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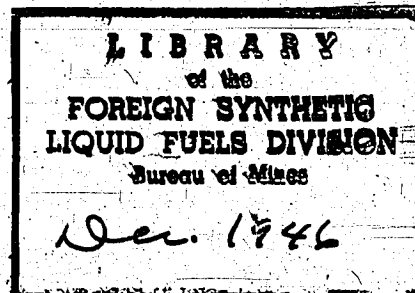
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COMPILATION OF GERMAN FUELS AND LUBRICANTS SPECIFICATIONS

Chaffee, G. C., and Ogilby, R. J.

RESTRICTED



COMBINED INTELLIGENCE OBJECTIVES
SUB-COMMITTEE

RESTRICTED

COMPIATION OF GERMAN
FUELS AND LUBRICANTS SPECIFICATIONS

Reported by:

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CIOS ITEM 30
FUELS & LUBRICANTS

COMBINED INTELLIGENCE OBJECTIVES SUB-COMMITTEE
G-2 DIVISION, SHAEF (REAR) APO 413

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PERSONNEL OF TEAM

Capt. C. C. Chaffee, U.S. Ord
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COMPILATION OF GERMAN FUELS AND LUBRICANTS SPECIFICATIONS

I. INTRODUCTION

Information has been obtained on German Armed Forces fuels and lubricants specifications from documents collected during CIOS field trips. The specifications have been translated and are briefly reviewed in this report. Information on the reason behind specification changes may be obtained by a detailed study of individual plant operations reported by CIOS investigators. It is intended that this report only summarize technical data on specifications.

II. DISCUSSION

The information on specification has been presented in four categories, that is, motor fuels, aviation fuels, lubricants and greases. The following general comments may be made at this time.

a. Motor Fuels. German Ground Forces fuel had to meet an Octane number of 72 and this was accomplished by using straight run, cracked and/or Fischer Tropsch gasoline and T.E.L., straight run, cracked and/or Fischer Tropsch gasoline T.E.L. and aromatics; and straight run crack and/or Fischer Tropsch gasoline and aromatics. Due to the need of aromatics in ammunition they were removed and T.E.L. substituted for them. Diesel fuel had to pass a minimum requirement of 45 Cetane number.

b. Aviation Fuels. Specifications have been obtained on fuels A-3 (80 ON), B-4 (89 ON) and C-3 (95 ON) and the components of these fuels made at Leuna, Scholven, Bohlens Gelsenberg and Brux. In general, the final product, was not altered greatly except that as the war progressed a larger amount of aromatics was allowable in each fuel, the maximum being 45% in C-3 gasoline. The only available specifications on aviation Diesel fuel reveal that a minimum octane value of 60 was allowed which was later reduced to 50.

c. Lubricants. Specifications have been obtained for both Air Force and Ground Force lubricants. They include lubricant S-3, V-2 and the synthetic lubricant components of these lubes and also summer and winter oil for Ground Force vehicles.

d. Greases. Specifications have been obtained for Rocker Arm Grease, Protective Grease 40 G, Axle Grease, Refrigeration Grease, Aviation Instrument Grease, Aviation Grease-Blue, Protective Grease 40 (Tp); Protective Grease 40, Weapon Grease, Instrument Grease, Water Pump Grease, and Lubricating Grease.

The translated specifications and comments on test technique are appended. In general the quality of fuels and lubricants as set by specifications was fairly well maintained during the war.

APPENDIX A **MOTOR FUEL SPECIFICATIONS**

OTTO ENGINE

**Motor Gasoline
with Tetra Ethyl
Lead**

**Motor Gasoline
with Aromatics
and Tetra-Ethyl
Lead (Min of 20
wt % of Aromatics**

**Motor Gasoline
with Aromatics
(Min of 35 wt %
of Aromatics)**

General Characteristics: The fuel must be clear free from undissolved water and solid impurities and should not attack copper.

Color

Density @ 15° C	0.720-0.780	0.740-0.780	0.753-0.790
Octane No. (Motor Method)	72	72	72
Boiling Range			
up to 75°C	25 vol %	25 vol %	25 vol %
up to 100°C	30 vol %	38 vol %	45 vol %
up to 200°C	95 vol %	95 vol %	95 vol %
Reid Vapor Pressure @ 40° C	0.20-0.60 kg/cm ²	0.20-0.60 Kg/cm ²	0.20-0.60 kg/cm ²
Residue mg/100 c.c.	10 max.	10 max.	10 max.
Cloud Point °C	-20	-20	-20
Heat Value	7500 Kg cal/Liter	7650 Kg cal/Liter	7700 Kg cal/Liter
Sulfur Content (wt %)	0.2 max.	0.2 max.	0.2 max.
Tetra Ethyl Lead (vol %)	0.04 max.	0.04 max.	0

