ether alcohol %		35.0	
Insoluble in xylene %		11.1	
Conradson Carbon %		17.5	
Flash point (P.M.)	≥ 65	79	
Flash point (D.V.M.) °C		96	
Fire point °C		114	
Pour point °C	≤ 0		

Quality	Navy Spec.	Determined Value F*	Tolerance
Jentzsch figures			
Flash point (fp) °C	≥ 65	82	
Vaporization time in the dish (v) °C	≤ 80	170	90
Spontaneous ignition (Sz P°C)	≤ 300/280	285	
Higher ignition value (Zo)		520	
Lower ignition value (Zu)	≥ 3	4.8	
Ignition value at 550° C			
Ignition delay (w) at 300° sec.	≤ 8/4		
310° sec		5.8	
320° "		3.8	
330° "		2.8	
340° "			
350° "			
550° "			
Boiling figure (Zk)	≥ 3	4.0	
Residue at 500° C (R 500)		17.6	
Residue at 350° C (R 350)		54(a)	
Boiling figure (Sz)	≥ 10/30	20	
Jentzsch figure		27	
Tendency to age (R 500A)		17	
Sludge level		51	
Corrosivity against iron			
" " copper			
Air consumption for theoretical combustion nm^3			
CO_2 max.%			

Adaptability for boilers or in the engine respect.

Miscibility : compare appendices

Remarks

x Temperature - viscosity diagram compare appendix

*F Analyses performed by Chemical - Physical - Research - Station of the Navy, Kiel

Bunker fuels (Technical qualities)

Type: Petroleum bunker fuel

Sample: From Texas, Hapag.

Quality	Navy Spec	Determined Value F*	Tolerance
Color (Ostwald)		> 10	
Transparency		opaque	
Spec. gravity (20°)		0.972	
Viscosity (x) 5° C E		950	
" 20 " E	≦ 10	200	190
" 50 " E		22.3	
" 100 " E		2.9	
Thermal value kcal/kg		10194	
Net calorific value "	≧ 9600	9711	
Analysis: C %		85.47	
H %		9.18	
O %			
N %			
S %	≦ 2	2.25	0.25
Creosote %		0	
Chlorine %			
Water content %	≦ 1	0.15	
Ash %		0.09	
Acids as SO_3 %		0.044	
Insoluble in light gasoline %		8.74	
" " ether alcohol %		11.9	
" " xylene %		traces	
Conradson Carbon %		13.6	
Flash-point (P.M.)	≧ 65	59	
Flash-point (D.V.M.) °C		88	
Fire point °C		104	
Pour point °C	≦ 0	- 19	

Quality	Navy Spec	Determined Value F*	Tolerance
Jentzsch figures			
Flash point (fp) °C	≧ 65	64	1
Vaporization time in the dish (v) °C	≦ 80	130	50
Spontaneous ignition (Szp C)	≦ 300/280	282	
Higher ignition value (Zo)		500	
Lower ignition value (Zu)	≧ 3	4.8	
Ignition value at 550° C			
Ignition delay (w) at 300° sec	≦ 8/4	6.4	
310° "		3.0	
320° "		2.1	
330° "		1.5	
340° "		1.0	
350° "		0.8	
550° "			
Boiling figure (Zk)	≧ 3	3.7	
Residue at 500°C(R 500)		13	
Residue at 350°C(R 350)		63 (t)	
Boiling figure (Sz)	≧ 10/30	8	
Jentzsch figure		26	
Tendency to age (R 500A)		11	
Sludge level		>100	
Corrosivity against iron			
" " copper			
Air consumption for theoretical combustion nm^3			
CO_2 max. %			

Adaptability for boilers or in the engine respect.

Miscibility : compare appendices

Remarks

x Temperature - viscosity diagram compare appendix

*F Analyses performed by Chemical - Physical - Research - Station of the Navy, Kiel

Bunker fuels (Technical qualities)

Type: Petroleum bunker fuel

Sample: Petroleum bunker fuel
from Aruba, SS "Bremen"
Nordd. Lloyd D. January 12, 1936

Quality		Navy Spec	Determined Value F*	Tolerance
Color (Ostwald)			>10	
Transparency			opaque	
Spec. gravity(20°)			0.989	
Viscosity (x) 5° C	E		1120	
20 "	E	≤ 10	236	126
50 "	E		31.5	
100 "	E		3.1	
Thermal value kcal/kg			10 174	
Net calorific value "		≥ 9600	9 659	
Analysis: C	%		86.31	
H	%		9.78	
O	%			
N	%			
S	%	≤ 2	1.95	
Creosote	%		0	
Chlorine	%			
Water content	%	≤ 1	0.25	
Ash	%		0.08	
Acids as SO_3	%		0.03	
Insoluble in light gasoline	%		10.5	
" " ether alcohol	%		9.27	
" " xylene	%		0.05	
Conradson Carbon	%		14.5	
Flash-point (P.M.)		≥ 65	88	
Flash-point (D.V.M.)	°C		130	
Fire point	°C		168	
Pour point	°C	≤ 0	- 17	

Quality	Navy Spec	Determined Value F*	Tolerance
Jentzsch figures			
Flash point (fp)°C	≥ 65	86	
Vaporization time in the dish (v) °C	≤ 85	180	100
Spontaneous ignition (Szp°C)	≤ 300/280	270	
Higher ignition value (Zo)		500	
Lower ignition value (Zu)	≥ 3	3.7	
Ignition value at 550° C			
Ignition delay (w) at 300° sec	≤ 8/4	5.1	
310° "		3.8	
320° "		2.6	
330° "		1.7	
340° "		1.4	
350° "			
550° "			
Boiling figure (Zk)	≤ 3	3.2	
Residue at 500°C(R 500)	≤ 3/2		
Residue at 350°C(R 350)	≤ 3/2		
Boiling figure (Sz)	≤ 10/30	1	
Jentzsch figure		25	
Tendency to age (R 500A)		16	
Sludge level		>100	
Corrosivity against iron			
" " copper			
Air consumption for theoretical combustion nm^3			
CO_2 max. %			

Adaptability for boilers or in the engine respect.

