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LABORATORY EVALUATION OF MULTIVISCOSITY-GRADE ENGINE OILS IN U.S. ARMY DIESEL ENGINES

INTERIM REPORT
AFLRL No. 112

By

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Seven multigrade engine oils were tested against 10 grade and 30 grade reference oil in the DD 6V-53T engine using a 240-hour tracked-vehicle cyclic endurance test and in the Teledyne Continental LD/LDT-465 engines using a 210-hour wheeled-vehicle cyclic endurance test. The results of these tests are tabulated and compared with results from reference oil tests. Two SAE 15W-40 oils proved equal or better than the reference oil and were recommended for adoption as MIL-L-2104 oils. Recommendations for (contd)

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Block 20. (contd)
further research are also presented.

FOREWORD

The work reported herein was conducted at the U.S. Army Fuels and Lubricants Research Laboratory (USAFLRL) located at Southwest Research Institute, San Antonio, Texas, under Contracts DAAK70-78-C-0001 and DAAK70-80-C-0001, during the period November 1978 through June 1980. The contracting officer's representative was Mr. F.W. Schaekel of U.S. Army Mobility Equipment Research and Development Command (USAMERADCOM), DRDME-GL, Ft. Belvoir, Virginia, and Mr. Tom Bowen of the same office was the technical project monitor.

ACKNOWLEDGMENT

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I. INTRODUCTION

The current military lubrication orders (LO's) for Army combat/tactical vehicle engines, except in Arctic conditions, specify the use of single-viscosity-grade engine oils qualified under MIL-L-2104C.(1)* The viscosity grades specified are 10, 30, 40, and 50 (Military equivalents to SAE 10W-20, 30, 40, and 50, respectively), with the proper grade of oil used dependent on ambient temperature.

Using single-grade engine oils results in frequent changes of still usable oil solely due to changes in ambient temperature, and not to any degradation of the oil. A multiviscosity-grade oil for year-round use would eliminate seasonal oil changes and result in (1) considerable saving on oil used, (2) a reduced number of stock items and associated logistical simplification, (3) a reduced number of engine failures due to the wrong viscosity grade being used, (4) a reduction in maintenance costs, and (5) an increase in equipment readiness.

The Army's high-output diesel engines typically have different operating cycles than the diesel engine used in commercial highway applications. Prolonged periods of wide-open throttle, alternating with relatively long periods of inactivity are more typical of Army use than continuously loaded commercial highway driving. To further compound the difference between commercial highway use and Army operations, the Army engines typically have a higher power output than their civilian counterparts and are operated in vehicles that often have marginal cooling systems due to the overriding requirements for armored protection. As a result, outside of Arctic conditions, commercially available multigrade engine oils have not been used in Army combat/tactical vehicles because of excessive wear and deposits that have resulted from their use.(2)

In the Arctic, the Army is currently using synthetic-based engine oils qualified under MIL-L-46167(3) in ambient temperatures from -55°C to +5°C.

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* Superscript numbers in parentheses refer to the list of references at the end of this report.

Their use in combat/tactical vehicles under these conditions has been very successful and has served as an indicator that the use of multigrade diesel engine oils at higher ambient temperatures may be possible.

Because the effectiveness of multigrade diesel engine oils for Army combat/tactical vehicles has been demonstrated in Arctic conditions, the decision was made to develop requirements for a multigrade diesel engine oil for Army tactical vehicles operating in ambient temperatures from -10°C to +50°C. A letter was sent to various lubricant and additive manufacturers soliciting help in the development of "a new generation of engine lubricants designed for use in military ground equipment."(4) This letter resulted in several candidate oils being sent to U.S. Army Mobility Equipment Research and Development Command (MERADCOM) for evaluation. These oils have been evaluated in this program to determine the acceptability of multiviscosity-grade lubricants for use in combat/tactical diesel engines, and to establish performance under future lubricant specification MIL-L-2104D.

II. OBJECTIVE AND SCOPE

The objective of this project was to test seven multiviscosity engine oils for suitability in MIL-L-2104 oil applications. Candidate oils were to meet or exceed the performance level of selected MIL-L-2104C reference oils. This work thus furthers the research needed to develop requirements for a new MIL-L-2104D specification covering multiviscosity combat/tactical diesel engine oils. The scope of the work encompasses the testing of the seven candidate oils and reference oils, evaluation of the candidate oils in comparison to the reference oils, and recommendations for action and further tests. The scope does not include the field testing necessary to corroborate laboratory engine tests.

III. EXPERIMENTAL PROCEDURES

A. Test Lubricants

The inspection properties of the nine different diesel engine lubricants evaluated during this program are shown in Table 1. Lubricant A is the U.S. Army MIL-L-2104C qualified OE/HDO-30 reference oil. This oil has petroleum basestocks and a calcium-based detergent-dispersant additive package with a sulfated ash content of 1.6 wt%. Lubricant B is the OE/HDO-10 grade of the Army's MIL-L-2104C qualified reference oil and has the same additive chemistry as Lubricant A. Lubricant C, a 10W-30 experimental product, contains a basestock blend of polyalkylated benzenes and mineral oil, and a calcium/magnesium detergent-dispersant additive system with a sulfated ash content of 1.2 wt%. Lubricant D is an experimental 10W-30 mineral oil which contains a magnesium/calcium additive system with a sulfated ash content of 1.1 wt%. Lubricant E is an experimental 10W-30 product which contains a basestock blend of polyalphaolefins and polyolester. The additive system of Lubricant E is calcium based with a sulfated ash content of 1.1 wt%. Lubricant F is a commercially available 15W-40 mineral oil and contains a magnesium/calcium additive system with a sulfated ash content of 1.0 wt%. Lubricant G is also a commercially available 15W-40 mineral oil with a sulfated ash content of 1.0 wt%; however, its detergent-dispersant package is calcium based. Lubricant H is an experimental 10W-30, which contains both synthetic and petroleum basestocks, with a calcium additive system and a sulfated ash content of 1.0 wt%. Lubricant I is an experimental 10W-30 product consisting of a synthetic hydrocarbon and ester basestock blend, with a calcium additive system and a 1.5 wt% sulfated ash. The complete inspection properties of these lubricants are shown in Table 1.

B. Test Engines

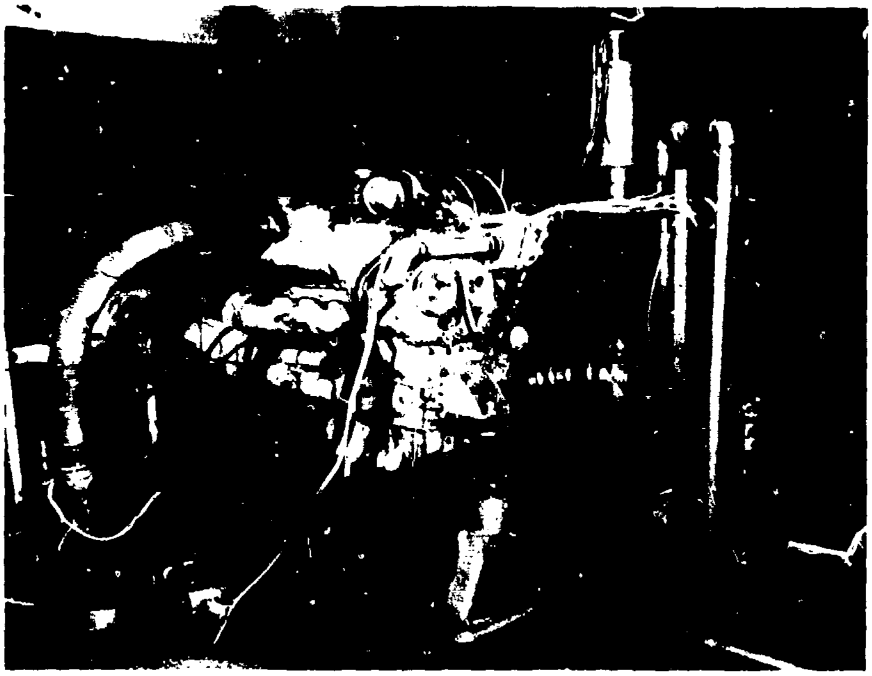
The diesel engines chosen for these multigrade engine oil evaluations were the two-cycle Detroit Diesel 6V-53T engine (Figure 1) and the four-cycle Teledyne Continental Motors LD-465-1 and LDT-465-1C engines (Figure 2).

These engines are representative of many of the same type the Army uses (Tables 2 and 3) and were chosen for test engines because both are "sensitive" to lubricants in different ways. The 6V-53T engine is intolerant of low viscosity combined with high volatility in a lubricating oil, and will severely score cylinders and burn rings if volatility is outside a critical limit.[5]

TABLE 1. NEW PROPERTIES OF TEST LUBRICANTS

Property	ASTM Method	Lubricant Designation A	B	C	D	E	F	G	H	I
SAE Viscosity Grade		30	10W	10W-30	10W-30	10W-30	15W-40	15W-40	10W-30	10W-30
Apparent Viscosity at −29°C, cP	D 2602	Solid	12250	9000	10500	3200	23000	23000	8500	7800
Apparent Viscosity at −18°C, cP	D 2602	1000	2180	2180	1760	1600	4200	3900	1800	2350
Kinematic Viscosity at 40°C, cSt	D 445	107	47	69	66	56	113	97	82	65
Kinematic Viscosity at 100°C, cSt	D 445	11.6	6.5	10.6	10.5	10.0	14.8	13.9	12.8	10.2
Viscosity Index	D 2270	96	103	143	146	167	135	146	156	133
Total Acid Number, mg KOH/g	D 664	2.3	2.5	2.5	2.1	3.0	1.9	3.3	3.0	3.7
Total Base Number, mg KOH/g	D 2896	13.9	12.7	8.6	10.3	6.3	8.2	6.5	9.1	10.2
Pentane B Insolubles, wt%	D 893	0.03	0.02	0.02	0.01	0.04	0.02	0.01	0.01	0.09
Toluene B Insolubles, wt%	D 893	ND	ND	ND	ND	0.02	ND	0.01	0.02	ND
Benzene B Insolubles, wt%	D 893	0.01	0.01	0.02	0.01	ND	0.01	ND	ND	0.02
Flash Point, °C	D 92	223	214	228	202	224	210	209	221	227
Pour Point, °C	D 97	−17	−31	−28	−31	−45	−30	−32	−39	−41
Gravity, °API	D 287	25.5	28.3	29.9	29.2	31.2	28.1	29.3	31.7	21.9
Carbon Residue, wt%	D 524	2.1	1.7	1.2	1.2	1.1	1.0	1.2	1.2	1.5
Sulfated Ash, wt%	D 874	1.6	1.7	1.2	1.1	1.1	1.0	1.0	1.0	1.5
Elements, wt%	**Method**									
Mg	AA	0.003	0.002	0.07	0.09	0.000	0.13	0.003	0.002	0.001
P	XRF	0.11	0.11	0.11	0.10	0.13	0.12	0.13	0.08	0.12
S	XRF	0.48	0.43	0.39	0.58	0.33	0.65	0.37	0.27	0.37
Ca	AA	0.46	0.46	0.22	0.10	0.25	0.10	0.26	0.24	0.35
Zn	AA	0.08	0.09	0.14	0.13	0.13	0.12	0.17	0.11	0.17
Ba	AA	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
N	CLM	0.07	0.07	0.04	0.17	0.14	0.12	0.15	0.13	0.03
Na	AA	0.001	0.002	0.000	0.000	0.001	0.002	0.000	0.07	0.001
Cl	AA	<0.01	<0.01	<0.01	<0.01	<0.02	<0.02	<0.01	<0.01	<0.01
AL Code		8980 6856 OE/HDO-30	6855 OE/HDO-10	6947	8531 7235	8924 8406	7172	9249	7288	6942

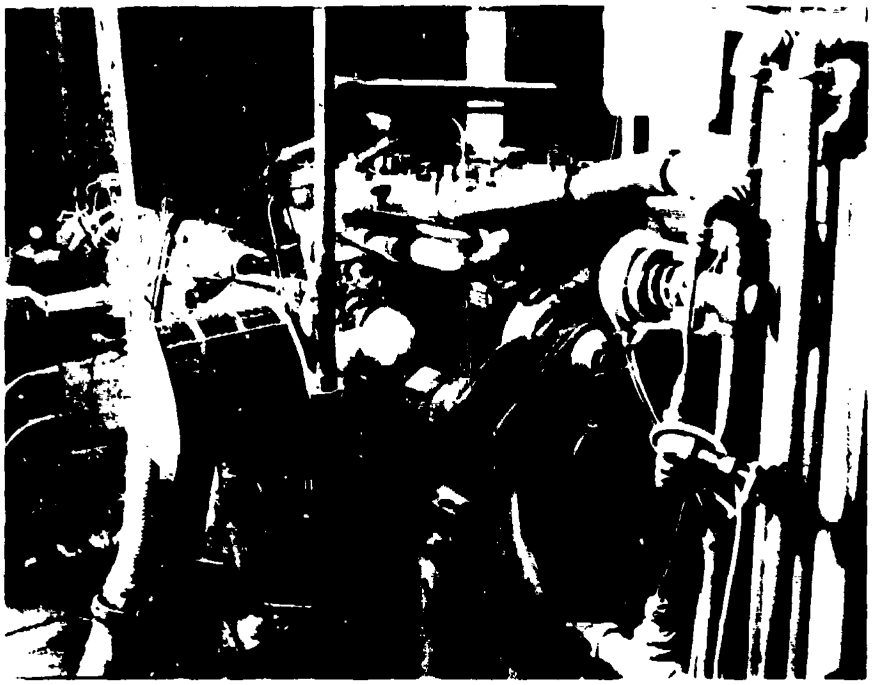
ND = Not Determined
CLM = Chemiluminescent Method
AA = Atomic Absorption
XRF = X-Ray Fluorescence



6V-53T ENGINE SPECIFICATIONS

Engine Type	Turbocharged, Direct Injection Uniflow Scavenged, Two-Cycle Compression Ignition
No. of Cylinders, arrangement	6, V
Displacement, liters (in.^{3})	5.2(318)
Bore x Stroke, mm (in.)	98.43 x 114.30 (3.875 x 4.500)
Rated Power, kW (Bhp)	224(300) @ 2800 rpm, 15.5°C (60°F) and 29.82 in. Hg
Rated Torque, Nm (ft.-lb)	834(615) @ 2200 rpm
Oil Capacity, liters (gal.)	19(5)
Piston Material, Design	Cast Iron, Trunk-Type

FIGURE 1. SPECIFICATIONS AND INSTALLATION OF THE DETROIT DIESEL 6V-53T ENGINE



LD-465-1 AND LDT-465-1C
ENGINE SPECIFICATIONS

Engine Type	Naturally Aspirated LDT-465-1C is turbocharged), Direct Injection Four-Cycle, Compression Ignition M.A.N. Combustion Chamber Design
Fuel	Multifuel Capability
No. of Cylinders, arrangement	6, in-line
Displacement, liters (in.^{3})	7.8(478)
Bore x Stroke, mm (in.)	115.8 x 123.7 (4.56 x 4.87)
Rated Power, kW (Bhp)	104(140) @ 2600 rpm,
Oil Capacity, liters (gal.)	21(5.5)

FIGURE 2. SPECIFICATIONS AND INSTALLATION OF THE
TELEDYNE CONTINENTAL MOTORS LD-465-1 AND LDT-465-1C ENGINES

TABLE 2. ARMY VEHICLES POWERED BY TELEDYNE CONTINENTAL MOTORS LD/LDS/LDT-465 ENGINES*

Designation	Description	Engine Model
M44A2	Chassis, Truck: 6x6	LD-465-1
M45A2	Chassis, Truck: 6x6	LD-465-1
M45A2G	Chassis, Truck: 6x6	LD-465-1
M46A2C	Chassis, Truck: 6x6	LD-465-1
M621	Chassis, Truck: 6x6	LD-465-1
M622	Chassis, Truck: 6x6	LD-465-1
M623	Chassis, Truck: 6x6	LD-465-1
M624	Chassis, Truck: 6x6	LD-465-1
M40A2	Chassis, Truck: 6x6	LDS-465-1A
M40A2C	Chassis, Truck: 6x6	LD-465-1A
M63A2	Chassis, Truck: 6x6	LDS-465-1A
M63A2C	Chassis, Truck: 6x6	LDS-465-1A
M35A2	Truck, Cargo: 6x6	LD-465-1
M35A2C	Truck, Cargo: 6x6	LD-465-1
M36A2	Truck, Cargo: 6x6	LD-465-1
M621	Truck, Cargo: 6x6	LD-465-1
M54A2C	Truck, Cargo: 6x6	LD-465-1A
M55A2	Truck, Cargo: 6x6	LD-465-1A
M656	Truck, Cargo: 8x8	LD-465-(TC)
M342A2	Truck, Dump: 6x6	LD-465-1
M624	Truck, Dump: 6x6	LD-465-1
M51A2	Truck, Dump: 6x6	LD-465-1A
M49A2C	Truck, Tank: Fuel, 6x6, 4542 L (1200 gal.)	LD-465-1
M50A2	Truck, Tank: Water, 6x6, 3785 L (1000 gal.)	LD-465-1
M622	Truck, Tank: Fuel Servicing, 6x6, 4542 L (1200 gal.)	LD-465-1
M275A2	Truck, Tractor: 6x6	LD-465-1
M52A2	Truck, Tractor: 6x6	LD-465-1A
M246A2	Truck, Tractor: Wrecker, 6x6	LDS-465
M109A3	Truck, Van: Shop, 6x6	LD-465-1
M185A2	Truck, Van: Shop, 6x6	LDS-427-2
M185A3	Truck, Van: Shop Repair, 6x6	LD-465-1
M623	Truck, Van: Shop, 6x6	LD-465-1
M291A2	Truck, Van: Expansible, 6x6	LDS-465-1A
M291A2C	Truck, Van: Expansible, 6x6	LDS-465-1A
M543A2	Truck, Wrecker: Medium, 6x6	LDS-465-1A

* Source: TM 43-0001-31, Equipment Data Sheets for TARCOM Equipment, July 1978.

Note: The LDT-465-1C engine is used interchangeably in vehicles utilizing the LD-465-1 engine.

TABLE 3. ARMY TACTICAL VEHICLES POWERED BY GMC DETROIT DIESEL TWO-CYCLE ENGINES

Designation	Description	Engine Model
M106A1	Mortar, Self-propelled, 107 mm	6V-53
M107	Gun, Self-propelled, 175 mm	8V-71T
M108	Howitzer, Self-propelled, 105 mm	8V-71T
M109	Howitzer, Medium, 155 mm	8V-71T
M110	Howitzer, Self-propelled	8V-71T
M113A1	Carrier, Personnel	6V-53
M125A1	Mortar, Self-propelled, Full-tracked	6V-53
M132A1	Flame Thrower, Self-propelled	6V-53
M548	Carrier, Cargo, Tracked	6V-53
M551	Armored Reconnaissance/Airborne Assault Vehicle (Sheridan)	6V-53T
M561	Gamma Goat	3-53
M577A1	Carrier, Command Post, Light-tracked	6V-53
M578	Recovery Vehicle	8V-71T
HET70	Heavy Equipment Transporter	12V-71T
XM 667	Carrier, GM, Equipment, SP	a
XM 727	Carrier, GM, Equipment, SP	a
XM 730	Carrier, GM, Equipment, SP	a
XM 741	Chassis, Gun, AA Artillery, 20 mm, SP	a
XM 806E1	Recovery Vehicle, FT Armored	a
---	Truck, Dump, Diesel Electric Driven	6V-71
M911	Heavy Equipment Transporter	8V-92T

a = Vehicles are powered by either 6V-43, 6V-53T, or 8V-71T (TB-750-652).

The LD-465 engine family will increase the viscosity of some lubricants so that at low temperatures, cranking, starting-and-running, lubricant pumpability, and subsequent lack of lubrication are potential problems. In addition, the LD-465 engine family produces high blowby which stresses the lubricant additive package.

C. Test Cycles

The endurance test cycle chosen for the 6V-53T engine was the Army/Coordinating Research Council (CRC) 240-hour Tracked-Vehicle Cycle (Table 4), which has been correlated to 6437 kilometers (4000 miles) of proving ground

TABLE 4. ARMY/CRC 240-HOUR TRACKED-VEHICLE ENDURANCE CYCLE

Period*	Time, hr	Rack/Throttle Setting	Coolant Jacket-Out Temp, °C(°F)
1	0.5	idle	38(100)
	2.0	Maximum Power**	77(170)
	0.5	idle	38(100)
	2.0	Maximum Torque**	77(170)
2	0.5	idle	38(100)
	2.0	Maximum Power	77(170)
	0.5	idle	38(100)
	2.0	Maximum Torque	77(170)
3	0.5	idle	38(100)
	2.0	Maximum Power	77(170)
	0.5	idle	38(100)
	2.0	Maximum Torque	77(170)
4	0.5	idle	38(100)
	2.0	Maximum Power	77(170)
	0.5	idle	38(100)
	2.0	Maximum Torque	77(170)
5	4	5 min idle, followed by shutdown	---

*These five periods yield 20 hours of running with a 4-hour shutdown; this cycle is repeated 12 times for a total test time of 240 hours.
**For the 6V-53T, Maximum Power occurs at 2800 rpm and Maximum Torque occurs at 2200 rpm.

operation.[22] The endurance test cycle chosen for the LD/LDT-465-1 engines was the Army/CRC 210-hour Wheeled-Vehicle Cycle (Table 5), which has been correlated to 32,187 kilometers (20,000 miles) of proving ground operation.[22]

TABLE 5. ARMY/CRC 210-HOUR WHEELED-VEHICLE ENDURANCE CYCLE

Period*	Time, hr	Rack/Throttle Setting	Coolant Jacket-Out Temp, °C(°F)
1	2	5 min idle followed by slow acceleration to maximum power**	82(180)
2	1	idle	38(100)
3	2	Maximum Power	82(180)
4	1	idle	38(100)
5	2	Maximum Power	82(180)
6	1	idle	38(100)
7	2	Maximum Power	82(180)
8	1	idle	38(100)
9	2	Maximum Power	82(180)
10	10	5 min idle followed by shutdown	---

* These 10 periods yield 14 hours of running with a 10-hour shutdown; this cycle is repeated 15 times for a total test time of 210 hours.

** For the LD-465 series engines, Maximum Power occurs at 2600 rpm.

D. Test Procedures

1. 6V-53T Engine--Prior to each endurance test, the 6V-53T engine was disassembled and rebuilt. New cylinder assemblies (which include piston, rings, and piston pin) were used for each rebuild, and the connecting rod bushings, connecting rod bearings, camshaft bearings, and main bearings were replaced only if the clearances were out of specification, or if appearance warranted replacement. The combustion chambers were cleaned by wire brushing, and the exhaust valves were refaced or replaced as necessary, and lightly

lapped. The manufacturer's rebuild specifications[23,24] were followed for all parts, and particular attention was given to all measurements and operations involving the cylinder assemblies, the main indicators of lubricant performance in this engine test.

Prior to each test, the instrumentation (Table 6) was recalibrated, with particular attention given to the tachometer, flowmeter, and dynamometer load system. After calibration the engine was broken in, and a before-test power curve at full-rack from 1800 to 2800 rpm at 200 rpm increments was run. The 240-hour Tracked-Vehicle Cycle Endurance Test was then run, with an oil change at 120 hours.

TABLE 6. TEST INSTRUMENTATION

Midwest Eddy Current Dynamometer, Type MW10K, 298 kW(400 hp) absorbing, 1500-5000 rpm.
Newport Digital Tachometer, Model 6130A, 0-10000 rpm.
Flotron Fuel Flowmeter, Part No. 10E48, 0-91 Kg (0-200 lb/hr).
Hagan Pneumatic Load Cell w/Wallace and Tiernen Readout, 0-499 Kg (0-1100 lb).
Honeywell Temperature Recorder, Model 153C64P2-228W7-42, -17.8°-537.8°C(0°-1000°F).
Moore Temperature Controller, Model 5311MT2(M2), 37.8°-121°C(100°-250°F).
Various Crosby and Helicoid Bourdon Tube Pressure Gauges, 0-30, 0-60, 0-100 psig.
King Manometer, Model AF5FF24, 0-635 mm(0-25 in).
Meriam Inclined Manometer, Model M177, 0-102 mm(0-4 in).
Omega Exhaust Thermocouple Readout, -17.8°-1093°C(0°-2000°F).

LD-465-1, LDT-465-1C Engines

Dynamatic Eddy Current Dynamometer, Model C-50-U, 244 kW(300 hp) absorbing 2100-5000 rpm.
Newport Digital Tachometer, Model 6130A, 0-10000 rpm.
Flowtron Fuel Flowmeter, Part No. 10E48, 0-91 kg/hr(0-200 lb/hr).
Tate-Emery Hydraulic-Pneumatic Load System, 0-227 kg(0-500 lb).
Honeywell Temperature Recorder Model 153X72-P16-II-III-6, -17.8°-315.6°C(0°-600°F).
Moore Temperature Controller, Model 5311MT2, 37.8°-121°C(100°-250°F).
Various Crosby Bourdon Tube Pressure Gauges, 0-15, 0-60, 0-100, 0-160 psig.
King Manometer, Model AF5FF24, 0-635 mm(0-25 in).
Meriam Inclined Manometer, Model 40HE35, 0-102 mm(0-4 in).
Omega Exhaust Thermocouple Readout, -17.8°-1093°C(0°-2000°F).

Oil samples were taken for chemical and physical analysis, oil additions were made, and the airbox was inspected according to the schedule in Table 7.

TABLE 7. 6V-53T ENGINE 240-HOUR TRACKED-VEHICLE CYCLE OIL ADJUSTMENTS AND SAMPLING SCHEDULE

	Test Hours												
Operation	0	20	40	60	80	100	120	140	160	180	200	220	240
Oil Adjustments	-	X	X	X	X	X	X	X	X	X	X	X	-
Used Oil Sampled	-	X	X	*	X	X	*	X	X	*	X	X	*
Airbox Inspected	X	-	-	X	-	-	X	-	-	X	-	-	-
Oil Change	X	-	-	-	-	-	X	-	-	-	-	-	-

X indicates adjustment, sampling, or inspection to be performed at given test time.
* indicates 0.94-L (32-oz.) samples.

After the endurance test was completed, an after-test power curve at full-rack from 1800 to 2800 rpm at 200 rpm increments was run. The engine was then disassembled and the same components measured before the test were remeasured, with particular attention given to the piston ring end gap and the cylinder liner inside diameter. Next, the engine was rated for deposits, according to applicable Coordinating Research Council (CRC) rating methods for diesel engines.(25,26) Then photographs of the pistons, rings, cylinders, combustion chambers, and any unusual parts were taken. The engine was then rebuilt for the next test. The test fuel for all tests was Caterpillar 1H2/1G2 Reference Fuel(27) (0.4 wt% sulfur), with a typical analysis shown in Table 8.

2. <u>LD-465-1 and LDT-465-1C Engines</u>--The rebuilding and testing of the LD-465-1 and LDT-465-1C engines generally followed the same procedures as the 6V-53T tests. Exceptions were the following: the 210-hour Wheeled-Vehicle Cycle was used (oil sampling and addition schedule given in Table 9); before-test and after-test power curves were from 1200 to 2600 rpm at 200 rpm increments; and photographs of the intake and exhaust valves were taken. The test fuel for these tests was also Caterpillar 1H2/1G2 reference fuel.

TABLE 8. TYPICAL ANALYSIS OF TEST FUEL CATERPILLAR 1H/1G REFERENCE FUEL (AL-9488-F)

Property	ASTM Method	Specification Requirements*	Analysis
Distillation, °C(°F)	D 86		
Initial Boiling Point		Report	207(405)
10% recovered		Report	241(465)
50% recovered		500 min.	273(524)
90% recovered		600-640	317(602)
End Point		650-690	348(658)
Recovery, vol%		NR	99.0
Residue, vol%		NR	1.0
Loss, vol%		NR	0.0
Flash Point, °C(°F)	D 93	100 min	86(187)
Cloud Point, °C(°F)	D 2500	Report	-2(28)
Pour Point, °C(°F)	D 97	20 max	-12(10)
Viscosity at 38°C(100°F), cSt	D 445	1.6-4.5	3.3
Neutralization No., mg KOH/g	D 664	NR	0.0
Water & Sediment, vol%	D 1796	0.05 max	0.0
Cetane Number	D 613	40-45	52
Gravity, °API	D 287	Report	34.5
Net Heat of Combustion, J/kg (Btu/lb)	D 240	Report	42.13×10^6 (18130)
Sulfur, wt%	D 1552	0.35 min	0.404
Carbon Residues on 10% Bottoms, wt%	D 524	0.20 max	0.10
Copper Strip Corrosion, 2 hr at 50°C(122°F)	D 130	No. 2 max	1A

*See Reference 27.
NR = Not required.

TABLE 9. LD/LDT-465 ENGINE 210-HOUR TRACKED-VEHICLE CYCLE

	Test Hours													
Operation	14	28	42	56	70	84	98	112	140	154	168	182	196	210
Oil Adjustments	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Used Oil Sampled	X	X	X	X	*	X	X	X	*	X	X	X	X	*

X indicates adjustment, sampling, or inspection to be performed at given test time.
* indicates 0.94-L (32-oz) samples.

E. Test Evaluation

The results of the multigrade oil tests were evaluated by comparison with single-grade OE/HDO-30 or OE/HDO-10 test results using the same engine and test cycle. These two MIL-L-2104C lubricants were chosen because the OE/HDO-30 oil has shown good performance in the 6V-53T engine in the field. The OE/HDO-10 oil would be expected to show the cylinder liner scoring and ring burning in the 6V-53T engine that the low viscosity/high volatility MIL-L-2104B predecessors have shown.[27] With this information as the basis, the OE/HDO-30 endurance test results were designated acceptable performance level and the OE/HDO-10 endurance test results were designated borderline fail.

The criteria chosen for the comparative evaluations were a combination of lubricant physical and chemical properties and engine condition (mainly wear and deposits). For the 6V-53T engine tests, more attention was given to engine condition than to lubricant analyses, while for the LD/LDT-465 engine tests more attention was given to lubricant analyses than to engine condition. Although engine condition and lubricant analyses are important for both tests, favoring either engine condition or lubricant analyses indicates the main area of lubricant concern for that engine as well as the importance of the data obtained.

For example, in the LD/LDT-465 engine tests the cylinder liner diameter increase and piston ring end gap increase did not vary much between tests. The cylinder liner diameter increase for all tests varied from 0.00254 to 0.0127 mm (0.0001 to 0.0005 in.). Changes of this magnitude are at the limits of the measuring instruments used and are of the same magnitude as changes in diameter due to changes in ambient temperature of 10° to 30°F, which commonly occur. For a 102-mm (4-in.) diameter cylinder, and a 30°F change in temperature between measurements, a change in diameter of 0.00254 mm (0.0001 in.) solely due to temperature will occur, using 12×10^{-6} meters per meter of length per °C (6×10^{-6} in./in./°F) as the coefficient of thermal expansion for cast iron. Similarly the piston ring end gap increases did not vary between tests by more than 0.051 mm (0.002 in.), near the limits of the measuring instrument for this measurement also. As a result, the main test evaluation criteria for the LD/LDT-465 engine tests were the lubricant properties.

While the 6V-53T engine experienced a similar magnitude of ambient temperature changes and measurement limits, the changes in cylinder liner diameter and piston ring end gap increase were greater than those found in the LD/LDT engine. This decreased the errors in measurement due to temperature changes and instrument limits. In addition, the lubricant properties, over the span of one endurance test, did not vary nearly as much in the 6V-53T engine as they did in the LD/LDT-465-1 engine. So for the 6V-53T engine tests, the main test evaluation criteria were the engine conditions.

A summary of the tests conducted during this program is given in Table 10. Complete test result summaries are listed in Appendices A through M.

III. DISCUSSIONS OF RESULTS

The following discussion is based mainly on the summarized data in Tables 11 and 12 for the 6V-53T engine; in Tables 13 and 14 for the LD-465-1 engine; and in Tables 15 and 16 for the LDT-465-1C engine. The data in Tables 12, 14, and 16 compare with the data of Tables 11, 13, and 15, respectively, with the latter expressed as a percentage of the baseline oil test results for ease of comparison.

A. <u>6V-53T Engine 240-Hour Tracked-Vehicle Cycle Endurance Tests</u>

A summary of the test results considered important in determining lubricant performance is given in Tables 11 and 12.

Cylinder liner diameter increase, piston ring gap increase, liner scuffing, liner glazing, and ring face scuffing are important. Large amounts of any of these parameters can cause reduced power output, increased fuel consumption, reduced engine life, increased oil consumption, and fuel dilution of the oil,

TABLE 10. SUMMARY OF THE TESTS CONDUCTED FOR THE MULTIVISCOSITY-GRADE DIESEL ENGINE OIL DEVELOPMENT PROGRAM

6V-53T Engine 240-Hour Tracked-Vehicle Cycle Endurance Tests

Test No.	Lubricant Designation	SAE Viscosity Grade	Lubricant Basestock
3	A	30	Mineral
4*	B	10W	Mineral
5	C	10W-30	Polyalkylated Benzenes + Mineral
6	D	10W-30	Mineral
7	E	10W-30	Polyalfaolefins (PAO) + Polyol Ester
8	F	15W-40	Mineral
9	G	15W-40	Mineral

LD-465-1 Engine 210-Hour Wheeled-Vehicle Cycle Endurance Tests

Test No.	Lubricant Designation	SAE Viscosity Grade	Lubricant Basestock
1	B	10W	Mineral
2	I	10W-30	Synthetic hydrocarbon + ester
3	H	10W-30	Mineral + Synthetic

LDT-465-1C Engine 210-Hour Wheeled-Vehicle Cycle Endurance Tests

Test No.	Lubricant Designation	SAE Viscosity Grade	Lubricant Basestock
4	A	30	Mineral
5	E	10W-30	Polyalfaolefins (PAO) + Polyol Ester
6	G	15W-40	Mineral

* Test stopped at 140 hours due to severe scoring of cylinder 1L.

TABLE 11. SUMMARY OF 6V-53T ENGINE 240-HOUR TRACKED-VEHICLE CYCLE ENDURANCE TEST RESULTS

	*Test No. 3 SAE 30 A	**Test No. 4 SAE 10W B	Test No. 5 SAE 10W-30 C	Test No. 6 SAE 10W-30 D	Test No. 7 SAE 10W-30 E	Test No. 8 SAE 15W-40 F	Test No. 9 SAE 15W-40 G
Avg. Engine Condition							
Cylinder Liner Diameter Increase, cm (in.)	0.003 (0.0012)	0.003 (0.0012)	0.004 (0.0015)	0.004 (0.0015)	0.003 (0.0011)	0.003 (0.0011)	0.001 (0.0002)
Piston Ring End Gap Increase, cm (in.)	0.010 (0.004)	0.023 (0.009)	0.023 (0.009)	0.036 (0.014)	0.015 (0.006)	0.008 (0.003)	0.010 (0.004)
Cylinder Liner Scuffing, % area	18	38	34	33	22	11	11
Cylinder Liner Glazing, % area	21	10	10	5	14	9	13
Piston Ring Face Scuffing, % area	33	67	65	65	26	16	19
Piston WTD Deposits, CRC rating	369	343	306	308	309	365	349
Piston Ring Groove Carbon Filling, vol%	27	25	30	26	24	25	27
Number of Stuck Rings	2	0	1	1	1	1	3
Oil Consumption, kg/hr (lb/hr)	0.30(0.67)	0.30(0.67)	0.17(0.38)	0.31(0.68)	0.21(0.46)	0.33(0.72)	0.32(0.71)
Lubricant Properties							
Apparent Viscosity Increase at -29°C, %	ND	ND	ND	ND	ND	74	89
Apparent Viscosity Increase at -18°C, %	ND	17	ND	65	-13	62	101
Kinematic Viscosity Increase at 40°C, %	40	0	9	6	2	2	26
Kinematic Viscosity Increase at 100°C, %	16	9	1	-1	-5	-6	14
Iron in oil, ppm at end of test by XRF	88	260	250	164	202	56	59
AL Code	6856	6855	6947	7235/8531	8406	7172	9249

* Reference Oil.
** Test 4 (Reference Oil) stopped at 140 hours due to severe scoring of cylinder 1L.
ND = Not Determined.

