7. APPENDIX

TABLE I.

KNOCK RATING OF GASES.

	Research Method	Motor Method
Methane	> 108	> 115
Ethane	> 108	103
Propane	108	98
n-Butane	95	90.5
i-Butane	102	97.5
Propylene	105	84.5
Butylene	99.5	83.0
i-Butylene	105	87.0
Power Gas	98-108	92-98
Propane-butylene mixture	109	93
Propane-isobutylene mixture	101.5	89
Dimethyl ether	Below 0	Below 0
Hydrogen	-	62.5
Ammonia	No knock	No knock

TABLE 2.A.

KNOCK BEHAVIOUR OF ALKYL BENZOLS PRODUCED BY HIGH PRESSURE WITH SULPHURIC ACID CATALYST.

Compound	Boiling Range	Mean Boiling Temp.	Motor Octane Number	Minimum p_{me} in atms.	tan α
n-butyl benzene	170-200	185	91.2	9.2	0.759
i-butyl benzene	150-200	175	90.4	10.2	1.105
n-di-butyl benzene	200-250	225	92.8	9.1	0.715
hexyl benzene	210-215	212.5	86.0	7.1	0.443
octyl benzene	240-250	245	70.0	4.3	0.258
ethyl propyl benzene	140-237	188.5	91.8	9.9	1.185
ethyl n-butyl benzene	200-250	225	89.6	9.0	0.955
ethyl di-propyl benzene	220-260	240	89.6	8.8	0.544
ethyl di-n-butyl benzene	230-274	252	87.4	7.2	0.369
di-ethyl propyl benzene	200-240	220	90.1	8.7	0.889
di-ethyl n-butyl benzene	210-260	235	87.4	7.9	0.655
di-ethyl i-butyl benzene	200-250	225	90.6	9.1	0.698
di-ethyl di-n-butyl benzene	260-300	280	86.2	6.5	0.481
di-ethyl di-i-butyl benzene	250-350	300	85.2	6.2	0.476
propyl n-butyl benzene	200-267	233.5	93.9	10.3	0.900
propyl i-butyl benzene	200-230	215	95.0	10.4	1.500
propyl-di n-butyl benzene	250-300	275	89.8	7.8	0.597
propyl-di i-butyl benzene	220-280	250	89.4	7.2	0.540
di-propyl n-butyl benzene	250-300	275	89.9	7.3	0.549
di-propyl i-butyl benzene	220-280	250	92.3	8.3	1.106
n-butyl i-butyl benzene	220-260	240	92.6	9.8	0.773
i-butyl n-butyl benzene	210-250	230	92.3	8.6	0.818
i-butyl di-n-butyl benzene	250-305	277.5	89.6	7.2	0.390
n-butyl di-i-butyl benzene	240-300	270	88.5	7.6	0.562

tan α = Slope of the tangent to the knock limit curve at the turning point of the latter

TABLE 2.B.

KNOCK BEHAVIOUR OF ALKYL BENZOLS PRODUCED BY HIGH PRESSURE WITH ALUMINIUM CHLORIDE CATALYST.

Compound	Boiling Range	Mean Boiling Temp.	Motor Octane Number	Minimum p_{me} in atms.	tan α
Ethyl Benzene	130-140	135	90.0	10.4	0.980
Di-ethyl benzene	170-182	175	92.2	10.8	0.881
Tri-ethyl benzene	210-220	215	89.0	8.1	0.570
Tetra-ethyl benzene	220-280	250	82.8	7.3	0.333
Tetra-ethyl benzene	280-320	300	81.0	6.1	0.406
Tetra-ethyl benzene	190-320	255	81.9	6.5	0.333
Propyl benzene	155-165	160	92.8	10.2	1.148
Di-propyl benzene	186-210	198	94.2	11.1	1.125
Tri-propyl benzene	225-230	227.5	98.3	12.8	1.000
Tri-propyl benzene	230-240	235	96.8	11.7	1.138
Tetra-propyl benzene	260-280	270	93.6	9.7	0.983
n-butyl benzene	170-175	172.5	90.8	9.5	1.158
i-butyl benzene	165-185	175	92.1	9.4	1.284
Di-n-butyl benzene	220-260	240	94.2	9.3	1.024
Di-i-butyl benzene	200-240	220	88.0	8.6	0.889
Di-i-butyl benzene	240-280	260	84.5	7.3	0.447

Cont'd.....