APPENDIX A MOTOR FUEL SPECIFICATIONS

DIESEL ENGINE

	<u>DIESEL FUEL</u>	<u>SPECIAL DIESEL FUEL</u>
<u>General Characteristics:</u> The fuel must be free from solid impurities		
Density @ 15° C	0.810-0.865	0.810-0.865
Viscosity of @ 20°C	1.1-2.0	1.1-2.0
Pour Point	-30°C	-30°C
Cloud Point	-10°C	-10°C
Filtering Rate		
Pour Point	200 cc/min. @ -25°C	200 cc/min @ -25°C
Cloud Point	200 cc/min. @ -5°C	200 cc/min @ -5°C
Flash Point	55°C min	21°C min.
Acid Value (mgKOH/gm)	0.4 max.	0.4 max.
Zinc Corrosion	4.0 mg max.	4.0 mg. max.
Sulfur Content (wt %)	1.0 max.	1.0 max.
Minimum Heat Value	9900 Kg Cal/Kg	9900 Kg Cal/Kg
Centan Value	45 min.	45 min.
Water Content (wt%)	0.5 max.	0.5 max.
Ash (wt %)	0.05 max.	0.05 max.
Residue		
Hagemunn/Hammerich	2.0 wt %	2.0 wt %
Conradson	0.05 wt %	0.05 wt %
Boiling Range	80 vol % @ 360°C	80 vol % @ 360°C
Miscibility: All Diesel fuels must be miscible with one another		

APPENDIX B
AVIATION FUEL SPECIFICATIONS--OTTO ENGINE

Specification Number	A-3 TL 147-257 1	A-3 TL 147-257 2	A-3 TL 147-257 3	A-3 TL 147-257 4
Date of Spec.		Jun. 1939	Oct. 1943	Nov. 1944
Appearance	Clear, free from undissolved water, acid and solids.			
Color	Dyed blue 2.0 mg/L Sudan blau G	Dyed blue 2.0 mg/L	Dyed blue 1.6 to 1.8 mg/L Sudan blau GN	Dyed blue 1.6 to 2.6 mg/L Dye
Octane Rating	80 min.	80 min.	80 min.	80 min.
Density @15°C	0.710-0.755	0.715-0.750	0.710-0.760	0.700-0.770
Distillation				
10 vol. %	70°C	70°C	75°C	---
50 vol. %	100°C	100°C	105°C	100°C
90 vol. %	160°C	130°C	160°C	---
End Pt.	170°C max	150°C	170°C max	190°C max
Evap.	2 vol. %	2 vol. %	2 vol. %	2 vol. %
Reid Vapor Pres. (kg/cm ²)	0.5 max	0.5 max	0.5 max	0.5 max
Iodine No. (g./100 g.)	5.0 max	5.0 max	---	---
Melting Point	-60°C max		-60°C max	-50°C max
Corrosion Test	No discoloration or attack in the copper dish test.			
Residue (mg./100-c.c)	8 max	8 max	10 max	10 max
TEL(vol %) min	0.045-0.050	---	0.045-0.050	0.045
Aromatic Content (vol. %)	---	---	25 Max	35 max
Ethylene Dibromide (vol. %)	---	---	0.019-0.022	---
Inspection	After ½ yr storage, at 3 mos inter- vals(visual)		After ½ yr storage, at 3 mos inter- vals(visual)	Monthly intervals
Comments				Ethanol con- tent of fuel =30 vol %

APPENDIX B
AVIATION FUEL SPECIFICATIONS--OTTO ENGINE

Specification Number	B-4 <u>TL 147-304</u> 1	B-4 <u>TL 147-304</u> 2	B-4 <u>TL 147-304</u> 3	B-4 <u>TL 147-304</u> 4
Date of Spec.		Jun. 1939	Oct. 1943	Nov. 1944
Appearance	Clear, free from undissolved water, acid and solids.			
Color	Dyed blue 3.6 mg/L Sudanblau G	Dyed blue 3.6 mg/L	Dyed blue 4.0-4.3 mg/L Sudanblau GN	Dyed blue 4.0-4.3 mg/L Dye
Octane Rating	89 min	89 min	89 min	89 min
Density @15°C	0.710-0.755	0.715-0.750	0.710-0.760	0.700-0.760
Distillation				
10 vol. %	70°C	70°C	75°C	75°C
50 vol. %	100°C	100°C	105°C	---
90 vol. %	160°C	130°C	160°C	---
End Pt.	170°C max	150°C	170°C max	190°C max
Evap.	2 vol %	2 vol %	2 vol %	---
Reid Vapor Pres. (kg/cm ²)	0.5 max	0.5 max	0.5 max	0.5 max
Iodine No. (g./100 g.)	5.0 max	5.0 max	5.0 max	---
Melting Point	-60°C max	-60°C	-60°C max	-50°C max
Corrosion Test	No discoloration or attack in the cuppe dish test.			
Residue (mg/100 c.c)	8 max	8 max	10 max	10 max
TEL(vol. %)	0.115-0.120	0.115-0.120	0.115-0.120	0.115-0.120
Aromatic content (vol.%) max	---	---	25	35
Ethylene Dibromide (vol.%)	---	---	0.050-0.053	0.050-0.053
Inhibitor(wt %)	---	---	---	---
Inspection	After ½ yr storage vis- ual inspec at 3 mos inter- vals		After ½ yr storage vis- inspec at 3 mos inter- vals	After ½ yr storage vis- ual inspec at 3 mos in- tervals