Miscibility : compare appendices

Remarks

x Temperature - viscosity diagram compare appendix

*F Analyses performed by Chemical - Physical - Research - Station of the Navy, Kiel

Bunker fuels (Technical qualities)

Type: Petroleum bunker fuel

Sample: Petroleum bunker fuel from Aruba, D.A.P.G. Hamburg

Quality	Navy Spec	Determined Value F*	Tolerance
Color (Ostwald)		7 10	
Transparency		opaque	
Spec. gravity (20°)		0.988	
Viscosity (x) 5° C E		1480	
" 20 " E	≤ 10	310	300
" 50 " E		31.8	
" 100 " E		4.0	
Thermal value kcal/kg		10 056	
Net calorific value "	≥ 9600	9 467	133
Analysis: C %		84.85	
H %		11.18	
O %			
N %			
S %	≤ 2	1.81	
Creosote %		0	
Chlorine %			
Water content %	≤ 1	0.30	
Ash %		0.33	
Acids as SO_3 %		0.024	
Insoluble in light gasoline %		17.7	
" " ether alcohol %		39.0	
" " xylene %		10.0	
Conradson Carbon %		14.4	
Flash-point (P.M.)	≥ 65	85	
Flash-point (D.V.M.) °C		127	
Fire point °C		168	
Pour point °C	≤ 0	- 20	

Quality	Navy Spec	Determined Value F*	Tolerance
Jentzsch figures			
Flash point (fp) °C	≥ 65	- 90	
Vaporization time in the dish (v) °C	≤ 80	200	120
Spontaneous ignition (Szp °C)	≤ 300/280	275	
Higher ignition value (Zo)		500	
Lower ignition value (Zu)	≥ 3	4.0	
Ignition value at 550° C			
Ignition delay (w) at 300° sec	≤ 8/4		
310° "		3.7	
320° "		2.6	
330° "		1.8	
340° "		1.5	
350° "			
550° "			
Boiling figure (Zk)	≥ 3	3.3	
Residue at 500° C (R 500)		14.3	
Residue at 350° C (R 350)		64 (t)	
Boiling figure (Sz)	≥ 10/30	1	9
Jentzsch figure		25	
Tendency to age (R 500A)		15	
Sludge level		73	
Corrosivity against iron			
" " copper			
Air consumption for theoretical combustion nm^3			
CO_2 max. %			

Adaptability for boilers or in the engine respect.

Miscibility : compare appendices

Remarks

x Temperature - viscosity diagram compare appendix

*F Analyses performed by Chemical - Physical - Physical - Research - Station of the Navy, Kiel

Bunker fuels (Technical qualities)

Type: Petroleum bunker fuel

Sample: Petroleum bunker fuel from Nordd.Lloyd SS "Bremen" Bunkered New York

Quality	Navy Spec	Determined Value F*	Tolerance
Color (Ostwald)		> 10	
Transparency		opaque	
Spec. gravity (20°)		0.989	
Viscosity (x) 5° C E		1610	
" 20 " E	≤ 10	330	320
" 50 " E		36.4	
" 100 " E		3.9	
Thermal value kcal/kg		9876	
Net calorific value "	≥ 9600	9459	150
Analysis: C %		85.64	
H %		8.09	
O %			
N %			
S %	≤ 2	1.79	
Creosote %		0	
Chlorine %			
Water content %	≤ 1	0.2	
Ash %		0.2	
Acids as SO_3 %		0.03	
Insoluble in light gasoline %		9.6	
" " ether alcohol %		2.0	
" " xylene %		0.19	
Conradson Carbon %		15.8	
Flash point (P. M.)	≥ 65	foaming	
Flash point (D.V.M.) °C		133	
Fire point °C		168	
Pour point °C	≤ 0	0	

Quality	Navy Spec	Determined Value F*	Tolerance
Jentzsch figures			
Flash point (fp) °C	≥ 65	98	
Vaporization time in the dish (v) °C	≤ 80	225	145
Spontaneous ignition (Szp °C)	≤ 300/280	286	
Higher ignition value (Zo)	=	530	
Lower ignition value (Zu)	≥ 3	3.7	
Ignition value at 550° C			
Ignition delay (w) at 300° sec	≤ 8/4		
310° "		3.6	
320° "		2.5	
330° "			
340° "			
350° "			
550° "			
Boiling figure (Zk)	≥ 3	3.2	
Residue at 500° C (R 500)		15.4	
Residue at 350° C (R 350)		55 (t)	
Boiling figure (Sz)	≥ 10/30	3	7
Jentzsch figure		23	
Tendency to age (R 500A)		18.5	
Sludge level		43	
Corrosivity against iron			
" " copper			
Air consumption for theoretical combustion nm^3			
CO_2 max. %			

Adaptability for boilers or in the engine respect.

Miscibility : compare appendices

Remarks

x Temperature - viscosity diagram compare appendix

*F Analyses performed by Chemical - Physical - Research - Station of the Navy, Kiel

Bunker fuels (Technical qualities)

Type: Petroleum bunker fuel — Sample: From Venezuela "HAPAG"

Quality		Navy Spec	Determined Value F*	Tolerance
Color (Ostwald)			10	
Transparency			opaque	
Spec. gravity (20°)			0.993	
Viscosity (x) 5° C	E		7000	
" 20 "	E	≤ 10	1010	1000
" 50 "	E		74.3	
" 100 "	E		5.3	
Thermal value kcal/kg			10 207	
Net calorific value "		≥ 9600	9 649	
Analysis: C	%		86.13	
H	%		10.60	
O	%			
N	%			
S	%	≤ 2	2.06	0.06
Creosote	%		0.	
Chlorine	%			
Water content	%	≤ 1	0.1	
Ash	%		0.09	
Acids as SO_3	%		0.02	
Insoluble in light gasoline	%		11.01	
" " ether alcohol	%		13.15	
" " xylene	%		traces	
Conradson Carbon	%		18	
Flash-point (P. M.)		≥ 65	89	
Flash-point (D.V.M.)	°C		132	
Fire point	°C		174	
Pour point	°C	≤ 0	- 14.5	