TABLE 2.B. (cont'd)

Compound	Boiling Range	Mean Boiling Temp.	Motor Octane Number.	Minimum p_{me} in atms.	tan α
Tri-i-butyl benzene	280-320	300	83.0	6.3	0.267
Hexyl benzene	200-220	210	86.5	6.8	0.421
Octyl benzene	230-250	240	75.2	5.0	0.360
Ethyl propyl benzene	150-230	190	94.2	10.4	1.790
Ethyl i-butyl benzene	160-200	180	90.8	9.0	1.078
Ethyl di-i-butyl benzene	180-240	210	90.6	9.6	1.309
Propyl n-butyl benzene	200-255	227.5	93.6	10.4	0.863
Propyl i-butyl benzene	170-220	195	91.8	8.7	0.745
Propyl di-n-butyl benzene	155-266	210.5	95.4	10.4	0.983
Propyl di-i-butyl benzene	200-270	235	89.0	7.9	0.550
Di-propyl di-n-butyl benzene	195-287	241	93.0	8.0	1.032
Di-propyl n-butyl benzene	230-256	243	96.2	9.9	2.579
Di-propyl i-butyl benzene	200-270	235	92.3	8.2	1.304
n-butyl i-butyl benzene	220-265	242.5	90.1	8.1	0.635
i-butyl n-butyl benzene	220-270	245	91.8	8.9	0.754
i-butyl di-n-butyl benzene	250-305	277.5	90.9	5.3	0.200

tan α = Slope of the tangent to the knock limit curve at the turning point of the latter.

TABLE 3.

KNOCK RATINGS.

Compound	Motor Octane No.	Research Octane No.
Benzene	115	>100
Toluene	109	>100
m-Xylene	104 (b.v.)	144 (b.v.)
p-diethyl benzene	116	-
Mesitylene	109 (b.v.)	-
n-propylbenzene	> 100	-
Methylnaphthalene	120	-
Acetone	100	-
Methyl ethyl Ketone	98.5	-
Di iso butyl Ketone	91 (108.7*)	106
Methyl iso propyl ketone	107	-
Pinacolin	112 (>115*)	-
Dimethyl ether	0	-
Diethyl ether	0	-
Iso propyl ether	105	-
Ethyl iso propyl ether	45 (b.v.)	-
Methyl iso propyl ether	42.5(b.v.)	-
Di iso propyl ether	98-99	105
Di n-propyl ether	29.5 (b.v.)	-
Methyl n-butyl ether	28.5 (b.v.)	-
Ethyl n-butyl ether	20.5 (b.v.)	-
Methyl iso-butyl ether	28.5 (b.v.)	-
Methyl sec-butyl ether	43 (b.v.)	-
Methyl tert-butyl ether	103	-
Ethyl tert-butyl ether	101.5	-
Iso-propyl tert-butyl ether	112	-
Ethyl tert-amyl ether	112	-

Cont'd.....

b.v. = blending value.
* + 0.12 ccs/litre T.E.L.

TABLE 3 (cont'd)

Compound	Motor Octane No.	Research Octane No.
di-allyl ether	39.7(b.v.)	-
Tetra hydro furan	25	-
Anisol	94(96*)	-
Acetal	<0 (b.v.)	
Methanol	98	-
Ethanol	93 (88*)	-
Iso propanol	approx.100	-
1:4-n Butandiol	93.5	-
1:3-butylene glycol	101	-
Ethylene glycol	101	-
tert-butyl mono glycol ether	150 (b.v.)	-
Methyl glycol	78.5	-
Ethyl glycol	63.8	-
Propyl glycol	63.8	-
Butyl glycol	40.0	-
Methyl di-glycol	49.5	-
Propyl di-glycol	<40	-
Butyl di-glycol	<40	-
Ethyl tri-glycol	<40	-
Di-allyl glycol	34.8(b.v.)	-
Nitro methane	74 (73.3*)	-
Nitro ethane	59 (59.5*)	-
1-nitro propane	71.5(70.0*)	-
2-nitro propane	67.5(66.0*)	-
1-nitro butane	70.5(66.0*)	-
2-nitro butane	70.5(68.0*)	-
Nitro benzene	87	-
Nitro propanol	63	-
Technical Di-iso-butylene	86.7(90.5*)	110.6
Tri-methyl ethylene	(81*)	-
Isoprene	81 (83*)	-
2:3-dimethyl butadiene-1:3	81	-
Iso-pentane	90 (100*)	94
2:2-dimethyl propane	-	116
Neohexane	94 (116*)	101
2:3-dimethyl butane	91.5	93.5
Triptane	101	-
2:2:3:3-tetra methyl butane	130 (b.v.)	-
Iso-octane	100 (115*)	100(116*)
2-methyl pentane	70.5	-
n-hexane	25	-
n-heptane	0	-
Cetane	-80	-
Cyclohexane	75	85