APPENDIX B
AVIATION FUEL SPECIFICATIONS--OTTO ENGINE

Specification Number	C-3 <u>TL 147-330</u> 1	C-3 <u>TL 147-330</u> 2	C-3 <u>TL 147-330</u> 3	C-3 <u>TL 147-330</u> 4
Date of Spec.		Jun. 1939	Oct. 1943	Nov. 1944
Appearance	Clear, free from undissolved water, acid and solids.			
Color	Dyed green 0.5 mg Sudan blau GN & 0.5 mg. Flurol per L		Dyed green 0.5 mg Sudan blau GN & 0.5 mg Flurol per L	Dyed green 0.5 mg Su- dan
Octane Rating	95		95	95
Density @15°C	0.760-0.795		0.760-0.795	0.740-0.795
Distillation				
10 vol. %	---		80°C	80°C
50 vol. %	100°C		110°C	120°C
90 vol. %	---		100°C	180°C
End Pt.	180°C max		180°C max	190°C max
Evap.	2 vol. %		2 vol. %	---
Reid Vapor Pres. (kg./cm ²)	0.45 max		0.45 max	0.45 max
Iodine No. (g./100 g.)	4 max		---	---
Melting Point	-60°C max		-60°C max	-60°C max
Corrosion Test	No discoloration or attack in the copper dish test.			
Residue (mg/100 c.c)	10 max		10 max	10 max
TEL(vol.%)	0.115-0.120		0.115-0.120	0.115-0.120
Aromatic content (vol. %) max	---		45	45
Ethylene Dibro- mide(vol. %) max	---		0.050-0.053	0.050-0.053
Inhibitor(wt %)	---		0.01	0.01
Inspection	After 3 mos storage, vis inspec at mo intervals		After 3 mos storage, vis inspec at mo intervals	After 3 mos storage, vis inspect at mo intervals

APPENDIX B
AVIATION FUEL SPECIFICATIONS--OTTO ENGINE

Specification Number	VT 702 TL 147-152 1	VT 702 TL 147-152 2	VT 702 TL 147-152 3
Date of Spec.	June 1939		
Appearance	Clear, free from undissolved water, acid and solids.		
Color	Water white		Water white
Octane Rating	70/---		70/89
Density @ 15°C	0.715-0.725		0.715-0.730
Distillation			
10 vol. %	60-70°C		70°C
50 vol. %	85-95°C		95°C
90 vol. %	120-130°C		130°C
End Pt.	135-145°C		145°C max
Evap.	2 vol. %		2 vol. %
Reid Vapor Pres. (kg./cm ²)	0.5 max		0.5 max
Iodine No. (g./100 g.)	3.0 max		3.0 max
Melting Point	-60°C max		-60°C max
Corrosion Test	No discoloration or attack in the copper dish test.		
Residue (mg./100 c.c)	5.0 max		5.0 max
TEL(vol. %)	0/		0/0.115
Aromatic Content (vol. %)	---		15
Ethylene Dibromide (vol. %)	---		---
Inhibitor (wt %)	---		---
Inspection	Yearly		Yearly
Comment:	This fuel is a hydro petrol made from German lignite by the high pressure hydrogenation process of the I.G. It must not contain straight run, cracked, or polymer gasoline, anti-knock or anti-corrosion dope or inhibitor. Maximum sulfur content--0.05-wt %.		

APPENDIX BAVIATION FUEL SPECIFICATIONS--OTTO ENGINE

Specification	V.T. 705	V.T. 705
Number	<u>TL 147-153</u> 1	<u>TL 147-153</u> 2
Date of Spec.	Sept. 1939	
Appearance	Clear, free from undissolved water, acid & solids.	
Color	Water white	Water white
Octane Rating	72/--	72/89
Density @15°C	0.725-0.740	0.730-0.745
Distillation		
10 vol. %	60-70°C	70°C
50 vol. %	85-95°C	100°C
90 vol. %	120-130°C	145°C
End Pt.	155°C	165°C max
Evap.	2 vol. %	2 vol. %
Reid Vapor Pres. (kg./cm ²)	0.45 max	0.45 max
Iodine No. (g./100 g.)	4.0 max	4.0 max
Melting Point	-60°C max	-60°C max
Corrosion Test	No discoloration or attack in the copper dish test.	
Residue (mg./100 c.c)	--	5 max
TEL (vol. %)	0/--	0/0.115
Aromatic Content (vol. %)	---	15 max
Ethylene Dibromide (vol. %)	---	---
Inhibitor (wt %)	---	---
Inspection	Yearly	Yearly
Comments	Maximum sulfur content--0.05 wt %.	