Quality	Navy Spec	Determined Value F*	Tolerance
Jentzsch figures			
Flash point (fp) °C	≥ 65	92	
Vaporization time in the dish (v) °C	≤ 80	160	80
Spontaneous ignition (Szp C)	≤ 300/280	282	
Higher ignition value (Zo)		510	
Lower ignition value (Zu)	≥ 3	4.0	
Ignition value at 550°C			
Ignition delay (w) at 300° sec	≤ 8/4	7.1	
310° "		4.7	
320° "		2.8	
330° "		2.1	
340° "		1.5	
350° "		0.9	
550° "			
Boiling figure (Zk)	≥ 3	3.2	
Residue at 500°C (R 500)		18	
Residue at 350°C (R 350)		57 (t)	
Boiling figure (Sz)	≥ 10/30	1	9
Jentzsch figure		23	
Tendency to age (R 500A)		14	
Sludge level		80	
Corrosivity against iron			
" " copper			
Air consumption for theoretical combustion nm^3			
CO_2 max. %			

Adaptability for boilers or in the engine respect.

Miscibility : compare appendices

Remarks

x Temperature - viscosity diagram compare appendix

*F Analyses performed by Chemical - Physical - Research - Station of the Navy, Kiel

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APPENDIX II 1st Sheet BUNKER - FUEL - MIXTURES

Mixing proportions	(1) 1 part V.f.T. 1 " Uhde	(2) 1 part V.f.T. 1 " Uhde 1 " Lignite oil	(3) 1 part V.f.T 1 " Uhde 1 " Estonia	(4) 1 part V.f.T. 1 " Uhde 1 " Gas oil	(5) 1 part V.f.T. 1 " Iran	(6) 1 part V.f.T. 1 " Iran 1 " Ebano	(7) 1 part V.f.T. 1 " Iran 1 " Ebano 1 " Lignite oil	(8) 1 part V.f.T. 1 " Aruba	(9) 1 part V.f.T. 1 " Aruba 1 " Ebano	(10) 1 part V.f.T. 1 " Aruba 1 " Ebano 1 " Lignite oil	(11) 1 part V.f.T. 1 " Venezuela	(12) 1 part V.f.T. 1 " Vene-zuela 1 " Ebano	(13) 1 part V.f.T. 1 " Vene-zuela 1 " Ebano 1 " Lignite oil	(14) 1 part V.f.T. 1 " Calif.	(15) 1part V.f.T. 1 " Calif. 1 " Ebano	(16) 1 part V.f.T., Calif., Ebano, & Lignite oil	(17) 1 part V.f.T. 1 part Texas
Spec. grav. at 20 C.	1.060	1.026	1.042	0.988	1.020	0.977	0.972	1.034	0.998	0.989	1.063	0.997	0.990	1.039	0.987	0.982	1.045
Ash content %	0.025%	0.006%	0.007%	0.010%	0.030%	0.020%	0.010%	0.045%	0.035%	0.033%	0.046%	0.030%	0.028%	0.052%	0.046%	0.038%	0.055%
R 500 %	0.7	0.6	1.3	0.8	4.0	3.1	2.8	8.2	6.2	5.4	10.0	7.5	6.1	6.6	4.9	4.3	7.8
Conradson Test	0.91%	0.53%	1.27%	0.43%	3.7%	3.0%	2.45%	7.7%	5.7%	4.4%	9.75%	7.0%	5.45%	6.3%	4.7%	3.7%	7.85%
R 350 %	8.2	8.3	18.1	6	40	33	27	42	35	28	44	30	29	34	32	24	35
Insoluble in light gasol. %	0.42%	1.2%	5.6%	0.36	0.91%	0.90%	0.86%	4.30%	3.03%	2.58%	5.33%	3.74%	3.17%	3.01%	2.36%	1.87%	4.60%
Viscosity E°																	
80 C°	1.10	1.10	1.20	1.05	1.4	1.2	1.2	1.7	1.25	1.25	1.95	1.4	1.35	1.65	1.4	1.3	1.6
50 "	1.20	1.30	1.60	1.15	2.3	1.8	1.8	3.7		2.0	5.2	2.25	2.1	4.3	2.2	1.9	3.05
30 "	2.20	2.30	4.70	1.60	22.2	5.15	5.0	22.8	8.2	6.2	32.6	8.0	6.6	21.5	6.95	5.45	18.6
Formation of deposits																	
After 48 hours	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	Approx. 0.2%	Approx. 0.2%	Approx. 0.2%	Approx. 0.2%	Approx. 0.2%	Approx. 0.2%	Approx. 0.2%	Approx. 0.2%	Approx. 0.2%	Approx. 0.2%
After 21 days	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	"	"	"	"	"	"	"	"	"	"
Flash point C°	107	101	101	87	114	100	95	112	101	98	114	91	78	99	90	81	78
Vaporization time in the dish sec.	40	40	45	40	100	75	75	120	90	85	120	95	115	120	80	95	100
Spontaneous ignition C°	398	330	395	296	340	281	290	360	298	289	350	299	291	340	290	290	328
Higher ignition value	660	580	580	560	570	540	540	570	540	540	580	540	540	560	540	540	570
Lower ignition value	0.9	0.6	1.4	2.1	1.1	4.2	4.0	1.2	2.7	3.2	0.9	3.1	3.2	1.2	2.9	3.4	0.8
Ignition value	0.3	0.4	0.6	1.9	0.8	3.9	3.4	0.7	2.2	2.8	0.6	2.5	2.7	0.8	2.5	2.9	0.6
Ignition delay 510° 500°C, 120 Bubbles 120 Bubbles	1.9	1.0	1.0	0.9	0.9	0.6	0.6	1.1	0.7	0.7	1.3	0.8	0.7	1.1	0.8	0.7	1.3
Boiling figure	27	23	20	40	7	13	17	17	10	15	5	13	10	7	10	8	7
Residue at 500°C after aging	3.1	3.6	4.9	2.9	6.2	5.1	4.7	10.8	8.4	7.4	12	9	7.7	9	7.8	6.3	10
Sludge level	25	13	2	13	26	34	25	55	52	40	54	66	58	27	42	74	58