TABLE 4.

CETANE RATINGS.

Compound	Cetane No.
Di-ethyl ether	approx. 110
Ethyl iso-propyl ether	92
Methyl sec-butyl ether	60
Methyl iso-butyl ether	50
Methyl iso-propyl ether	40-45
Di iso-propyl ether	13
Methyl n-butyl ether	84
Di-n-propyl ether	113
Ethyl n-butyl ether	98
Di-n-butyl ether	125
Di-iso-amyl ether	108
Di allyl ether	77
Acetal	45
Tetrahydrofuran	30
Methyl ethyl glycol ether	125
Di-ethyl glycol ether	152
Ethylene glycol	approx. 5
Methyl glycol	15
Ethyl glycol	24
Propyl glycol	26
Butyl glycol	32
Methyl diglycol	22
Propyl diglycol	41
Butyl diglycol	52.5
Ethyl triglycol	38
Di Allyl glycol	77
Nitromethane	10
Nitroethane	15
1-nitro propane	14
2-Nitropropane	16
1-Nitrobutane	15
2-Nitrobutane	14
Di-iso butyl ketone	25
Di-iso butylene	10.5
Benzene	2.5
Methyl naphthalene	0
Cyclohexane	19.4
2-Methyl pentane	33.5
Iso octane	15
n-heptane	55
Cetane	100

TABLE 5

SPECIFICATION FOR AVIATION FUEL A3.

Oberkommando der Luftwaffe.
TLR/M 2 III(A)

Sheet 21. Issued November, 1944.
For Service use only.

Method of Test as in BVM 40/48 Edn. and alterations as in technical information service of RLM-GL-A-M since Oct. '45. No.	Specification	TL 147-257/4
	Appearance	Clear, free from undissolved water and acids, must contain no solid impurities
	Colour	Blueish, corresponding to 1.6 - 2.6 mg. of Sudan Blue ON per litre of colourless fuel.
7070 - 7094	Octane number	at least 80 with 0.045 vol. % T.E.L.
7055	Density at 15°C.	0.700 - 0.770
7100 - 7118	Boiling Range	I.B.P. - not below 40°C. 50% Vol. point - about 100°C. F.B.P. - below 190°C. Distillation loss - 2% Vol. max. Reaction of residue - Trace of acidity only
7120 - 7128	Vapour Pressure	0.5 Kg./cm.² max.
7150	Freezing Point	As determined by initial crystallisation point, must not be above -50°C.
7160	Evaporation Residue	10 mg./100 ml. max.
7200	Corrosion Test	No grey or black spots or pitting in the copper strip test. (3 Hours at 50°C.)
7200 - 7211	Ethanol content	30 Vol. % (± 3 Vol. %)
7270 - 7271	T.E.L. Content	0.045 Vol. % min. (up to 0.120 permitted for use at the Front)
7280 - 7282	Aromatic Content	35 Vol. % max.
Storage and Storage Stability	Containers of black plate or burnt lacquer treated. No zinc treatment. Since the alcohol content is accompanied by a certain danger of separation of the fuel, it is essential to keep out water. The specified "water safety value" (see Tagtt-Kn: I C qc, No. 4 Lfd. No. 342/44) is at least 0.7 Vol. %. Admixture of B 4 and C 3 with A 3 in storage tanks is in all cases prohibited. A monthly examination of A 3 is necessary.	

NOTE: Earlier delivery specifications for A 3 are hereby superseded.