TABLE 12. SUMMARY OF 6V-53T ENGINE 240-HOUR TRACKED-VEHICLE CYCLE ENDURANCE TEST RESULTS AS A PERCENTAGE OF LUBRICANT A OE/HDO-30 TEST RESULTS*

Avg. Engine Condition	Test 4** SAE 10W B	Test 5 SAE 10W-30 C	Test 6 SAE 10W-30 D	Test 7 SAE 10W-30 E	Test 8 SAE 15W-40 F	Test 9 SAE 15W-40 G
Cylinder Liner Diameter Increase, %	0	+30	+30	-10	-10	-30
Piston Ring End Gap Increase, %	+130	+130	+250	+50	-20	0
Cylinder Liner Scuffing, % RTA	+110	+90	+80	+20	-40	-40
Piston Ring Face Scuffing, %	+100	+100	+100	-20	-50	-40
Piston WTD Deposits, %	-10	-20	-20	-20	0	-10
Piston Ring Groove Carbon Filling, %	-10	+10	0	-10	-10	0
Oil Consumption, %	0	-40	0	-30	+10	+10
Lubricant Properties						
Kinematic Viscosity Increase at 40°C***, %	-100	-80	-90	-100	-100	-40
Kinematic Viscosity Increase at 100°C, %	-40	-90	-100	-130	-130	-10
Iron in the Oil, %	+200	+180	+90	+130	-40	-30
Averaged Performance Percentage, %	+38	+31	+34	-12	-39	-24
AL Code	6855	6947	7235/8531	8406	7172	9249

* The numbers indicate the percent more (+) or less (-) of the given quantity than the acceptable performance level test results. Negative numbers reflect better performance.

** Test 4 stopped at 140 hours due to severe scoring of cylinder 1-left.

*** For viscosity, % increase = [(% increase test oil/% increase acceptable performance level oil)-1] x 100.

RTA = Ring Travel Area.

TABLE 13. SUMMARY OF LD-465-1 ENGINE 210-HOUR WHEELED-VEHICLE CYCLE TEST RESULTS

Lubricant Properties	Test 1 SAE 10W B	Test 2 SAE 10W-30 I	Test 3 SAE 10W-30 H
Kinematic Viscosity Increase at 40°C, %	38	61	48
Kinematic Viscosity Increase at 100°C, %	38	42	32
Pentane B Insolubles, wt%, ASTM D 893	5.0	1.3	0.2
Iron in the Oil, ppm by XRF*	263	167	247
Avg. Engine Condition			
Cylinder Liner Diameter Increase,			
cm	-0.0003	-0.0005	0.0006
(in.)	(-0.0001)	(-0.0002)	(-0.0059)
Piston Ring Gap Increase,			
cm	0.008	0.008	0.010
(in.)	(0.003)	(0.003)	(0.004)
Piston WTD Deposit Rating	131	91	112
Intake Valve Tulip Deposit Rating	3.9	2.7	2.9
Oil Consumption, kg/hr(lb/hr)	0.17(0.38)	0.10(0.21)	0.07(0.15)
AL Code	6855	6942	7288

*XRF = X-ray fluorescence.

TABLE 14. SUMMARY OF LD-465 ENGINE 210-HOUR WHEELED-VEHICLE CYCLE TEST RESULTS AS A PERCENTAGE OF LUBRICANT B OE/HDO-10 BORDERLINE TEST RESULTS*

Lubricant Properties	Test 2 SAE 10W-30 I	Test 3 SAE 10W-30 H
Kinematic Viscosity Increase at 40°C**, %	+61	+28
Kinematic Viscosity Increase at 100°C, %	+11	-16
Pentane B Insolubles, %, ASTM D 893	-74	-96
Iron in the oil, % by XRF***	-37	-6
Avg. Engine Condition		
Piston Ring Gap Increase, %	0	+33
Piston WTD Deposit Rating, %	-31	-15
Intake Valve Tulip Deposit Rating, %	-31	-26
Oil Consumption, %	-45	-61
Averaged Performance Percentage, %	-18	-20
AL Code	6942	7288

* The numbers indicate the percent more (+) or less (-) of the given quantity than the borderline fail test results.

** For viscosities, % increase = [(% increase test oil/% increase borderline fail oil) - 1] x 100.

*** XRF = X-ray fluorescence.

TABLE 15. SUMMARY OF LDT-465-1C ENGINE 210-HOUR WHEELED-VEHICLE CYCLE TEST RESULTS

Lubricant Properties, End of Test	ASTM Method	Test 4 SAE 30 A	Test 5 SAE 10W-30 E	Test 6 SAE 15W-40 G
Kinematic Viscosity Increase at 40°C, %		170	15	86
Kinematic Viscosity Increase at 100°C, %		100	8	46
Total Acid Number, mg KOH/g	D 664	6.0	4.4	5.8
Total Base Number, mg KOH/g	D 2896	5.5	2.3	2.6
Pentane B Insolubles, wt%	D 893	6.7	2.4	3.2
Toluene B Insolubles, wt%	D 893	5.3	2.1	2.4
Carbon Residue, wt%	D 524	7.1	3.1	3.9
Sulfated Ash, wt%	D 874	3.6	1.8	1.9
Iron in the Oil, ppm by XRF*		108	252	157
Avg. Engine Condition				
Cylinder Liner Diameter Increase, cm (in.)		0.0013 (0.0005)	0.0002 (-0.0001)	0.0013 (0.0005)
Piston Ring End Gap Increase, cm (in.)		0.0051 (0.002)	0.0051 (0.002)	0.0051 (0.002)
Piston WTD Deposit Rating		274	177	274
Intake Valve Tulip Deposit Rating		3.5	0.4	1.8
Oil Consumption, kg/hr(lb/hr)		0.34(0.74)	0.16(0.35)	0.17(0.38)
AL Code		8980	8924	9249

*XRF = X-ray fluorescence.

TABLE 16. SUMMARY OF LDT-465-1C ENGINE 210-HOUR WHEELED-VEHICLE CYCLE TEST RESULTS AS A PERCENTAGE OF LUBRICANT A OE/HDO-30 TEST RESULTS

Lubricant Properties	ASTM Method	Test 5 SAE 10W-30 E	Test 6 SAE 15W-40 G
Kinematic Viscosity Increase at 40°C**, %		-91	-49
Kinematic Viscosity Increase at 100°C, %		-92	-54
Total Acid Number, %	D 664	-27	-3
Total Base Number, %	D 2896	-58	-53
Pentane B Insolubles, %	D 893	-64	-52
Toluene B Insolubles, %	D 893	-60	-55
Carbon Residue, %	D 524	-56	-45
Sulfated Ash, %	D 874	-50	-47
Iron in the Oil, % by XRF***		+133	+45
Avg. Engine Condition			
Cylinder Liner Diameter Increase, %		0	0
Piston Ring End Gap Increase, %		0	0
Piston WTD Deposit Rating, %		-35	0
Intake Valve Tulip Deposit Rating, %		-89	-49
Oil Consumption, %		-53	-49
Averaged Performance Percentage, %		-39	-29
AL Code		8924	9249

* The numbers indicate the percent more (+) or less (-) of the given quantity than the acceptable performance level test results.
** For viscosities, % increase = [(% increase test oil/% increase acceptable performance level oil) - 1] x 100.
*** XRF = X-ray fluorescence.

all due to ineffective gas sealing between the combustion chamber and crankcase. Deposits are important because they can also contribute to ineffective sealing between the combustion chamber and crankcase by causing ring sticking and cylinder liner wear. Deposits can also cause the exhaust valves to stick and burn, resulting in a poor combustion chamber seal.

The lubricant properties of Apparent and Kinematic Viscosity are important because changes in them are indicators of the oxidation, fuel dilution, and soot quantity as well as the stability of the viscosity index (VI) improvers. Oxidation and soot tend to increase the viscosity, while fuel dilution and shearing of the polymeric VI improvers tend to decrease the viscosity as an oil is used. Areas to check during observation of viscosity change of the oil include ensuring that the oil does not become so viscous that cranking, starting, running, or pumpability is impaired, or becomes thin so that the oil fails to maintain an adequate hydrodynamic film on critical engine components such as bearing and cams.

Since there was only one endurance test run with a given lubricant, the effect of variables on the repeatability and reproducibility of the test results is unknown and can only be estimated.

From the data in Tables 11 and 12, cylinder liner diameter increase was essentially equal for all oils, with the exception of Lubricant G which had roughly 17 percent of the increase of the others. Although the uncertainty due to ambient temperature differences between before and after test measurements remained, the difference in cylinder liner diameter increase between Lubricant A, the OE/HDO-30 and Lubricant G was enough to conclude that cylinder wear was less using Lubricant G.

Piston ring end gap increase was substantially higher for all the oils except the two 15W-40 oils, Lubricant F and Lubricant G, which were equal to the acceptable performance level results. With end gap changes of such magnitude, the errors due to ambient temperature changes were much less, and the changes seen here can be much more confidently attributed to differences in oils. It is worth noting that all the oils with the larger end gap increases are 10W-30 oils, while the two oils with end gap increases equal to the baseline are both 15W-40 oils.

The average cylinder liner scuffing also roughly followed the same trend that the ring gap increase did; the 10W-30 oils had more scuffing than the OE/HDO-30 baseline while the 15W-40 oils had less scuffing than the OE/HDO-30 baseline.

Ring face scuffing was higher than the OE/HDO-30 oil for Lubricant B, C, and D. It was less than the OE/HDO-30 oil for Lubricants E, F, and G. Again, the two 15W-40 oils performed better than the OE/HDO-30 oil, with one 10W-30, Lubricant E, also doing better than the OE/HDO-30 oil.

Piston Weighted Total Deposits (WTD) ratings, ring groove carbon filling, and number of stuck rings were essentially equal for all oils tested, leading to the conclusions that either all these oils had similar deposit-forming tendencies, or the test was unable to discriminate between oils in this respect.

Oil consumption was also roughly equal for all oils tested, except for Lubricant C and Lubricant E, which had 60 and 70 percent of the oil consumption of the OE/HDO-30 oil, respectively.

The kinematic viscosity increases at 40° and 100°C were less for all oils tested, with Lubricants D, E, B, and F performing the best.

The apparent viscosity increases at -29° and -18°C cannot be compared to acceptable performance level oil test results since viscosities at these temperatures were not obtained for the OE/HDO-30 oil (SAE 30 grade does not flow at these temperatures). However, comparisons between the different test oils show that Lubricant E had the least increase (actually a 13 percent decrease) of all oils, with Lubricant B next.

The amount of iron in the oil, an indicator of wear, was substantially more for all oils tested except the two 15W-40 oils, Lubricant F and Lubricant G.

The averaged performance percentage (APP) is the average of all the performance figures for a given oil. For all of the quantities in Table 11, a more positive (+) value is worse, so that the more negative (-) a value is, the better. Lubricant F has the best APP at -39 percent, indicating that overall it performed substantially better than the OE/HDO-30 baseline. Lubricant G was next at -24 percent APP, also substantially better than the OE/HDO-30 baseline. The next APP was Lubricant E, just slightly better overall than the baseline. Lubricants C, D, and B with APP ratings of 31, 34, and 38 percent, respectively, were alike in that all were substantially worse overall than the OE/HDO-30 oil.

Figure 3 graphically represents these APP results and shows that Lubricants G, F, and E all performed better than the OE/HDO-30, while Lubricants C, D, and B all performed worse.

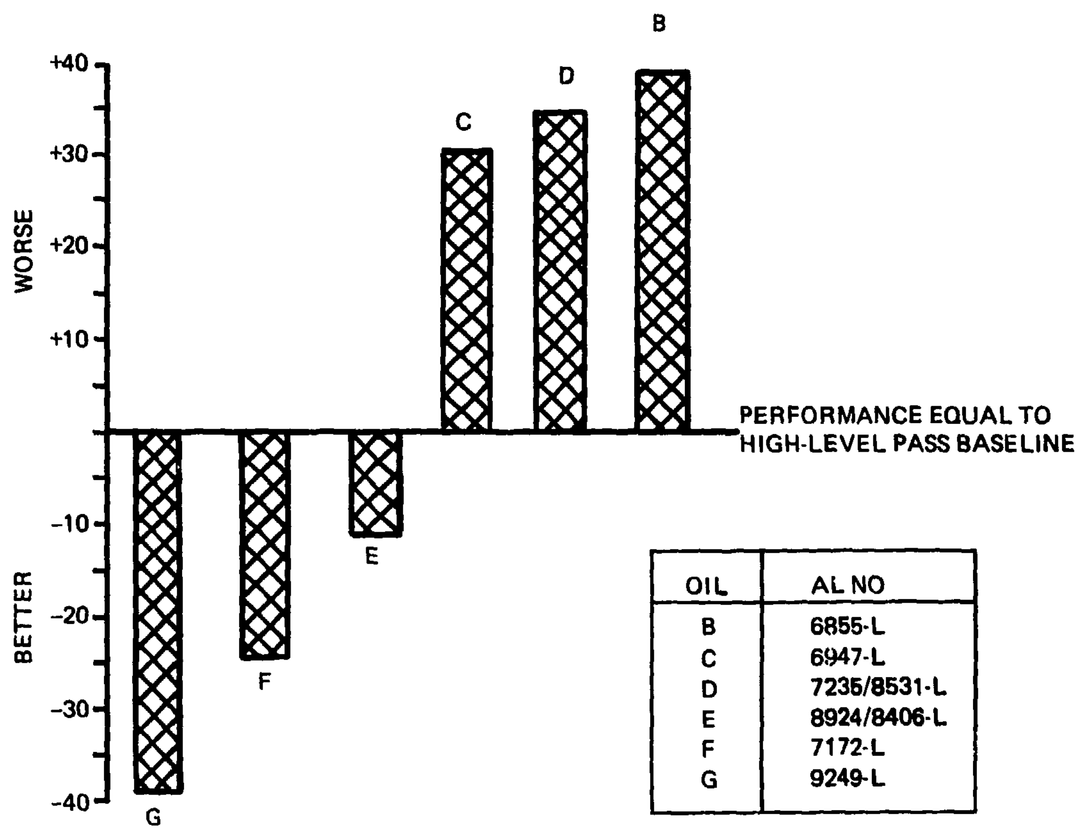


FIGURE 3. AVERAGE PERFORMANCE PERCENTAGES FOR THE 6V-53T ENGINE 240-HOUR TRACKED-VEHICLE CYCLE TESTS

B. LD/LDT-465 Engine 210-Hour Wheeled-Vehicle Cycle Endurance Tests

Initially, the LD-465-1 engine configuration was used for these endurance tests, but was later changed to the LDT-465-1C engine turbocharged configuration to make the test more severe than it had been. Since the two types of 465 engines had different operating conditions [LD-465-1 engine maximum power of approximately 99 kW (133 bhp) versus LDT-465-1C engine maximum power of approximately 112 kW (150 bhp)], the test results using one configuration will be considered separately from the test results of the other configuration. Tables 13 through 16 summarize the LD-465 engine and LDT-465-1C engine test results considered important in determining lubricant performance.

Again, since only one endurance test was run with a given lubricant, the effect of random variables on test results is unknown. Complete data for all tests are given in References 8 through 20.

C. LD-465-1 Engine 210-Hour Wheeled-Vehicle Cycle Endurance Tests

From the data in Tables 13 and 14, the kinematic viscosities at 40°C of both oils increased much more than the borderline fail baseline oil. While the borderline fail oil, Lubricant B, was designated so because of its high volatility and subsequent poor performance in the 6V-53T engine, it also was the oil the Army used in low-ambient temperature conditions. Because of this, Lubricant B was a suitable reference oil for low-temperature viscosity increases. Any oil which increased in viscosity more than the Lubricant B OE/HDO-10 baseline was suspect due to the insufficient data on cold cranking, starting-and-running, and lubricant pumpability for Army engines,[6] compounded by a lack of agreement among manufacturers concerning viscosity limits (Figure 4). Since both Lubricant I and Lubricant H increased in viscosity more than the OE/HDO-10 baseline, there is some doubt as to its desirability as a MIL-L-2104C oil.

D. LDT-465-1C Engine 210-Hour Wheeled-Vehicle Cycle Endurance Tests

The data in Tables 15 and 16 show that both test oils Lubricant E and Lubricant G had much less viscosity increase at 40°C and at 100°C than the OE/HDO-30 oil. While this lack of increase is encouraging, the data did not tell how the two test oils performed relative to the OE/HDO-10 oils used at the lower ambient temperatures. Nor did it indicate whether viscosity increases encountered in the test oils would cause cold cranking, starting-and-running, and lubricant pumpability problems in the engines the Army uses. Although limited data exist,[6] additional information is necessary before any lubricant can be evaluated for its low-temperature properties. The best

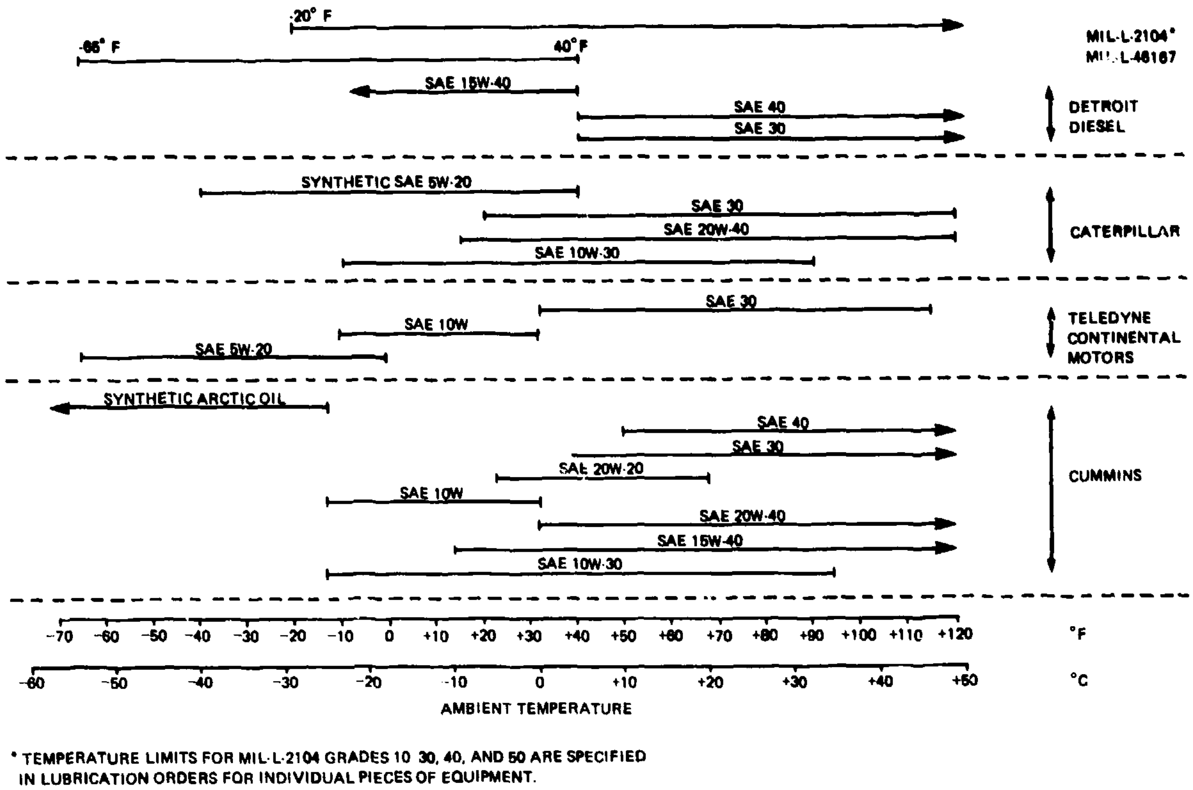


FIGURE 4. SURVEY OF RECOMMENDED AMBIENT TEMPERATURE AND LUBRICANT VISCOSITY RANGES

use for the present data is evaluating it against the OE/HDO-30 oil and deciding whether the two test oils are better than the OE/HDO-30 in the applications where the OE/HDO-30 is presently in use.

Examination of the data on this basis shows both test oils performed much better in all categories except in the amount of iron in the oil, as determined by X-ray fluorescence (XRF). Since the measured wear of the critical engine parts (cylinders, rings) was equal for all tests, and all engine parts looked normal regarding wear, perhaps the difference was due to differing oil consumptions or corrosion and wear of engine parts not measured.

The Total Base Number (TBN) for both test oils was less than the OE/HDO-30 baseline oil at the end of the test, indicating less reserve alkalinity remaining to offset the acidic products of combustion. Since the two test oils both had a lower TBN and a higher iron concentration than the OE/HDO-30 oil, there may be a relation between the two that further investigations could uncover. The sludge and deposit-forming tendency indicators of Pentane B Insolubles, Toluene B Insolubles, Carbon Residue, and Sulfated Ash were much lower for both test oils, as were actual piston and intake valve deposits. The oil consumption was also much lower for both test oils. All these factors averaged together gave an APP of -39 percent for Lubricant E and -29 percent for Lubricant G, indicating that both oils tested were better overall than the OE/HDO-30 acceptable performance level oil in this test.

E. Relationships Between Variables

In this section, the possible relationship between different variables (e.g., oil viscosity or volatility versus wear, and oil basestock or oil additives versus wear or deposits) is explored. The discovery of relationships between variables can hopefully be used to set specifications and specification limits, to reduce test costs, to improve lubricant performance, and to aid in preventive maintenance.

One of the relationships of interest is whether the rate of engine wear can be obtained from examination of properties of the new or used oil. Table 17 lists the variables examined for relations to wear and the resulting curve fits with the "goodness of fit" measure, R^2, having a value of $R^2 = 0$ for no fit and $R^2 = 1$ for a perfect fit. Note that iron production rate and ring gap increase rate correlate excellently. This means that most of the iron in the lubricant is coming from ring wear, assuming the quantity of iron in the oil agrees with ring weight loss. The iron production rate was obtained by taking the amount of iron in the oil as determined by XRF, accounting for the iron lost in sampling and consumption, and converting this to a rate basis along with the other variables examined. This way comparisons with 240-Hour Tracked-Vehicle Cycle Tests that did not finish the full 240 hours (such as Test 4) are possible, and an indication is given in terms of rate-of-wear/hour that can be compared with other test cycles and test engines for test severity.

TABLE 17. WEAR-RELATED CORRELATIONS BETWEEN VARIABLES FOR THE 6V-53T ENGINE 240-HOUR TRACKED-VEHICLE CYCLE TESTS

Test Number	Fe Production Rate, mg/hr	Ring Gap Increase rate, in.x10^{-5}/hr	Liner Scuffing Rate, % Area/hr Thrust	Liner Scuffing Rate, % Area/hr Overall	Ring Face Scuff Rate, % Area/hr	Cylinder ID Change rate, in.x10^{-6}/hr
3	24	1.7	0.10	0.08	0.14	5.0
4	102	6.4	0.29	0.27	0.48	8.6
5	71	3.8	0.20	0.14	0.27	6.3
6	103	5.8	0.19	0.14	0.27	6.3
7	42	2.5	0.10	0.09	0.11	4.6
8	23	1.3	0.05	0.05	0.07	4.6
9	21	1.7	0.06	0.05	0.08	0.8

Linear Regression Data Fits With Coefficients of Determination (R^2)

Fe production rate vs. Ring gap increase rate: $Y = -2.8 + 17.5X$, $R^2 = 0.98$

Fe production rate vs. Liner scuffing rate, Thrust: $Y = 0.8 + 384X$, $R^2 = 0.84$

Fe production rate vs. Liner scuffing rate, Overall: $Y = 7.0 + 410X$, $R^2 = 0.74$

Fe production rate vs. Ring face scuffing rate: $Y = 10.0 + 220X$, $R^2 = 0.79$

Fe production rate vs. Cylinder ID change rate: $Y = -7.5 + 12X$, $R^2 = 0.62$

Liner scuffing rate, thrust vs. Ring face scuffing rate: $Y = 0.02 + 0.59X$, $R^2 = 0.98$

Ring gap increase rate vs. Ring face scuffing rate: $Y = 0.69 + 13X$, $R^2 = 0.85$

Also showing an excellent correlation is Liner Scuffing Rate versus Ring Face Scuffing Rate, with $R^2 = 0.98$. This correlation indicates that a third quantity is affecting both the liner and the rings in a directly proportional manner, or that the rings or the liner are scuffed, which in turn scuffs the other. Showing less correlation, but nonetheless relatively good fits are iron products versus liner scuffing and Ring Gap Increase Rate versus Ring Face Scuff Rate with $R^2 = 0.84$ and 0.85, respectively. This correlation is an indication that the predominant wear mechanism is done by scuffing as opposed to smooth, even wear. Since there is a tentative connection between ring/ liner wear and lubricant volatility,(6) these data suggest that to reduce wear, scuffing is the major area of focus, and lubricant volatility may be the indicator. Lubricant volatility experiments should be performed in order to test the assertions of Reference 5, and to investigate correlations with oil consumption. The other data fits show some correlation, but not enough for a definite conclusion to be drawn. Other attempted correlations show that there is some linear correlation between ring wear versus kinematic viscosity at 40° or 100°C (R^2 = 0.61 and 0.67), or between ring scuffing versus kinematic viscosity at 40° or 100°C (R^2 = 0.48 and 0.57). Experiments should be performed to see if viscosities at the temperature encountered on the cylinder walls would correlate better with wear. The lack of volatility data, high-temperature viscosity data, and the limited number of lubricants of varying basestocks make it impossible at this time to discriminate the performance of different lubricants on the basis of lubricant basestock, additives, or interactions between the two.

There is insufficient data to draw significant correlations between variables in either the LD-465-1 engine tests or the LD-465-1C engine tests, each with a total of three tests conducted. The fact that little difference is seen between available test results, besides oil consumption and viscosity increases, also makes any significant analysis difficult.

V. CONCLUSIONS

A. 6V-53T Engine 240-Hour Tracked-Vehicle Cycle Tests

- Cylinder liner wear is not great enough to make distinctions between oils.
- Ring wear is great enough to begin making distinctions between oils.
- Piston WTD deposits and ring groove carbon filling did not vary much between the tested oils.
- A correlation exists between the rate that iron is introduced into the oil and the observed piston ring wear rate. The curve fit for this correlation with R^2 = 0.98 is: Fe production rate (mg/hr) = -2.8 + 17.5

[Ring Gap Increase Rate (in. x 10^{-5}/hr)] or Ring Gap Increase Rate = 0.23 + 0.056 (Fe production rate).

- There is also a direct correlation between cylinder liner scuffing and ring face scuffing. The equation is Linear Scuffing Rate = 0.02 ± 0.59 (Ring Scuffing Rate).

- Overall, the test oils Lubricants E, F, and G performed better than the OE/HDO-30 reference oil and would be satisfactory replacements for OE/HDO-30 in 6V-53T engines. Lubricants C, D, and B performed worse than the OE/HDO-30 oil. Use of the three oils that performed better overall might result in more ring wear with Lubricant E, less with Lubricant F, and equal ring wear with Lubricant G. Use of all three might also result in less scuffing, equal or less deposits, less oil thickening and equal or slightly more oil consumption, except for Lubricant E with less oil consumption. Use of the three oils that performed worse might result in more wear, more scuffing, less deposits, equal or less oil consumption and less oil thickening.

- 240-hr 6V-53T cycle provides lubricant discrimination and is suitable for use in the proposed MIL-L-2104D specification.

B. <u>LD-465-1C Engine 210-Hour Wheeled-Vehicle Cycle Tests</u>

- The viscosities of both test oils Lubricant I and Lubricant H increased more than the OE/HDO-10 baseline oil, and are doubtful as MIL-L-2104 oils until more data on cold cranking, starting-and-running, and lubricant pumpability for Army engines can be obtained.

- Insufficient data exist to make significant correlations between variables.

C. <u>LDT-465-1C 210-Hour Wheeled-Vehicle Cycle Tests</u>

- Overall, the two test oils, Lubricant E and Lubricant G, both performed better than the OE/HDO-30 baseline and would be satisfactory replacements for applications in LD/LDT-465 engines where the OE/HDO-30 oil is used now. Potential benefits are equal wear, equal or fewer deposits, less oil thickening, and less oil consumption.

- The performance of the two test oils in regards to excessive low-temperature viscosity increases is still unknown due to the lack of data on cold cranking, starting-and-running, and lubricant pumpability for Army engines.

- Lubricant F and Lubricant G appear acceptable as SAE 15W-40 multiviscosity-grade MIL-L-2104 specification oils. Acceptance should be provisional pending the results of work defining low-temperature viscosity limits in Army engines. Although Lubricant E performed acceptably overall, the ring wear seen when using this oil is cause for further investigation.

VI. RECOMMENDATIONS

- A detailed cost-benefit analysis should be performed based on the costs (initial, operational, logistical) of the current MIL-L-2104C oils, and initial screening criteria should be developed to eliminate those candidate lubricants that would not result in an economical solution to the problems they solve.

- Additional testing should be conducted in order to evaluate current and future 10W-X candidate MIL-L-2104 lubricants.

- The effects that current and potential MIL-L-2104 lubricants have on Army combat/tactical engines should be quantified through extensive analysis of field service records, or controlled field tests as necessary to obtain clear results concerning service life at rated power, startability, and fuel and oil consumption rates. In the past, uncontrolled field tests and field service records have yielded ambiguous figures.[7] Modifications to past procedures or using controlled field tests may be necessary. The data derived from such tests are necessary to evaluate the discriminatory capabilities of other tests used to evaluate lubricants. Any test used to evaluate lubricant performance should rank oils in the same order as actual service.

- The actual limits of oil viscosity for successful cranking, starting-and-running, and lubricant pumpability should be defined. This could be done by testing Army combat/tactical engines at temperatures ranging from extreme cold to moderate cold.

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APPENDIX A

ENGINE-LUBRICANT COMPATIBILITY TEST #3
240-HOUR TRACKED-VEHICLE CYCLE
USING 6V-53T DIESEL ENGINE

ENGINE-LUBRICANT COMPATIBILITY TEST
240-HOUR TRACKED VEHICLE CYCLE
USING 6V53T DIESEL ENGINE

Test Lubricant: MC-520 (AL-6856-L)
Engine Test Number: CI 5136206-3
Date Completed: 2 February 1979

Conducted for

U.S. Army Mobility Equipment Research and Development Command
Energy and Water Resources Laboratory
Fort Belvoir, Virginia

By

U.S. Army Fuels and Lubricants Research Laboratory
Southwest Research Institute
San Antonio, Texas 78284

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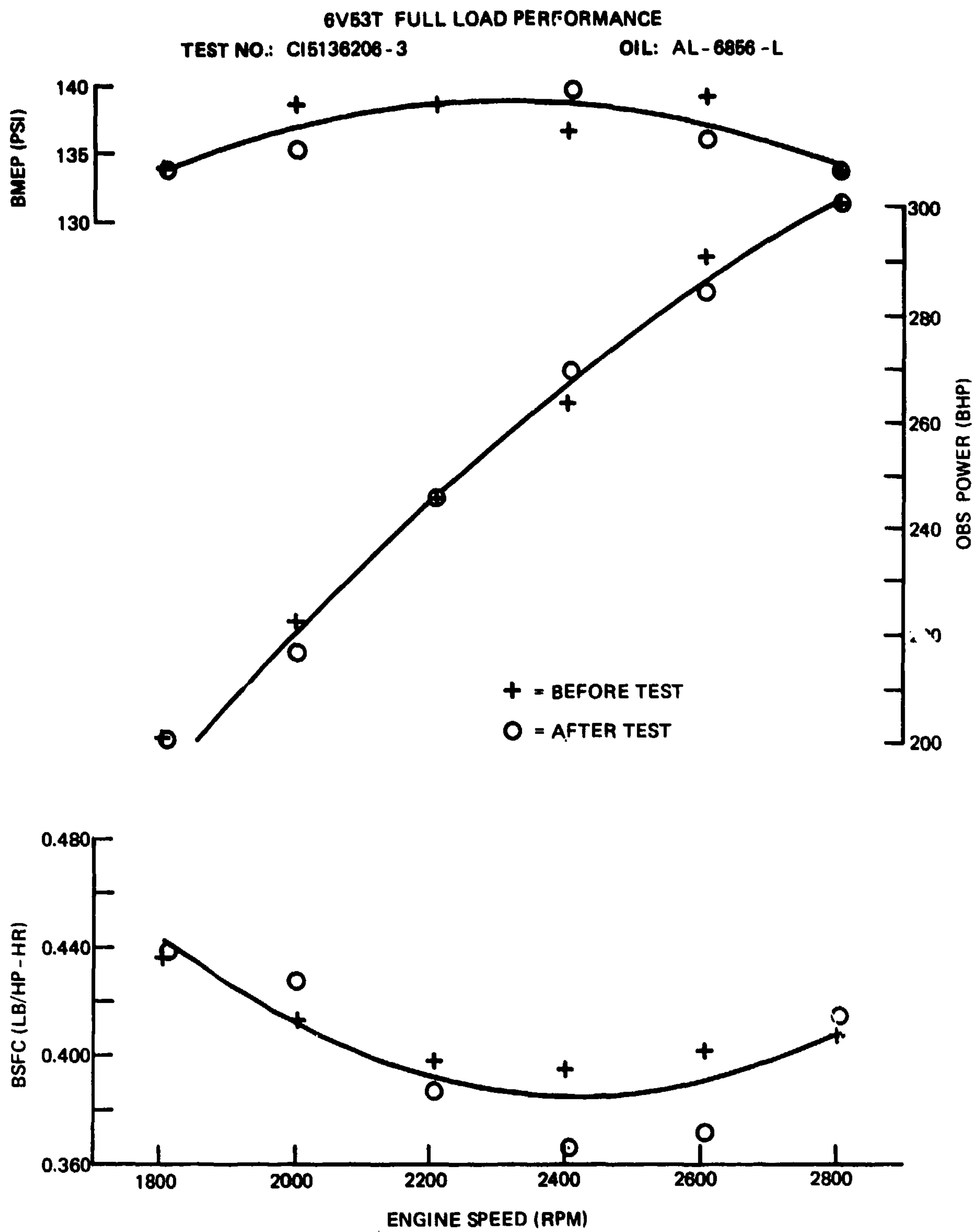
6V53T CI5136206-3
BUILD-UP ENGINE MEASUREMENTS

	INCHES			
Measurements	Min	Max	Avg	Specified Limits (1)
Crankshaft main bearing clearance	0.0043	0.0046	0.0044	0.0010-0.0040
Camshaft bearing clearance				
Left Cam	0.0040	0.0055	0.0047	0.0080 max
Right Cam	0.0041	0.0050	0.0045	0.0080 max
Connecting rod bearing clearance	0.0014	0.0026	0.0021	0.0011-0.0041
Crankshaft end-play			0.005	0.004-0.011
Oil pump				
Between rotors			0.003	0.004-0.011
Outer rotor/housing	0.0015	0.0015	0.0015	0.001-0.0035
Cylinder liner block bore				
Taper	0.0000	0.0005	0.0003	0.0015 max
Out-of-round	0.0000	0.0012	0.0007	0.0015 max
Inside diameter	4.3568	4.3580	4.3573	4.3595 max
Cylinder liners (installed)				
Taper	0.0001	0.0009	0.0004	0.002 max (2)
Out-of-round	0.0000	0.0005	0.0001	0.003 max (2)
Inside diameter	3.8750	3.8766	3.8754	3.8752-3.8767
Piston to liner fit	0.0075	0.0095	0.0081	0.0060-0.0095
Piston diameter	3.8653	3.8675	3.8666	3.8669-3.8691
Fire ring				
End gap	0.026	0.034	0.030	0.020-0.046
Side clearance	0.002	0.003	0.003	0.003-0.006
#1 Compression ring				
End gap	0.025	0.030	0.029	0.020-0.046
Side clearance	0.008	0.009	0.008	0.007-0.010
#2 & #3 Compression rings				
End gap	0.025	0.034	0.028	0.020-0.046
Side clearance	0.006	0.007	0.006	0.005-0.008
Oil rings				
End gap	0.018	0.023	0.020	0.010-0.025
Side clearance	0.002	0.003	0.002	0.0015-0.0055

(1) Limits on new parts unless maximum wear limit specified.
(2) Wear limits with new liners in a used block.