REMARK Composition of mixture #16
1 part V.f.T.
1 " California
1 " Ebano
1 " Lignite oil

APPENDIX VI 1st Sheet BUNKER - FUEL - MIXTURES (Continued)

Mixing proportions	(18) 1 part V.f.T. 1 " Texas 1 " Ebano	(19) 1 part V.f.T. 1 " Texas 1 " Ebano 1 " Lignite oil	(20) 1 part V.f.T. 1 " lignite oil 1 " Eurotank	(21) 2 parts V.f.T. 1 " lignite oil 1 " Eurotank	(22) 1 part V.f.T. 1 " lignite oil 2 " Eurotank	(23) 1 part V.f.T 2 " lignite oil 1 " Eurotank	(24) 1 part V.f.T. 1 " Eurotank 1 " Ebano	(25) 2 part V.f.T. 1 " Eurotank 1 " Ebano	(26) 1 part V.f.T. 2 " Eurotank 1 " Ebano	(27) 1 part V.f.T. 1 " Eurotank 2 parts Ebano	(28) 1 part V.f.T. 1 " bunker oil H 38	(29) 1 part V.f.T. 1 part bunker oil H 38 1 part Ebano	(30) 1 part V.f.T. 1 part bunker oil H 38 1 part Ebano 1 " lignite oil	(31) 1 part V.f.T. 1 " Nienhagener	(32) 1 part V.f.T. 1 " Nienhagener 1 part Ebano
Spec. grav. at 20°C.	0.991	0.985	1.020	1.043	1.014	1.006	1.000	1.025	0.997	0.972	1.047	0.990	0.983	1.006	0.973
Ash content %	0.040%	0.035%	0.040%	0.040%	0.050%	0.040%	0.043%	0.040%	0.033%	0.037%	0.040%	0.035%	0.017%	traces	traces
R 500 %	6.5	5.7	8.2	6.0	10.8	6.9	7.7	6.8	10	6.3	6.6	5.2	4.4	2.2	1.1
Conradson Test	5.8%	4.5%	6.4%	5.2%	9.1%	5.0%	6.2%	5.0%	9.0%	4.7%	6.7%	4.5%	3.5%	1.6%	0.69%
R 350 %	31	29	26	21	33	27	26	26	33	26	42	33	28	24	18
Insoluble in light gasol. %	3.46%	2.64%	1.9%	1.9%	2.0%	5.4%	2.5%	2.1%	3.8%	2.2%	2.9%	3.2%	1.9%	0.89%	0.58%
Viscosity E°															
80°C	1.45	1.35	1.4	1.3	1.5	1.3	1.3	1.2	1.4	1.25	1.75	1.4	1.3	1.2	1.1
50 "	2.35	2.05	2.1	1.8	2.6	1.8	1.8	1.7	2.3	1.56	3.8	2.4	1.9	1.35	1.3
30 "	7.3	5.75	7.8	6.4	11.6	6.3	5.2	4.8	8.4	3.7	25.2	7.8	5.9	2.4	2.15
Formation of deposits	Approx.	Approx.													
After 48 hours	0.2%	0.2%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%
After 21 days	"	"	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	Approx. 0.2%	< 0.1%	< 0.1%	< 0.1%	< 0.1%
Flash point °C	75	75	98	120	101	98	86	85	84	86	118	98	89	84	81
Vaporization time in the dish sec.	90	90	95	60	125	125	135	105	95	95	80	110	105	70	65
Spontaneous ignition °C	288	315	299	415	300	299	291	297	288	285	330	295	299	302	292
Higher ignition value	540	540	560	600	560	560	550	560	540	520	580	530	540	550	530
Lower ignition value	4.7	2.1	2.2	1.5	2.4	2.8	3.2	2.1	3.8	4.2	0.8	3.2	3.7	4.9	4.8
Ignition value	4.1	1.5	2.0	0.7	2.0	2.5	2.9	1.9	3.4	3.5	0.6	2.5	3.0	4.1	3.9
Ignition delay 500°C, 120 Bubbles	0.8	0.8	1.0	1.9	1.0	0.9	0.8	1.0	0.8	0.5	1.3	0.7	0.7	0.7	0.5
Boiling figure	13	7	7	10	3	17	7	7	7	13	1	3	5	20	17
Residue at 500°C after aging	8.8	7.7	11	8.4	13	9.2	9.2	7.9	13	7.6	8.5	5.5	6.6	3.8	2.7
Sludge level	57	50	23	16	31	19	44	22	32	35	45	58	35	18	19

APPENDIX II 1st Sheet BUNKER - FUEL - MIXTURES (Continued)

Mixing proportions	(33) 1 part V.f.T. 1 " Nienhagener 1 " Ebano 1 " lignite oil	(34) 1 part V.f.T. 1 " D.A.P.G.	(35) 1 part V.f.T. 1 " D.A.P.G. 1 " Ebano	(36) 1 part V.f.T. 1 " D.A.P.G. 1 " Ebano 1 " lignite oil
Spec. grav. at 20°C.	0.970	1.048	1.500	0.986
Ash content %	traces	traces	traces	traces
R 500 %	1.1	8.1	6.1	5.9
Conradson Test	0.9%	8.0%	5.3%	4.2%
R 350 %	18	40	32	27
Insoluble in light gasol. %	0.66%	3.95%	2.8%	2.3%
Viscosity E°				
80°C	1.15	1.7	1.35	1.3
50 "	1.35	3.8	2.1	2.0
30 "	2.4	21.4	6.4	5.6
Formation of deposits				
After 48 hours	<0.1%	<0.1%	<0.1%	<0.1%
After 21 days	<0.1%	Approx. 0.2%	<0.1%	<0.1%
Flash point °C	84	98	95	99
Vaporization time in the dish sec.	55	130	120	95
Spontaneous ignition °C	290	332	293	292
Higher ignition value	530	580	540	530
Lower ignition value	4.3	0.8	3.4	3.8
Ignition value	3.6	0.6	2.9	3.1
Ignition delay 500°C, 120 Bubbles	0.6	1.3	0.7	0.6
Boiling figure	17	1	3	3
Residue at 500°C after aging	3.7	10	8	7.8
Sludge level	12	73	73	43