APPENDIX B
AVIATION FUEL SPECIFICATIONS--OTTO ENGINE

Specification Number	V.T. 810 <u>TL 147-154</u> 1	V.T. 810 <u>TL 147-154</u> 2
Date of Spec.	Sept. 1939	
Appearance	Clear, free from undissolved water, acid & solids.	
Color	Water white	Water white
Octane Rating	70/-	67/
Density @15°C	0.715-0.725	0.715-0.725
Distillation		
10 vol %	60-70°C	65°C
50 vol %	85-95°C	95°C
90 vol %	120-130°C	135°C
End Pt.	135-145°C	150°C max
Evap.	2 vol. %	2 vol. %
Reid Vapor Pres. (kg./cm ²)	0.5	0.5
Iodine No. (g./100 g.)	3.0 max	3.0 max
Melting Point	-60°C max	-60°C max
Corrosion Test	No discoloration or attack in the copper dish test.	
Residue (mg./100 c.c)	--	5.0 max
TEL (vol. %)	0/-	
Aromatic Content (vol. %)	--	11-15
Ethylene Dibromide (vol. %)	--	--
Inhibitor (wt %)	--	--
Inspection	Yearly	Yearly
Comments	Maximum sulfur content--0.05 wt %.	

APPENDIX B

AVIATION FUEL SPECIFICATIONS--OTTO ENGINE

Specification Number	VT 100 <u>TL 147-100</u> 1	VT 100 <u>TL 147-100</u> 2	VT 100 <u>TL 147-100</u> 3
Date of Spec.	October 1943		
Appearance	Clear, free from undissolved water, acid and solids		
Color	Water white		
Octane Rating	72/89		
Density @15°C	0.710-0.755		
Distillation			
10 vol. %	70°C		
50 vol. %	100°C		
90 vol. %	150°C		
End Pt.	170°C		
Evap.	2 vol. %		
Reid Vapor Pres. (kg./cm ²)	0.5		
Iodine No. (g./100 g.)	5 max		
Melting Point	-60°C max		
Corrosion Test	No discoloration or attack in the copper dish test.		
Residue (mg./100 c.c)	5 max		
TEL (vol. %)	0/0.115 vol %		
Aromatic Content (vol. %)	25 max		
Ethylene Dibromide (vol. %)	---		
Inhibitor (wt %)	---		
Comments:	Straight run gasolng. Max sulfur content 0.05 wt %		

APPENDIX B
AVIATION FUEL SPECIFICATIONS--OTTO ENGINE

Specification Number	VT 708 <u>TL 147-158</u> 1	VT 708 <u>TL 147-158</u> 2	VT 708 <u>TL 147-158</u> 3
Date of Spec	Oct. 1943		
Appearance	Clear, free from undissolved water, acid & solids.		
Color			Water white
Octane Rating			70 / 89
Density @15°C			0.710-0.740
Distillation			
10 Vol. %			70°C
50 Vol. %			100°C
90 Vol. %			150°C
End Pt.			170°C
Evap.			2 vol.
Reid Vapor Pres. (kg./cm ²)			0.5
Iodine No. (g./100 g.)			4 max
Melting Point			-60°C max
Corrosion Test	No discoloration or attack in the copper dish test		
Residue (mg./100 c.c)			5 max
TEL (vol. %)			0 / 0.115 vol %
Aromatic Content (vol. %)			15 max
Ethylene Dibromide (vol. %)			---
Inhibitor (wt %)			---
Comments			Hydrogenated gasoline. Analine point of 55°C max. Maximum sulfur content 0.05 wt %.

APPENDIX B

AVIATION FUEL SPECIFICATIONS--OTTO ENGINE

Specification Number	VT 207 <u>TL 147-157</u> 1	VT 707 <u>TL 147-157</u> 2
Date of Spec.	October 1943	
Appearance	Clear, free from undissolved water, acid & solids.	
Color	Water white	
Octane Rating	72 / 89	
Density @ 15°C	0.720-0.740	
Distillation		
Init.	40°C	
10 Vol. %	70°C	
50 Vol. %	100°C	
90 Vol. %	145°C	
End Pt.	165°C	
Evap.	2 vol. %	
Reid Vapor Pres. (kg./cm ²)	0.45 max	
Iodine No. (g./100 g.)	3 max	
Melting Point	-60°C max	
Corrosion Test	No discoloration or attack in the copper dish test.	
Residue (mg./100 c.c)	5 max	
TEL (vol. %)	0 / 0.115 vol %	
Aromatic Content (vol. %)	15 max	
Ethylene Dibromide (vol. %)	---	
Inhibitor (wt.%)	---	
Comments	Hydrogenated gasoline. Analine point of 50°C. Maximum sulfur content-0.05 wt %	