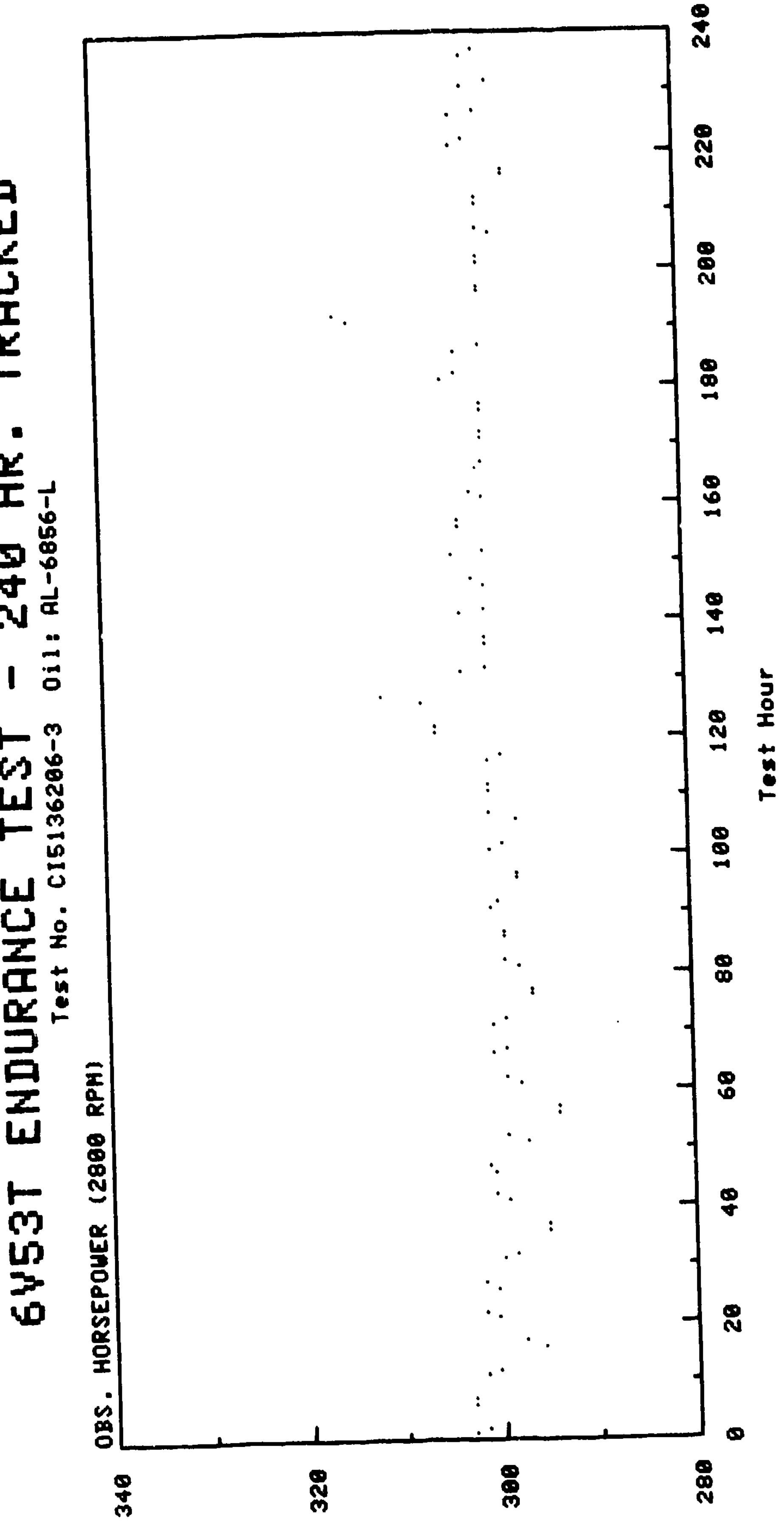

6V53T FULL LOAD PERFORMANCE
TEST NO.: CI5136206-3
OIL: AL-6856-L
BMEP (PSI)
140
135
130
OBS POWER (BHP)
300
280
260
240
200
+ = BEFORE TEST
O = AFTER TEST
BSFC (LB/HP-HR)
0.480
0.440
0.400
0.360
1800
2000
2200
2400
2600
2800
ENGINE SPEED (RPM)

6V53T ENDURANCE TEST
SUMMARY OF OPERATING DATA

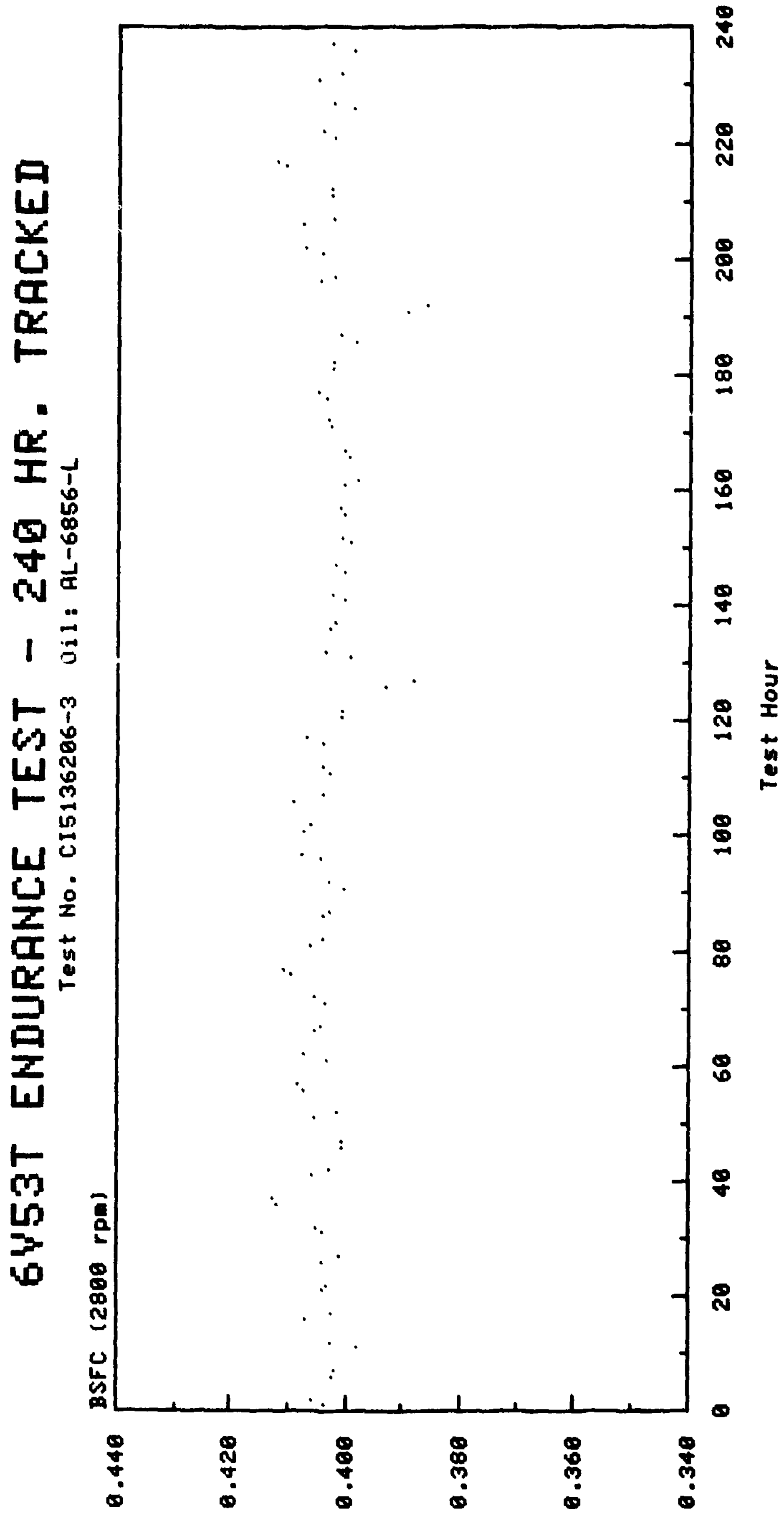
OIL: AL-6856-L

TEST NO.: CI 5136206-3

	2200 RPM			2800 RPM		
	Avg	Min	Max	Avg	Min	Max
Engine Speed, rpm	2204	2198	2210	2807	2798	2818
Load, lb	462	445	469	438	433	469
Obs. Power, bhp	248	239	253	300	296	322
Fuel Rate, lb/hr	97.2	96.1	98.2	120.7	119.6	121.8
BSFC, lb/bhp-hr	0.392	0.388	0.402	0.402	0.378	0.404
Temperatures, °F						
Jacket In	145	127	155	136	125	145
Jacket Out	158	150	165	152	149	158
Oil Sump	247	245	249	250	248	250
Inlet Air (Compressor)	73	52	83	76	52	86
Airbox	226	239	203	273	249	293
Exhaust before Turbo	985	930	1010	1012	950	1040
Exhaust after Turbo	774	370	870	726	490	890
Fuel at Filter	85	99	62	91	78	99
Pressures, psig						
Compressor Discharge	8.5	8.4	9.0	12.0	11.6	12.7
Blower Discharge	10.7	10.4	11.4	18.0	17.4	19.0
Exhaust Before Turbo	8.3	8.2	8.7	12.5	12.2	12.7
Oil Consumption (lb/hr avg for 240 hr)	0.646					



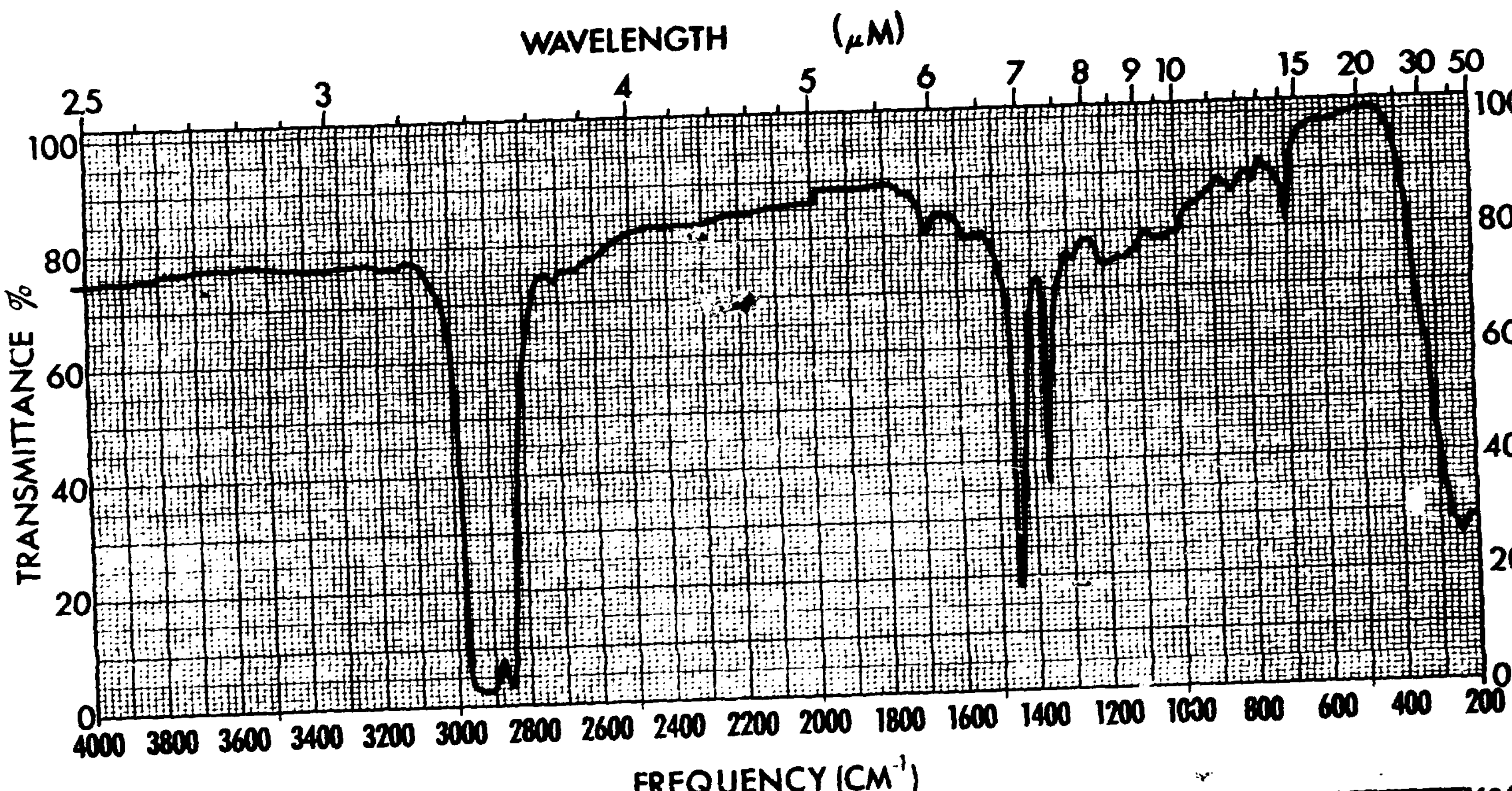
6V53T ENDURANCE TEST - 240 HR. TRACKED
Test No. CI5136206-3 Oil: AL-6856-L
OBS. HORSEPOWER (2800 RPM)
340
320
300
280
0
20
40
60
80
100
120
140
160
180
200
220
240
Test Hour


6V53T ENDURANCE TEST - 240 HR. TRACKED
Test No. CI5136206-3 Oil: AL-6856-L
BSFC (2800 rpm)
0.440
0.420
0.400
0.380
0.360
0.340
0
20
40
60
80
100
120
140
160
180
200
220
240
Test Hour

LUBRICANT ANALYSIS
6V53T - CI5136206-3
LUBRICANT: AL-6856-L
FUEL: 1-H CAT

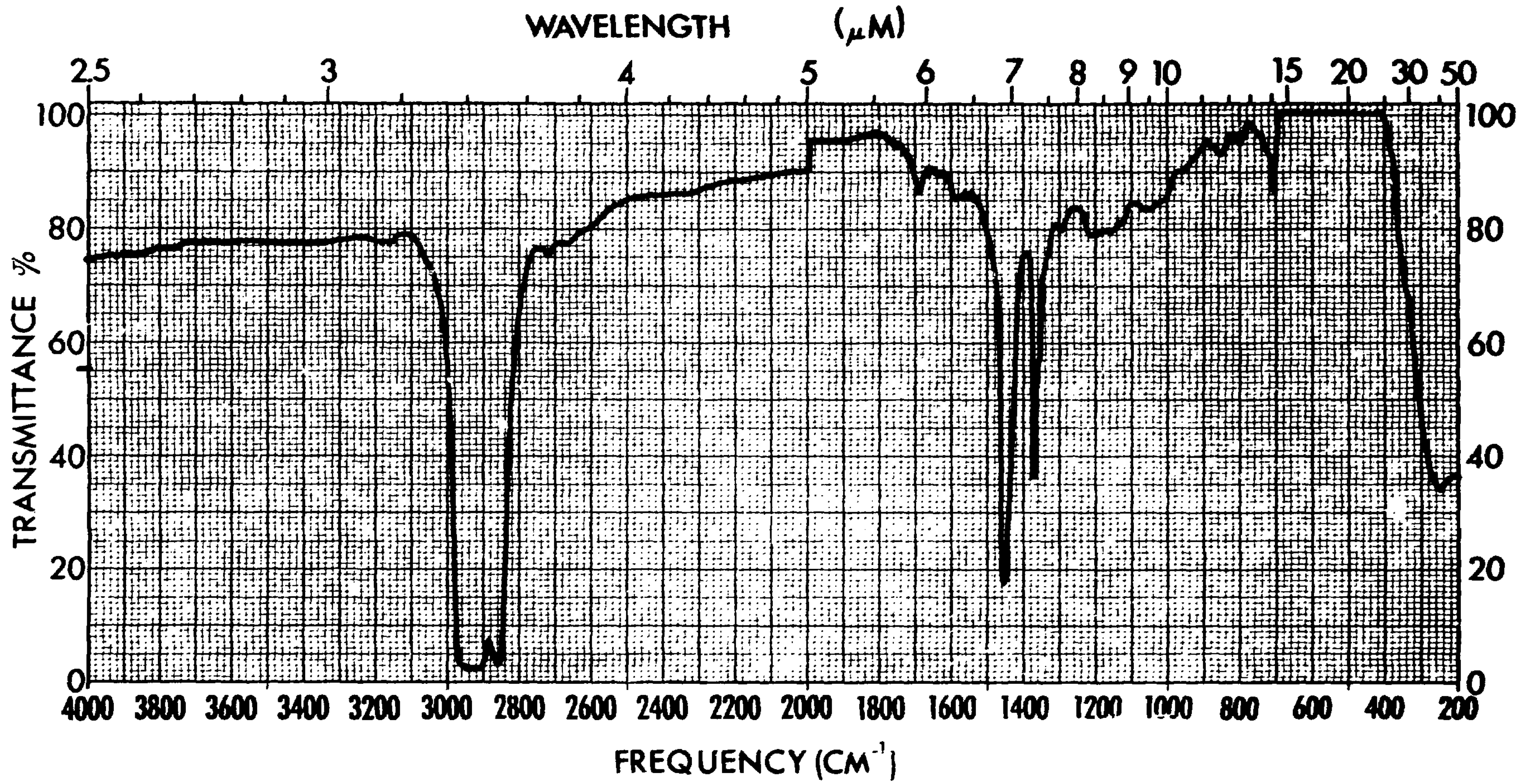
Property	ASTM Method	New	20	40	60	80	100	120	140	160	180	200	220	240
								TEST HOUR						
K. Vis @40°C, cSt	D 445	106.7	127.0	139.8	148.5	153.0	154.5	155.4	128.9	136.3	142.6	146.3	149.2	149.6
K. Vis @100°C, cSt	D 445	11.65	11.91	12.70	13.06	13.43	13.66	13.69	12.09	12.40	12.78	13.08	13.26	13.39
VI	D 2270	96	78	79	77	78	81	80	80	77	77	79	79	81
TAN	D 664	2.3	2.56	2.65	2.76	3.24	3.21	3.52	2.83	3.09	3.09	3.73	3.63	3.53
TBN	D 2896	13.9	12.00	11.26	11.75	11.75	11.75	12.98	11.26	11.51	11.51	12.00	11.51	12.00
Insolubles, %	D 893													
Pentane A		0.04	0.05	0.08	0.06	0.09	0.08	0.08	0.07	0.08	0.10	0.08	0.09	0.07
Benzene A		0.04	0.08	0.09	0.05	0.09	0.08	0.05	0.06	0.07	0.07	0.06	0.06	0.05
Pentane B		0.03	0.07	0.12	0.11	0.66	0.93	0.97	0.08	0.26	0.33	0.49	0.87	1.14
Benzene B		0.01	0.08	0.10	0.12	0.56	0.75	0.64	0.08	0.18	0.21	0.34	0.70	0.88
Flash Point, °C	D 92	223	-	-	-	-	-	236	-	-	-	-	-	240
Carbon Residue, %	D 524	2.1	-	-	-	-	-	3.12	-	-	-	-	-	3.32
Sulfated Ash, %	D 872	1.6	-	-	-	-	-	2.04	-	-	-	-	-	2.01
Gravity, °API	D 287	25.5	-	-	-	-	-	23.8	-	-	-	-	-	23.3
Wear Metals by XRF														
Fe, ppm			31	45	53	63	65	74	30	40	56	60	65	88
No others detected														

- = Not determined



SPECTRUM NO. 1632	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6856-L 120 HR		1.	
	PURITY	2.	
	PHASE	DATE 2/13/79	
	THICKNESS 0.015	OPERATOR DDD	

SPECTRUM NO. 1632
SAMPLE AL-6856-L 120 HR

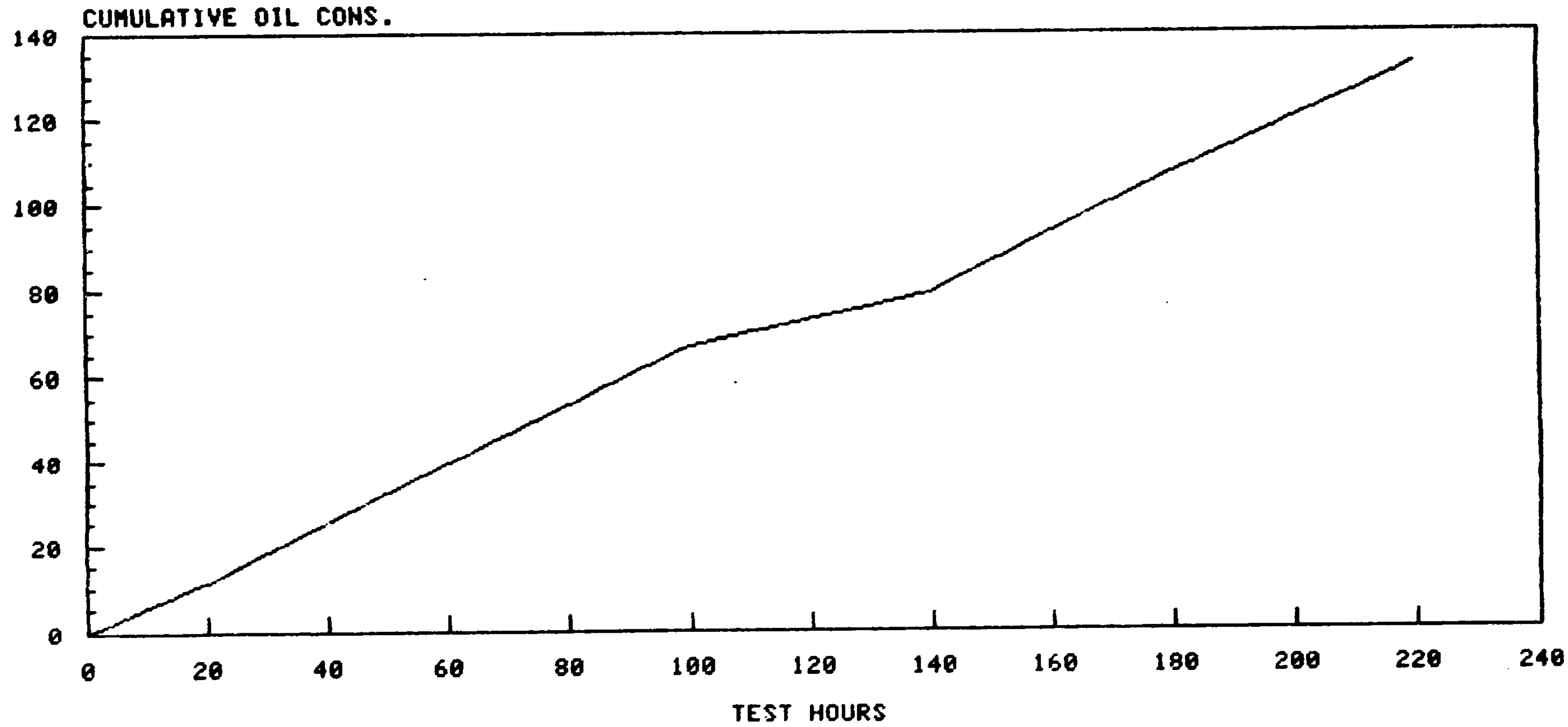


SPECTRUM NO. 1633	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6856-L		1.	
240 HR	PURITY	2.	
	PHASE	DATE 2/13/79	
	THICKNESS 0.015	OPERATOR DDD	

SPECTRUM NO. 1633
SAMPLE AL-6856 240 HR

6V53T ENDURANCE TEST -CUM. OIL CONS.

Test No.CI5136206-3 OIL:AL-6856-L



ENGINE NO. CI 5136206-3
OIL: AL-6856-L
TEST HOURS: 240

Cylinder No.		Cylinder Liner ID: Perpendicular to Crankshaft			Parallel to Crankshaft		
		Top	Middle	Bottom	Top	Middle	Bottom
1L	Before	3.8751	3.8750	3.8753	3.8752	3.8755	3.8758
	After	3.8764	3.8762	3.8763	3.8759	3.8760	3.8765
	Change	0.0013	0.0012	0.0010	0.0007	0.0005	0.0007
2L	Before	3.8752	3.8754	3.8758	3.8750	3.8755	3.8758
	After	3.8763	3.8770	3.8769	3.8760	3.8761	3.8759
	Change	0.0011	0.0016	0.0011	0.0010	0.0006	0.0001
3L	Before	3.8757	3.8762	3.8766	3.8757	3.8762	3.8764
	After	3.8768	3.8770	3.8771	3.8768	3.8770	3.8771
	Change	0.0011	0.0008	0.0005	0.0011	0.0008	0.0007
1R	Before	3.8750	3.8751	3.8753	3.8750	3.8750	3.8752
	After	3.8768	3.8771	3.8770	3.8766	3.8765	3.8768
	Change	0.0018	0.0020	0.0017	0.0016	0.0015	0.0016
2R	Before	3.8750	3.8750	3.8751	3.8750	3.8750	3.8752
	After	3.8765	3.8764	3.8764	3.8759	3.8758	3.8761
	Change	0.0015	0.0014	0.0013	0.0009	0.0008	0.0009
3R	Before	3.8750	3.8751	3.8752	3.8750	3.8751	3.8753
	After	3.8768	3.8771	3.8770	3.8761	3.8761	3.8766
	Change	0.0018	0.0020	0.0018	0.0011	0.0010	0.0013

ENGINE NUMBER CI5136206-3
OIL: AL-6856-L
TEST HOURS: 240

Piston No.		Piston Ring Gap, Inches						
		1	2	3	4	5	6	7
1L	Before	0.026	0.030	0.030	0.028	0.021	0.018	0.018
	After	0.029	0.031	0.031	0.030	0.027	0.025	0.025
	Change	0.003	0.001	0.001	0.002	0.006	0.007	0.007
2L	Before	0.034	0.028	0.028	0.029	0.023	0.019	0.019
	After	0.035	0.027	0.029	0.029	0.028	0.025	0.024
	Change	0.001	0.001	0.001	0.000	0.005	0.006	0.005
3L	Before	0.029	0.030	0.030	0.028	0.022	0.018	0.019
	After	0.035	0.031	0.034	0.029	0.028	0.025	0.024
	Change	0.006	0.001	0.004	0.001	0.006	0.007	0.005
1R	Before	0.031	0.030	0.025	0.031	0.020	0.020	0.020
	After	0.034	stuck	0.025	0.031	0.028	0.025	0.024
	Change	0.003	-	0.000	0.000	0.008	0.005	0.004
2R	Before	0.032	0.028	0.027	0.027	0.021	0.019	0.018
	After	0.034	0.028	0.026	0.027	0.026	0.025	0.024
	Change	0.002	0.000	-0.001	0.000	0.005	0.006	0.006
3R	Before	0.027	0.025	0.023	0.024	0.021	0.019	0.018
	After	0.029	0.034	0.022	0.025	0.028	Collapsed	0.025
	Change	0.002	0.009	-0.001	0.001	0.007	-	0.007

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-6856-L

RATER E. Lyons DATE 2-5-79
LABORATORY TEST NUMBER CI5136206-3
STAND NO. 5 ENGINE NO. 5136206
FUEL 1-H CAT

PISTON NO. 1 Right

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	384.01

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00					70	70.00			85	85.00	90	90.00	40	40.00				
CARBON	MHC	0.75					30	22.50												
CARBON	MC	0.50													60	30.00				
CARBON	LC	0.25																		
CARBON	VLC	0.15	100	15.00							15	2.25	10	1.50			25	3.75		
	CARBON RATING		15.00		RING NOT REMOVED		92.50				87.50		91.50		70.00		3.75			
LACQUER	BL	0.100							80	8.00							50	5.00		
LACQUER	DBrL	0.075															25	1.875	100	7.50
LACQUER	AL	0.050																		
LACQUER	LAL	0.025																		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING								9.50								6.875		7.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		15.00		0		92.50		9.50		87.50		91.50		70.00		10.625		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-6856-L

RATER E. Lyons DATE 2-5-79
LABORATORY TEST NUMBER CI5136206-3
STAND NO. 5 ENGINE NO. 5136206
FUEL 1-H CAT

PISTON NO. 2 Right

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	372.3

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES								LANDS								UNDER-CROWN	
			NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
			AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON	HC	1.00			70	70.00					85	85.00	60	60.00						
CARBON	MHC	0.75	5	3.75	30	22.50														
CARBON	MC	0.50	70	35.00											50	25.00				
CARBON	LC	0.25					10	2.50			15	3.75								
CARBON	VLC	0.15	25	3.75			90	13.50					40	6.00	25	3.75	80	12.00		
CARBON	CARBON RATING		42.50		92.50		16.00				88.75		66.00		28.75		12.00			
LACQUER	BL	0.100							100	10.00					25	2.50	5	5.00		
LACQUER	DBrL	0.075																	100	7.50
LACQUER	AL	0.050																		
LACQUER	LAL	0.025															15	0.75		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
LACQUER	LACQUER RATING								10.00						2.50		5.75		7.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		42.50		92.50		16.00		10.00		88.75		66.00		31.25		17.75		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-6856-L

RATER E. Lyons DATE 2-5-79
LABORATORY TEST NUMBER CI5136206-3
STAND NO. 5 ENGINE NO. 5136206
FUEL 1-H CAT

PISTON NO. 3 Right

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	430.3

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00			100	100.00					85	85.00	80	80.00	50	50.00				
CARBON	MHC	0.75																		
CARBON	MC	0.50					85	42.50												
CARBON	LC	0.25	100	25.00			15	3.75							10	2.50				
CARBON	VLC	0.15									15	2.25	20	3.00	40	6.00	60	9.00		
	CARBON RATING		25.00		100.00		46.25				87.25		83.00		58.50		9.00			
LACQUER	BL	0.100							100	10.00							30	3.00		
LACQUER	DBrL	0.075															10	0.75	100	7.50
LACQUER	AL	0.050																		
LACQUER	LAL	0.025																		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING								10.00								3.75			
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		25.00		100.00		46.25		10.00		87.25		83.00		58.50		12.75		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-6856-L

RATER E. Lyons DATE 2-5-79
LABORATORY TEST NUMBER CI5136206-3
STAND NO. 1-H CAT ENGINE NO. 5136206
FUEL

PISTON NO. 1 Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	359.0

DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES								LANDS								UNDER-CROWN	
		NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
		AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON HC	1.00			100	100.0					80	80.00	85	85.00						
CARBON MHC	0.75																		
CARBON MC	0.50													50	25.00				
CARBON LC	0.25	100	25.00							20	5.00								
CARBON VLC	0.15											15	2.25	40	6.00				
CARBON RATING		25.00		100.00						85.00		87.25		31.00					
LACQUER BL	0.100					100	10.00							5	0.50	35	3.50		
LACQUER DBrL	0.075													5	0.375	25	1.875	100	7.50
LACQUER AL	0.050							100	5.00							40	2.00		
LACQUER LAL	0.025																		
LACQUER VLAL	0.010																		
LACQUER RL	0.001																		
LACQUER RATING						10.00		5.00						0.875		7.375		7.50	
CLEAN	0																		
ZONAL RATING																			
LOCATION FACTOR																			
WEIGHTED RATING		25.00		100.00		10.00		5.00		85.00		87.25		31.875		7.375		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-6856-L

RATER E. Lyons DATE 2-5-79
LABORATORY TEST NUMBER CI513606-3
STAND NO. 5 ENGINE NO. 5136206
FUEL 1-H CAT

PISTON NO. 2 Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	369.4

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00			100	100.00					90	90.00	80	80.00						
CARBON	MHC	0.75																		
CARBON	MC	0.50																		
CARBON	LC	0.25	100	25.00											70	17.50				
CARBON	VLC	0.15									10	1.50	20	3.00	20	3.00	70	10.50		
	CARBON RATING		25.00		100.00						91.50		83.00		20.50		10.50			
LACQUER	BL	0.100					100	10.00	50	5.00					10	10.00	15	1.50		
LACQUER	DBrL	0.075							50	3.75							15	1.125	100	7.50
LACQUER	AL	0.050																		
LACQUER	LAL	0.025																		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING						10.00		8.75						10.00		2.625		7.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		25.00		100.00		10.00		8.75		91.50		83.00		30.50		13.125		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-6856-L

RATER E. Lyons DATE 2-5-79
LABORATORY TEST NUMBER CI5136206-3
STAND NO. 5 ENGINE NO. 5136206
FUEL 1-H CAT

PISTON NO. 3 Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	297.5

		GROOVES								LANDS								UNDER-CROWN	
		NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
DEPOSIT TYPE	DEPOSIT FACTOR	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON HC	1.00			10	10.00					20	20.00	80	80.00						
CARBON MHC	0.75			90	67.50														
CARBON MC	0.50	45	22.50																
CARBON LC	0.25	55	13.75			25	6.25							70	17.50				
CARBON VLC	0.15					75	11.25			80	12.00	20	3.00	15	2.25	75	11.25		
CARBON RATING		36.25		77.50		17.50				32.00		83.00		19.75		11.25			
LACQUER BL	0.100							100	10.00					15	1.50				
LACQUER DBrL	0.075																	100	7.50
LACQUER AL	0.050															25	1.25		
LACQUER LAL	0.025																		
LACQUER VLAL	0.010																		
LACQUER RL	0.001																		
LACQUER RATING								10.00						1.50		1.25		7.50	
CLEAN	0																		
ZONAL RATING																			
LOCATION FACTOR																			
WEIGHTED RATING		36.25		77.50		17.50		10.00		32.00		83.00		21.25		12.50		7.50	

*WEIGHTED TOTAL DEPOSITS

RATING DATA SHEET

Test Run at AFLRL
Test Oil: AL-6856-L
Test No. CI 5136206-3
Test Stand: 5
Engine No.: 5136206
Test Fuel: 1-H CAT
Date Started: 14 January 1979
Date Completed: 2 February 1979
Test Hours: 240

A. Cylinder Liner Ratings

Intake Port Plugging

Cylinder No.	Restriction,%
1 L	1
2 L	2
3 L	5
1 R	3
2 R	10
3 R	5
Average	4.0

Scuffing, Glazing and Lacquer*

Cylinder No.	Scuffing, % Thrust	Anti-Thrust	Total	Glazing,%	Lacquer,%
1 L	5	10	7	20	80
2 L	15	10	12	30	70
3 L	10	10	10	15	85
1 R	20	10	15	10	90
2 R	75	25	50	30	70
3 R	10	10	10	20	80
Average	22.5	12.5	17.0	21.0	79

* Ring Travel Area

RATING DATA SHEET - CONTINUED

B. Piston Ratings

Ring Sticking and Condition

Cylinder No.	Ring: Fire	No.1	No.2	No.3
1 L	F 40%	F 1%	F 5%	F
2 L	•57.C.5 30%	F 5%	F 7%	F 10%B
3 L	yF 60B	F 15B	F 30B	F 35B
1 R	yF 75B	+F 100B	F 70B	F 35B
2 R	F 15B	F 20B	F 50B	F 70B
3 R	*•40% C.S. 40B	F 50B	F 5B	F 15B

y=ring face chipped
•=rings removed

\+ Ring collapsed, not removed
* Face has two small chipped places

Ring Groove Carbon Filling and Oil Groove Lacquer

Cylinder No.	Groove Filling, %: Fire	No.1	No.2	No.3	Oil Groove Lacquer: Upper	Lower
1 L	10	90	0	0	3.0	3.0
2 L	5	90	5	0	3.0	3.0
3 L	5	85	15	0	3.0	3.0
1 R	5	+	85	0	3.0	3.0
2 R	10	75	15	0	3.0	3.0
3 R	10	95	15	0	3.0	3.0

\+ Ring collapsed, not removed

Land Description

Cylinder No.	Description
1 L	Normal H. C.
2 L	Normal H. C.
3 L	Normal H. C.
1 R	Normal H. C.
2 R	Normal H. C.
3 R	Normal H. C.

Skirt

Cylinder No.	Side: Thrust	Anti-Thrust
1 L	5.0 Light Scratches	5.2 Light Scratches
2 L	5.0 Plate Melt 20% Scratches	5.5 Light Scratches
3 L	5.4 Scuff 10% Scratches	5.4 Scuff 5% Scratches
1 R	5.3 Platemelt 5%, Scuff 10%	5.3 Scuff 5% Scratches
2 R	5.6 Platemelt 15%, Scuff 30%	5.5 Scuff 5% Scratches
3 R	5.6 Platemelt 5% Scratches	5.3 Light Scratches

RATING DATA SHEET - CONTINUED

C. Other Ratings

Combustion Chambers

Cylinder No.	Description	Cylinder No.	Description
1 L	20% BHC 70 AHC 10% Soot	1 R	20% AHC 80% Soot
2 L	10% CHC 90 AHC	2 R	10% CHC 20% BHC 70% AHC
3 L	10 BHC 70 AHC	3 R	5% DHC 10 BHC 85 AHC

Valve Covers, Oil Pan and Cylinder Head Deck

Covers	Clean
Pan	Clean
Deck	Clean

D. Interim Inspections

120 Hour	Inspection
1 L	Normal
2 L	Normal
3 L	Normal
1 R	2nd comp ring blackened, heavy glaze, ports normal
2 R	Normal
3 R	Heavy Lacquer on skirt, fire ring blackened

180 Hour	
1 L	Normal
2 L	Normal
3 L	Normal
1 R	No. 2 comp ring black, same as 120 hour
2 R	Normal
3 R	Same as 120 hour

RING STICKING

Test No. CI-3

Engine Model 6V53T-CI Serial No. CI 5136206-3 Date 2-5-79

Fuel 1-H CAT Lubricant AL-6856-L Observer E. Lyons

Piston Number

Ring No.	1L	2L	3L	1R	2R	3R
1	F	5% P	F	F	F	40%P
2	F	F	F	Collapsed F	F	F
3	F	F	F	F	F	F
4	F	F	F	F	F	F

Indicate by letter — **Free** or **Sluggish**, or by *number and letter* — percent **Pinched** (cold stuck) or percent **Hot** stuck (Pages 6 and 7 of Manual).