TABLE 6

SPECIFICATION FOR AVIATION FUELS B4 AND C3

Oberkommando der Luftwaffe.
TLR/M 2 III(A)

Sheet 22, issued November, 1944(1)
For Service use only.

Method of Test as in BVM 40/42 Ken. Alterations as in technical information service of RLM-GL/A-M since Oct. '43. No.	Description of Test	B 4	C 3
	Technical Specification	TL 147 - 304 / 4	TL 147 - 380 / 4
	Appearance	Clear, free from undissolved water and acids. Must not contain solid impurities.	
	Colour	Blueish (2) corresponding to ca. 4.0-4.3 mg. Sudan Blue GN	Greenish addition of 0.5 mg. Sudan Blue GN and 0.5 mg. Alizarol /per litre of colourless fuel
7070 - 7095	Octane Number	89 min. with 0.115 Vol.% T.E.L.	about 95
7250 - 7259	Single Cylinder Performance	In the region = 0.8-1.15 the curve must be above that of the comparison fuel.	
7055	Density at 15°C.	0.700 - 0.760	0.740 - 0.795
7106 - 7115	Boiling Range I.B.P. 10 Vol. % min. 35 " " 50 " " 90 " " 95 " " F.B.P.	not below 40°C. 75°C. 110°C. - - 180°C. below 190°C.	not below 40°C. 80°C. - 120°C. 230°C. - below 250°C.
7120 - 7125	Vapour Pressure	0.5 kg./cm.² max.	0.45 kg./cm.² max.
7160	Melting Point	- 60°C. max.	- 60°C. max.
7160	Evaporation Residue	10 mg./100 ml. max.	
7200	Corrosion Test	No grey or black spots or pitting in the copper strip test.	
7280 - 7282	Aromatic Content	35 Vol. % max.	45 Vol. % max.
7270 - 7271	T.E.L. Content	0.115 - 0.120 Vol. % (3)	
7274	Ethylene Dibromide Content	0.050 - 0.053 Vol. % (4)	
7214	Inhibitor Content		0.01% by wt. (5)
	Storage Stability	After 6 months' storage, examination should be carried out every 3 months.	

NOTES: (1) Sheet 22 renders invalid :
(a) Specifications for fuels B4 and C3 in sheet 1, issued May, '44, and sheet 2, issued April '44.
(b) Technical Regulations 8/44, 11/44 and 12/44. These should be destroyed.
(2) When a mixed colour results on the addition of C3 to B4 a corresponding quantity of Sudan Blue GN (max. 2 mg./lt.) should be added.
(4) See also Techn. Regulation 3/44.
(5) " " " " 6/43.
(6) In special cases aviation fuel C3 delivered without inhibitor must not be held. However OKL Chef TLR/M 2 III should be informed.

TABLE 7.

Specification for Motor Fuel (Wehrmacht)

Issued March 26th 1945. Applied to summer grade fuel.

General	The fuel must be clear, free from undissolved water, solid matter and should not attack copper.
Colour	Red
Specific gravity at 15°C.	0.710 to 0.820
Octane Number (Motor Method)	72 (minimum 71.5)
Distillation Range	Up to 75°C. Maximum 30% by vol. including loss. Up to 100°C. Minimum 20% by vol. including loss. Up to 225°C Minimum 95% by vol. including loss.
Reid Vapour Pressure.	0.20 to 0,65 Kg/cm^2 at 40°C (Vapour pressure should be as low as 0.15 Kg/cm^2 when the 100° point of the distillation curve is a minimum of 30%, including distillation loss)
Residue after evaporation.	Not more than 10 mg/100 cc (220°C).
Freezing Point	Must be clear and free of crystals at -10°C (The temperature at which ice crystals form is to be noted on the inspection form).
Calorific Value	Greater than 7,500 calories/ltr
Sulphur Content	Not more than 0.8% by weight
Lead Content	Not more than 0.08% by weight

TABLE 8

SPECIFICATION FOR AERO DIESEL FUEL K1.