APPENDIX B
AVIATION FUEL SPECIFICATIONS--OTTO ENGINE

Specification Number	VT 302 TL 147-150 1	VT 811 TL 147-155 1	VT 812 TL 147-162 1
Appearance	Clear, free from undissolved water, acid & solids		
Color	Water white	Water white	Water white
Octane Rating	---	70 / 89	70 / 89
Density @ 15°C	0.875	0.725-0.750	0.720-0.740
Distillation			
Init.	80°C	40°C	40°C
10 vol. %	--	70°C	70°C
50 vol. %	--	105°C	110°C
75 vol. %	100°C	--	--
90 vol. %	--	145°C	150°C
95 vol. %	145°C		
End Pt.	--	165°C	165°C
Evap.	2 vol %	2 vol %	2 vol %
Reid Vapor Pres. (kg./cm ²)	0.25	0.50	0.50
Iodine No. (g./100 g.)	1.0 max	3.0 max	3.0 max
Melting Point	-10°C max	-60°C max	-60°C max
Corrosion Test	No discoloration or attack in the copper dish test.		
Residue (mg./100 c.c.)	5 max	5 max	5 max
TEL (vol. %)	--	0 / 0.115 vol %	0 / 0.115 vol %
Aromatic Content (vol. %)	100.0	6-15.0	15.0 max
Ethylene Dibromide (vol. %)	--	--	--
Inhibitor (wt %)	--	--	--
Comments	Max. sulfur content 0.08 wt %	Hydrogenated gasoline. Aniline point of 52°C. Max Sulfur content 0.05 wt %	Hydrogenated gasoline. Aniline point of 44-54°C. Max sulfur content 0.05 wt %

APPENDIX B

AVIATION FUEL SPECIFICATIONS--DIESEL ENGINE

Specification Number	K-1 <u>TL 147-351</u> 1	K-1 <u>TL 147-351</u> 2
Date	April 1944	
Centare No.	60 min.	50 min
Density @ 20°C	0.810 min.	0.810 min.
Boiling Range	I.B.P. about 160°C.	I.B.P. about 160°C. 95 vol % off-350°C.
Setting Point °C	-45 max	-45 max
Viscosity	1.1°E min @20°C	1.1°E min @20°C
Flash Point °C	above 50	above 50
Acid Value mg KOH/gm	0.7 max.	0.7 max
Sulfur Content wt %	1 max	1 max
Ash Content	Traces only	Traces only
Corrosion Test	Negative	4 mg max
Conradson Test Wt %	0.1 max	0.1 max
Water Content	Traces only	Traces only
Storage Stability	After 1 yr inspec at 6 mos intervals	After 1 yr inspec at 6 mos intervals

APPENDIX C

ACCEPTANCE CONDITIONS FOR THE AERO-ENGINE OILS.

S3 and V2

Military Name		S 3	V 2
Filling Station Mark		VK,VB,NM,WD,WH,WN,WL, WR,WM,WY,WV,WF,WB,WG.	RG,HL,WD,WH,WN,WL,WR, WM,WG,WV,WF,WB,WG.
Technical Specific for Delivery (1)		TL 147-502 TL 147-503 TL 147-506	TL 147-(561-563) TL 147-(571-573) TL 147-(581-583) TL 147-500
Appearance		The lubricating oil must be clear, free from undissolved water and mineral acids and must contain no solid impurities.	
Refractive Index	Max.	1.4995	1.4990 1.5070
Density @ 20°C. Kg/Ltr.	Max.	0.897	0.895 0.920
Viscosity @ 50°C @ 100°C	Min.	cs. 125-137 18.5 (16.5-18.0) (2.70)	cs. 125-143 19.0 (16.5-18.8) (2.75) cs. 133-144 19.4 (17.5-19.0) (2.80)
Pole Height	Max.	2.04	1.95 1.9
Slope	Max.	3.45	3.35 3.4
Viscosity Index	Min.	92	98 95

ACCEPTANCE CONDITIONS FOR THE AERO-ENGINE OILS. (CONTD)
S3 and V2

Setting Point °C	Max.	-17(2)	-20	-25
Flash Point °C	Min.	260	225	235
Ignition Point °C	Min.	300	255	270
Acid Value mg.KOH/g.	Max.	0.06	0.06	0.1
Saponification Value mg.KOH/g.	Max.	0.2	0.2	8.0
Evaporation Test (Dr.Noack) (3)				
250°C. % wt.	Max.	3.0(4)	11.0	5.0
Conradson % wt.	Max.	0.35	0.25	0.5
Ash Content % wt.	Max.	0.01	0.01	0.02
Hard Asphalt % wt.		0	0	0
Water Content % wt.		0	0	0

- Notes:
1. Constructional specifications for BVM Aero-Engines "Test Regulation for Aero-Engine lub. oils for use in Otto engines". Can be obtained from the Scientific Reports section (ZWB) of the DVL, Berlin-Adlershof, Rudower Chaussee 16/25.
 2. For S3, the filling station mark VK allows a max. setting point of -10°C.
 3. "Angewandte Chemie" 1936. Vol. 49, page 385.
 4. For S3--VK the max. Noack Test value is 5.0.
 5. The present sheet 7 supersedes the "Technical Acceptance Conditions for Aero-Engine Lub. Oils" issued by the RIMLC II 2e on 15.3.36. Copies still in existence should be destroyed.

Abbreviations: V--Vakuum X--Koln B--Bremen W--Wifo

Prepared by: Mineral Oil Section. Group GL/A-M II. This sheet is primarily intended for the suppliers. Thus there are two columns for S3 (to differentiate finished products from blended stocks)- see the other sheet 7 for military applications.