APPENDIX II 2nd Sheet BUNKER-FUEL-MIXTURE

Mixing proportion	Estonian 1 part V.f.T. oil 1 " Lignite oill "	Estonian 1 part V.f.T. oil 2 " Lignite oil 1 "	Estonian 2 part V.f.T. oil 1 " Lignite " 1 "	Estonian 1 part V.f.T. oil 1 " Lignite " 2 "	V.f.T. oil 1 part Eurotank 1 part	V.f.T. oil 1 part Ebano oil 1 "	V.f.T. oil 1 part Lignite oil 1 "	V.f.T. oil 1 part Ebano oil 1 " Eurotank 1 " Lignite oil 1 "	V.f.T. oil 2 parts Ebano " 1 part Eurotank " 1 " Lignite oil 1 "	V.f.T. oil 1 part Ebano 1 part Eurotank 2 parts Lignite oil 1 part	V.f.T. oil 1 part Ebano 2 parts Eurotank 1 part Lignite oil 1 part	V.f.T. oil 1 part Ebano 1 part Eurotank 1 part Lignite oil 2 parts
Spec. grav. at 20° C.	1.023	1.044	1.020	1.008	1.044	1.003	1.031	0.989	1.010	1.000	0.972	0.982
Ash Content %	0.025%	0.026%	0.019%	0.024%	0.066%	0.025%	0.020%	0.042%	0.028%	0.055%	0.025%	0.030%
R 500 %	2.8	2.9	2.7	2.3	9.3	1.0	1.0	4.4	5.6	8.9	6.0	6.1
Conradson Test	1.69%	1.47%	2.54%	1.38%	9.3%	0.74%	0.69%	4.9%	4.2%	7.3%	3.9%	4.0%
R 350 %	26	26	24	25	37	17	12	25	27	27	24	23
Viscosity E												
80° C	1.30	1.24	1.40	1.25	1.50	1.15	1.15	1.30	1.20	1.25	1.20	1.20
50° C	1.98	1.80	2.40	1.80	2.60	1.35	1.50	1.80	1.60	1.80	1.60	1.50
30° C	8.35	6.80	13.0	6.35	12.5	2.50	3.45	4.60	4.10	5.70	3.50	3.10
Insoluble in Light Gasoline %	5.59%	4.89%	7.35%	5.08%	4.55%	0.53%	1.50%	2.16%	1.40%	3.5%	1.4%	1.6%
Formation of deposits after 96 hours	<0.1%	<0.1%	<0.1%	<0.1%	<0.2%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
after 30 days	<0.1%	<0.1%	<0.1%	<0.1%	<0.2%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Flash point C°	101	107	94	103	101	92	99	88	86	82	78	95
Vaporization time in the dish sec.	60	70	55	55	110	60	60	65	120	140	70	65
Spontaneous ignition °C	309	309	299	302	336	290	310	296	298	297	284	292
Higher ignition value	550	560	540	550	590	540	580	550	550	540	530	540
Lower ignition value	2.3	1.5	3.9	2.4	0.7	3.0	1.8	3.3	2.7	3.0	4.2	4.0
Ignition value	1.8	1.2	3.2	2.0	0.5	2.6	1.5	2.8	2.3	2.5	3.7	3.4
Ignition delay sec. 508° C, 120 bubbles per min.	0.7	1.0	0.7	0.9	2.0	0.8	1.0	0.8	0.8	0.7	0.7	0.7
Boiling figure	3	3	10	8	10	10	10	13	10	10	15	17
Residue at 500° C after aging	7.4	6.2	6.2	5.5	14	3.1	5.3	7.7	6.3	11	7	8
Sludge level	6	8	*	*	*33	15	10	70	19	50	30	27

*Sticks to the wall.

Appendix II, 3rd Sheet, Bunker-fuel and Gas Oil Mixtures

Mixing Proportions	Estonian - 1 Part V.f.T. Oil-1 Part Lignite oil-1 Part Gas Oil -1 Part	Estonian - 1 Part V.f.T. Oil-2 Part Lignite Oil-1 Part Gas Oil -1 Part	Estonian - 2 Part V.f.T. Oil-1 Part Lignite Oil-1 Part Gas Oil -1 Part	Estonian - 1 Part V.f.T. Oil-1 Part Lignite Oil-1 Part Gas Oil -1 Part	V.f.T. Oil - 1 Part Eurotank - 1 Part Gas Oil - 1 Part	V.f.T. Oil - 1 Part Ebano - 1 Part Gas Oil - 1 Part	V.f.T. Oil - 1 Part Lignite Oil- 1 Part Gas Oil - 1 Part	V.f.T. Oil - 1 Part Ebano - 1 Part Eurotank - 1 Part Lignite Oil- 1 Part Gas Oil - 1 Part	V.f.T. Oil - 2 Part Ebano - 1 Part Eurotank - 1 Part Lignite Oil- 1 Part Gas Oil - 1 Part	V.f.T. Oil - 1 Part Ebano - 1 Part Eurotank - 2 Part Lignite Oil- 1 Part Gas Oil - 1 Part	V.f.T. Oil - 1 Part Ebano - 2 Part Eurotank - 1 Part Lignite Oil- 1 Part Gas Oil - 1 Part	V.f.T. Oil --1 Part Ebano - 1 Part Eurotank - 1 Part Lignite Oil- 2 Part Gas Oil - 1 Part
Spec. grav. at 20°	0.983	1.008	0.987	0.983	0.986	0.956	0.973	0.960	0.979	0.968	0.947	0.957
Asphalt	0.022 %	0.018 %	0.018 %	0.022 %	0.055 %	0.016 %	0.017 %	0.020 %	0.022 %	0.037 %	0.010 %	0.065 %
Comradson Test	1.34 %	1.23 %	1.78 %	1.18 %	6.2 %	0.46 %	0.43 %	3.9 %	3.5 %	6.1 %	3.3 %	3.4 %
Viscosity °E												
80°	1.20	1.20	1.25	1.20	1.20	1.10	1.10	1.20	1.15	1.20	1.20	1.18
50°	1.70	1.60	2.0	1.70	1.60	1.20	1.35	1.65	1.35	1.60	1.40	1.40
30°	4.25	3.95	6.75	4.50	3.45	1.90	2.0	2.95	2.0	3.70	2.40	2.70
Insoluble in Light Gas	2.54 %	3.14 %	5.12 %	4.83 %	2.54 %	0.16 %	0.45 %	1.05 %	1.37 %	2.3 %	1.37 %	
ormation of Deposits:												
After 96 hours	< 0.1 %	< 0.1 %	< 0.1 %	< 0.1 %	< 0.2 %	< 0.1 %	< 0.1 %	< 0.2 %	< 0.1 %	< 0.1 %	< 0.1 %	< 0.1 %
After 30 days	< 0.1 %	< 0.1 %	< 0.1 %	< 0.1 %	0.18 %	0.20 %	< 0.1 %	< 0.2 %	< 0.1 %	< 0.5 %	< 0.27 %	< 0.1 %