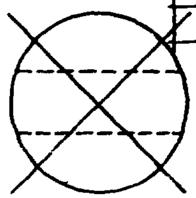
PISTON GROOVE INSIDE DIAMETER—% RING SUPPORTING CARBON

Test No. CI-3

Engine Model 6V53T-CI   Serial No. CI513206-3   Date 2-5-79

Fuel 1-H CAT   Lubricant AL-6856-L   Observer E. Lyons

Piston Ring	Quadrant	Piston Number 1L	2L	3L	1R	2R	3R
1	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
2	1	10	0	0	RING NOT REMOVED	0	95
	2	50	80	0		85	85
	3	95	10	0		20	85
	4	40	100	40		40	95
3rd Groove	1				100		
	2				100		
	3				85		
	4				0		



PISTON SURFACE CONDITION

Test No. CI-3

Engine Model 6V53T-CI — Serial No. CI 5135206-3 — Date 2-5-79

Fuel 1-H CAT — Lubricant AL-6856-F — Observer E. Lyons

	Piston Number					
	1L	2L	3L	1R	2R	3R
Top Land	N	N	N	N	N	N
Skirt						
Piston Pin	N	N	N	N	N	N

Pages 1 through 2 and 59 through 65 of Manual.

VALVE DEPOSITS

Test No. CI-3

Engine Model 6V53T-CI Serial No CI5136206-3 Date 2-5-79

Fuel 1-H CAT Lubricant AL-6856-L Observer E. Lyons

		Cylinder Number											
		1L		2L		3L		1R		2R		3R	
		CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ
Head*	INT												
	EXH	HEAVY CARBON BUILD UP C TO A H. C.											
Face	INT	100%#9 LACQ TO LIGHT CARBON											
	EXH												
Tulip†	INT		10%#9 LACQ TO HEAVY CARBON										
	EXH												
Stem	INT		100%#9 LACQ TO CLEAN										
	EXH												

*Carbon and Ash: Use Volume Factor Technique (Pages 5 and 40 through 47 of Manual).
†Use Chart, Page 21—Indicate H, M, or S, (Page 5).
Lacquer: Pages 4, 36 and 37.

EXHAUST VALVE SURFACE CONDITIONS

Test No. CI-3

Engine Model 6V53T -CI Serial No. CI5136206-3 Date 2-5-79

Fuel 1-H CAT Lubricant AL-6856-L Observer E. Lyons

	1L	2L	3L	1R	2R	3R
Freeness in Guide	F	F	F	F	F	F
Head	N	N	N	N	N	N
Face	SOME LIGHT PITTING AND LEAKING					
Seat	N	N	N	N	N	N
Stem	N	N	N	N	N	N
Tip	N	N	N	N	N	N

See Pages 1, 2, 16 through 23, and 54 through 65 of Manual.

TAPPETS, CAMS, AND ROCKER ARMS

Test No. CI-3

Engine Model 6V53T-CI   Serial No. CI5136206-3   Date 2-5-79

Fuel 1-H CAT   Lubricant AL-6856-L   Observer E. Lyons

			Cylinder Number					
			1L	2L	3L	1R	2R	3R
Tappet Deposit		INT						
		EXH						
Tappet Surface Condition		INJ						
		INT	N O	R M	A L			
		EXH						
Cam Lobes				"				
Rocker Arms	Tip	INT		"				
		EXH						
	Bushing	INT		"				
		EXH						
	Shaft	INT		"				
		EXH						

Lacquer: Pages 4, 36 and 37 of Manual.
See Pages 1, 2, 16 through 23, and 54 through 65.

SURFACE CONDITION

Test No. CI-3

Engine Model 6V53T-CI Serial No. CI 5136206-3 Date 2-5-79

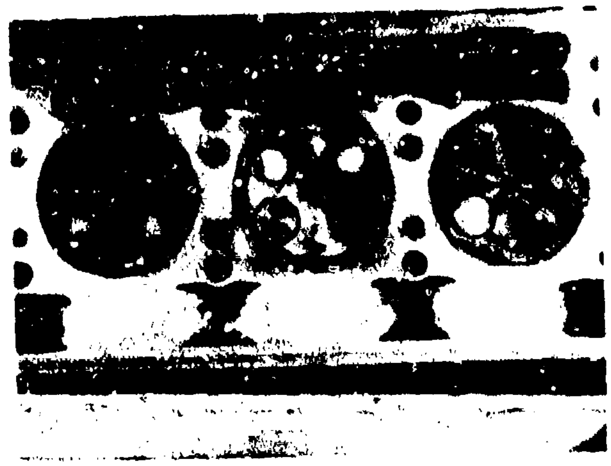
Fuel 1-H CAT Lubricant AL-6856-L Observer E. Lyons

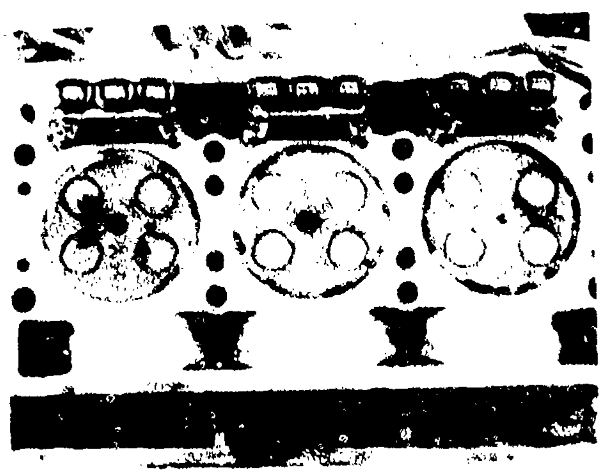
Bearing No.	1	2	3	4	5	6	7
Main—Bearing		N	O	R	M	A	L
—Journal				"			
Rod—Bearing				"			
—Journal				"			
Piston Pin				"			
Bushing				"			

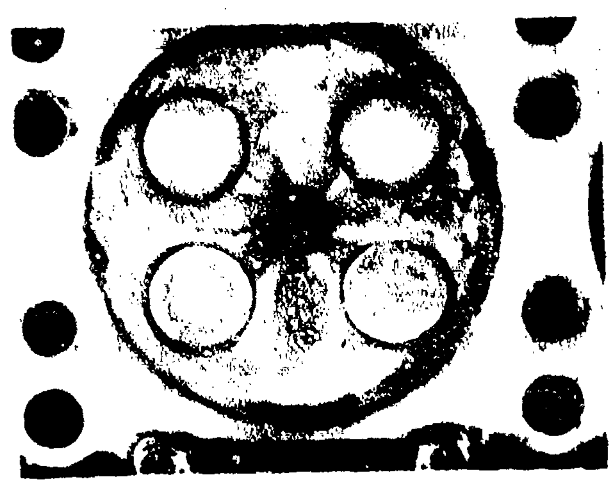
Note surface condition. See pages 1, 2, 16 through 23 and 54 through 65 of Manual.

CONDITION OF CYLINDER HEADS

TEST TIME: 240 HOURS TEST NO.: CI5136206-3 OIL: AL-8856-L







REPRESENTATIVE CYLINDER (2 LEFT)

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 240 HOURS TEST NO.: CI5136206–3 OIL: AL–6856–L

3–LEFT ANTI–THRUST

CONDITION OF PISTON RING FACE

TEST TIME: 240 HOURS TEST NO.: C15136206-3 OIL: AL-6856-L

1 RIGHT

2 RIGHT

3 RIGHT

CONDITION OF PISTON RING FACE

TEST TIME: 240 HOURS   TEST NO.: CI5136206-3   OIL: AL-6856-L

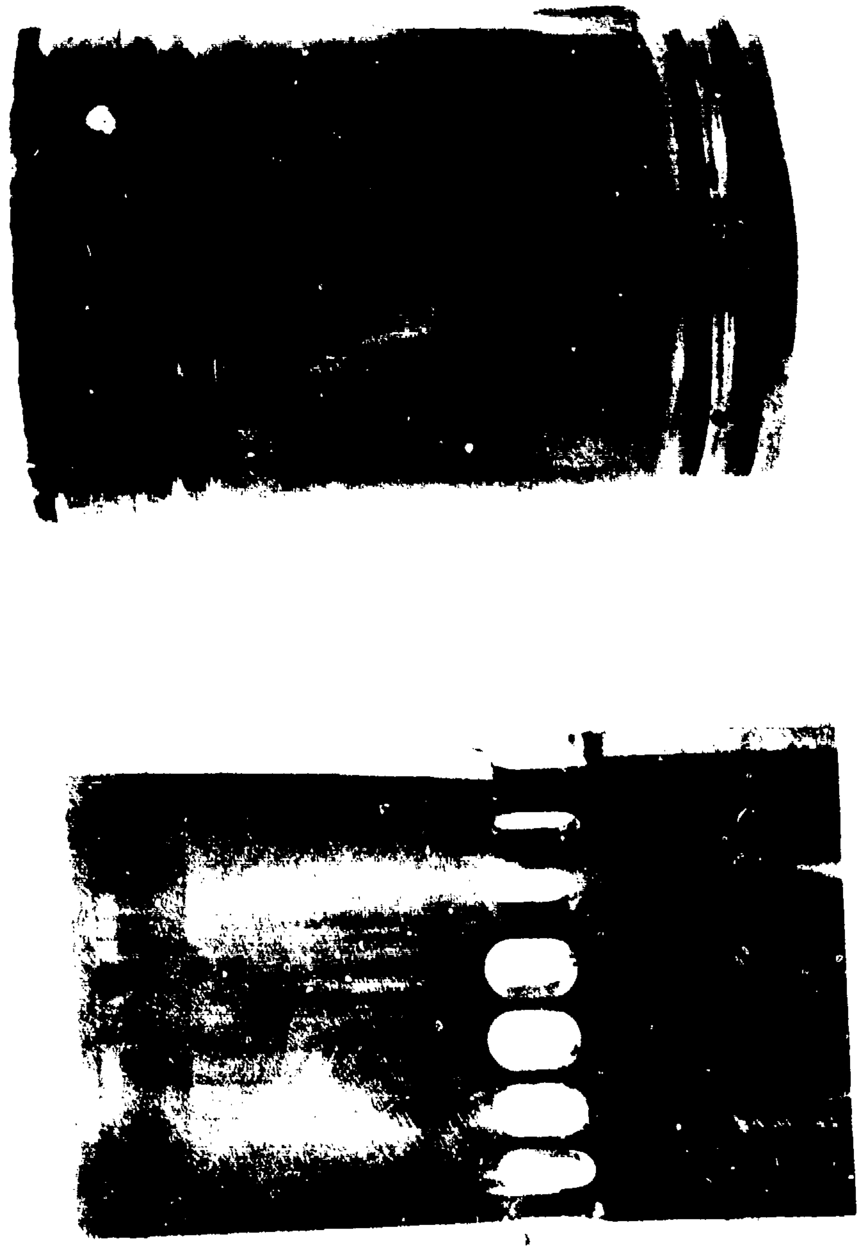
1 LEFT

2 LEFT

3 LEFT

CONDITION OF PISTON AND CYLINDER LINER

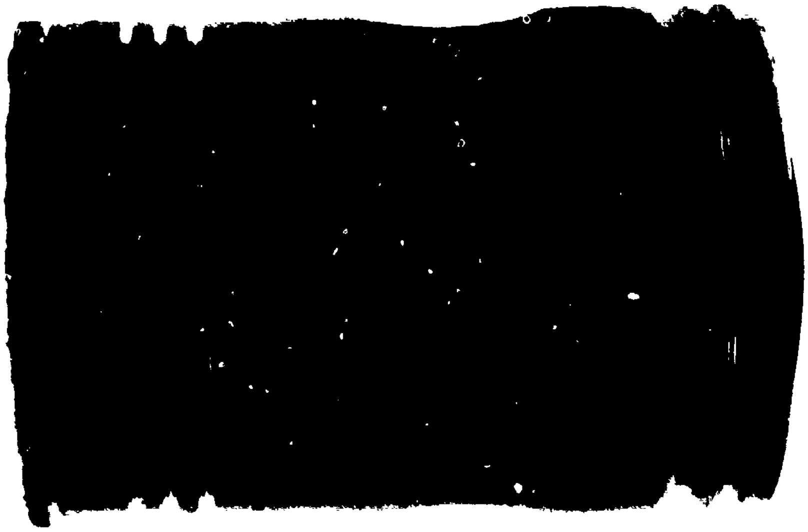
TEST TIME: 240 HOURS TEST NO.: C15136206-3 OIL: AL-6856-L

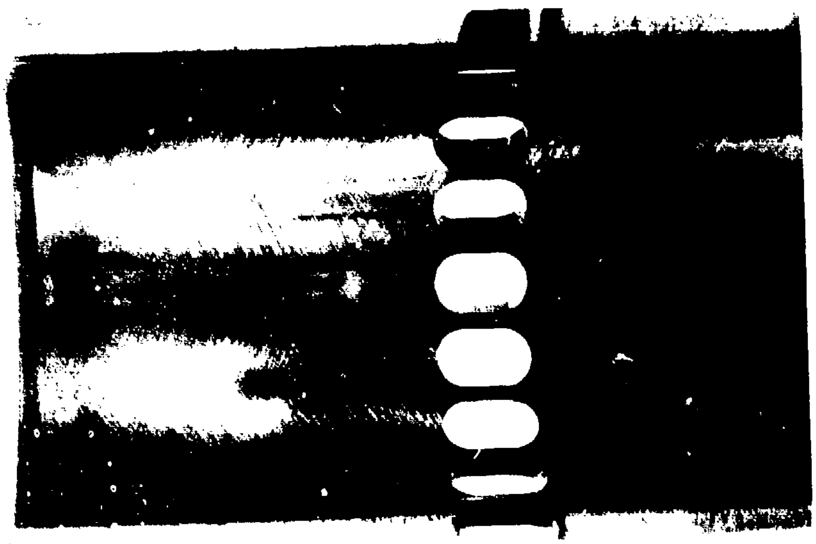


1-RIGHT THRUST

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 240 HOURS TEST NO.: C15136206-3 OIL: AL-6856-L



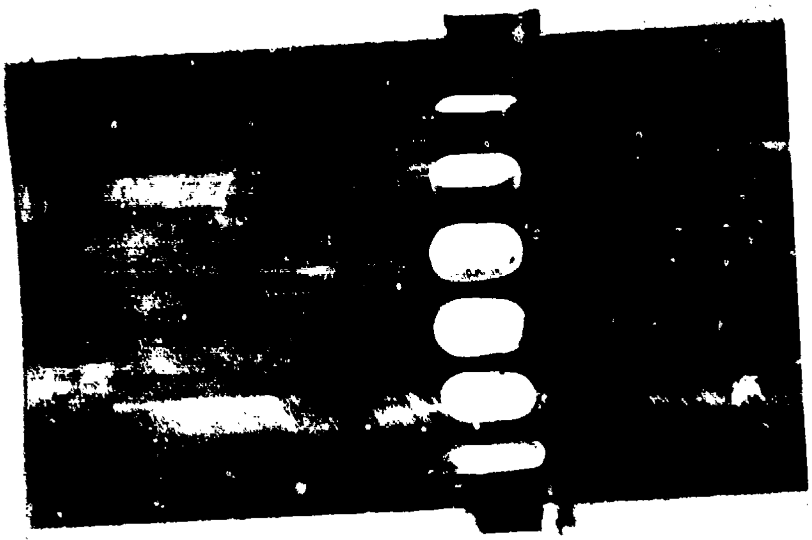


1-LEFT THRUST

CONDITION OF PISTON AND CYLINDER LINER

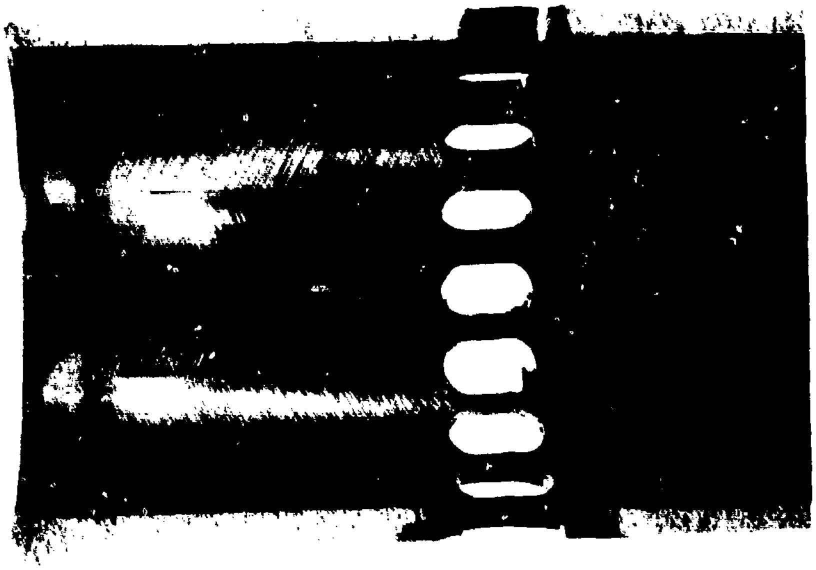
TEST TIME: 240 HOURS TEST NO.: CI5136206 OIL: AL-6856-L

2-RIGHT THRUST



CONDITION OF PISTON AND CYLINDER LINER

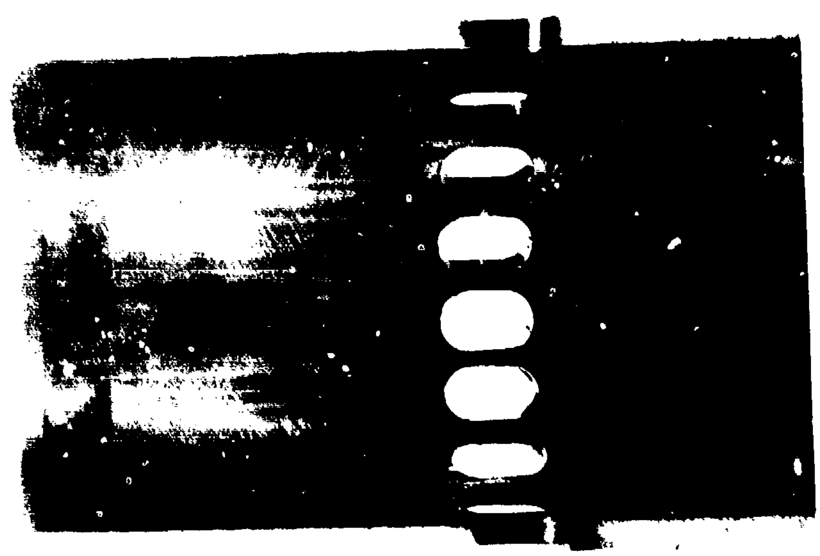
TEST TIME: 240 HOURS TEST NO.: C15136206-3 OIL: AL-6856-L



2-LEFT THRUST

CONDITION OF PISTON AND CYLINDER LINER

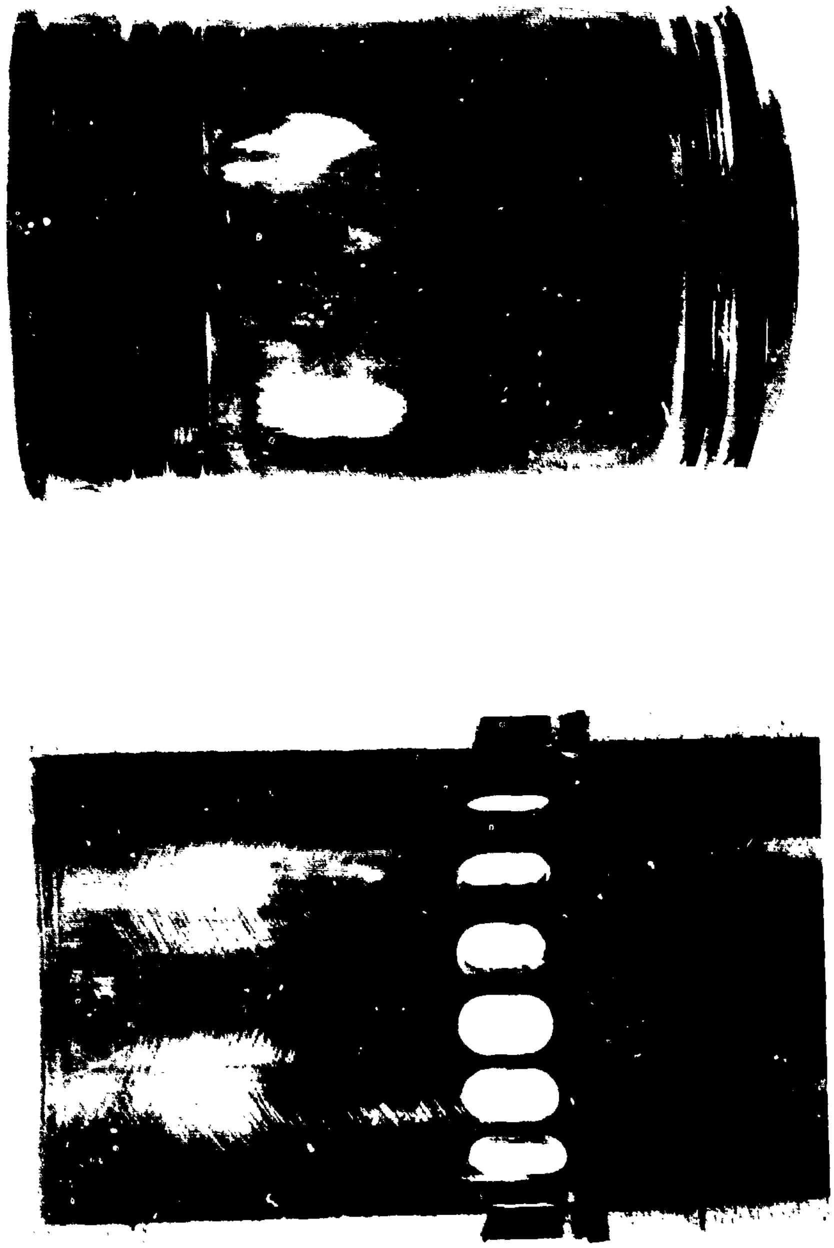
TEST TIME: 240 HOURS TEST NO.: CI5136206-3 OIL: AL-6856-L



3-RIGHT THRUST

CONDITION OF PISTON AND CYLINDER LINER

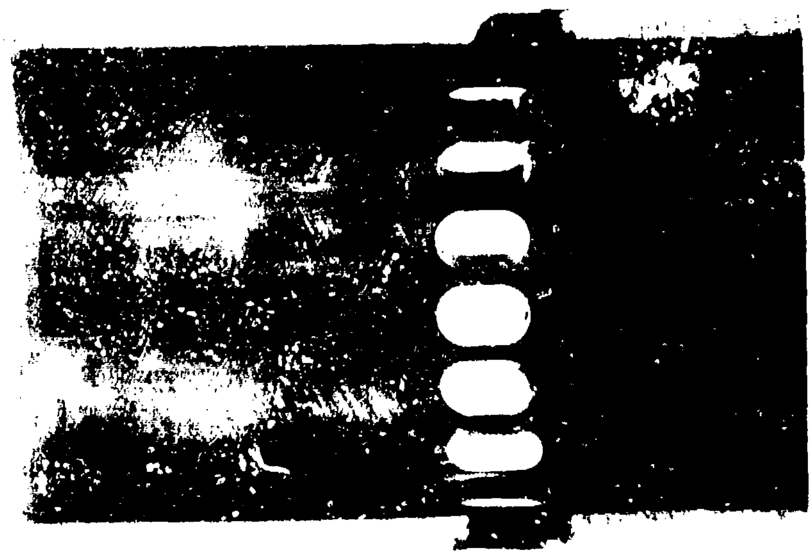
TEST TIME: 240 HOURS TEST NO.: CI5136206-3 OIL: AL-6856-L



3-LEFT THRUST

CONDITION OF PISTON AND CYLINDER LINER

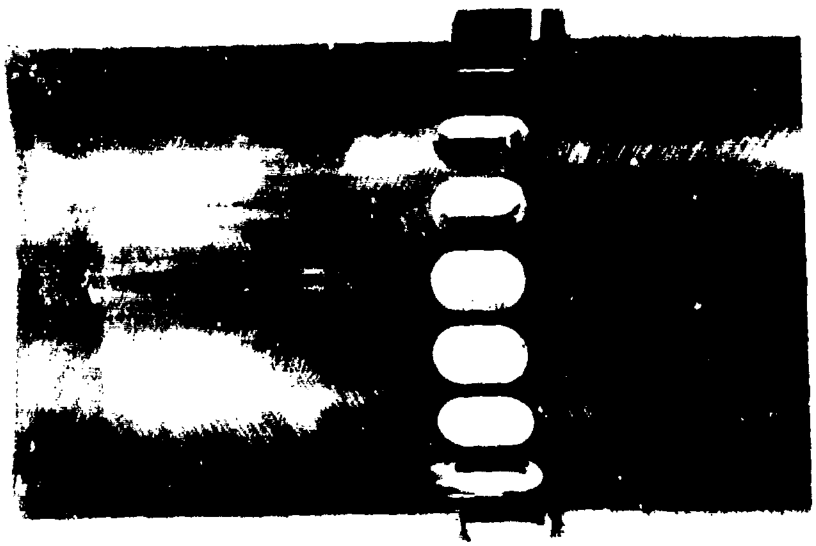
TEST TIME: 240 HOURS TEST NO.: CI5136206-3 OIL: AL-6856-L



1-RIGHT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

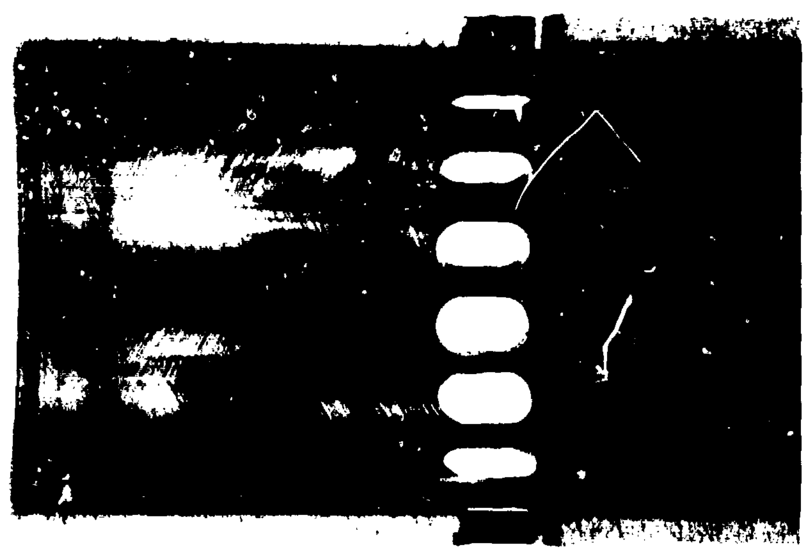
TEST TIME: 240 HOURS TEST NO.: C15136206-3 OIL: AL-6856-L



1-LEFT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

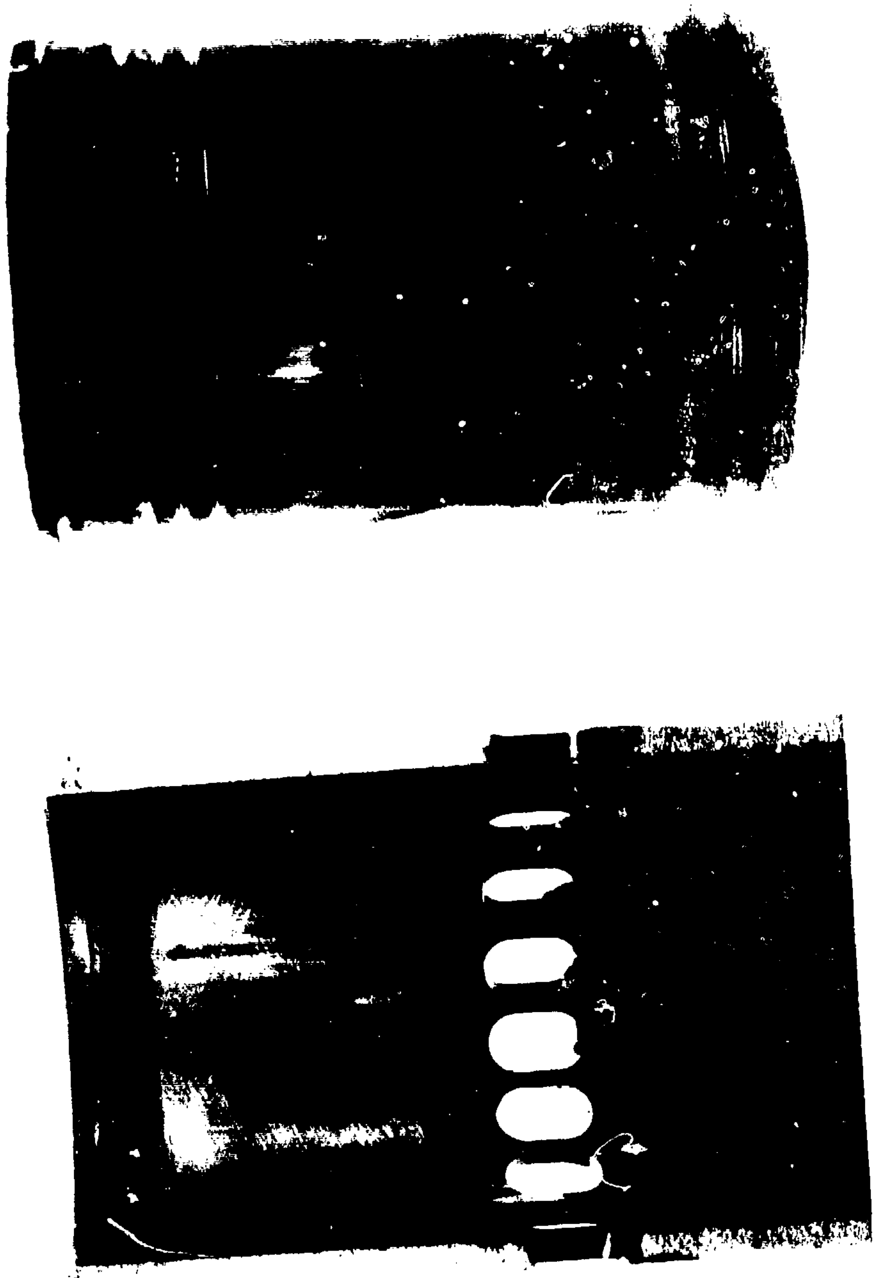
TEST TIME: 240 HOURS TEST NO.: CI5136206–3 OIL: AL–6856–L



2–RIGHT ANTI–THRUST

CONDITION OF PISTON AND CYLINDER LINER

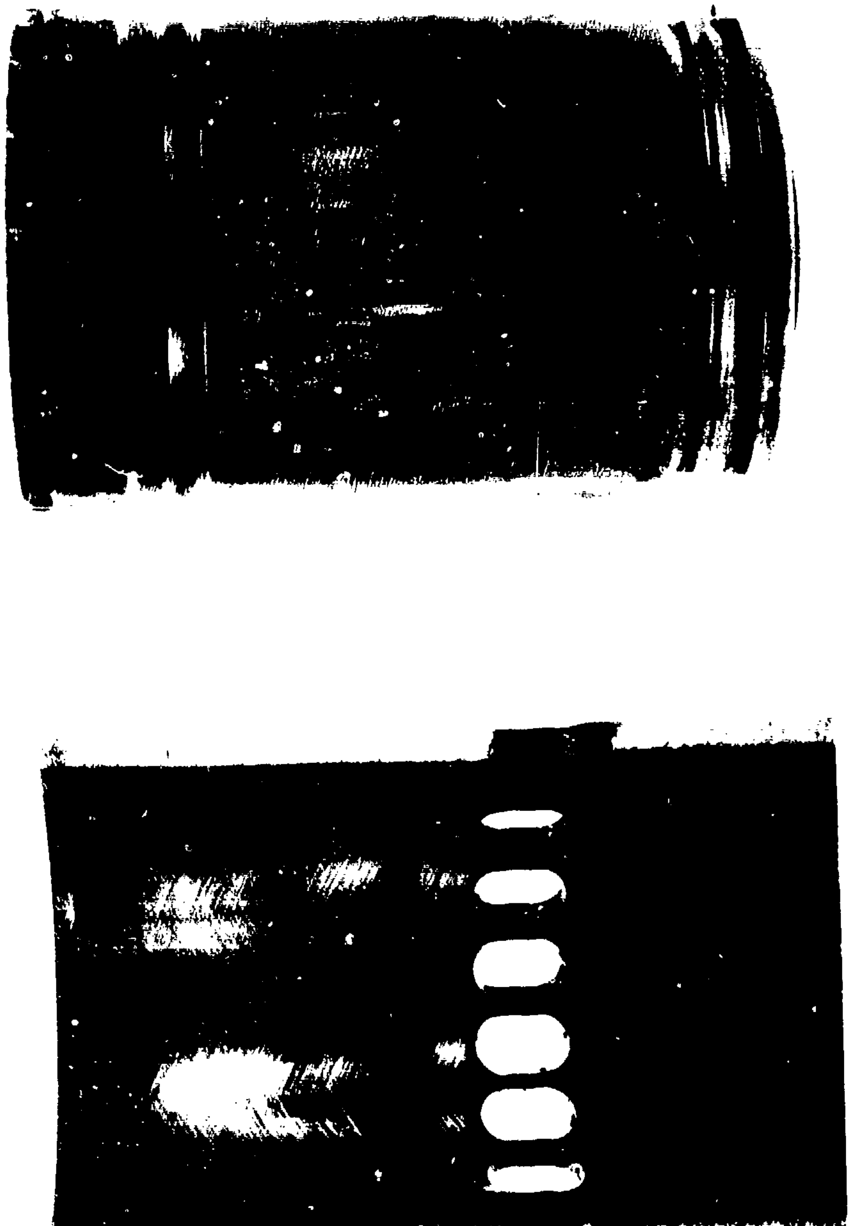
TEST TIME: 240 HOURS TEST NO.: CI5136206-3 OIL: AL-6856-L



2-LEFT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 240 HOURS TEST NO.: CI5136206–3 O L: AL–6956–L



3–RIGHT ANTI–THRUST

APPENDIX B

ENGINE-LUBRICANT COMPATIBILITY TEST #4

240-HOUR TRACKED-VEHICLE CYCLE

USING 6V-53T DIESEL ENGINE

ENGINE-LUBRICANT COMPATIBILITY TEST
240-HOUR TRACKED-VEHICLE CYCLE
USING 6V53T DIESEL ENGINE

Test Lubricant: MC-606 (AL-6855-L)
Engine Test Number: CI5136206-4
Date Completed: 27 February 1979

Conducted for

U.S. Army Mobility Equipment Research and Development Command
Petroleum and Materials Department

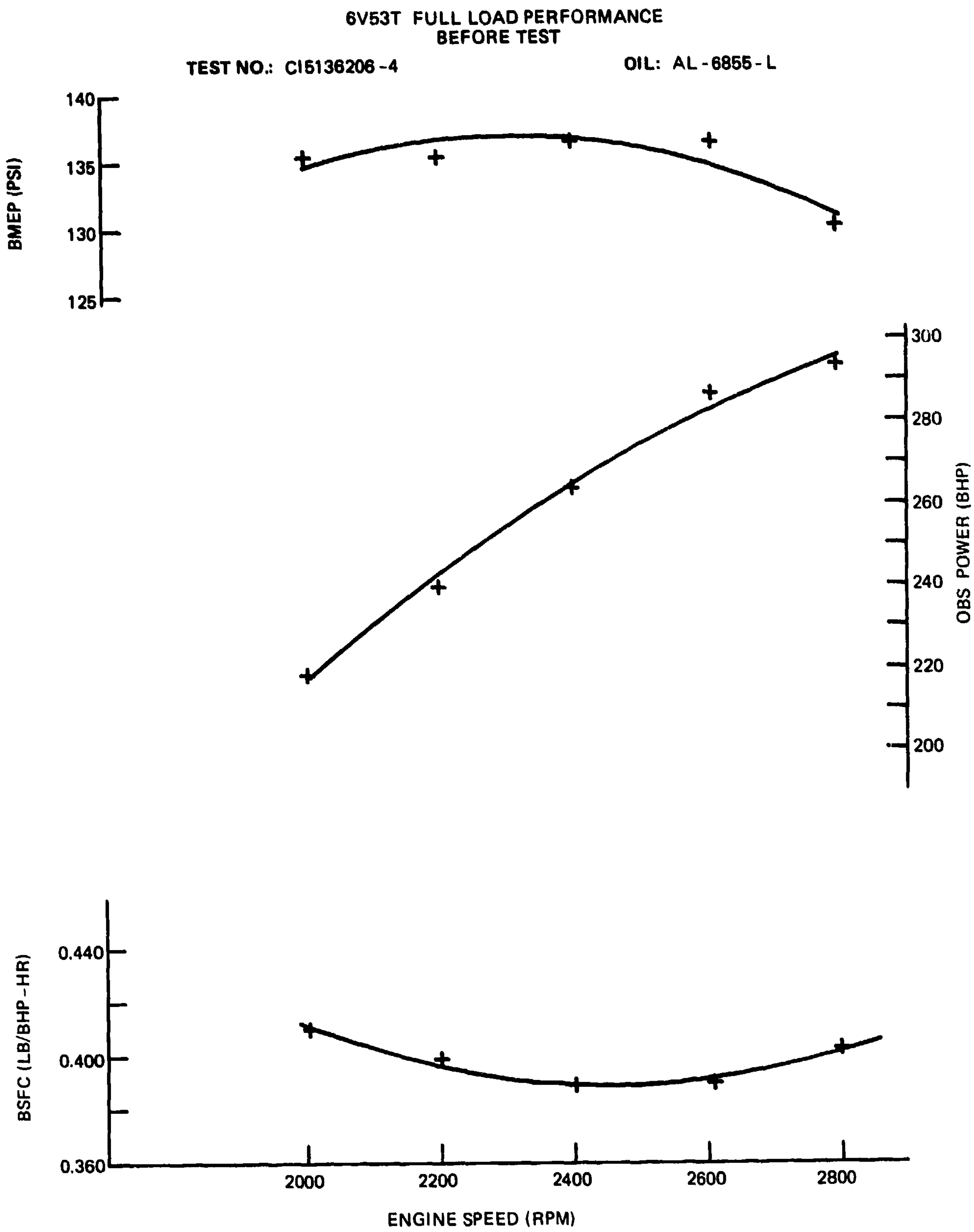
by

U.S. Army Fuels and Lubricants Research Laboratory
Southwest Research Institute
San Antonio, Texas 78284

6V53T
BUILD-UP ENGINE MEASUREMENTS
CI 5136206-4

Measurements	Inches			
	Min	Max	Avg	Spec. Limits (1)
Connecting rod bearing clearance	0.0030	0.0034	0.0032	0.0016-0.0046
Cylinder liner block bore				
Taper	0.0003	0.0007	0.0005	0.0015 max
Out-of-round	0.0002	0.0007	0.0005	0.0015 max
Inside diameter	4.3569	4.3580	4.3574	4.3595 max
Cylinder Liners (installed)				
Taper	0.0001	0.0008	0.0005	0.0020 max (2)
Out-of-round	0.0001	0.0009	0.0003	0.0030 max (2)
Inside diameter	3.8756	3.8768	3.8762	3.8752-3.8767
Piston to liner fit	0.0074	0.0090	0.0082	0.0060-0.0095
Piston Diameter	3.8673	3.8685	3.8680	3.8669-3.8691
Fire Ring				
End gap	0.026	0.035	0.031	0.020-0.046
Side clearance	0.002	0.003	0.003	0.003-0.006
No. 1 Compression ring				
End gap	0.025	0.035	0.030	0.020-0.046
Side clearance	0.008	0.009	0.008	0.007-0.010
No. 2 & No. 3 Compression ring				
End gap	0.025	0.035	0.029	0.020-0.046
Side clearance	0.006	0.007	0.007	0.005-0.010
Oil rings				
End gap	0.012	0.022	0.018	0.010-0.025
Side Clearance	0.002	0.003	0.0025	0.0015-0.0055

(1) Limits on new parts unless maximum wear limit specified.
(2) Wear limits with new liners in a used block.