APPENDIX C
MOTOR OIL SPECIFICATIONS FOR COMPONENTS OF AVIATION MOTOR OIL S-3

	<u>Low Viscosity Oil</u>			<u>High Viscosity Oil</u>		
Code Designation	SS 607	SS 707	SS 807	SS 906	SS 1006	SS 1106
Specification Number	TL 147-560	TL 147-570	TL 147-580	TL 147-600	TL 147-610	TL 147-620
Appearance	The oil must be clear, free from undissolved water and mineral acids, and contain no solid impurities.					
Refractive Index Max.	1.4995	1.4935	1.5010	1.4770	1.4860	1.4816
Density @20°C Max.	0.905	0.895-0.897	0.905	0.862	0.875	0.870
Viscosity @50°C	CS 57.5-62.0 OE	CS 52.0-57.5 OE	CS 51.0-60.0 OE	CS 334-350 OE	CS 300-380 OE	CS 278 min. OE
@100°C Min.	7.6-8.2 CS	6.9-7.6 CS	6.8-7.9 CS	44-46 CS	40-50 CS	365 min. CS
	9.66 OE	9.35 OE	9.35 OE	42.3 OE	41.3-45.2 OE	38.0 OE
	1.80	1.77	1.77	5.63	5.5-6.0	5.1
Pole Height Max.	2.40	2.08	2.20	1.73	1.75	1.65
Slope Max.	3.80	3.66	3.75	3.05	3.05	3.00
Viscosity Index Min.	70	88	80	107	105	107
Cloud Point °C Max.	-15	-15	-16	-25	-20	-25
Flash Point °C Min.	225	225	222	225	295	280
Ignition Point °C Min.	265	258	258	263	325	330
Acid Value mg KOH/gm	0.03	0.06	0.07	0.06	0.06	0.06
Saponification No. mg KOH/gm	0.10	0.17	0.17	0.2	0.1	0.2
Noack Evap @250°C wt %	9.0	14.0	12	8	1	5.5
Conradson wt %	0.2	0.25	0.30	0.2	0.45	0.25
Ash wt %	0	0	0	0	0	0
Hard Asphalt wt %	0	0	0	0	0	0
Water Content wt %	0	0	0	0	0	0

APPENDIX C

MOTOR OIL SPECIFICATIONS
GROUND FORCE WINTER AND SUMMER OIL

	WEHRMACHT (SU) Summer	WEHRMACHT (WI) Winter
General Characteristics	The oil must be clear and contain no sediment	
Density @ 20°C Max.	0.91	
Evaporation Test	7-14%	20%
Viscosity		
Engler @ -15°C	1800° F	550° F
Engler @ 100°C	1.9-2.1	1.6° F
c.s. @ -15°C	18800	--
c.s. @ 100°C	10.8-12.8	--
Pole Height	2.1	2.0
Total Impurities		
Hard Asphalt	Free	Free
Benzol-alcohol solution	Free	Free
Solid Impurities	Free	Free
Combustibles	Free	Free
Ash	Trace	Trace
Acid Value mg KOH/gm	0.10	0.07
Saponification No. mg KOH/gm	0.25	0.25
Water	Free	Free
Flash Point °C		200
Pour Point °C		-25

APPENDIX C

MOTOR OIL SPECIFICATIONS GENERAL COMMENTS ON TEST TECHNIQUE

GENERAL:

1. The tests should be carried out with officially authorized standard testing equipment, either in the possession of the supplier or in that locality (at suppliers expense) or at the State Chemical Institute, Berline-Polotzensee.
2. No additional payment will be made to the supplier for the testing, check testing, packing and shipping of the samples.
3. If the tests are not performed by the government institution preliminary recognition by the consignee of the testing equipment used is essential. The consignee will instruct the responsible testing department representative regarding test technique. The supplier will be responsible for his own equipment and test personnel. The consignee has the privilege of retesting any sample at the state institute.
4. Only firms authorized by the High Command may supply motor oil (winter or summer) to the German Ground Forces. Information of the suppliers production technique must be made known to the High Command and also to the state institute. Any changes in composition of the product must be authorized.
5. The motor oil must be supplied in sealed containers which can be readily opened for spot testing.

ACCEPTANCE:

6. A sample of 1.5 kgms is required in each of the tests. After removing sample the container will be properly sealed.
7. Tests will be made on each sample. If any one of the tests is unsatisfactory the sample will be rejected.
 - a. The density @ 20°C will be determined in accordance with German Industrial Standards DVM 3653. It is satisfactory to use a hydrometer.
 - b. The volatility will be determined by the Noack Method described in "Avg. Chemie 49,385 (1936)" and in "Alud Kohle 1942".

c. The viscosity will be determined by the Vogel-Ossag-Viscosimeter using a sensitive thermostat, calibrated capillaries, thermometers calibrated to $1/10^{\circ}\text{C}$, and calibrated stop watches. All the above apparatus should be calibrated by the State Physical Technical Institutes.