00040

APPENDIX III.

Bunker-fuel mixtures		Conradson Test	
		Determined by experiment	Completed
V.f.T. -	Iranian bunker-fuel 1:1	3.75 %	3.79 %
"	" " - Ebano 1:1:1	3.0 %	2.31 %
"	" " - Ebano Lignite oil 1:1:1:1	2.45 %	2.4 %
"	Aruba 1:1	7.7 %	7.6 %
"	" - Ebano 1:1:1	5.7 %	5.4 %
"	" - " - lignite oil 1:1:1:1	4.4 %	4.73 %
"	Venezuela 1:1	9.75 %	8.8 %
"	" - " 1:1:1	7.0 %	5.97 %
"	" " - lignite oil 1:1:1:1	5.45 %	5.5 %
"	California 1:1	6.3 %	5.3 %
"	" - " 1:1:1	4.7 %	4.1 %
"	" - " - lignite oil 1:1:1:1	3.7 %	3.2 %
"	Texas 1:1	7.85 %	7.3 %
"	" - " 1:1:1	5.8 %	5.6 %
"	" - " - lignite oil 1:1:1:1	4.5 %	5.2 %

Navy bunker-fuel

The following bunker fuel qualities comply with the military and technical requirements of the Navy:

1)	Spec. gravity at 20°C:	Above 1.03
2)	Flash point (Pensky Martens)	Above 90°C
3)	Ignition value (Jentzsch)	0.5 - 2.0
4)	Net carbon p.c. value kcal/liter:	As high as possible
5)	Viscosity	As low as possible a) If delivered to the Navy: Not more than 35°E at 20°C, not more than 300°E at 0°C. b) For procurement: Upper limit depending on the quantity and on the quantity of diluting oils available.
6)	Reaction upon cold:	a) If delivered to the Navy: Free from deposits at 0°C b) For Procurement: 1) Oils with a viscosity of below 200°E at 0°C: Free from deposits of cooled to 0°C. 2) Oils with a viscosity of above 200°E at 0°C: Deposits must beddissolved after one hour at such a temperature at which the viscosity of the oil is 200°E. Widely dispersed paraffin waxes which do not form any deposits are not regarded as deposits. All oils after cooling to 0°C followed by heating to a temperature which corresponds with the temperature at which the viscosity is 35°E shall form no deposits and shall not contain any widely dispersed paraffin waxes.
7)	Insoluble in light gasoline:	According to DIN DVM 3660, paragraph 1-4 below 3%. With an increased application of aromatic oils a higher amount is permissible.
8)	Carbon deposits:	Particles which are insoluble in xylol according to DIN DVM 3792, draft 2, not more than 0.2%. With an increased application of aromatic oils a higher amount is permissible. For oils which are utilized without being blended a higher amount is permissible.
9)	Conradson carbon residue:	Not higher than 6%.
10)	Sulfur:	Not more than 1%.
11)	Ash:	Not more than 0.05%.
12)	Water:	Not more than 1%.
13)	Mineral acids:	Must be absent.
14)	Foreign substances:	Must be absent.

Bunker fuels which do not meet all items of the preceding specification will not be refused. As usual tolerances for each type of those oils are established. As soon as the production of such oils shall be increased beyond the actual production of the 4 years plan the High Command of the Navy intends to take deciding steps.

Copy

High Command of the Navy
SKl/Adm. Qu III N IV 9316/44

Berlin, September 13, 1944.

Subject: Specifications concerning bunker-fuel and SDK2.

(SDK2 = special brand of diesel fuel)

Precedence: OKM SKl/Adm. Qu. III N IV 7816/44 dated July 29, 1944.

By the above mentioned letter new specification concerning "Navy - bunker-fuel" and instructions concerning the application of "Special - diesel-fuel 2 were delivered. With reference to the specification concerning "Navy bunker-fuel" the following alterations are effective October 1, 1944:

Reaction upon cold: The specification: The oil must flow and be free from deposits at temperatures of + 5°C

has to be superseded by the following specification: The oil must flow and be free from deposits at +0°C.

By a preceding letter it was requested that the application of "Special diesel-fuel 2" should be favoured with every possible means. From now on the Navy will be excepted because the changed situation does not require any more the application of "Special diesel-fuel 2".

SKl/Adm. Qu. III

signed Adam

Attested
(
signature

Employee.

High Command of the Navy
SKl/Adm Qu. III N IV Nr. 7816/44

Berlin, July 29, 1944

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Subject: Specifications for bunker-fuel and SD.K.2.

The situation requires a lessening of the specifications for Navy diesel fuel and the application of "Special diesel fuel 2" which consists of Navy diesel fuel and benzine.