6V53T FULL LOAD PERFORMANCE
BEFORE TEST
TEST NO.: C15136206-4
OIL: AL-6855-L
BMEP (PSI)
140
135
130
125
300
280
260
240
220
200
OBS POWER (BHP)
BSFC (LB/BHP-HR)
0.440
0.400
0.360
2000
2200
2400
2600
2800
ENGINE SPEED (RPM)

6V-53T ENDURANCE TEST
SUMMARY OF OPERATING DATA

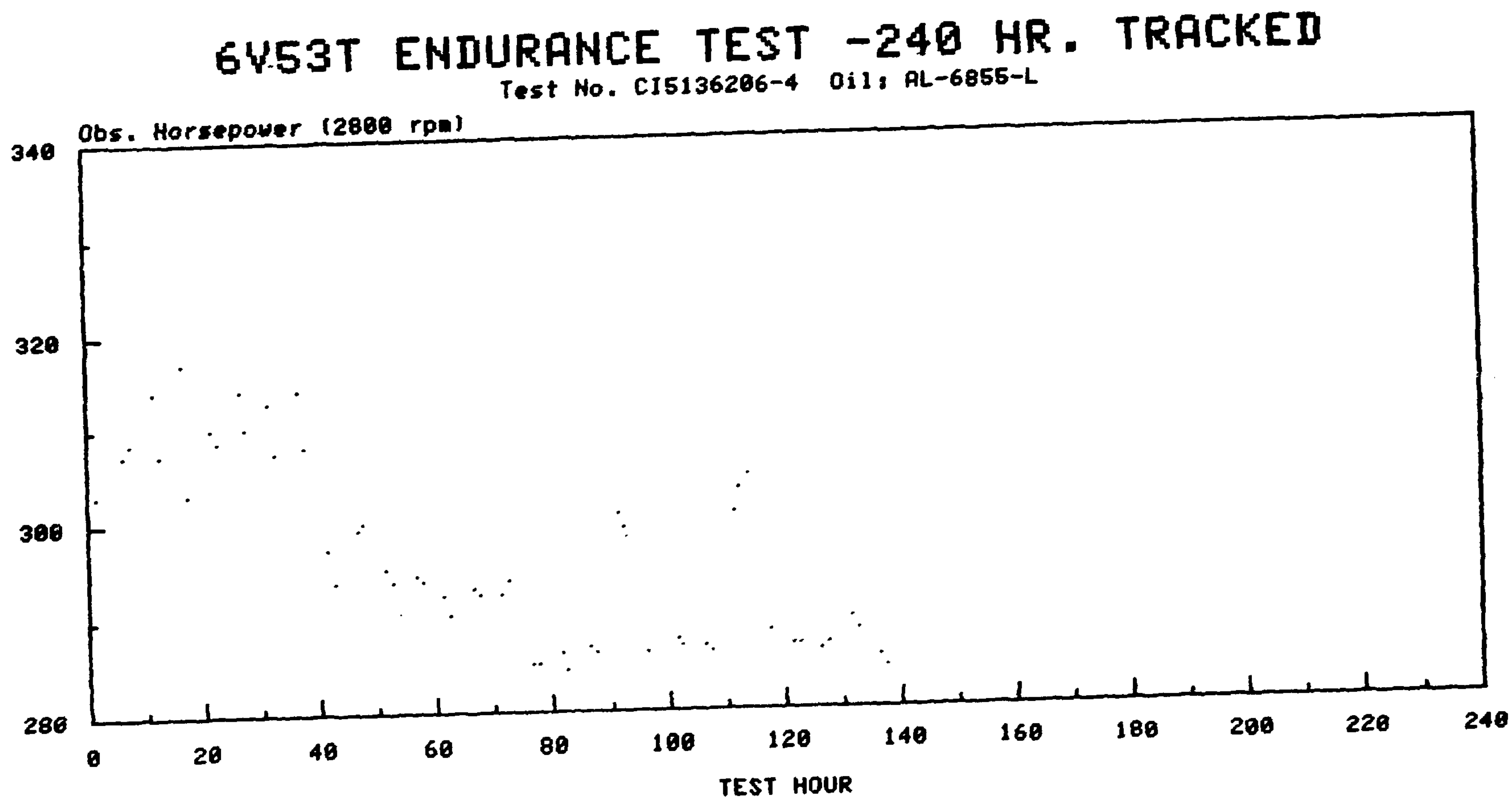
TEST NO.: CI5136206-4

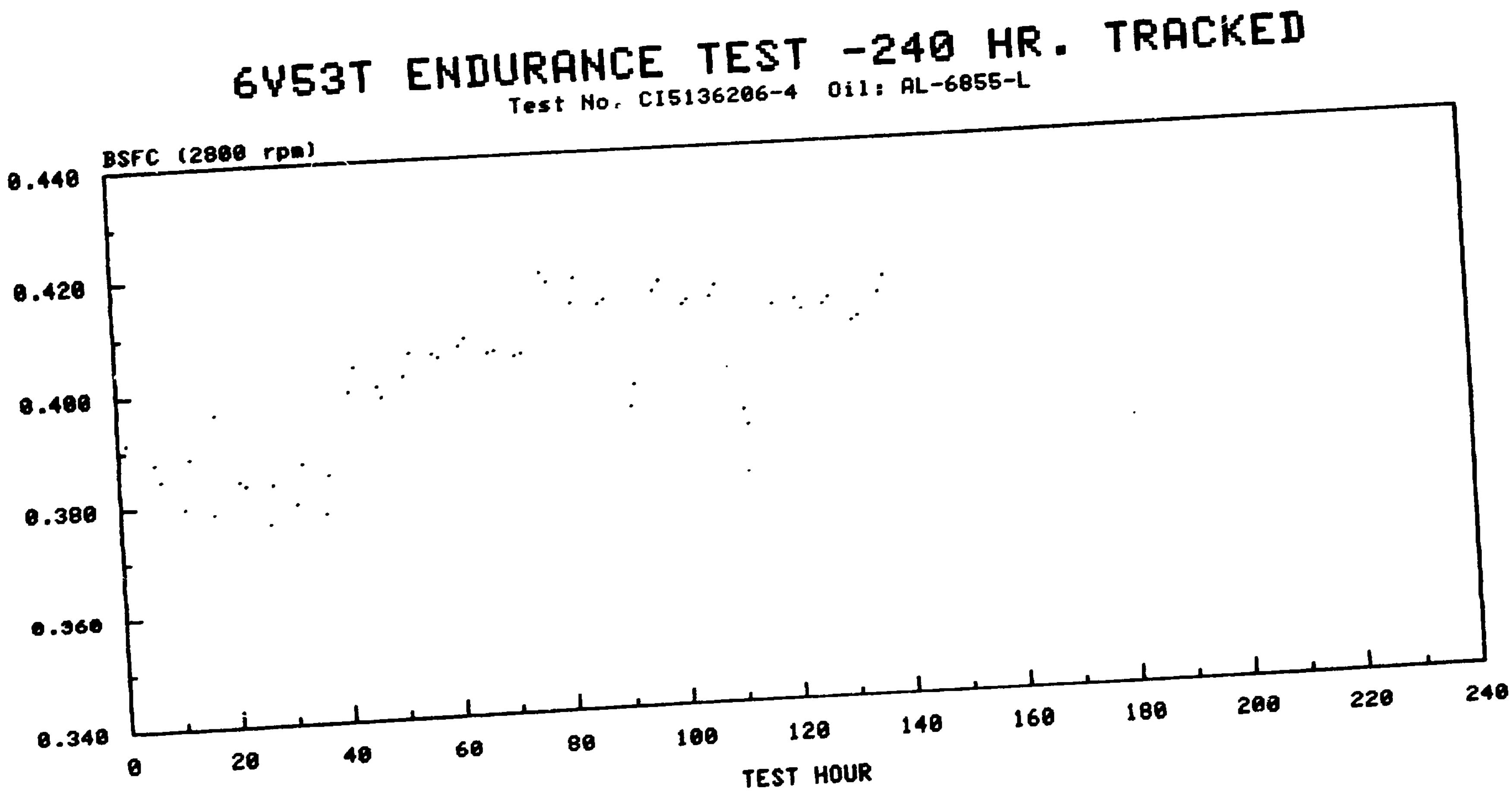
OIL: AL-6855-L

	2200 RPM			2800 RPM		
	Avg	Min	Max	Avg	Min	Max
Engine Speed, rpm	2205	2199	2217	2805	2795	2815
Load, lb	456	440	474	435	417	464
Obs. Power, bhp	245	236	254	297	286	318
Fuel Rate, lb/hr	95.3	94.3	96.4	118.6	117.5	119.9
BSFC, lb/bhp-hr	0.389	0.374	0.404	0.399	0.376	0.417
Temperatures, ^{o}F						
Jacket In	154	150	160	154	148	160
Jacket Out	168	164	170	167	162	170
Oil Sump	236	230	246	247	242	250
Inlet Air (Compressor)	72	63	87	73	60	89
Airbox	232	224	240	278	270	290
Exhaust before Turbo	956	920	1000	982	960	1010
Exhaust after Turbo	824	800	870	845	820	880
Fuel at filter	86	79	90	88	85	93
Pressures						
Compressor Discharge	9.0	8.5	9.5	12.4	11.9	13.0
Blower Discharge	10.8	10.1	11.5	18.0	17.1	19.0
Exhaust Before Turbo	8.2	7.9	9.4	12.4	12.0	13.0
Oil Consumption (lb/hr avg for 140 hr)	0.667					

Unscheduled Shutdowns

1. At 4 hours - Oil Pump bypass leakage reduced oil pressure- lost 20 minutes
2. At 140 hours - High iron wear metals in oil and visual inspection of cylinder 1-left indicated incipient failure - Stopped test.

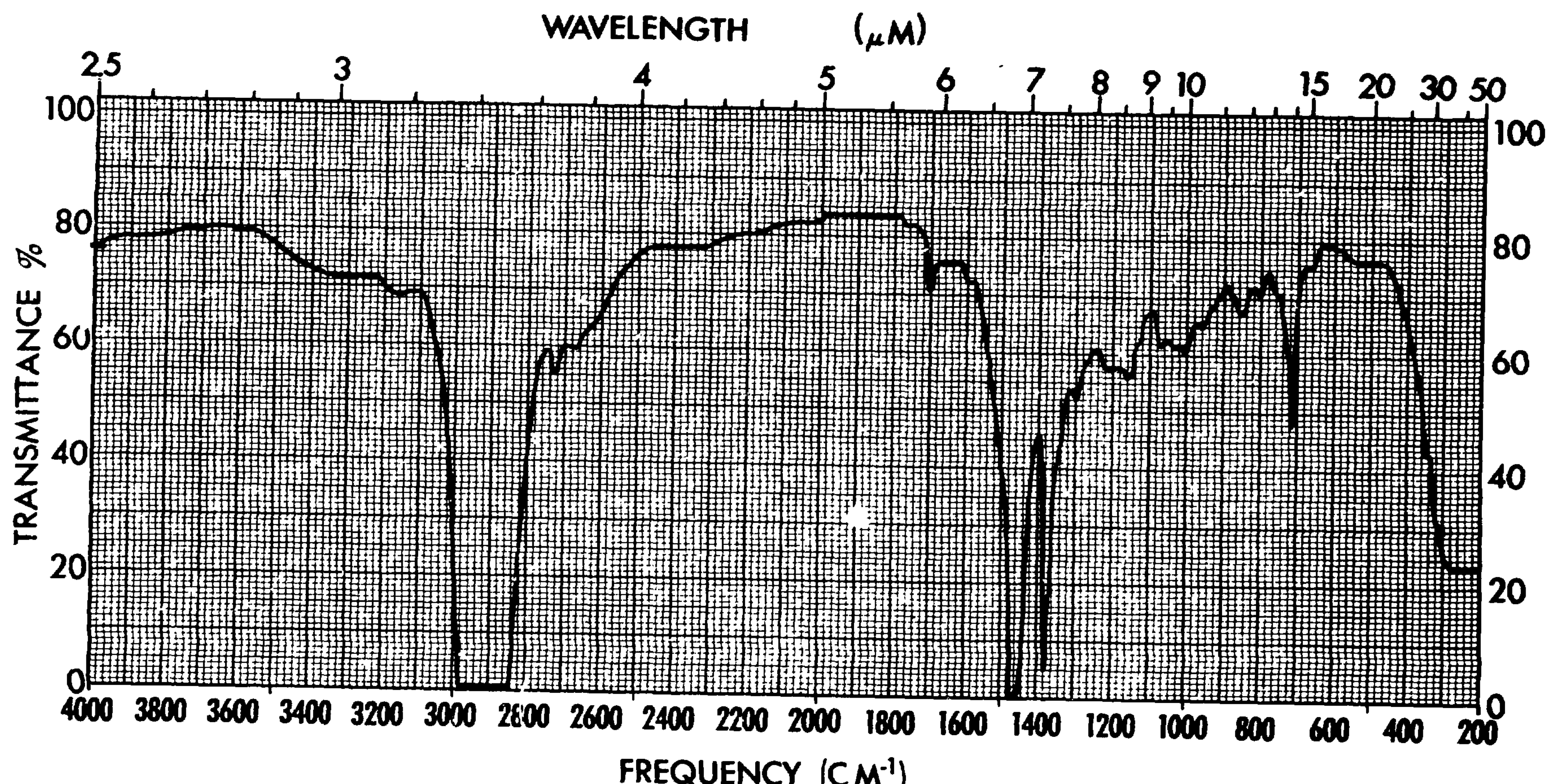

6V53T ENDURANCE TEST -240 HR. TRACKED
Test No. CI5136206-4 Oil: AL-6855-L
Obs. Horsepower (2800 rpm)
340
320
300
280
0
20
40
60
80
100
120
140
160
180
200
220
240
TEST HOUR


6V53T ENDURANCE TEST -240 HR. TRACKED
Test No. CI5136206-4 Oil: AL-6855-L
BSFC (2800 rpm)
0.440
0.420
0.400
0.380
0.360
0.340
0
20
40
60
80
100
120
140
160
180
200
220
240
TEST HOUR

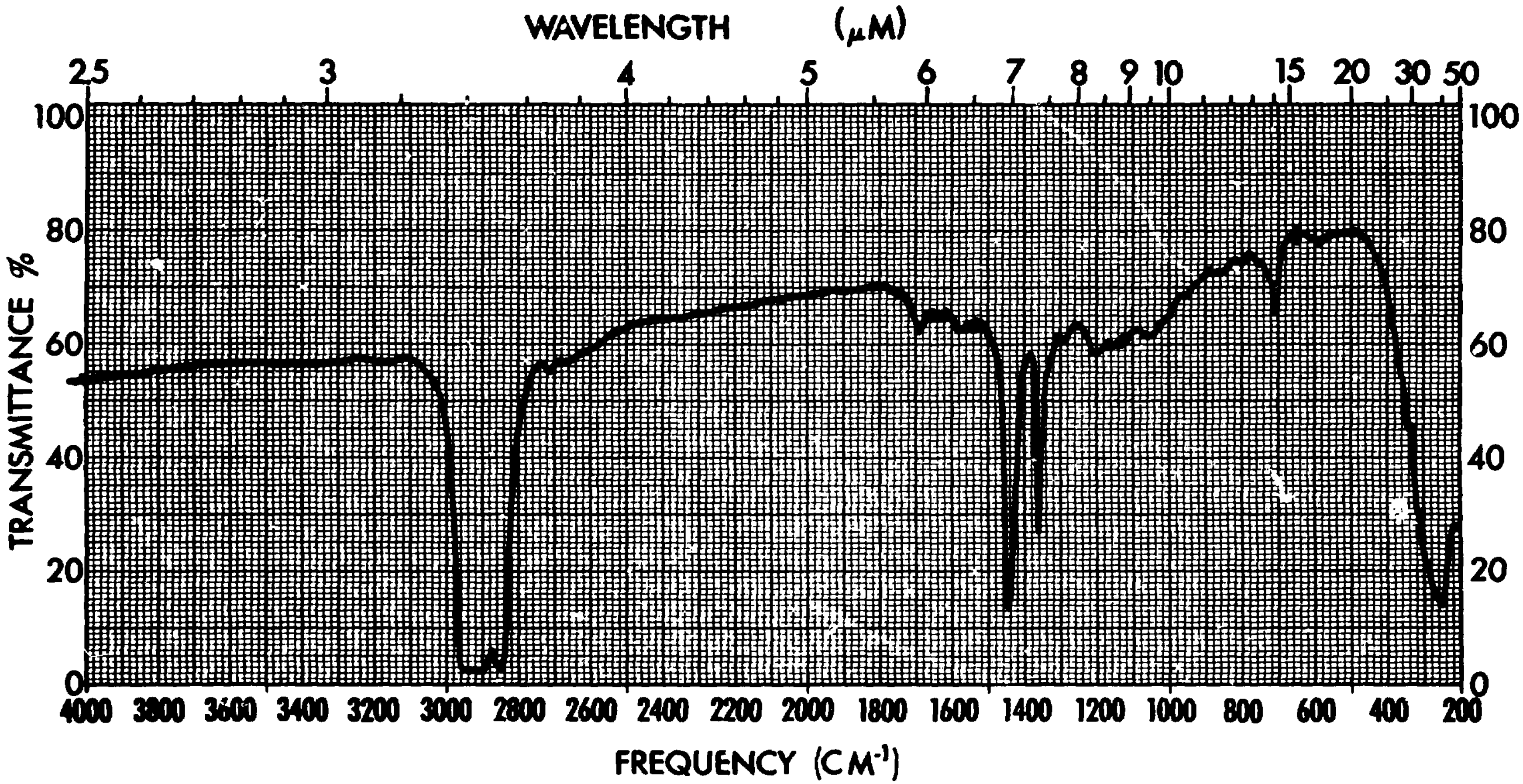
LUBRICANT ANALYSIS
6V53T - CI5136206 - 4
LUBRICANT: AL-6855-L
FUEL: 1-H CAT

Property	ASTM Procedure	New	20	40	60	80	100	120	140
K. Vis @40°C, cSt	D445	47.0*	47.03	50.60	52.85	53.33	55.30	56.69	47.21
K. Vis @100°C, cSt	D445	6.5	7.09	7.42	7.61	7.76	7.98	8.01	7.08
V.I.	D2270	103	108	108	107	110	111	108	107
TAN	D664	2.5	3.16	2.86	3.59	3.01	3.35	3.49	3.11
TBN	D2896	12.7	12.24	12.24	12.73	12.98	12.24	11.75	12.73
Insolubles, %	D893								
Pentane B		0.02	0.04	0.12	0.49	0.22	1.35	1.59	0.06
Benzene B		0.01	0.03	0.10	0.21	0.19	1.21	1.36	0.06
Flash Point, °C	D92	214	-	-	-	-	-	220	214
Carbon Residue, %	D542	1.7	-	-	-	-	-	3.62	2.53
Sulfated Ash, %	D874	1.7	-	-	-	-	-	2.23	1.91
Gravity, °API	D287	28.3	-	-	-	-	-	26.7	27.4
Iron by XRF, PPM			97	139	177	221	236	258	260
Cold Cranking Vis, cP	D2602								
At 0°F		2180	-	-	-	-	-	3400	2560
At -20°F			-	-	-	-	-	19,300	13,900

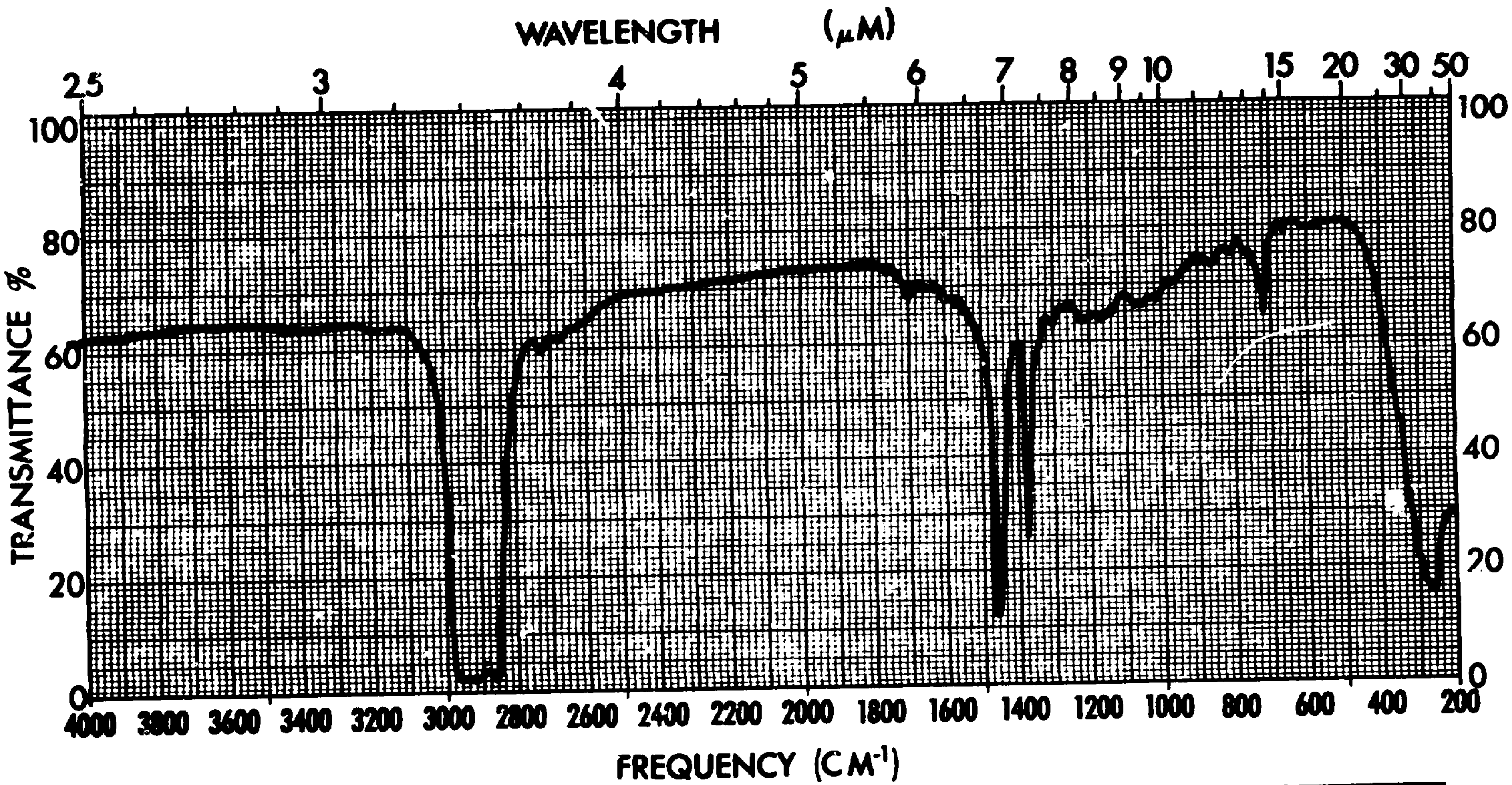
- Not Determined
*At 100°F



SPECTRUM NO. 1128	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6855-L		1.	
	PURITY	2.	
	PHASE	DATE 4-14-77	
	THICKNESS 0.05	OPERATOR D.B.	

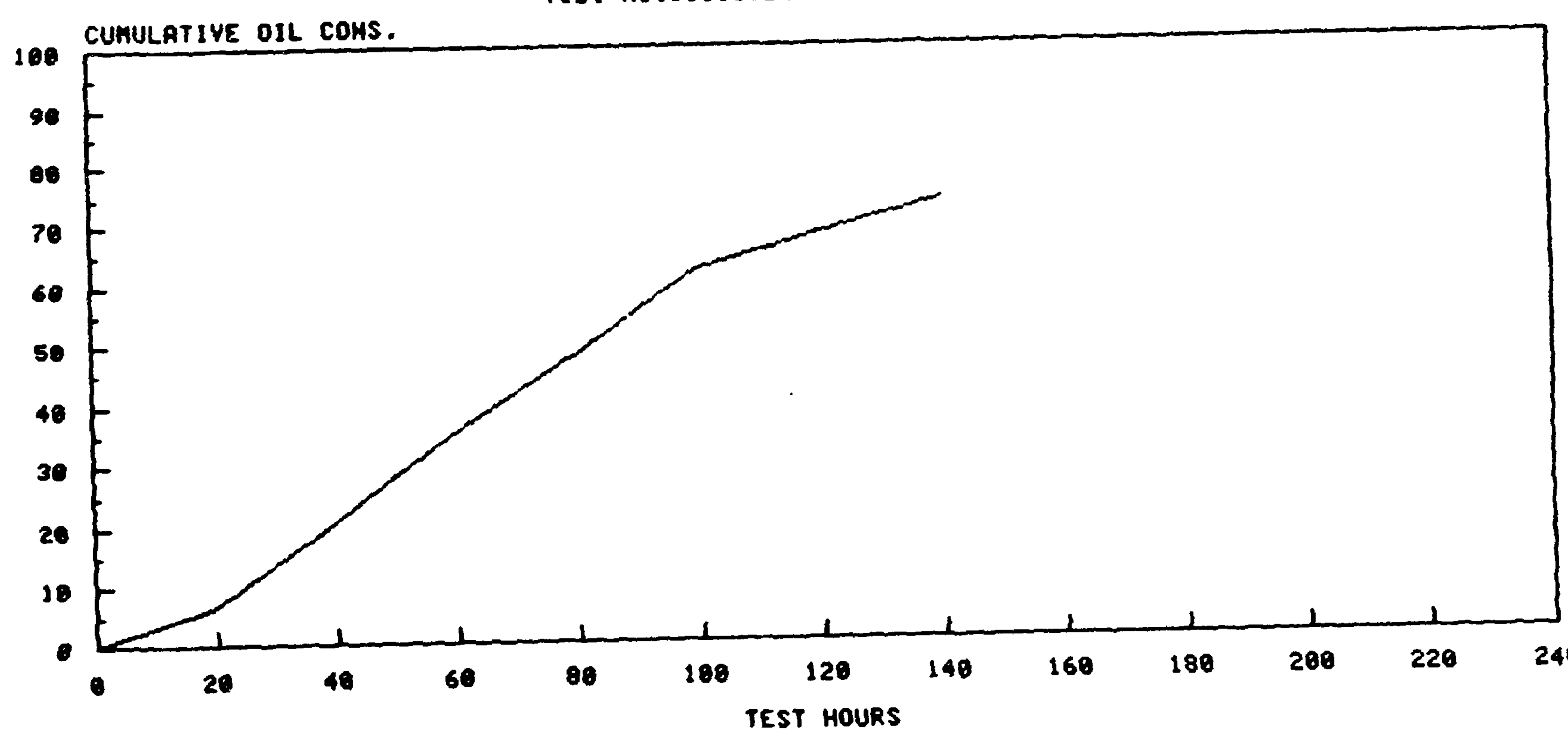


SPECTRUM NO. 1645	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6855-L		1.	
6V-53-T 120 HR	PURITY	2.	
	PHASE	DATE 3/5/79	
	THICKNESS 0.015	OPERATOR DDD	



SPECTRUM NO. 1646	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6855-L		1.	
6V-53-T 140 HR	PURITY	2.	
	PHASE	DATE 3/5/79	
	THICKNESS 0.015	OPERATOR DDD	

6V53T ENDURANCE TEST -CUM. OIL CONS.
Test No.CI5136206-4 OIL:AL-6855-L



WEAR MEASUREMENTS
TEST NO. CI5136206-4
OIL: AL-6855-L
TEST HOURS: 140

Cylinder No.		Cylinder Liner I.D.					
		Perpendicular to Crankshaft			Parallel to Crankshaft		
		Top	Middle	Bottom	Top	Middle	Bottom
1L	Before	3.8768	3.8768	3.8766	3.8760	3.8759	3.8766
	After	3.8698	3.8708	3.8777	3.8795	3.8792	3.8778
	Change	-0.0070	-0.0060	0.0011	0.0035	0.0033	0.0012
2L	Before	3.8760	3.8762	3.8765	3.8759	3.8762	3.8764
	After	3.8789	3.8776	3.8766	3.8759	3.8762	3.8770
	Change	0.0029	0.0014	0.0001	0.0000	0.0000	0.0006
3L	Before	3.8759	3.8760	3.8763	3.8759	3.8759	3.8762
	After	3.8775	3.8775	3.8771	3.8763	3.8761	3.8765
	Change	0.0016	0.0015	0.0008	0.0004	0.0002	0.0003
1R	Before	3.8763	3.8763	3.8764	3.8764	3.8763	3.8764
	After	3.8770	3.8766	3.8771	3.8766	3.8766	3.8769
	Change	0.0007	0.0003	0.0007	0.0002	0.0003	0.0005
2R	Before	3.8759	3.8760	3.8763	3.8760	3.8760	3.8764
	After	3.8772	3.8770	3.8772	3.8808	3.8798	3.8784
	Change	0.0013	0.0010	0.0009	0.0048	0.0038	0.0020
3R	Before	3.8756	3.8760	3.8762	3.8762	3.8763	3.8764
	After	3.8766	3.8769	3.8769	3.8764	3.8765	3.8769
	Change	0.0010	0.0009	0.0007	0.0002	0.0002	0.0005

WEAR MEASUREMENTS
ENGINE NO. 5136206-4
OIL: AL-6855-L
TEST HOURS: 140

Cylinder No.	Rod Bearing Journal AA	Rod Bearing Journal BB	Rod Bearing F	Rod Bearing R
1L Before	2.7499	2.7499	2.7530	2.7530
After	2.7498	2.7498	2.7532	2.7531
Change	-0.0001	-0.0001	0.0002	0.0001
2L Before	2.7499	2.7499	2.7527	2.7527
After	2.7498	2.7498	2.7531	2.7531
Change	-0.0001	-0.0001	0.0004	0.0004
3L Before	2.7499	2.7498	2.7524	2.7524
After	2.7498	2.7498	2.7528	2.7528
Change	-0.0001	0.0000	0.0004	0.0004
1R Before	2.7498	2.7499	2.7524	2.7523
After	2.7498	2.7498	2.7529	2.7528
Change	0.0000	-0.0001	0.0005	0.0005
2R Before	2.7499	2.7499	2.7525	2.7525
After	2.7498	2.7498	2.7530	2.7530
Change	-0.0001	-0.0001	0.0005	0.0005
3R Before	2.7499	2.7499	2.7528	2.7528
After	2.7498	2.7498	2.7531	2.7532
Change	-0.0001	-0.0001	0.0003	0.0004

WEAR MEASUREMENTS
ENGINE NUMBER 5136206-4
OIL: AL-6855-L
TEST HOURS: 140

Piston No.		Piston Ring Gap, inches						
		1	2	3	4	5	6	7
1L	Before	0.035	0.032	0.032	0.030	0.022	0.017	0.017
	After	*	*	N.R.	0.037	0.078	0.035	0.038
	Change	-	-	-	0.007	0.056	0.018	0.021
2L	Before	0.030	0.029	0.026	0.025	0.019	0.020	0.019
	After	0.038	0.030	0.028	0.026	0.035	0.028	0.028
	Change	0.008	0.001	0.002	0.001	0.016	0.008	0.009
3L	Before	0.031	0.030	0.027	0.028	0.021	0.017	0.017
	After	0.033	0.035	0.028	0.030	0.038	0.025	0.024
	Change	0.002	0.005	0.001	0.002	0.017	0.008	0.007
1R	Before	0.034	0.035	0.035	0.035	0.018	0.012	0.013
	After	0.044	0.038	0.038	0.038	0.034	0.018	0.020
	Change	0.010	0.003	0.003	0.003	0.016	0.006	0.007
2R	Before	0.026	0.025	0.029	0.030	0.022	0.018	0.018
	After	0.032	0.025	0.030	0.032	0.045	0.028	0.028
	Change	0.006	0.000	0.001	0.002	0.023	0.010	0.010
3R	Before	0.030	0.028	0.025	0.029	0.019	0.018	0.017
	After	0.038	0.028	0.026	0.030	0.035	0.028	0.026
	Change	0.008	0.000	0.001	0.001	0.016	0.010	0.009

* Broken

N.R. - Not Removed

RATING DATA SHEET
C1-4

Test Run at AFLRL
Test Oil: AL-6855-L
Test Fuel: AL-8060-F
Test No.: CI5136206-4
Test Stand: 5
Engine No.: 5136206
Test Hours: 140
Date Started: 14 February 1979
Completed: 27 February 1979

A. Cylinder Liner Ratings

Intake Port Plugging

Cylinder No.	Restriction, %
1 L	05
2 L	01
3 L	01
1 R	05
2 R	01
3 R	02
Average	

Scuffing, Glazing and Lacquer*

Cylinder No.	Thrust	Anti-Thrust	Total	Glazing, %	Lacquer,%
1 L	75	75	75	10	90
2 L	30	15	22	10	90
3 L	40	45	43	10	25
1 R	25	05	15	10	30
2 R	60	55	57	05	95
3 R	15	20	17	15	25
Average	41	34	38	10	59

*Ring Travel Area.