Capillaries will not be used interchangeably as erroneous results will be obtained. Additional calibration is required from time to time using calibrated oils as standards.

The minimum time of flow is dependant upon the diameter of the capillary as shown in the following table.

<u>K</u>	<u>t (s)</u>
2- 0.8	30
0.6	34
0.4	42
0.2	60
0.1	85

A time of flow of 90 seconds should not be exceeded if possible. Measurements will be made at 20°C , 50°C and 90°C . The values for -15°C , 100°C and VP are calculated from E20 and E90 according to the Uble Code Weather formula, or directly from the next issue of CTR tables. The measurement of the 50°C value is a control for the 20°C & 90°C values.

d. To estimate total impurities mix 5 gms of oil with 50 c.c. of normal (standard) gasoline in an iodine bottle. Stopper, and allow to stand for three hours in the dark and filter the normal gasoline solution through a pre-treated Jenaer IG 4 glass filter crucible mounted on a vacuum flash. The residue is washed with cold normal gas to free it of oil, and then with warm normal gas to dissolve possible paraffin and ceresin. It is then dried for $\frac{1}{2}$ hour at 105°C , left to cool in a dessicator and then weighed. The gain in weight represents the content of hard asphalt, alcohol, soluble benzol and solid impurities. The contents of the crucible should then be washed with benzol on the vacuum flash until the filtrate is colorless; dry, cool and weigh as above; the difference of the two weights is the hard asphalt content. Wash crucible contents with a 1:1 benzol alcohol mixture, treat as above; difference in weight is the alcohol soluble benzol. The final residue represents the solid impurities.

Preparation for use of the I.G. 4 crucible

The crucible is cleaned with chromic acid (H_2SO_4), washed with water till neutral; 5 gms of pure cryolite powder are put in, the crucible is mounted on a vacuum flash and the powder is tamped down (fast)

under vacuum with a flattened glass rod. The crucible is then washed out with 20 ccs of a benzol-alcohol mixture and some normal gasoline. Air is then sucked through for 1 to 2 minutes and the crucible is dried for $\frac{1}{2}$ hour in a desicator at 105°C. After adequate cooling it is weighed in a weighing glass. The weighing glass should not be used with a rapid analytical balance. Without such a balance, weighing glasses are to be used for all the above mentioned weighings.

Ash content is determined according to "German Industrial Standards" DVM 3657, with one alteration, namely that 100 gms of oil are weighed out. The difference between the solid impurities and the ash is the combustible matter.

e. The acid-value is determined according to DIN, DVM 3658. To be able to titrate dark colored oils without trouble, the DVM procedure is deviated from in the preparation of the solvent mixture. This is prepared according to Wizoff as follows: 33.8 gms analytical alkali blue 6 B are added to a mixture of 3 litres pure benzol and 1.5 litres 90% (at least) alcohol. The mixture is then agitated for a few hours, left to stand over night, and filtered. The solution is then ready for use.

f. The saponification number is determined according to DIN DVM 3659. Solvent mixture as for acid-value.

g. H_2O content is determined by a visual test on the sample after vigorous shaking up and pouring into a calibrated test tube. It is essential to carry out the heating test for presence of water.

High Command of the Army
Army Ordnance Office (Wa Chief Engineer)

APPENDIX D

GREASE SPECIFICATIONS TABLE 1

Type	Rocker Arm Grease	Protective Grease (40L)	Axle Grease	Refrigeration Grease	Avia. Instr. Grease	Aviation Grease Blue
Specification Number	TL 147-730	TL 147-770	TL 147-740	TL 147-750	TL 147-750	TL 147-735
Appearance	(1)	(1)	(1)	(1)	(1)	(1)
Drop Point (Min.) °C	80	50	160	90	165	90
Color (2)	brown to black	dark brown to black	brown to dark green	brown	red/brown (distillate)	blue (dyed)
Acid Value (3)	--	neutral	--	--	--	--
Alkali Value (3)	--	neutral	--	--	--	--
Ash Content wt % (min)	2	0.5	2	4	1	3
Oil Separation wt %	4	--	1	1.5	1	1.5
Water Resistance	--	waterproof	--	waterproof	waterproof	waterproof
Homogeneity	homogeneous	homogeneous	homogeneous	homogeneous	homogeneous	homogeneous
Consistency	--	--	--	--	Penetrometer 280 ± 20	Penetrometer 250 ± 20
Water content (min) wt%	0.5	--	1	3	0.5	2.5
Storage Stability yrs	1	2	1	2	1	1
Cold behavior range (2)	0°C to -30°C (4)	(5)	0°C to -35°C (6)	(7)	0°C to -65°C (8)	0°C to -60°C (9)

CODE:

- (1) Appearance should be structureless, smooth with short fibers.
- (2) Test instructions may be obtained from the Air Ministry.
- (3) No limit specified but reading should be recorded.
- (4) (5) (6) (7) (8) (9) Calibration curves may be obtained from the G.A.F. Laboratory, Travemunde, E 3L. The curves are attached in the order shown.