The attached appendix contains the newly established specifications and general directions for the utilization of SDK2.

With respect to the reaction upon cold of Navy bunker-fuel new specifications will be established and forwarded before the beginning of the cold season.

The utilization of SDK2 must be favoured with every possible means.

The stock of SDK2 must be listed separately at the end of the teletype using the forms B and K.

(Seal)

Appendix of SKl/Adm. Qu III N IV 7816/44

Specifications for Navy bunker-fuel

	Bunker-fuel from Petroleum Hydrogenetion Synthesis	Bunker-fuel from lignite
Appearance	transparent	
Mechanical Deposits	must be absent	
Spec. Gravity at 20° C	not higher than 0.88	not higher than 0.90
	The operation of submarines requires bunker-fuels which have a specific gravity between 0.84 - 0.87. Oils which are furnished by the Central Office for mineral oil are in compliance with the requirement. The commander of the submarine must be informed if an oil of an irregular spec. gravity should be delivered.	
Viscosity at 20° C	not more than 2.6° E " less " 1.2° E	
Flash point (Pensky-Martens)	not below 55° C	
" " (DVM)	" " 70° C	
Boiling range	at least 60% shall have been vaporized at 350° C.	
Water content	not more than 0.5%	
Ash Content	" " " 0.05%	
Sulfur content	not more than 1%	not more than 1.3%
Neutralization number	not more than 1.5	
Mineral acids	must be absent	
Reaction upon cold	oils must flow and be free from deposits at + 10° C; oils which are delivered to Norway must flow and be free from deposits at + 5° C.	
Net calorific value	not less than 9900 local per leg	
Conradson carbon residue	not more than 0.8%	not more than 1%
Cetane number	not below 32	

If the oils are subjected to the shaking test at normal temperatures and applying distilled water no permanent emulsions should be formed. (10 ccm distilled water are poured into a 50 ccm graduated cylinder and vigorously shaken during 1/2 minute). The separation of the water must begin during the first minute following the shaking test.

After settling for 1/2 hour oil and water must be separated in such a manner that a layer of emulsion is not thicker than 1 graduation mark (corresponding with 1 ccm) of the cylinder. A foam consisting of large bubbles is permissible.

After adding of 1 ccm of n/10 Na OH to the above mentioned sample and vigorously shaking for 1/2 minute the water must remain colorless during the next following 30 minutes. Decisive for the acceptance is the reaction of the oils upon sea-water, which in many cases is less colored. Should a slight coloring of the distilled water be observed a test employing sea-water should be repeated (no NaOH should be added). Sea-water will be furnished upon request by the Navy Yard Wilhelmshaven, Ress IX, Achim near Bremen.

The color of the oil (applying the Ostwald-scale) must be at least 4-5. Oils which have lighter colors must be dyed by means of Sudan-brown R and Zapon-black.

If colorless oils are present the required color is obtained by adding the following quantities of the dyes:

13 mg Sudan-brown R)
3 mg Zapon-black) per 1 kg oil

The dyes must be ordered:

By Navy Department: I.G. Farben, subsidiary W, Berlin NW 7, Unter den Linden 78

By Companies: I.G. Farben, Frankfort a. M.

Bunker-fuels which are in compliance with the specifications except the formation of emulsions, color of the admixed water and color of the oil can be used for navy vessels or ground force vehicles but not for submarines.'

Specifications for "Special Diesel-fuels 2".

With reference to "Special Diesel-fuel 2" the specifications for Navy - bunker-fuel must be met, with the exception of the following items:

Flash point	not below 21° C
Viscosity at 20° C	" " 1.1° E

It is not necessary that the diesel-fuel SDK2 complies with the following items:

Formation of emulsions,
Color of the admixed water
Color of the oil

Storage specifications which must apply to diesel-fuel SDK2:

SDK2 is classified under Danger-regulations, Section A2 of the Police-regulation dealing with the handling of inflammable liquids. With respect to the navy permission is hereby granted to store SDK2 in tanks which are in compliance with the specifications of Danger-classification 3. If SDK2 is blended with Navy bunker-fuel, the mixture must be designated as SDK2.

Directions for the Proper Application of SDK2.

1) The "Special Diesel-fuel 2 differs in its chemical - physical proportion from a normal diesel-fuel but with respect to its spec. gravity and to its flash point. Due to its lower spec. gravity the heat content per unit of volume (thermal value per liter) is lower causing a slight decrease of the performance of the diesel engines (appr. 5%) if the "Special diesel-fuel 2" is utilized instead of a normal diesel-fuel. But the decrease of the performance is so small that it can almost not be observed in practice or at least can be neglected. It is not necessary to alter the type of the injector pump or any other auxiliaries if the "Special diesel-fuel 2" replaces the commonly used diesel-fuel.

2) The flash point which is as low as 21 - 55° C requires the highest cleaners in the engine room especially during bunkering, starting and operation of the engine. Before bunkering all installations must be carefully checked with reference to their complete tightness. It is absolutely necessary to recover the fuel which may trickle from the engine due to leakages. The recovered fuel must be removed from the engine room.

3) The bilges must be kept free from diesel-fuel.

4) The filling pipes must be permanently fixed to the storage tanks and led up to the deck proper so that no by-passing fuel is able to flow into the engine room. The ventilating shafts must be led up to the deck and their openings must be provided with safety devices which prevent any passage of flames or protected by Davy's wire screens.

5) The engines rooms, storage rooms, and bilges must be ventilated as good as possible by the artificial or natural ventilating gadgets which are available. Notice that all fuel-vapors accumulate near the floor of the rooms. A thoroughly ventilation is important when the engine is started or if during operation of the engine leakages of the tanks, fuel-pipes or of the engine should be observed.

6) Auxiliary agents which aid the ignition and which must be kindled by means of an open flame must be handled with all possible precautions. Clamps to which "glow-paper" is fixed must not be removed sooner than 5 minutes after misfiring.