RATING DATA SHEET - CONTINUTED
C1-4

B. Piston Ratings

Ring Sticking and Condition

Cylinder No.	Ring: Fire	No. 1	No. 2	No. 3
1 L	* 100%B	* 100%B	Fy100%B	F 100%B
2 L	F 30%B	F 2%B	F 25%B	F 15%B
3 L	Sluggish 20%B	F 85%B	F 50%B	F 50%B
1 R	F 10%B	F 75%B	F 100%B	F 100%B
2 R	F 100%B	F 100%B	F 100%B	F 100%B
3 R	F 20%B	F 95%B	F 85%B	F 55%B

* Rings broken, + collapsed, y partially collapsed

Ring Groove Carbon Filling and Oil Groove Lacquer

Cylinder No.	Fire	Groove Filling, % No.1	No.2	No.3	Oil Groove Lacquer Upper	Lower
1 L	10	0	10	60	3.0	3.0
2 L	10	70	35	5	3.0	3.0
3 L	60	80	10	0	3.0	3.0
1 R	15	70	5	0	3.0	3.0
2 R	10	65	0	0	3.0	3.0
3 R	20	50	2	0	3.0	3.0

Cylinder No.	Land Description
1 L	Top Land-Distorted where ring broke (others normal)
2 L	Normal
3 L	Normal
1 R	Normal
2 R	3rd Land-Thrust side has plate melt (others normal)
3 R	Normal

Skirt

Cylinder No.	Side: Thrust	Anti-Thrust
1 L	6.0-10% Plate melt 30% Scuff	5.5-15% Melt 10% Scuff
2 L	5.5 Lt Scuff	5.5 Lt. Scratches
3 L	5.5 5% Plate melt 20% Scuff	5.5 Very Lt. Scratches
1 R	5.0 Lt Scratches	5.8 15% Plate melt and Scratches
2 R	4.8 Lt Scuffing	5.8 10% Plate melt and scuffing
3 R	5.5 Lt Scratches	5.9 Lt. Scuff and Scratches

RATING DATA SHEET - CONTINUED
C1-4

C. Other Ratings

Combustion Chambers

Cylinder No.	Description	Cylinder No.	Description
1 L	15% AHC	1 R	15% CHC 15 BHC 10 AHC
2 L	10% BHC 20 AHC	2 R	80% AHC
3 L	5% BHC 80% AHC	3 R	10% BHC 70 AHC

Valve Covers, Oil Pan and Cylinder Head Deck

Covers	Clean
Pan	Clean
Deck	Clean

Remarks

L - 1: When the two top rings broke, the top oil control ring was subjected to severe stress, resulting in more wear than usual.

D. Interim Inspections

Zero Test Hours	Inspection
1 L	Normal
2 L	Normal
3 L	Normal
1 R	Normal
2 R	Normal
3 R	Normal

20 Test Hours	
1 L	Normal
2 L	Normal
3 L	Normal
1 R	Normal
2 R	Normal
3 R	Normal

40 Test Hours

1L	Light glazing at ports
2L	Light glazing at ports
3L	Light glazing at ports
1R	Fire ring black, light glazing at ports
2R	Light glazing at ports
3R	Light glazing at ports

60 Test Hours

1L	Light cyl. scuff and glazing
2L	Same as 40 hours
3L	Same as 40 hours
1R	Same as 40 hours
2R	Same as 40 hours
3R	Same as 40 hours

80 Test Hours

1L	Fire ring has section missing at gap
2L	Same as previous
3L	Same as previous
1R	No black showing on ring-rotated from inspection port
2R	Same as previous
3R	Same as previous

100 Test Hours

1L	Same as 80 hours
2L	Light scuffing on cylinder
3L	Same as 80 hours
1R	Light port deposits, otherwise same
2R	Same as 80 hours
3R	Same as 80 hours

120 Test Hours

1L	Some port plugging and more blowby deposits. Nos. 1 and 2 compression rings worn, fire ring stuck
2L	Liner shows light scuffing, glazing and lacquer, some port plugging
3L	Same as previous
1R	Same as previous
2R	More cylinder glaze
3R	Same as previous

140 Test Hours

1L	More piston deposits
2L	Same as previous
3L	Same as previous
1R	Fire ring stuck
2R	Same as previous
3R	Same as previous

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked
TEST HOURS 140
TEST LABORATORY AFLRL
LUBRICANT AL-6855-L

RATER Lyons DATE 3-5-79
LABORATORY TEST NUMBER CI 5136206-4
STAND NO. 5 ENGINE NO. 5136206
FUEL AL-8060-F

PISTON NO. 1 Right

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	300.1

			GROOVES								LANDS								UNDER-CROWN	
			NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
	DEPOSIT TYPE	DEPOSIT FACTOR	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON	HC	1.00			75	75.00					10	10.00	75	75.00						
CARBON	MHC	0.75																		
CARBON	MC	0.50			25	12.50	20	10.00					25	12.50						
CARBON	LC	0.25	100	25.00			30	7.50			90	22.50			60	15.00	20	5.00		
CARBON	VLC	0.15					50	7.50												
CARBON	CARBON RATING		25.00		87.50		25.00				32.50		87.50		15.00		5.00			
LACQUER	BL	0.100							50	5.00					40	4.00	5	.50		
LACQUER	DBrL	0.075							50	3.75										
LACQUER	AL	0.050																	100	7.50
LACQUER	LAL	0.025															75	1.875		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
LACQUER	LACQUER RATING								8.75						4.00		2.375		7.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		25.00		87.50		25.00		8.75		32.50		87.50		19.00		7.375		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked
TEST HOURS 140
TEST LABORATORY AFLRL
LUBRICANT AL-6855-L

RATER E. Lyons DATE 3-6-79
LABORATORY TEST NUMBER CI5136206 - 4
STAND NO. 5 ENGINE NO. 5136206
FUEL AL-8060-F

PISTON NO. 2 Right

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	279.2

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00			70	70.00					20	20.00	70	70.00						
CARBON	MHC	0.75																		
CARBON	MC	0.50			30	15.00					70	35.00	20	10.00						
CARBON	LC	0.25	40	10.00							10	2.50								
CARBON	VLC	0.15	60	9.00									10	1.50	40	6.00				
CARBON	CARBON RATING		19.00		85.00						57.50		81.50		6.00					
LACQUER	BL	0.100					100	10.00							40	4.00	5.	.50		
LACQUER	DBrL	0.075													10	.75			100	7.50
LACQUER	AL	0.050							100	5.00										
LACQUER	LAL	0.025															95	2.375		
LACQUER	VLAL	0.010													10	.10				
LACQUER	RL	0.001																		
LACQUER	LACQUER RATING						10.00		5.00						4.85		2.875		7.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		19.00		85.00		10.00		5.00		57.50		81.50		10.85		2.875		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked
TEST HOURS 140
TEST LABORATORY AFLRL
LUBRICANT AL-6855-L

RATER Lyons DATE 3-6-79
LABORATORY TEST NUMBER CI5136206-4
STAND NO. 5 ENGINE NO. 5136206
FUEL AL-8060-F

PISTON NO. 3 Right

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	308.0

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00			65	65.00					20	20.00	80	80.00						
CARBON	MHC	0.75																		
CARBON	MC	0.50	50	25.00	35	17.50	5	2.50			65	32.50			25	12.50				
CARBON	LC	0.25	10	2.50							15	3.75	10	2.50	35	8.75				
CARBON	VLC	0.15	40	6.00									10	1.50	40	6.00				
	CARBON RATING		33.50		82.50		2.50				56.25		84.00		27.25					
LACQUER	BL	0.100					95	9.50												
LACQUER	DBrL	0.075																	100	7.50
LACQUER	AL	0.050																		
LACQUER	LAL	0.025							100	2.50							100	2.50		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING						9.50		2.50								2.50		7.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		33.50		82.50		12.00		2.50		56.25		84.00		27.25		2.50		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked
TEST HOURS 140
TEST LABORATORY AFLRL
LUBRICANT AL-6855-L

RATER Lyons DATE 3-5-79
LABORATORY TEST NUMBER CI5136206-4
STAND NO. 5 ENGINE NO. 5136206
FUEL I-H CAT AL-8060-F

PISTON NO. 1 Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	394.5

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00							10	10.00	50	50.00	65	65.00	75	75.00	95	95.00		
CARBON	MHC	0.75							20	15.00										
CARBON	MC	0.50																		
CARBON	LC	0.25									50	12.50	10	2.50						
CARBON	VLC	0.15	100	15.00	100	15.00	100	15.00	70	10.50			15	2.25	15	2.25				
CARBON	CARBON RATING		15.00		15.00		15.00		35.50		62.50		69.75		77.25		95.00			
LACQUER	BL	0.100															5	.50		
LACQUER	DBrL	0.075											10	.75	10	.75			100	7.50
LACQUER	AL	0.050																		
LACQUER	LAL	0.025																		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
LACQUER	LACQUER RATING												.75		.75		.50		7.50	
CLEAN		0																		
ZONAL RATING																				
LOCATION FACTOR																				
WEIGHTED RATING			15.00		15.00		15.00		35.50		62.50		70.50		78.00		95.50		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked
TEST HOURS 140
TEST LABORATORY AFLRL
LUBRICANT AL-6855-L

RATER Lyons DATE 3-5-79
LABORATORY TEST NUMBER CI5136206-4
STAND NO. 5 ENGINE NO. 5136206
FUEL AL-8060-F

PISTON NO. 2 Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	348.0

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00			25	25.00					65	65.00	80	80.00	30	30.00				
CARBON	MHC	0.75																		
CARBON	MC	0.50			70	35.00	40	20.00			25	12.50								
CARBON	LC	0.25			5	1·25	60	15.00	5	1.25					35	8.75	45	11.25		
CARBON	VLC	0.15	100	15.00							10	1.50	5	.75			10	1.50		
	CARBON RATING		15.00		61.25		35.00		1.25		79.00		80.75		38.75		12.75			
LACQUER	BL	0.100							95	9.50			15	1.50	35	3.50	15	1.50	100	7.50
LACQUER	DBrL	0.075																		
LACQUER	AL	0.050																		
LACQUER	LAL	0.025															30	.75		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING								9.50				1.50		3.50		2.25		7.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		15.00		61.25		35.00		10.75		79.00		82.25		42.25		15.00		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked
TEST HOURS 140
TEST LABORATORY AFLRL
LUBRICANT AL-685[illegible]-L

RATER Lyons DATE 3-5-79
LABORATORY TEST NUMBER CI513206-4
STAND NO. 5 ENGINE NO. 5136206
FUEL AL-8060-F

PISTON NO. 3 Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	429.4

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES								LANDS								UNDER-CROWN	
			NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
			AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON	HC	1.00	10	10.00	100	100.00	20	20.00			90	90.00	75	75.00	40	40.00				
	MHC	0.75																		
	MC	0.50	90	45.00																
	LC	0.25									10	2.50	25	6.25						
	VLC	0.15													55	8.25	50	7.50		
	CARBON RATING		55.00		100.00		20.00				92.50		81.25		48.25		7.50			
LACQUER	BL	0.100					80	8.00	35	3.50										
	DBrL	0.075															25	1.875	100	7.50
	AL	0.050							65	3.25										
	LAL	0.025													5	.125	25	.625		
	VLAL	0.010																		
	RL	0.001																		
	LACQUER RATING						8.00		6.75						.125		2.50		7.50	
CLEAN		0																		
ZONAL RATING																				
LOCATION FACTOR																				
WEIGHTED RATING			55.00		100.00		28.00		6.75		92.50		81.25		48.375		10.00		7.50	

*WEIGHTED TOTAL DEPOSITS

RING STICKING C1-4

Engine Model 6V53T   Serial No. CI 5136206-4   Date 3-5-79
Fuel AL-8060-F   Lubricant AL-6855-L   Observer E. Lyons

Piston Number

Ring No.	1L	2L	3L	1R	2R	3R
1	Broken Partially Collapsed	F	Sluggish	F	F	F
2 Not Removed	Broken Collapsed	F	F	F	F	F
3 Not Removed	Free Collapsed	F	F	F	F	F
4	F	F	F	F	F	F

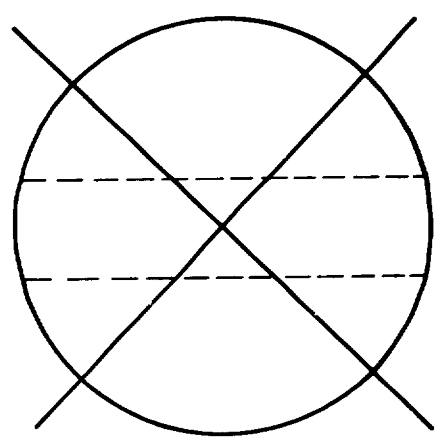
Indicate by letter—Free or Sluggish, or by number and letter—percent Pinched (cold stuck) or percent Hot stuck (Pages 6 and 7 of Manual).

PISTON GROOVE INSIDE DIAMETER—% RING SUPPORTING CARBON C1-4

Engine Model 6V53T Serial No. CI 5136206-4 Date 3-5-79

Fuel AL-8060-F Lubricant AL-6855-L Observer E. Lyons

Piston Ring	Quadrant	Piston Number 1L	2L	3L	1R	2R	3R
1	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
2	1	0	0	0	0	0	0
	2	0	0	100	50	0	25
	3	0	80	30	10	0	0
	4	0	0	100	50	20	25



VALVE DEPOSITS   C1-4

Engine Model 6V53T   Serial No. CI 5136206-4   Date 3-5-79
Fuel AL-8060-F   Lubricant AL-6855-L   Observer E. Lyons

		1L CARB	1L LACQ	2L CARB	2L LACQ	3L CARB	3L LACQ	1R CARB	1R LACQ	2R CARB	2R LACQ	3R CARB	3R LARQ
Head*	INT	A -	B -	C H	C	O	N	A L	L				
	EXH												
Face	INT	C L	E A	N	T O	# 9	L	A C	Q				
	EXH												
Tulip†	INT	L I	G H	T	C A	R B O	N	+	# 9	L	A C Q		
	EXH												
Stem	INT	9	L A	C Q	T O	C	L E	A N					
	EXH												

*Carbon and Ash: Use Volume Factor Technique (Pages 5 and 40 through 47 of Manual).
†Use Chart, Page 21—Indicate H, M, or S (Page 5).
Lacquer: Pages 4, 36 and 37.

EXHAUST VALVE SURFACE CONDITIONS C1-4

Engine Model 6V53T Serial No. CI 5136206 -4 Date 3-5-79

Fuel AL-8060-F Lubricant AL-6855-F Observer E. Lyons

	1L	2L	3L	1R	2R	3R
Freeness in Guide	F	F	F	F	F	F
Head	N	N	N	N	N	N
Face	N	N	N	N	N	N
Seat	N	N	N	N	N	N
Stem	N	N	N	N	N	N
Tip	N	N	N	N	N	N

See Pages 1, 2, 16 through 23, and 54 through 65 of Manual.

TAPPETS, CAMS, AND ROCKER ARMS C1-4

Engine Model 6V53T　　Serial No. CI 5136206-4　　Date 3/5/79

Fuel AL-8060-F　　Lubricant AL-6855-L　　Observer E. Lyons

			Cylinder Number					
			1L	2L	3L	1R	2R	3R
Tappet Deposit		INT	C	L E	A N			
		EXH						
Tappet Surface Condition		INJ	N	N	N	N	N	N
		INT						
		EXH	Lt Scratches	N	N	N	N	N
Cam Lobes			N	N	N	N	N	N
Rocker Arms	Tip	INT						
		EXH	N	N	N	N	N	N
	Bushing	INT						
		EXH	N	N	N	N	N	N
	Shaft	INT						
		EXH	N	N	N	N	N	N

Lacquer: Pages 4, 36 and 37 of Manual

See Pages 1, 2, 16 through 23, and 54 through 65.

SURFACE CONDITION C.1-4

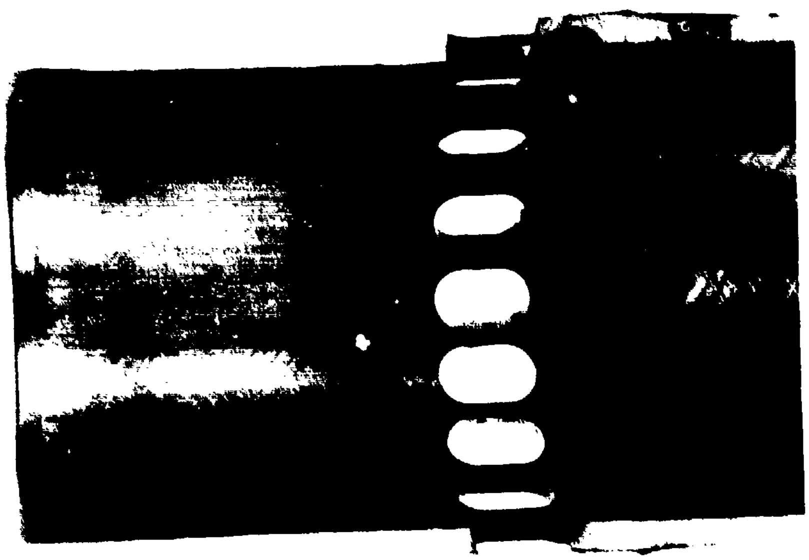
Engine Model 6V53T
Fuel AL-8060-F
Serial No. CI 5135206-4
Lubricant AL-6855-L
Date 3-6-79
Observer E. Lyons

Bearing No.	L 1	L 2	L 3	R1	R2	R3	7
Main–Bearing	Scratched Metal Lifting off bottom half	Same as #1	Copper showing metal lifting off	Copper showing deep scratches			
–Journal	N	N	N	N			
Rod–Bearing	Some Scratches	N	Scratched Copper Shows	Light Scratches			
–Journal	N	N	N	N	N	N	
Piston Pin	N	N	*	N	N	N	
Bushing	N	N	*	N	N	N	

Note surface condition. See pages 1, 2, 16 through 23 and 54 through 65 of Manual.
*Looks like pin was tight in bushing light gall on pin bushing.

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 140 HOURS   TEST NO.: C15136206-4   OIL: AL-6855-L

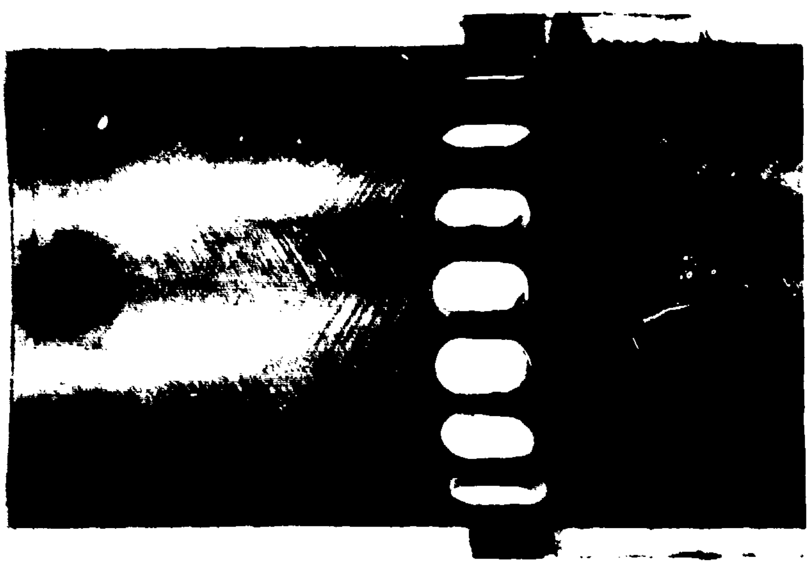


1-RIGHT THRUST

CONDITION OF PISTON AND CYLINDER LINER

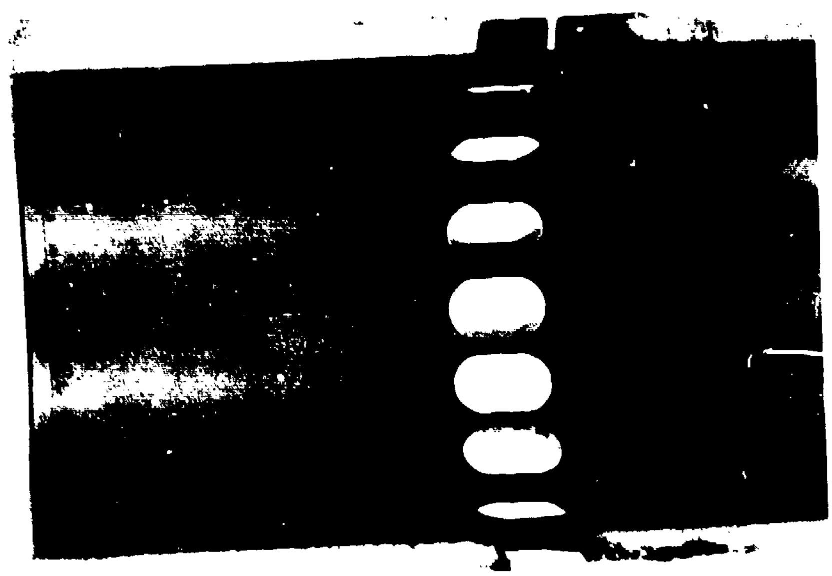
TEST TIME: 140 HOURS TEST NO.: C15136206-4 OIL: AL-6855-L

1-RIGHT ANTI-THRUST



CONDITION OF PISTON AND CYLINDER LINER

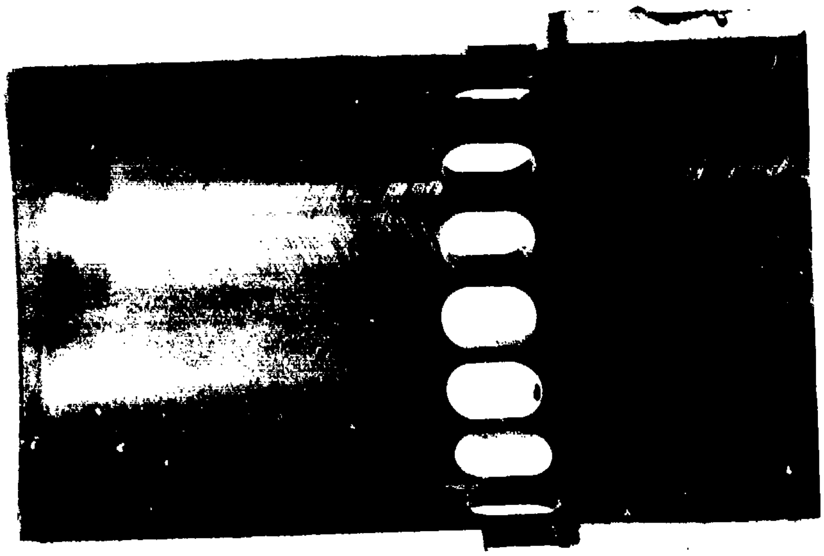
TEST TIME: 140 HOURS TEST NO.: CI5136206–4 OIL: AL–6855–L



2–RIGHT THRUST

CONDITION OF PISTON AND CYLINDER LINER

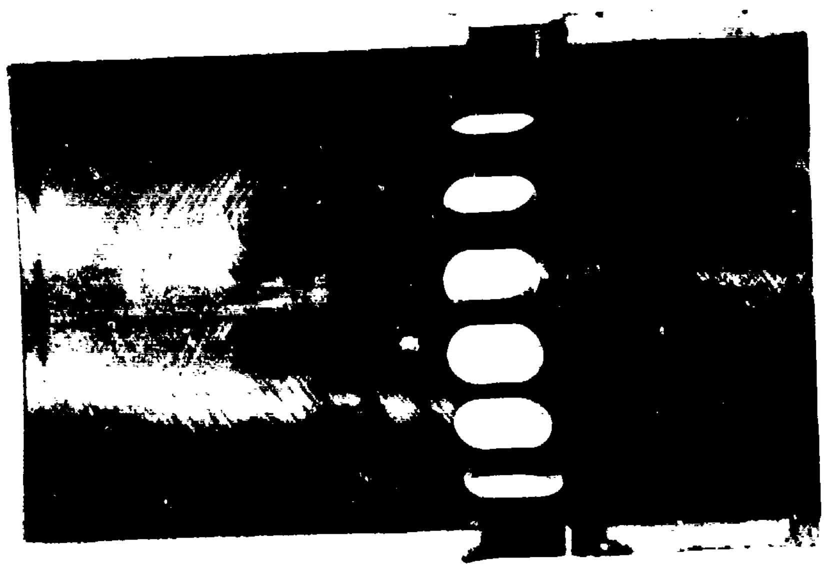
TEST TIME: 140 HOURS TEST NO.: CI5136206-4 OIL: AL-6855-L



2-RIGHT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

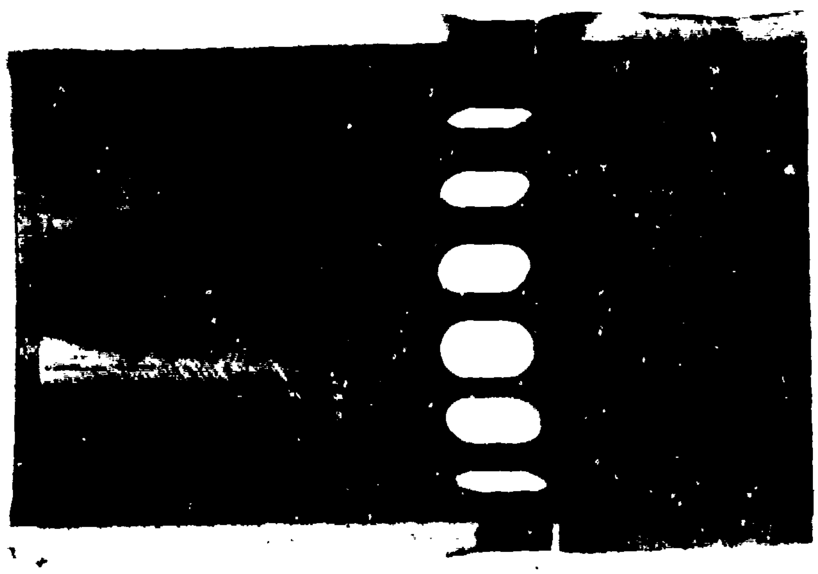
TEST TIME: 140 HOURS TEST NO.: CI5136206-4 OIL: AL-6855-L



3-RIGHT THRUST

CONDITION OF PISTON AND CYLINDER LINER

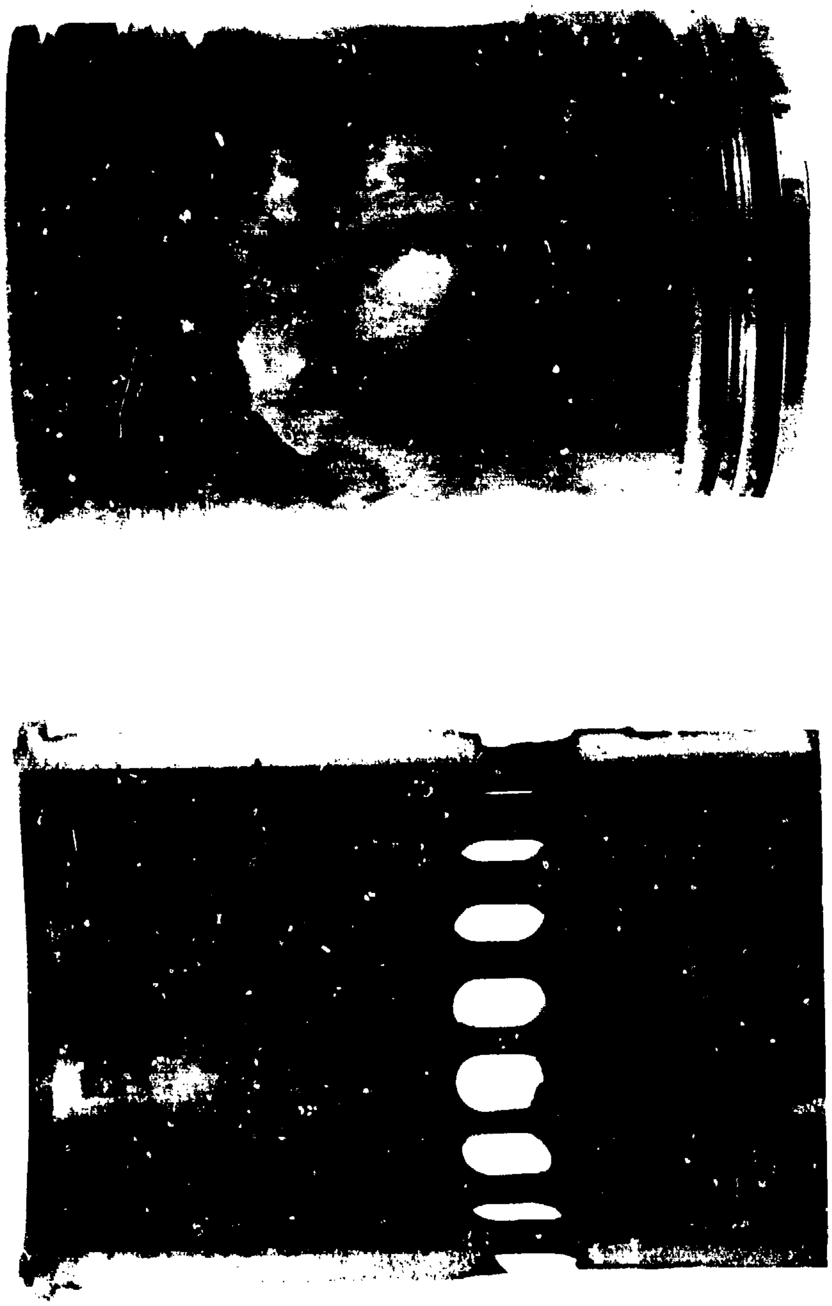
TEST TIME: 140 HOURS TEST NO.: CI5136206-4 OIL: AL-6855-L



3-RIGHT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

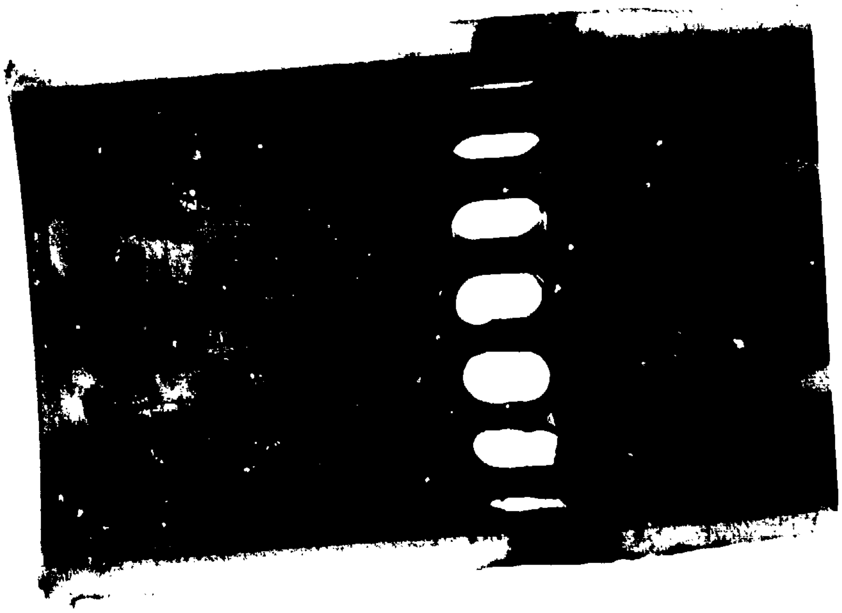
TEST TIME: 140 HOURS TEST NO.: CI5136206-4 OIL: AL-6855-L



1-LEFT THRUST

CONDITION OF PISTON AND CYLINDER LINER

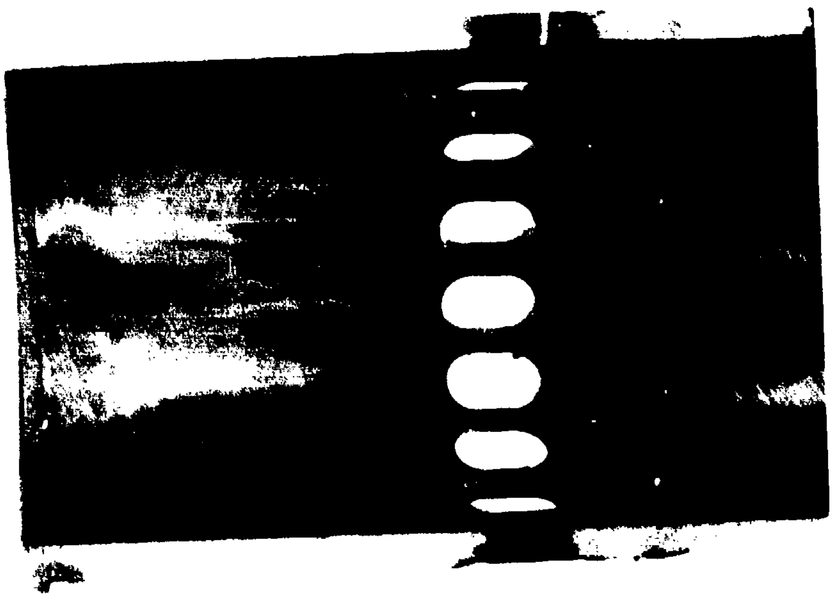
TEST TIME: 140 HOURS TEST NO.: CI5136206–4 OIL: AL–6855–L



1–LEFT ANTI–THRUST

CONDITION OF PISTON AND CYLINDER LINER

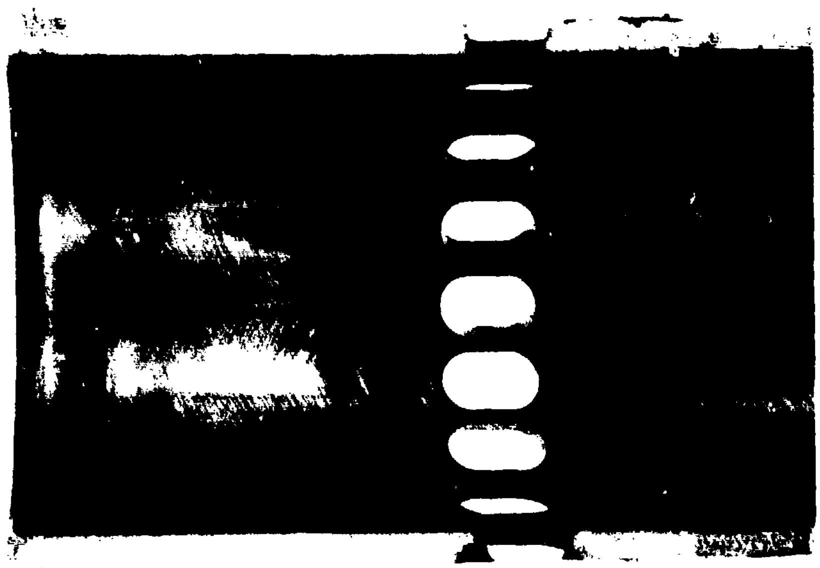
TES. TIME: 140 HOURS TEST NO.: CI5136206-4 OIL: AL-6855-L



2-LEFT THRUST

CONDITION OF PISTON AND CYLINDER LINER

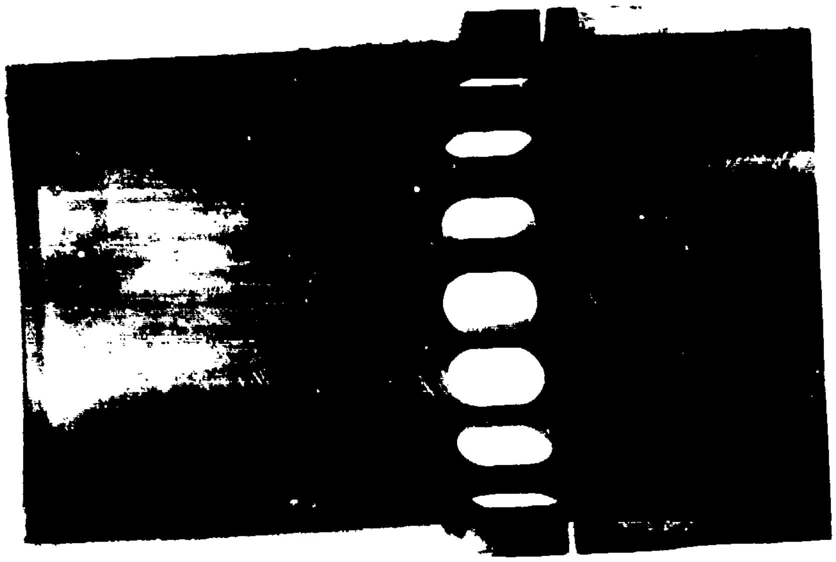
TEST TIME: 140 HOURS TEST NO.: CI5136206-4 OIL: AL-6855-L



2-LEFT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

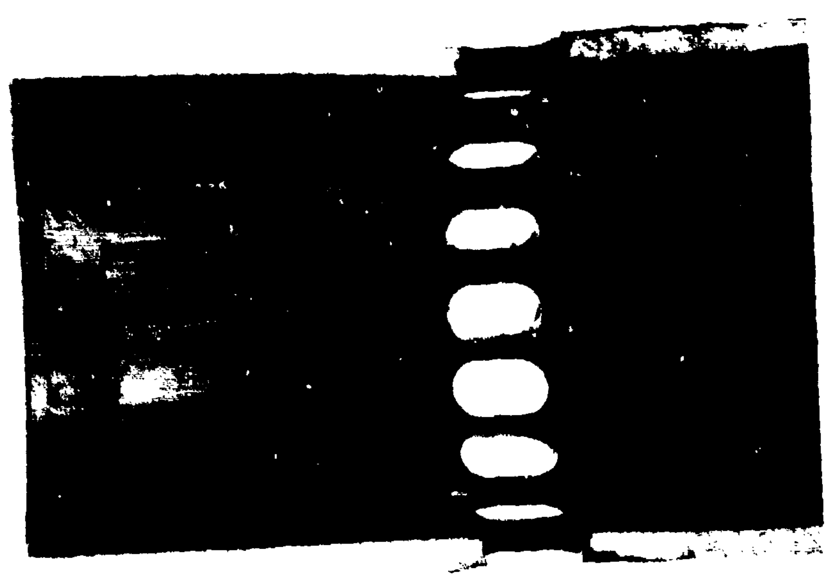
TEST TIME: 140 HOURS TEST NO.: CI5136206-4 OIL: AL-6855-L