APPENDIX D

GREASE SPECIFICATIONS

General Comments on Greases Listed in Preceding Table

1. The Air Ministry must be informed on the types and quality of the raw materials, mixing proportions, operating conditions used in the manufacture of the grease. The manufacturer is obliged to inform the Air Ministry of any change in the composition of the grease.
2. Contents of containers delivered to the Air Force and/or the Aircraft Industries must be made known.
3. The material should be packed in clean containers which conform to specific form, size and material of construction.
4. The manufacture of the grease must be done by firms authorized by the Air Ministry. If new or additional facilities are required the Air Ministry must be notified in advance.
5. The grease must conform to the listed specifications.
6. Only tests approved by the Air Ministry are to be used in testing the grease for quality and acceptance.

APPENDIX D
GREASE SPECIFICATIONS TABLE 2

Type	Protective Grease 40(Tp)	Protective Grease 40
Spec. No.	TL 6023	TL 6017
Appearance	Transparent and must not become liquid when stirred.	Transparent and must not become liquid when stirred
Drop Point(Min)°C	75	50
Color	Colorless	colorless
Acid Value	Mineral Acid--0	Mineral Acid--0
mg KOH/gm	Organic Acid--0.5	Organic Acid--0.2
Alkali Value	--	--
Ash Content	1.0	0.5
wt % (min)		
Oil Separation	None permitted	None permitted
Water Resistance	Completely water resistant at 20°C with no oil separation.	Completely water resistant at 20°C.
Homogeneity	No change in homogeneity after 3 hrs heating at 150°C	No change in homogeneity after 3 hrs heating at 150°C
Consistency	Must be spreadable at 0°C as well as at 20°C.	Must be spreadable at 0°C as well as at 20°C
Water content		
wt % (min)	---	---
Storage Stability	---	---
Corrosion Stability	Rust proof for a minimum of 3 days at 40°C and 100% relative humidity	Rust proof for a minimum of 3 days at 40°C and 100% relative humidity.

COMMENTS:

A sample of 500 grams is required from each 100 kg batch. One sample has to pass the minimum requirement for each test listed above otherwise the whole batch is rejected. Additional comments regarding test techniques follow.

1. Drop point test done according to DIN DVM 3654.
2. Heat Resistance--A sample of grease is spread on a sheet metal container with raised edges and then heated for 3 hours at 50°C. The sample must be spreadable and show no marked changes.
3. Water Resistance--A layer of grease 10 cm long, 1 cm wide and about 1 mm thick is spread on a prepared glass strip 16 cm x 1.5 cm. The prepared glass strip is placed in a flask with 100 cc. distilled water so that the grease layer projects 5 mm above the water surface. If the layer has not changed after 48 hours the sample passes provided

that the water is clear. If the water is clouded or a slight change occurs on the greased surface the test should be continued for one week.

4. Ash Content--Done according to DIN DVM 3657
5. Free Acid--Done according to DIN DVM 3658
6. Corrosion Stability--Emery cloth polished steel rods, 50 mm x 10 mm are dried for 3 hours in a desiccator and then coated with grease by dipping for three minutes in molten grease at 130°C. The coated rods are hung so that surplus grease runs off and the sample reaches room temperature. The rods are next put in an air sealed chamber over warm water at about 50°C, so that a constant air temperature of 40°C is maintained. The sample passes when there is no trace of corrosion after 3 days.

APPENDIX D
GREASE SPECIFICATIONS | TABLE 3

Type	Weapon Grease	Instrument Grease	Water Pump Grease	Lubricating Grease
Spec. No.	TL 6006	TL 6009	TL 6035	TL 6014
Appearance	Without lumps	Transparent	without lumps	Transparent and free of oil pockets
Drop Point °C (min)	145	160	95	130
Color	Transparent	Colorless	Salve color	Colorless
Acid Value mg KOH/gm	0	0.10	Mineral Acid-0	---
Alkali Value	0	---	Organic Acid-0.2	---
Ash Content wt %(min)	--	0.5	Slightly alkaline	---
Oil Separation wt %	None permitted	0.5	4	---
Water Resistance	--	waterproof	5	0.5
Homogeneity	No change after 3 hrs @ 50°C	homogeneous	---	---
Consistency	Between solid and tallow consistency at 20°C	2.0 Kg @ 0°C (1)	No change after 5 hrs @ 50°C	No change after 5 hrs @ 50°C
Water Content wt %(min)	---	0	---	0.3 Kg @ 50°C (1)
Storage Stability	---	---	4	---
Unspcnitiable wt %	70°	---	---	---

- CODE:** (1) The consistency value is the smallest weight in Kg, which causes the extension of a 10 mm length strip in a period of 60 seconds. The details of the test follow.
- Each sample must be kneaded in special apparatus for 200 strokes.
 - Fill the test cylinder with grease sample, taking necessary precautions to exclude air bubbles.
 - Place test cylinder in thermostat. A minimum of 45 minutes is required at 50°C and a minimum of 2 hours at -10°C.
 - Place the necessary weights on plunger to extrude grease.