RLM
GL/A - M II

For Service Use Only.
Sheet 2, issued April 1944 (1)

Method of Test	Description of Test	K1
BVM 2940/42 Edn.	Technical Specification	TL $\frac{147 - 361}{2}$
No.	Appearance	Clear, free from undissolved water and acids. Must not contain solid impurities.
	Cetane Number	50 min.
7065	Density at 20°C.	0.810 min.
7100 - 7113 Water Cooling	Boiling Range	I.B.P. about 180°C. 98 Vol. % min. at 360°C.
8075	Pour Point	-45°C. max.
8070	Viscosity at 20°C.	1.1°E. min.
Pensky-Martens	Flash Point	above 50°C.
8085	Acid Value	0.7 mg. KOH/g. max.
7190 - 7191	Sulphur Content	1% by wt. max.
8095	Ash Content	Traces only.
DIN 2 BVM 5763	Corrosion Test	4 mg. max.
8110	Conradson Test	0.1% by wt. max.
8105	Water Content	Traces only.
	Storage Stability	After storage for 1 year six-monthly tests are necessary.

NOTES: (1) Sheet 2, April 1944 supersedes Sheet 2, May 1942. Copies still in existence should be destroyed.

TABLE 9.

DIESEL FUEL SPECIFICATIONS

	NAVY		ARMY
	Submarines	Surface Vessels	
Conditions, General	Free from solid impurities.		
Specific Gravity at 15°C.	0.839-0.877	Min. 0.887	0.800-0.900
Viscosity	1.2-2.6 E.G.	1.2-2.6 E.G.	1.1-2 E.G.
Cloud Point	0°C	0°C	-
Pour Point	-	-	-10°C and (-40°C winter)
Filter Test	-	-	-5/60 sec. (-35/60 sec.winter)
Flash Point	Not below +50°C	Not below +40°C	Not below +21°C
Neut. No.	Not over 1.5	Not over 1.5	Not over 0.4
Corrosion Zinc.	-	-	Not over 4 mg.
Sulphur Content	Not over 1% wt.	Not over 1% wt.	Not over 1% wt.
Lower Calorific value	Not less than 9,900	Not less than 9900	Not less than 9900
Cetane Number	Not less than 32	Not less than 32	Not less than 40
Distillation Range	Up to 350°C at 60% vol.	Up to 350°C at 60% vol.	Up to 360°C at 80% vol.

TABLE 10

PROVISIONAL SPECIFICATION FOR JET FUEL J2 AND KEROSINE FUEL EINHEITS J2

Oberkommando der Luftwaffe
Chef der Technischen Luftrüstung
Az. : 65 g. TLR/M 2 III (A)

For Service Use Only
Sheet 14, issued Oct. 1944 (1)

Method of Test DVM 1940/42 Edn. of Technical Information Service No.	Technical Specification	J 2 VTL 127 - 226 2	Einheit - J 2
	Appearance and Colour	Clear, free from undissolved water and acids, must not contain solid impurities.	
7055	Density at 15°C. kg./lt.	0.800 min.	0.760 min.
7120 - 7128	Vapour Pressure at 37.8°C.	0.2 kg./cm.² max.	0.5 kg./cm.² max.
8070 - 8072	Viscosity at 40°C. " 0°C. " -25°C.	1°E min. - - - - 3°E max.	1°E min. 3°E max. - - - -
8075	Pour Point (2)	Below -25°C.	below 0°C.
7190 - 7191	Sulphur Content % wt.	1.5 max.	
7214	Phenol Content Vol. %	1.0 max.	
7200 - 7201	Aromatic Content Vol. %	45 max.	
8110	Conradson Test % wt.	1.5 max.	
8095	Ash Content % wt.	0.5 max.	
7225 - 7226	Lower Cal. Value (2)	8000 K.Cal./Kg. min.	
7200 DIN 2, DVM 3763	Corrosion Test. Copper Strip Zinc Strip	negative 4 mg. max.	
(3)	Filtrability (2) (Hemmerich) at 400 mm. Vacuum	120 secs. max. at -25°C.	120 sec. max. at 0°C.
	Re-examination	After a year	
	Storage	The fuels must be kept apart from one another and from other fuels (AS, B4, C3, Z1) during storage. Admixture with the remains of other fuels and admixture of the latter with J2 in pipe-lines, barrels etc. is strictly to be avoided.	

NOTES: (1) This sheet renders Sheet 14, March 1944 obsolete and the latter should be destroyed.
(2) This is only to be carried out during acceptance tests.
(3) See "Techn. Anord." 1/45 and A.T. 45.