3-LEFT THRUST

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 140 HOURS   TEST NO.: CI5136206-4   OIL: AL-6855-L



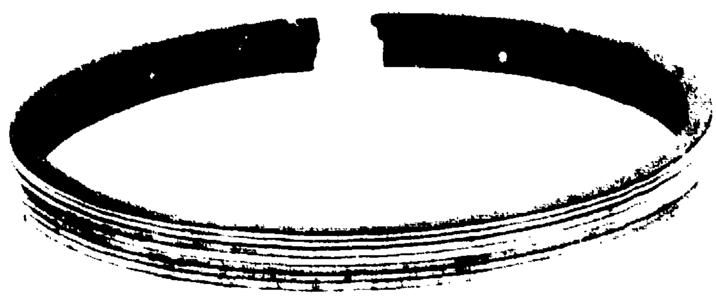
3-LEFT ANTI-THRUST

CONDITION OF PISTON RING FACE

TEST TIME: 140 HOURS TEST NO.: CI5136206-4 OIL: AL-6855-L

1 RIGHT

2 RIGHT



3 RIGHT

CONDITION OF PISTON RING FACE

TEST TIME: 140 HOURS   TEST NO.: CI5136206-4   OIL: AL-6856-L

1 LEFT

2 LEFT

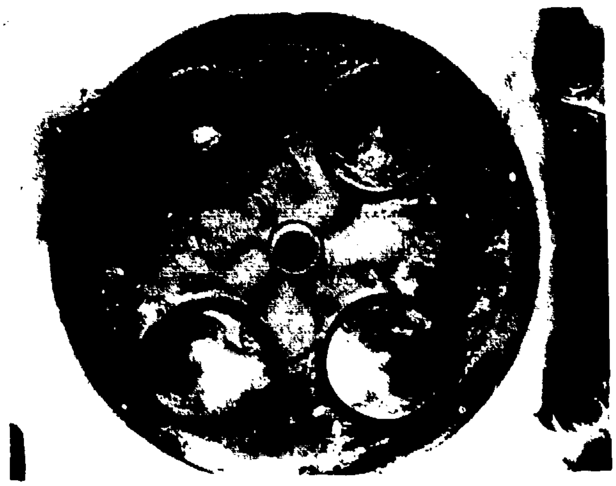
3 LEFT

CONDITION OF CYLINDER HEAD

TEST TIME: 140 HOURS TEST NO.: CI5136206-4 OIL: AL-6855-L

1 RIGHT

2 RIGHT

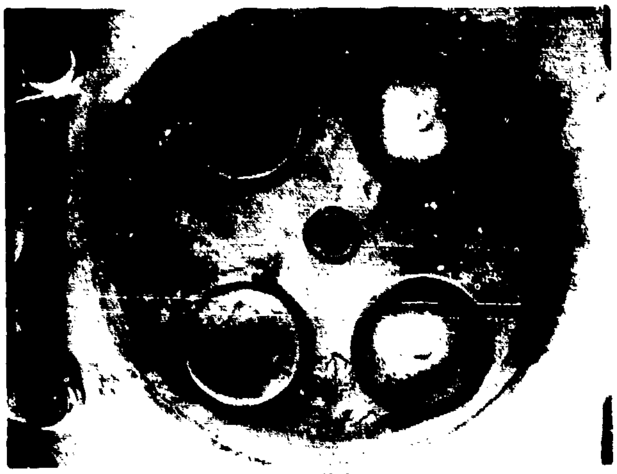


3 RIGHT

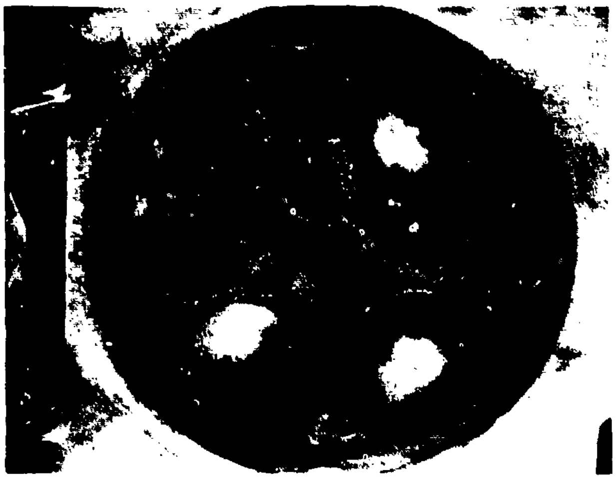
CONDITION OF CYLINDER HEAD

TEST TIME: 140 HOURS   TEST NO.: CI5136206-4   OIL: AL-6855-L

1 LEFT



2 LEFT



3 LEFT

APPENDIX C

ENGINE-LUBRICANT COMPATIBILITY TEST #5

240-HOUR TRACKED-VEHICLE CYCLE

USING 6V-53T DIESEL ENGINE

ENGINE-LUBRICANT COMPATIBILITY TEST
240-HOUR TRACKED VEHICLE CYCLE
USING 6V53T DIESEL ENGINE

Test Lubricant: AL-6947-L
Engine Test Number: CI 5136206-5
Date Completed: 2 May 1979

Conducted for

U.S. Army Mobility Equipment Research and Development Command
Energy and Water Resources Laboratory
Fort Belvoir, Virginia

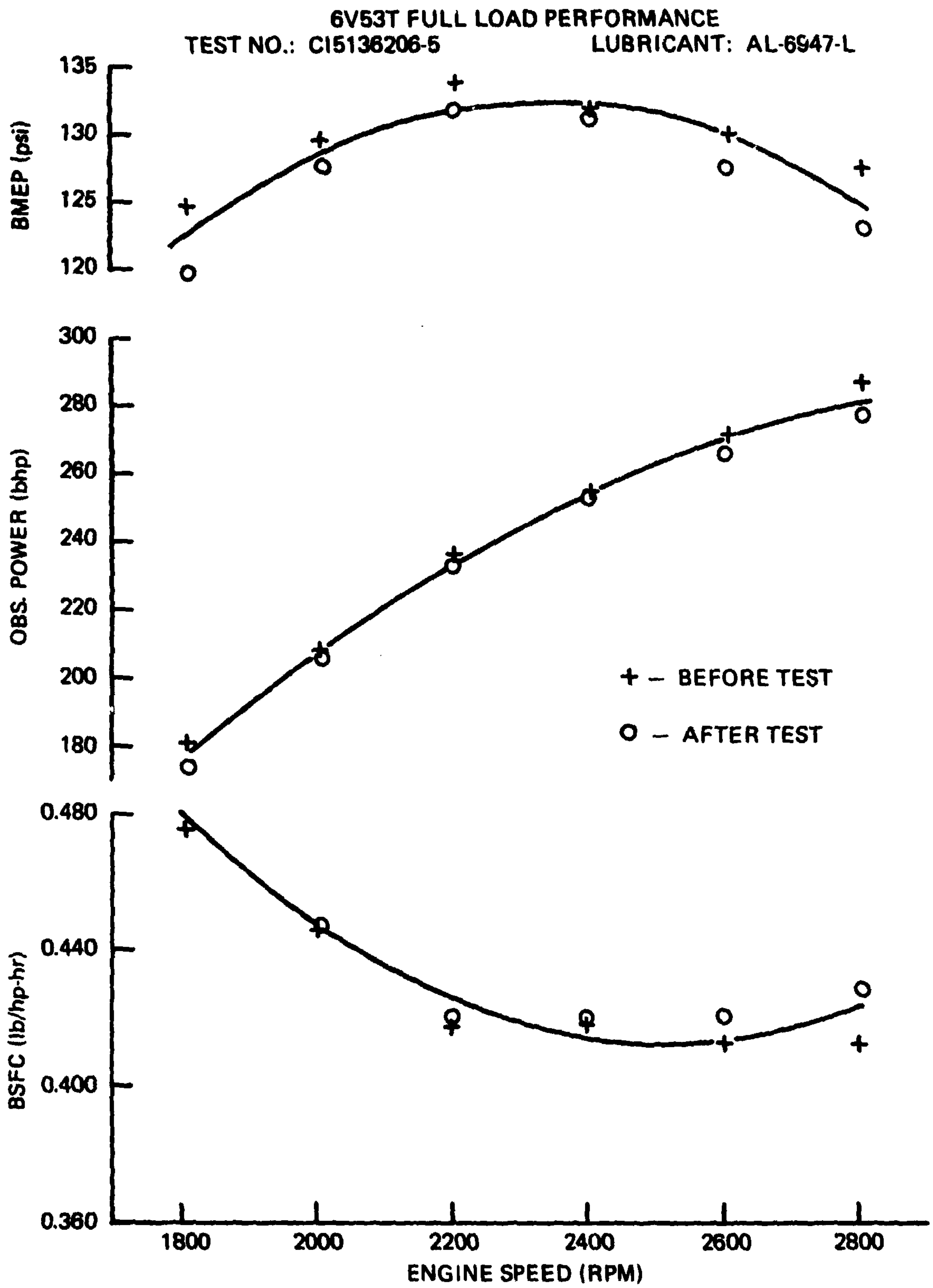
By

U.S. Army Fuels and Lubricants Research Laboratory
Southwest Research Institute
San Antonio, Texas 78284

6V53T
BUILD-UP ENGINE MEASUREMENTS
CI 5136206-5

Measurements	Inches			
	Min	Max	Avg	Spec. Limits (1)
Cylinder liner block bore				
Taper	0.0000	0.0002	0.0001	0.0015 max
Out-of-round	0.0000	0.0002	0.0001	0.0015 max
Inside diameter	4.3570	4.3575	4.3573	4.3595 max
Cylinder Liners (installed)				
Taper	0.0001	0.0008	0.0004	0.0020 max (2)
Out-of-round	0.0000	0.0003	0.0001	0.0030 max (2)
Inside diameter	3.8753	3.8762	3.8758	3.8752-3.8767
Piston to liner fit	0.0067	0.0088	0.0074	0.0060-0.0095
Piston Diameter	3.8659	3.8688	3.8676	3.8669-3.8691
Fire Ring				
End gap	0.027	0.036	0.033	0.020 -0.046
Side clearance	0.003	0.003	0.003	0.003 -0.006
No. 1 Compression ring				
End gap	0.028	0.034	0.031	0.020 -0.046
Side clearance	0.008	0.009	0.008	0.007 -0.010
No. 2 & No. 3 Compression ring				
End gap	0.025	0.036	0.030	0.020 -0.046
Side clearance	0.006	0.007	0.006	0.005 -0.010
Oil rings				
End gap	0.016	0.022	0.019	0.010 -0.025
Side clearance	0.002	0.003	0.002	0.0015-0.0055

(1) Limits on new parts unless maximum wear limit specified.
(2) Wear limits with new liners in a used block.



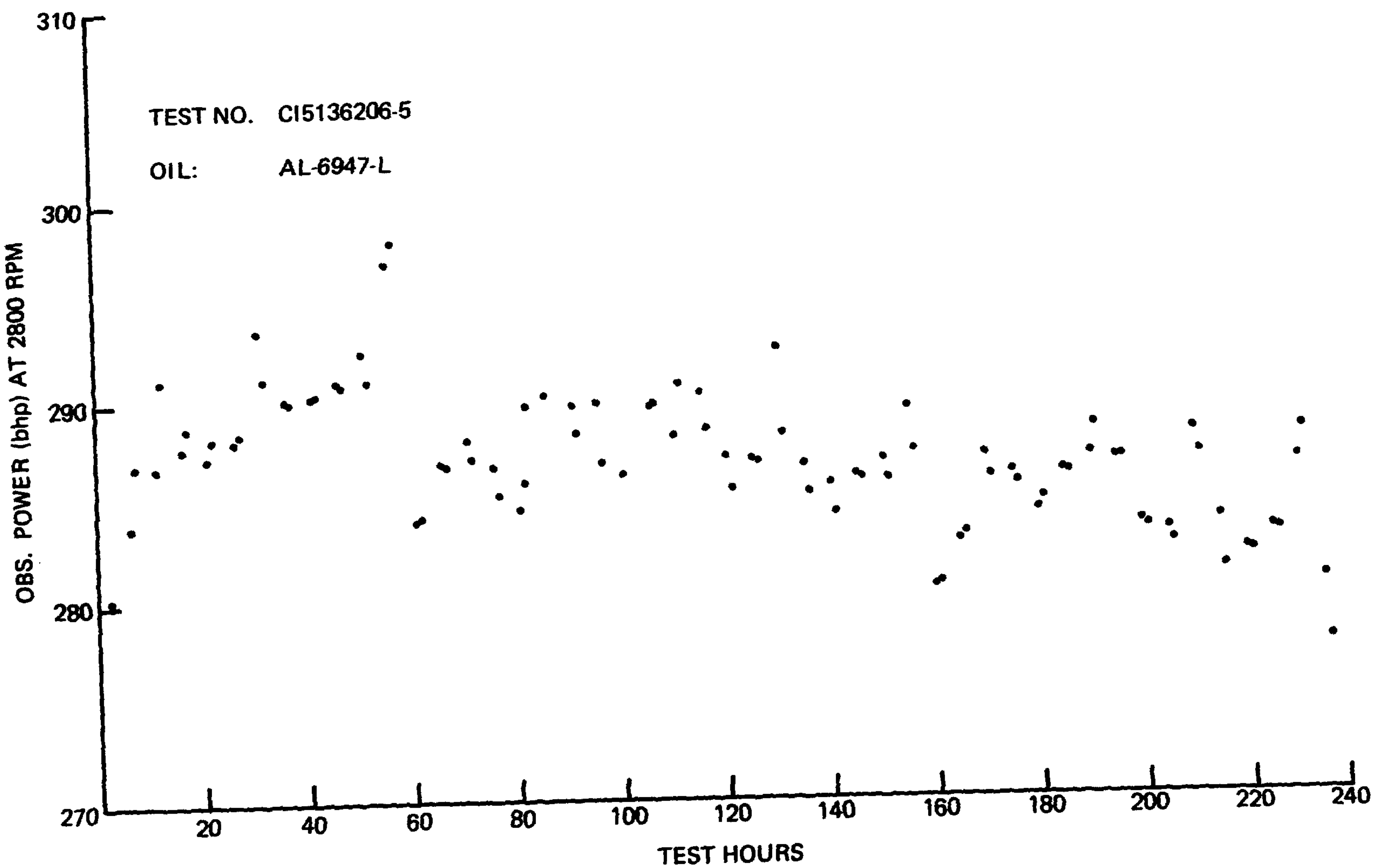
6V53T FULL LOAD PERFORMANCE
TEST NO.: CI5136206-5
LUBRICANT: AL-6947-L
BMEP (psi)
135
130
125
120
OBS. POWER (bhp)
300
280
260
240
220
200
180
+ – BEFORE TEST
O – AFTER TEST
BSFC (lb/hp-hr)
0.480
0.440
0.400
0.360
1800
2000
2200
2400
2600
2800
ENGINE SPEED (RPM)

6V53T ENDURANCE TEST
SUMMARY OF OPERATING DATA

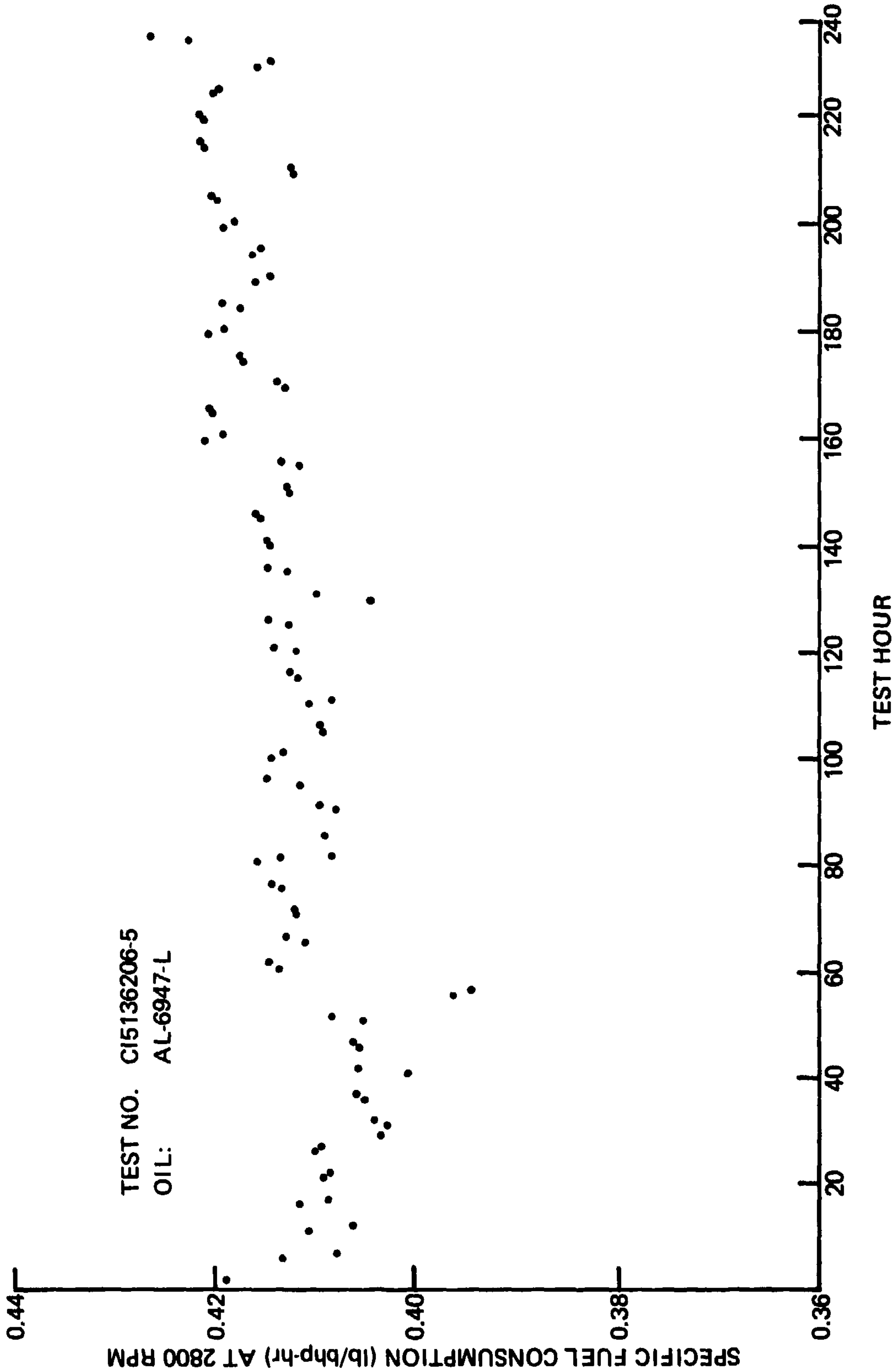
Oil: AL-6947-L

Test No.: CI 5136206-5

	2200 RPM			2800 RPM		
	Avg	Min	Max	Avg	Min	Max
Engine Speed, rpm	2205	2199	2209	2804	2799	2810
Load, lb	448	436	464	420	406	436
Obs. Power, bhp	241	234	249	287	278	298
Fuel Rate, lb/hr	98.3	96.9	99.3	118.5	116.4	120.0
BSFC, lb/bhp-hr	0.408	0.392	0.419	0.413	0.395	0.426
Temperatures, °F						
Jacket In	148	72	156	139	67	145
Jacket Out	162	149	166	152	140	160
Oil Sump	247	237	250	248	244	250
Inlet Air (compressor)	81	75	92	82	73	90
Airbox	258	232	280	299	281	311
Exhaust before Turbo	1137	1100	1180	1142	1100	1190
Exhaust after Turbo	977	940	1030	984	940	1130
Fuel at Filter	88	80	92	90	84	94
Pressures						
Compressor Discharge	7.8	7.1	8.4	10.2	9.1	11.1
Blower Discharge	9.7	9.0	10.2	15.6	15.0	16.4
Exhaust Before Turbo	7.5	7.0	7.8	11.0	10.1	11.6
Oil Consumption (lb/hr avg for 240 hr)	0.378					



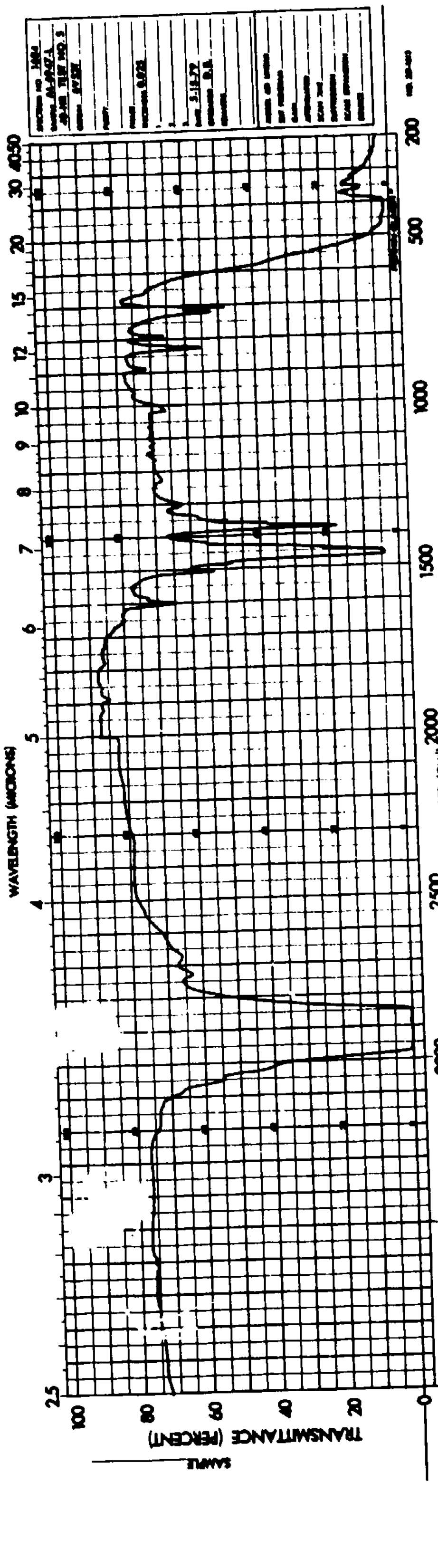
TEST NO. CI5136206-5
OIL: AL-6947-L
310
300
290
280
270
OBS. POWER (bhp) AT 2800 RPM
20
40
60
80
100
120
140
160
180
200
220
240
TEST HOURS

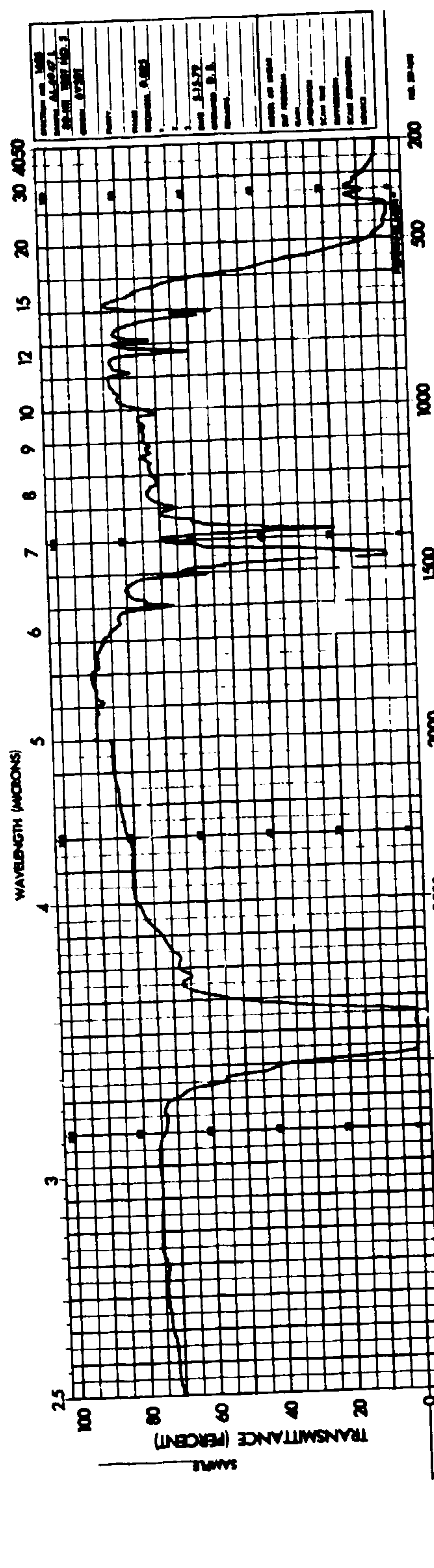

TEST NO. CI5136206-5
OIL: AL-6947-L
SPECIFIC FUEL CONSUMPTION (lb/bhp-hr) AT 2800 RPM
0.44
0.42
0.40
0.38
0.36
TEST HOUR
20
40
60
80
100
120
140
160
180
200
220
240

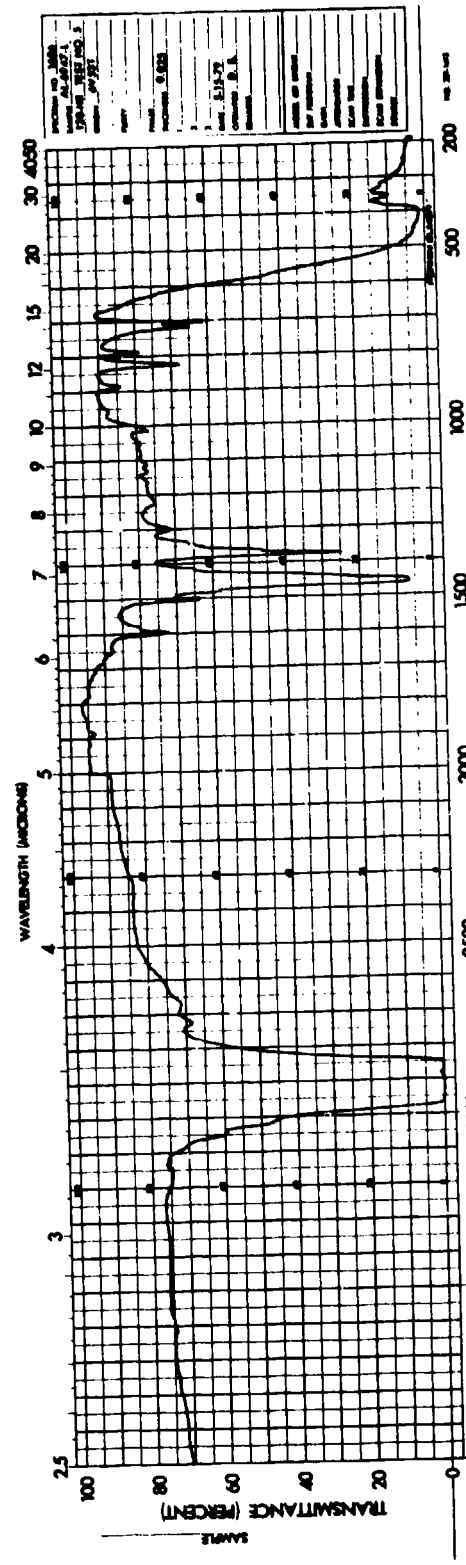
LUBRICANT ANALYSIS
6V53T-CI 5136206-5
LUBRICANT: AL-6947-L
FUEL: 1-H CAT

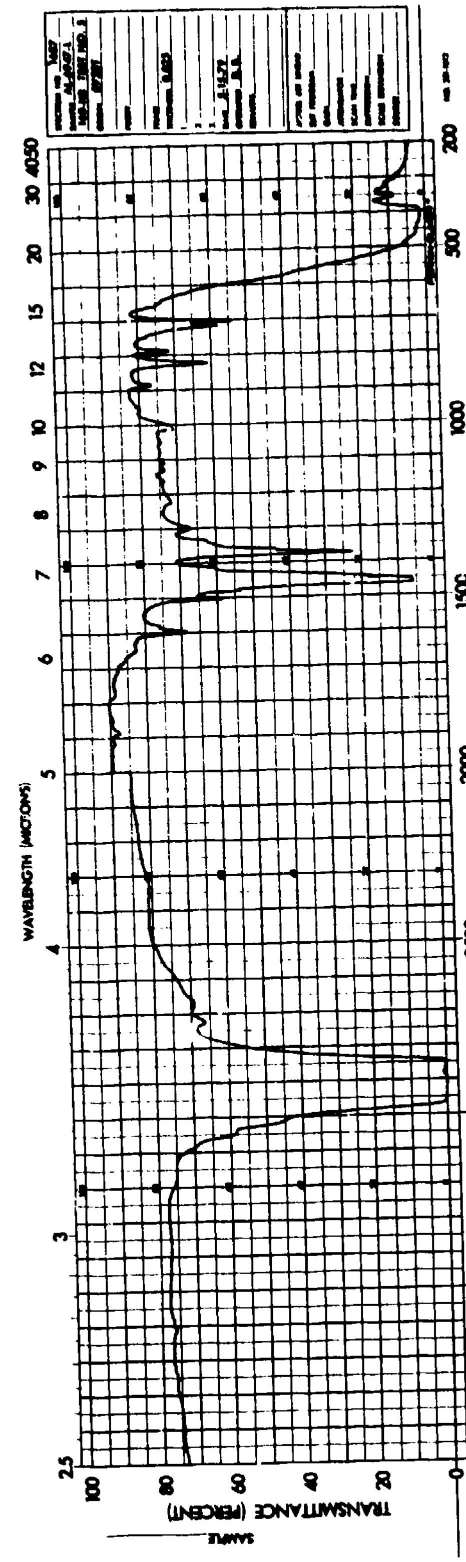
Property	ASTM Method	TEST HOUR: New	20	40	60	80	100	120	140	160	180	200	220	240
K. Vis @40°C,cSt	D 445	68.51	69.22	70.86	71.13	72.45	72.78	74.48	68.92	70.28	71.79	72.15	73.48	74.63
K. Vis @100°C,cSt	D 445	10.58	10.18	10.34	10.40	10.53	10.56	10.66	10.26	10.33	10.44	10.52	10.59	10.72
VI	D 2270	143	132	133	132	132	132	130	134	132	132	132	131	131
TAN	D 664	2.5	2.6	2.7	2.9	2.9	2.9	2.9	3.0	3.0	3.0	3.0	3.1	3.1
TBN	D 2896	8.6	8.6	8.4	8.8	8.6	8.9	8.8	8.8	8.5	7.7	8.2	8.1	8.5
Insolubles, %	D 893													
Pentane B		0.02	-	0.049	-	0.056	-	0.086	-	0.084	-	0.099	-	0.208
Benzene B		0.02	-	0.034	-	0.051	-	0.083	-	0.073	-	0.074	-	0.146
Toluene B		-	-	0.028	-	0.050	-	0.083	-	0.070	-	0.072	-	0.147
Flash Point, °C	D 92	228	-	-	-	-	-	240	-	-	-	-	-	246
Carbon Residue, %	D 524	1.22	-	-	-	-	-	2.21	-	-	-	-	-	2.48
Sulfated Ash, %	D 872	1.16	-	-	-	-	-	1.46	-	-	-	-	-	1.52
Gravity, °API	D 287	29.9	-	-	-	-	-	28.7	-	-	-	-	-	28.3
Wear Metals by XRF														
Fe, ppm		-	85	140	199	233	237	241	219	251	249	246	250	250
Cu, ppm		-	-	35	28	22	26	20	10	-	-	-	-	-