7) Smoking, open fires, open lights or all other sources which are able to cause a spontaneous ignition are strictly prohibited in the engine-storage and all adjacent rooms. Should any stokers or stoves be operated inside the engine room precautions must be taken against the impinging or blowing of flames, glowing coal or ash against the engine, fuel pipes, and tanks.

8) The electric installation, especially the generators, motors and switch-boards must be cared for, that sparking is prevented as good as possible.

9) During bunkering the diesel engines must be stopped and all open fires extinguished. In addition during bunkering smoking and open fires are strictly prohibited even on deck.

High Command of the Navy

Specifications for Navy - Diesel-fuel.

Appearance	transparent
Mechanical deposits	must be absent
Spec. grav. at 20° C	not higher than 0.88 (for shipments to the occupied western zones 0.85 - 0.86)
Viscosity at 20° C	not more than 2.6° E " less " 1.2° E
Flash point (Pensky Martens)	not below 55° C
Flash point (DVM)	" " 70° C
Boiling range	at least 70% must distil up to 350° C
Content of: Water	not more than 0,5%
Ash	" " " 0.05%
Sulfur	" " " 1.0%
Neutralization number	" " " 1.5
Mineral acids	must be absent
Reaction upon cold	oils must flow and stay free from deposits at 0° C.
Net calorific value	not less than 9900 kcal per kg
Conradson carbon residue	not more than 0.5%
Cetane number	hitherto 38, 30.5 just permissible for MAN diesel engines.

If the oils are subjected to the shaking test at normal temperatures and applying distilled water no permanent emulsions should be formed. (10ccm diesel-fuel and 10 ccm distilled water are poured into a 50 ccm graduated cylinder and vigorously shaken for 1/2 minute). The separation of the water must begin during the first minute following the shaking test. After settling for 1/2 hour oil and water must be separated without formation of an interface or bubbles. After adding of 1 ccm of n/10 NaOH to the above mentioned sample and vigorously shaking for 1/2 minute the water must stay colorless during the next following hour.

The color of the oil (applying the Ostwald scale) must be at least 4-5. Oils which are of a lighter color must be dyed by means of Sudan-brown R and Zapon-black.

If colorless oils are present the required color is obtained by adding the following quantities of the dyes:

13 mg Sudan-brown R)
3 mg Zapon-black) per 1 kg oil.

Specification for Diesel-fuels from Petroleum

It is requested that the diesel-fuel is a pure distillate from petroleum. Blending with crude oil or distillation residue is prohibited. Solid deposits must be absent.

Spec. gravity at 20° C	at least 0.835 not higher than 0.880
Reaction upon cold:	no paraffin wax deposits at - 10° C.
Viscosity at 20° C	below 2.6° E
Flash point applying the D.V.M. tester	not below 80° C
Flash point applying the Pensky-Martens tester	not below 65° C
Evaporative capacity	at least 70% must vaporize up to 350° C.
Conradson carbon residue	not more than 0.5%
Content of:	
Water	not higher than 0.5%
Hydrogen	at least 12%
Ash	not more than 0.05%
Insoluble in light gasoline	" " " 0.20%
Organic acids computed as SO_3	" " " 0.12%
Mineral acids	must be absent
Drop test applying filtering paper:	light transparent spot, like water, a very slight yellow permissible
Net colorific value	at least 9900 kcal per kg

The following figures are determined in the laboratories of the Navy applying the Jentzsch tester:

Spontaneous ignition	(Szp)	$\leq$	280° C
Lower ignition value	(Zn)	$\geq$	8
Ignition value	(Zk)	$\geq$	8
Ignition delay at 300° C	(W_{300})	$\leq$	4 sec
Solid residue at 350° (coke)	(R350)	$\leq$	traces
Residue at 500°	(R500)	$\leq$	"
Evaporization time applying a thin layer	(v)	$\leq$	60 sec
Boiling figure at 500°	(Sz500)	$\geq$	40
Jentzsch figure	(V.Z.)	$\geq$	44
Tendency to age			R500

Army - Ordnance - Department

Preliminary Specifications for diesel-fuels

which are employed for the operation of diesel-powered vehicles.

The diesel-fuel must be free from solid deposits.

Net calorific value		Not below 9700 kcal per kg
Flash point employing and open cup tester:		Not below 65° C
Water content:		Not more than 0.5% wt.
Ash content:		" " " 0.05% wt.
Viscosity at 20° C:		" " " 2° E and not less than 1° E
Fourpoint:		Below - 10° C
Filtering test:		200 ccm not more than 60 sec at - 5° C
Corrosivity:	Against copper	Not more than 1 mg
	" zinc	" " " 1.0
Coking test:		" " " 2% wt. (Coke + hard asphalt)
Ignitability:		Not less than 45 cetane numbers.

Lignite tars: Tar from Rolle-furnaces (indirect)

Tar from Lurgi-furnaces (purging gas)

Tar from Producers (direct)

Coal tar:

Low temperature carbonization of coal:
composition of the recovered tar:

Type of coal carbonized:	Sub-bituminous coal	Bituminous coal
Light oils + middle oils	15	33%
Viscous oils	10	15%
Paraffin wax	1	0.4%
Phenoles	50	14%
Resins	1	4%
Pitch	6	19%
H_2O + losses	17	13%

Employing high temperature carbonization processes the heat is indirectly transferred to the coal by means of externally heated refractory walls whilst applying low temperatures metal-walls of the retorts can be employed.

Difference: Low temp. carb coal tar: Recovery of max quantities of oil (fuel-oil

High " " " " : Isolation of chemical individuals

Spec. gravity of the recovered tar oil depending on the applied carbonization temperature:

Carb. temp. °C	400	500	600	700
Spec. grav.	0.958	0.986	1.039	1.080

Coal - tar (Distillation)

Distillate

Water	Light oil	Middle oil	Heavy oil	Anthracene oil
Ammonia	hydrocarb. cont. N O S	hydrocarb. Bases neutr. oils cont. O phenols	hydrocarb. Bases Phenols	hydrocarb. Fluorene etc.

Residue = Pitch

Components which are soluble in benzine — Insoluble components