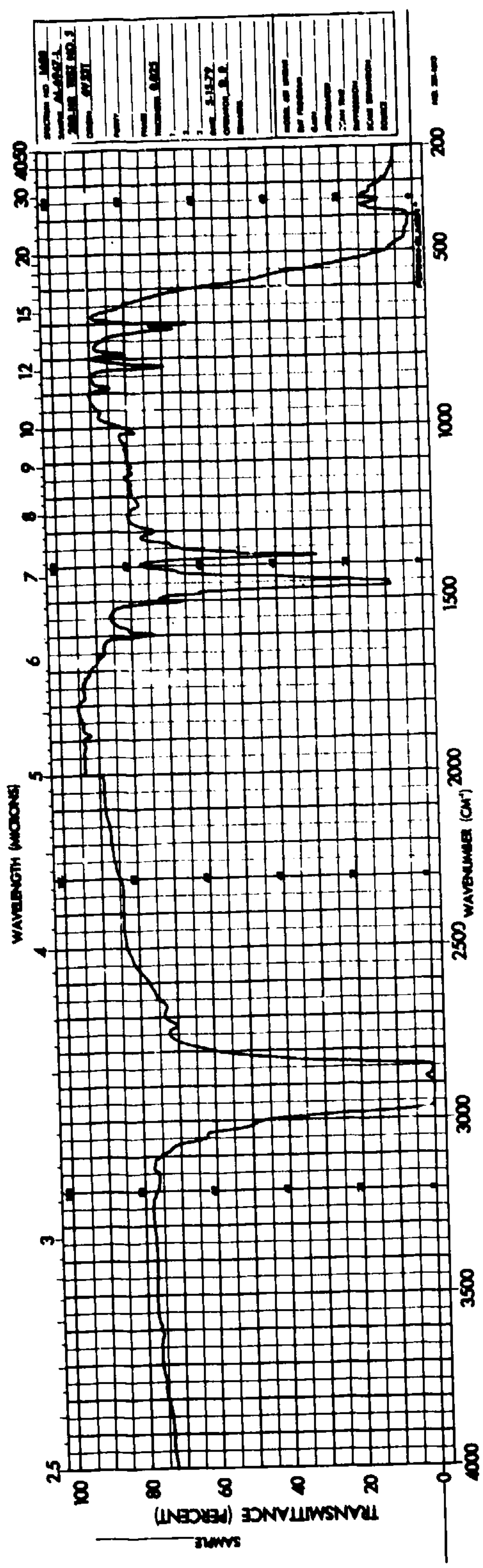
- = Not determined

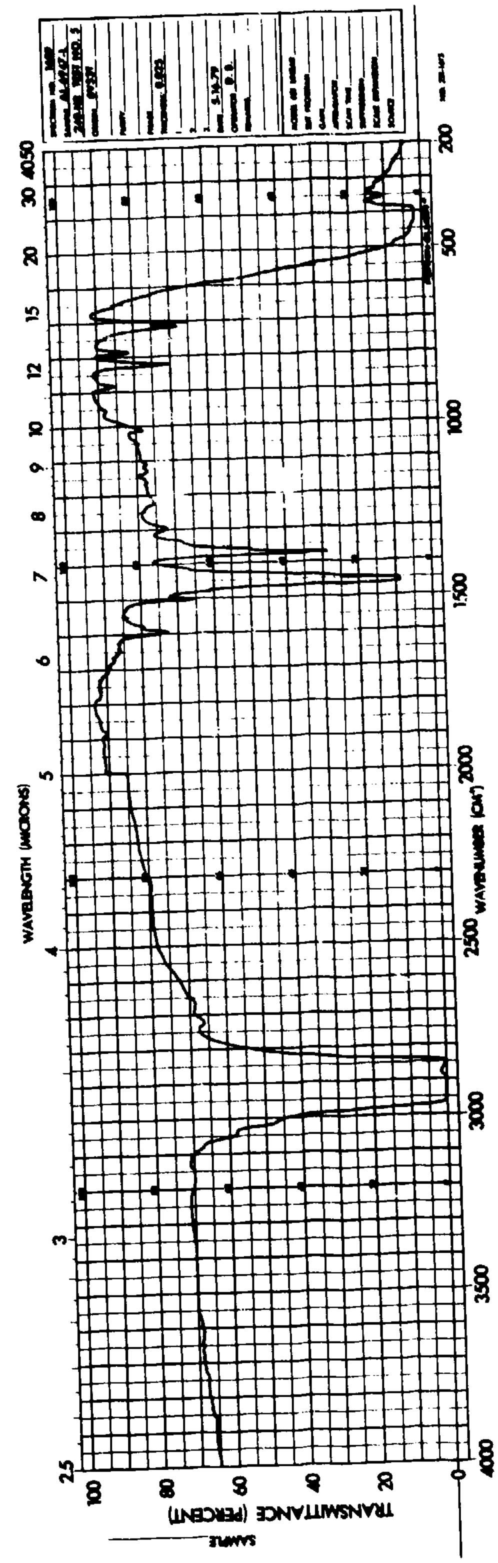





WAVELENGTH (MICRONS)
WAVENUMBER (CM⁻¹)
TRANSMITTANCE (PERCENT)
SAMPLE

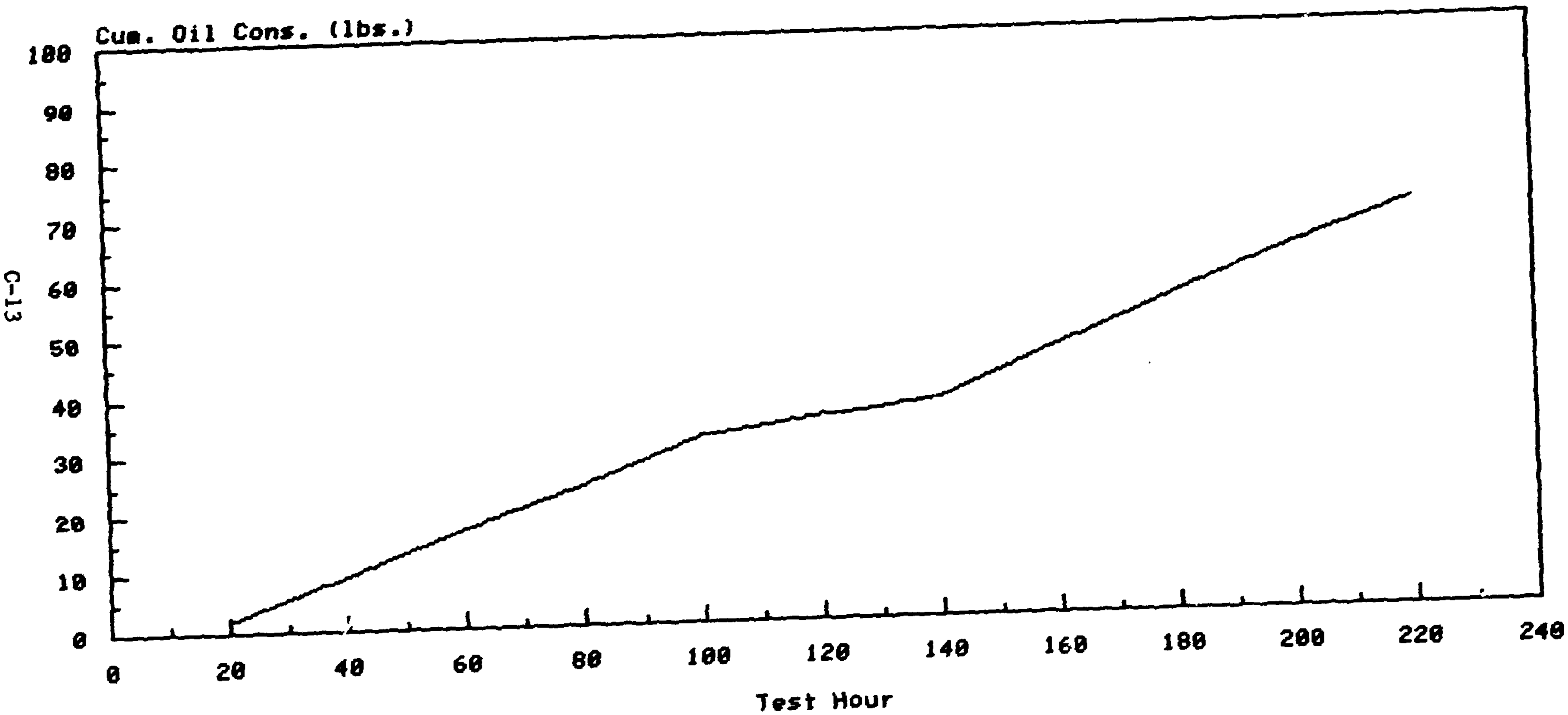

WAVELENGTH (MICRONS)
WAVENUMBER (CM⁻¹)
TRANSMITTANCE (PERCENT)
SAMPLE


WAVELENGTH (MICRONS)
WAVENUMBER (CM⁻¹)
TRANSMITTANCE (PERCENT)
SAMPLE


WAVELENGTH (MICRONS)
WAVENUMBER (CM⁻¹)
TRANSMITTANCE (PERCENT)
SAMPLE

6V53T ENDURANCE TEST - 240 Hr. TRACKED

Test No. CI5136206-5 Oil: AL-6947-L



WEAR MEASUREMENTS
TEST NO.: CI 5136206-5
OIL: AL-6947-L
TEST HOURS: 240

Cylinder No.		Cylinder Liner I.D. Perpendicular to Crankshaft Top	Middle	Bottom	Parallel to Crankshaft Top	Middle	Bottom
1L	Before	3.8756	3.8757	3.8761	3.8757	3.8758	3.8759
	After	3.8790	3.8770	3.8769	3.8755	3.8756	3.8761
	Change	0.0034	0.0013	0.0008	-0.0002	-0.0002	0.0002
2L	Before	3.8755	3.8756	3.8760	3.8756	3.8758	3.8760
	After	3.8798	3.8775	3.8770	3.8778	3.8774	3.8774
	Change	0.0043	0.0019	0.0010	0.0022	0.0016	0.0014
3L	Before	3.8758	3.8758	3.8759	3.8755	3.8757	3.8758
	After	3.8781	3.8776	3.8778	3.8763	3.8762	3.8768
	Change	0.0023	0.0018	0.0019	0.0008	0.0005	0.0010
1R	Before	3.8755	3.8756	3.8758	3.8754	3.8756	3.8759
	After	3.8798	3.8788	3.8774	3.8784	3.8776	3.8771
	Change	0.0043	0.0032	0.0016	0.0030	0.0020	0.0012
2R	Before	3.8753	3.8756	3.8761	3.8753	3.8757	3.8758
	After	3.8762	3.8762	3.8769	3.8759	3.8760	3.8766
	Change	0.0009	0.0006	0.0008	0.0006	0.0003	0.0008
3R	Before	3.8757	3.8760	3.8762	3.8759	3.3760	3.8761
	After	3.8770	3.8768	3.8770	3.8758	3.8760	3.8766
	Change	0.0013	0.0008	0.0008	-0.0001	0.0000	0.0005

WEAR MEASUREMENTS
ENGINE NUMBER 5136206-5
OIL: AL-6947-L
TEST HOURS: 240

Piston No.		Piston Ring End Gap, inches 1	2	3	4	5	6	7
1L	Before	0.036	0.032	0.035	0.031	0.022	0.018	0.018
	After	0.044	0.035	0.038	0.033	0.040	0.030	0.032
	Change	0.008	0.003	0.003	0.002	0.018	0.012	0.014
2L	Before	0.033	0.032	0.027	0.025	0.021	0.018	0.018
	After	0.044	0.032	0.027	0.027	0.065	0.036	0.036
	Change	0.011	0.000	0.000	0.002	0.044	0.018	0.018
3L	Before	0.032	0.034	0.032	0.036	0.020	0.019	0.018
	After	0.035	0.036	0.036	0.042	0.038	0.030	0.032
	Change	0.003	0.002	0.004	0.006	0.018	0.011	0.014
1R	Before	0.033	0.028	0.026	0.032	0.021	0.016	0.017
	After	0.045	0.028	0.026	0.035	0.035	0.025	0.032
	Change	0.012	0.000	0.000	0.003	0.014	0.009	0.015
2R	Before	0.035	0.026	0.025	0.028	0.018	0.018	0.018
	After	0.037	0.026	0.025	0.030	0.032	0.030	0.030
	Change	0.002	0.000	0.000	0.002	0.014	0.012	0.012
3R	Before	0.027	0.033	0.031	0.035	0.021	0.018	0.018
	After	0.028	0.035	0.035	0.039	0.036	0.032	0.030
	Change	0.001	0.002	0.004	0.004	0.015	0.014	0.012
AVERAGE		0.006	0.001	0.002	0.003	0.021	0.013	0.014

RATING DATA SHEET
CI-5136206-5

Test Run at AFLRL
Test Oil: AL-6947-L
Test Fuel: CAT 1-H
Test No: 5
Test Stand: 5
Engine No.: 6V53T 5136206
Test Hours: 240
Date Started: 15 April 1979
Completed: 2 May 1979

A. Cylinder Liner Ratings

Intake Port Plugging

Cylinder No.	Restriction, %
1 L	2
2 L	2
3 L	30
1 R	1
2 R	1
3 R	5
Average	7

Scuffing, Glazing and Lacquer*

Cylinder	Scuffing,% Thrust	Anti-Thrust	Total	Glazing,%	Lacquer,%
1 L	70	10	40	10	90
2 L	75	15	45	15	85
3 L	30	10	20	5	95
1 R	35	65	50	10	90
2 R	25	15	20	15	85
3 R	50	5	28	5	95
Average	48	20	34	10	90

*Ring Travel Area

RATING DATA SHEET - CONTINUED
CI-5136206-5

B. Piston Ratings

Ring Sticking and Condition

Cylinder No.	Ring Fire	No. 1	No. 2	No. 3
1 L	F x 15%B	F x 80%B	F x 80%B	F x 100%B
2 L	F x 5%B	F 65%B	F 100%B	F 75%B
3 L	F x 60%B	F 100%B	F 75%B	F 100%B
1 R	F 75%B	F 100%B	F 100%B	F 70%B
2 R	5%P 5%B	F 2%B	F 5%B	F 2%B
3 R	F 100%B	F 90%B	F 100%B	F 50%B

P=Pinched, x=Part of ring face chrome chipped.

Ring Groove Carbon Filling and Oil Groove Lacquer

Cylinder No.	Groove Filling, % Fire	No. 1	No. 2	No. 3	Oil Groove Lacquer Upper	Lower
1 L	10	85	60	5	3.0	3.0
2 L	5	80	30	5	3.0	3.0
3 L	5	95	30	5	3.0	3.0
1 R	10	75	30	0	3.0	3.0
2 R	5	65	10	0	3.0	3.0
3 R	10	85	15	5	3.0	3.0

Cylinder No.	Land Description
1 L	Normal
2 L	Normal
3 L	Normal
1 R	Normal
2 R	Normal
3 R	Normal

Skirt

Cylinder No.	Side Thrust	Anti-Thrust
1 L	7.0 10% Plate melt and scuff	7.0 5% Plate melt and light scuff
2 L	7.0 5% Scuff and light scratches	7.4 5% Plate melt,10%scuff w/lt.scratches
3 L	6.5 10% Scuff and light scratches	7.0 15% Plate melt, lt.scratches
1 R	6.0 Light Scratches	6.3 Light scratches
2 R	6.8 Light Scratches	7.0 Light scratches
3 R	6.5 20% Plate melt, 25% scuff with scratches	6.5 5% Scuff and light scratches

RATING DATA SHEET - CONTINUED
CI-5136206-5

C. Other Ratings

Combustion Chambers

Cylinder No.	Description	Cylinder No.	Description
1 L	90% AHC	1 R	90% AHC
2 L	90% AHC	2 R	90% AHC
3 L	90% AHC	3 R	90% AHC

Valve Covers, Oil Pan and Cylinders Head Deck

Covers	Clean
Pan	Clean
Deck	Clean

Remarks

NONE

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked cycle
TEST HOURS 240
TEST LABORATORY *FLRL
LUBRICANT AL-6947-L

RATER E. Lyons DATE 5-7-79
LABORATORY TEST NUMBER 5136206-5
STAND NO. 5 ENGINE NO. 6V53T 5136206
FUEL 1-H Cat

PISTON NO. 1-Right

NO. 1 GROOVE, VOLUME %	
PISTON WTD* RATING	308.25

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00			10	10.00					10	10.00	50	50.00	30	30.00				
CARBON	MHC	0.75			90	67.50	25	15.00												
CARBON	MC	0.50	20	10.00							65	32.50			30	15.00				
CARBON	LC	0.25									25	6.25	10	2.50	10	2.50				
CARBON	VLC	0.15	80	12.00			75	11.25					40	6.00	30	4.50				
	CARBON RATING		22.00		77.50		26.25				48.75		58.50		52.00					
LACQUER	BL	0.100															15	1.50	100	10.00
LACQUER	OBrL	0.075							100	7.50										
LACQUER	AL	0.050															85	4.25		
LACQUER	LAL	0.025																		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING								7.50								5.75		10.00	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		22.0		77.50		26.25		7.50		48.75		58.50		52.00		5.75		10.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-6947-L

RATER E. Lyons DATE 5-7-79
LABORATORY TEST NUMBER 5136206-5
STAND NO. 5 ENGINE NO. 6V53T 5136206
FUEL 1-H CAT

PISTON NO. 2 - Right

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	276.75

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES								LANDS								UNDER-CROWN	
			NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
			AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON	HC	1.00			35	35.00							75	75.00						
	MHC	0.75			45	33.75														
	MC	0.50			20	10.00					90	45.00			10	5.00				
	LC	0.25	10	2.50							10	2.50	10	2.50						
	VLC	0.15	90	13.50									15	2.25	90	13.50				
	CARBON RATING		16.00		78.75						47.50		79.75		18.50					
LACQUER	BL	0.100					100	10.00									50	5.00	100	10.00
	DBrL	0.075							100	7.50							50	3.75		
	AL	0.050																		
	LAL	0.025																		
	VLAL	0.010																		
	RL	0.001																		
	LACQUER RATING						10.00		7.50											
CLEAN		0																		
ZONAL RATING																				
LOCATION FACTOR																				
WEIGHTED RATING			16.00		78.75		10.00		7.50		47.50		79.75		18.50		8.75		10.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-6947-L

RATER E. Lyons DATE 5-7-79
LABORATORY TEST NUMBER 5136206-5
STAND NO. 5 ENGINE NO. 6V53T 5136206
FUEL 1-H CAT

PISTON NO. 3-Right

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	298.75

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1		GROOVES NO. 2		GROOVES NO. 3		GROOVES NO. 4		LANDS NO. 1		LANDS NO. 2		LANDS NO. 3		LANDS NO. 4		UNDER-CROWN	
			AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON	HC	1.00			90	90.00							85	85.00						
CARBON	MHC	0.75																		
CARBON	MC	0.50			10	5.00					90	45.00								
CARBON	LC	0.25					65	16.25			10	2.50			100	2.50				
CARBON	VLC	0.15	100	15.00			35	5.25					15	2.25						
CARBON	CARBON RATING		15.00		95.00		21.50				47.50		87.25		2.50					
LACQUER	BL	0.100							100	10.00							100	10.00	100	10.00
LACQUER	DBrL	0.075																		
LACQUER	AL	0.050																		
LACQUER	LAL	0.025																		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
LACQUER	LACQUER RATING								10.00								10.00		10.00	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		15.00		95.00		21.50		10.00		47.50		87.25		2.50		10.00		10.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-6947-L

RATER E. Lyons DATE 5-7-79
LABORATORY TEST NUMBER 5136206-5
STAND NO. 5 ENGINE NO. 6V53T 5136206
FUEL 1-H CAT

PISTON NO. 1-Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	382.75

DEPOSIT TYPE		DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00									10	10.00	75	75.00	70	70.00				
CARBON	MHC	0.75			100	75.00	25	18.75												
CARBON	MC	0.50					10	5.00			70	35.00			20	10.00				
CARBON	LC	0.25					65	17.25			20	5.00	25	6.25	10	2.50	30	7.50		
CARBON	VLC	0.15	100	15.00													70	10.50		
CARBON RATING			15.00		75.00		41.00				50.00		81.25		82.50		18.00			
LACQUER	BL	0.100							100	10.00									100	10.00
LACQUER	DBrL	0.075																		
LACQUER	AL	0.050																		
LACQUER	LAL	0.025																		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
LACQUER RATING									10.00										10.00	
CLEAN		0																		
ZONAL RATING																				
LOCATION FACTOR																				
WEIGHTED RATING			15.00		75.00		41.00		10.00		50.00		81.25		82.50		18.00		10.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-6047-L

RATER E. Lyons DATE 5-7-79
LABORATORY TEST NUMBER 5136206-5
STAND NO. 5 ENGINE NO. 6V53T 5136206
FUEL 1-H CAT

PISTON NO. 2-Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	324.00

DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON HC	1.00			10	10.00							65	65.00						
CARBON MHC	0.75			70	52.50					80	60.00								
CARBON MC	0.50					25	12.50							40	20.00	20	10.00		
CARBON LC	0.25			20	5.00	45	11.25			20	5.00	10	2.50	60	15.00				
CARBON VLC	0.15	100	15.00			30	4.50					25	3.75			80	12.00		
CARBON RATING		15.00		67.50		28.25				65.00		71.25		35.00		22.00			
LACQUER BL	0.100							100	10.00									100	10.00
LACQUER DBrL	0.075																		
LACQUER AL	0.050																		
LACQUER LAL	0.025																		
LACQUER VLAL	0.010																		
LACQUER RL	0.001																		
LACQUER RATING								10.00										10.00	
CLEAN	0																		
ZONAL RATING																			
LOCATION FACTOR																			
WEIGHTED RATING		15.00		67.50		28.25		10.00		65.00		71.25		35.00		22.00		10.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-6947-L

RATER E. Lyons DATE 5-7-79
LABORATORY TEST NUMBER 5136206-5
STAND NO. 5 ENGINE NO. 6V53T 5136206
FUEL 1-H CAT

PISTON NO. 3-Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	246.75

DEPOSIT TYPE		DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00			60	60.00							75	75.00						
CARBON	MHC	0.75			20	15.00					70	35.00	10	5.00	15	7.50				
CARBON	MC	0.50			20	10.00	25	12.50			20	5.00			85	21.25				
CARBON	LC	0.25					75	18.75			10	1.50	15	2.25			30	4.50		
CARBON	VLC	0.15	100	15.00																
CARBON RATING			15.00		85.00		31.25				41.50		14.25		28.75		4.50			
LACQUER	BL	0.100							100	10.00							50	5.00	100	10.00
LACQUER	DBrL	0.075															20	1.50		
LACQUER	AL	0.050																		
LACQUER	LAL	0.025																		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
LACQUER RATING																	6.50		10.00	
CLEAN		0																		
ZONAL RATING																				
LOCATION FACTOR																				
WEIGHTED RATING			15.00		85.00		31.25		10.00		41.50		14.25		28.75		11.00		10.00	

*WEIGHTED TOTAL DEPOSITS

RING STICKING

Test No. CI-5

Engine Model 6V53T Serial No. 5136206 Date 5-7-79

Fuel 1-H CAT Lubricant AL-6947-L Observer E. Lyons

Piston Number

Ring No.	1L	2L	3L	1R	2R	3R
1	F	F	F	F	5% Pinched	F
2	F	F	F	F	F	F
3	F	F	F	F	F	F
4	F	F	F	F	F	F

Indicate by letter – Free or Sluggish, or by number and letter – percent Pinched (cold stuck) or percent Hot stuck (Pages 6 and 7 of Manual).

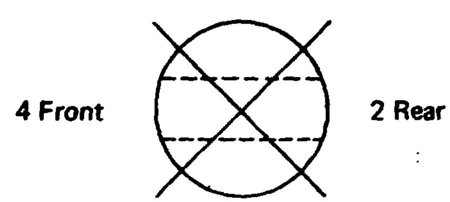
PISTON GROOVE INSIDE DIAMETER—% RING SUPPORTING CARBON

Test No. CI-5

Engine Model 6V53T   Serial No. 5136206   Date 5-7-79

Fuel 1-H CAT   Lubricant AL-6947-L   Observer E. Lyons

Piston Ring	Quadrant	Piston Number					
		1L	2L	3L	1R	2R	3R
1	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
2	1	0	0	15	0	60	95
	2	0	0	5	20	5	95
	3	20	0	50	20	50	100
	4	85	40	90	0	20	95



VALVE DEPOSITS

Test No. CI-5

Engine Model 6V53T　Serial No. 5136206　Date 5-7-79

Fuel 1-H CAT　Lubricant AL-6947-L　Observer E Lyons

		Cylinder Number											
		1L		2L		3L		1R		2R		3R	
Head*	INT	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ
	EXH	90% AHC		10% SOOT				40% AHC	10% AHC		50% SOOT		
Face	INT												
	EXH	100 %	#9 LACQUER TO LIGHT CARBON										
Tulip†	INT	100 %	AHC TO #9 LACQUER										
	EXH												
Stem	INT	#9 LACQUER TO CLEAN											
	EXH												

*Carbon and Ash: Use Volume Factor Technique (Pages 5 and 40 through 47 of Manual).
†Use Chart, Page 21—Indicate H, M, or S, (Page 5).
Lacquer: Pages 4, 36 and 37.

EXHAUST VALVE SURFACE CONDITIONS

Test No. CI-5

Engine Model 6V53T   Serial No. 5136206   Date 5-7-79

Fuel 1-H CAT   Lubricant AL-6947-L   Observer E. Lyons

	1L	2L	3L	1R	2R	3R
Freeness in Guide	F	F	F	F	F	F
Head	N	N	N	N	N	N
Face	N	Light Leaking	Leaking	Leaking	Light Leaking	Leaking
Seat	N	N	N	N	N	N
Stem	N	N	N	N	N	N
Tip	X N	N	N	N	N	N

See Pages 1, 2, 16 through 23, and 54 through 65 of Manual.

X= The tip on the first valve on the camside is worn; also one of the keepers was worn enough to almost be out of position.

TAPPETS, CAMS, AND ROCKER ARMS

Test No. CI-5

Engine Model 6V53T   Serial No. 5136206   Date 5-7-79

Fuel 1-H CAT   Lubricant AL-6947-L   Observer E. Lyons

			Cylinder Number					
			1L	2L	3L	1R	2R	3R
Tappet Deposit		INT						
		EXH	C L E A N					
Tappet Surface Condition		INJ						
		INT						
		EXH	N O R M A L		L I G H T		W E A R	
Cam Lobes			N	N	N	N	N	N
Rocker Arms	Tip	INT						
		EXH	N	N	N	N	N	N
	Bushing	INT						
		EXH	N	N	N	N	N	N
	Shaft	INT						
		EXH	N	N	N	N	N	N

Lacquer: Pages 4, 36 and 37 of Manual.
See Pages 1, 2, 16 through 23, and 54 through 65.

SURFACE CONDITION

Test No. CI-5

Engine Model 6V53T　Serial No. 5136206　Date 5-7-79

Fuel 1-H CAT　Lubricant AL-6947-L　Observer E. Lyons

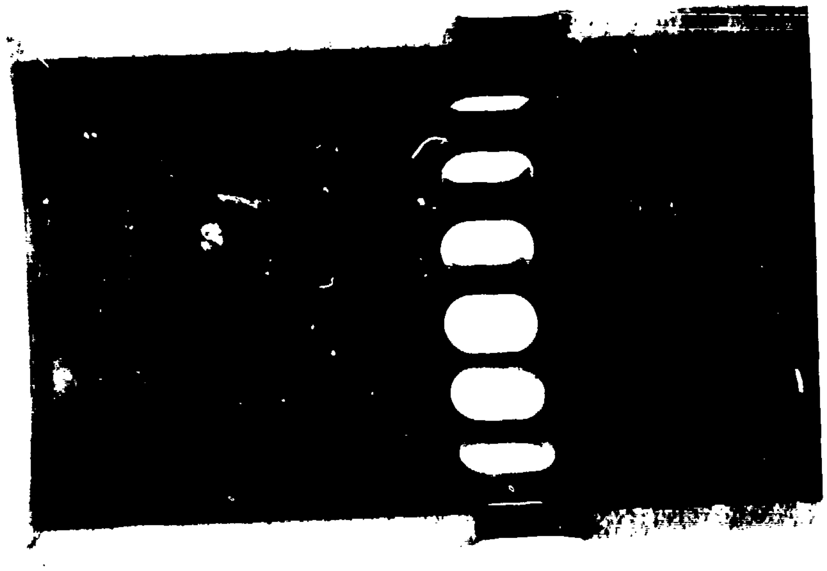
Bearing No.	L1	L2	L3	R1	R2	R3	
Main–Bearing	Flaking & Scratched	Flaking & Scratched	Flaking & Scratched Copper showing	Pitting & Scratched	X	X	
–Journal	N	N			X	X	
Rod–Bearing	Light Scratches	Light Scratches & Pitting	Light Scratches	Light Scratches	Light Scratches	Light Scratches	
–Journal	N	N	N	N	N	N	
Piston Pin	N	N	N	N	N	N	
Bushing	N	N	N	N	N	N	

Note surface condition. See pages 1, 2, 16 through 23 and 54 through 65 of Manual.

CONDITION OF PISTON AND CYLINDER LINER

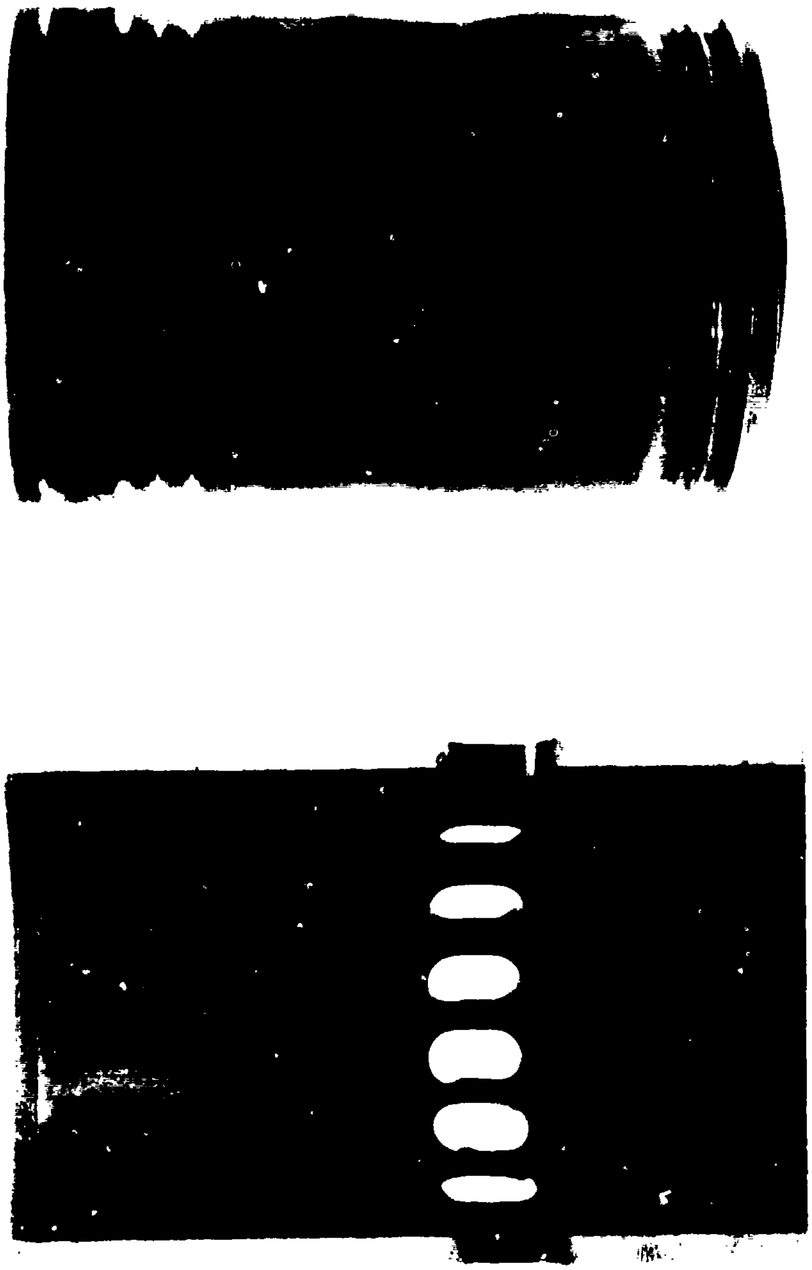
TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L

1—RIGHT THRUST



CONDITION OF PISTON AND CYLINDER LINER

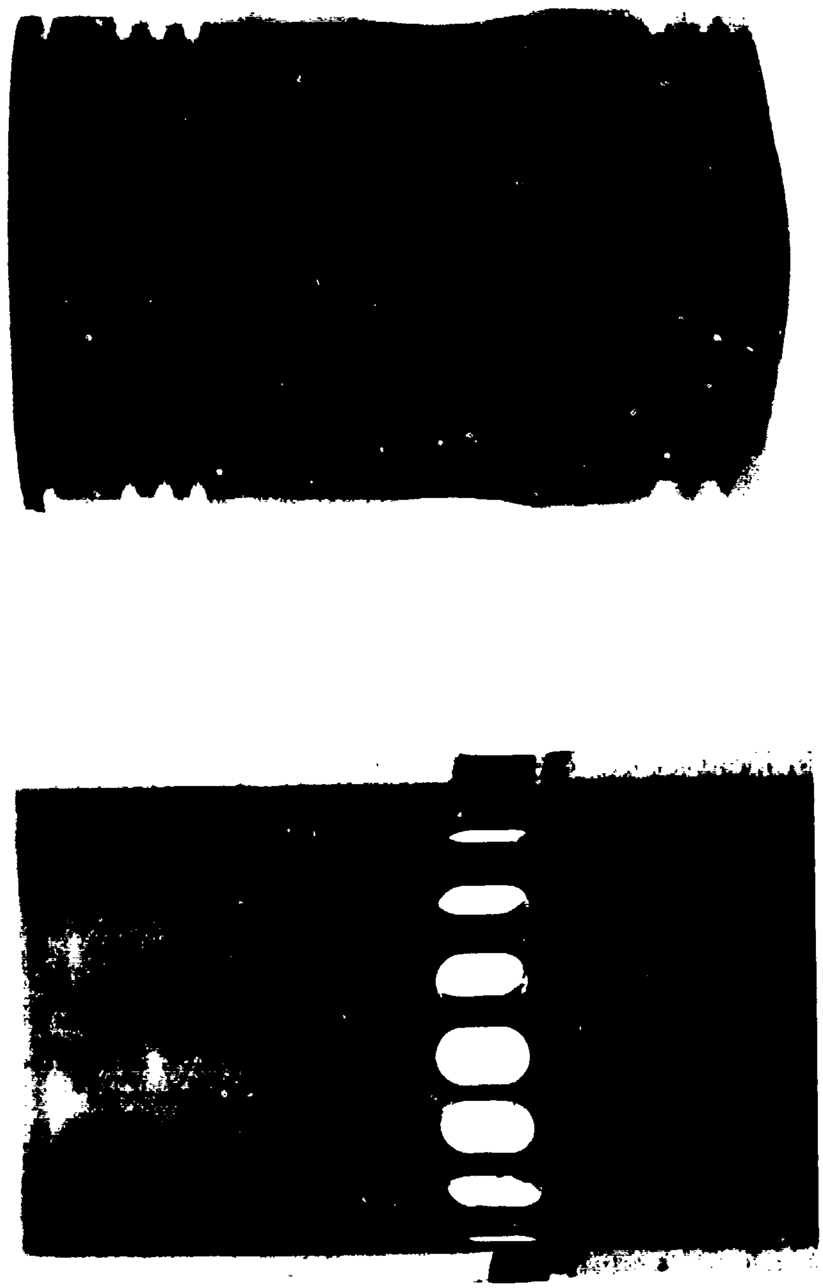
TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L



1—RIGHT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

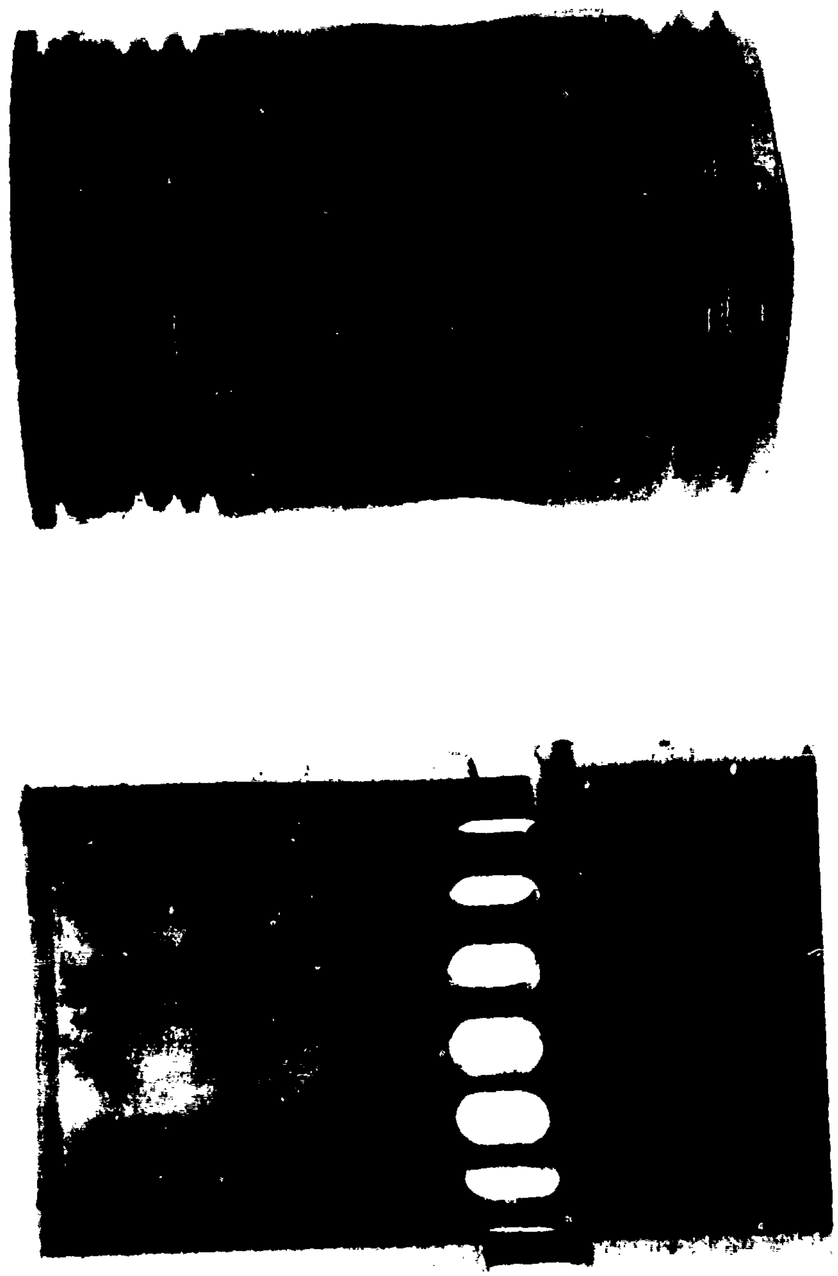
TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L



2–RIGHT THRUST

CONDITION OF PISTON AND CYLINDER LINER

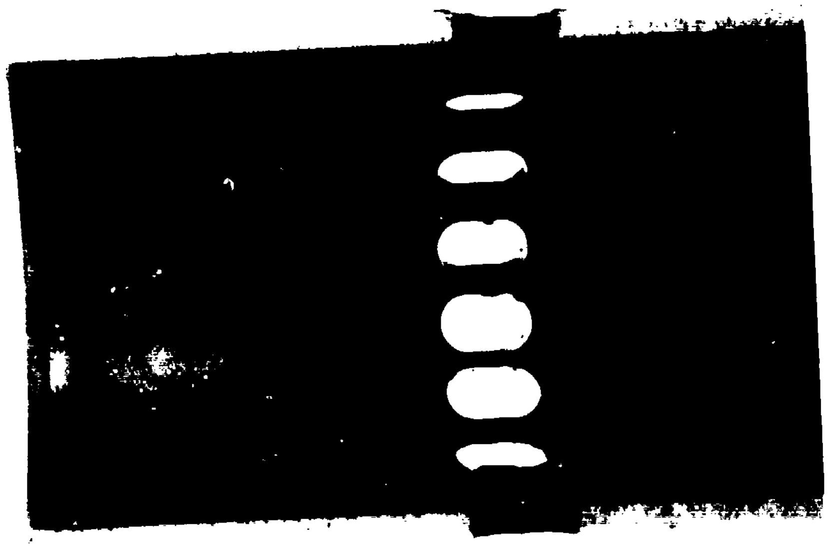
TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L



2—RIGHT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

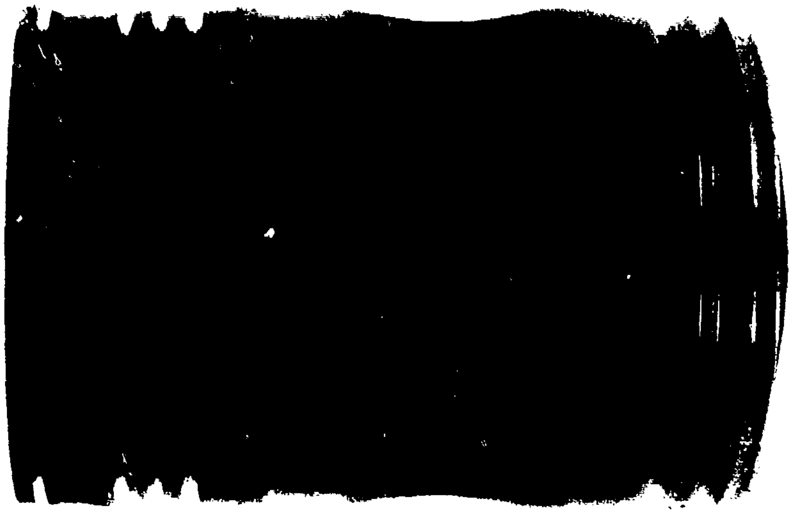
TEST TIME: 240 HOURS · TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L

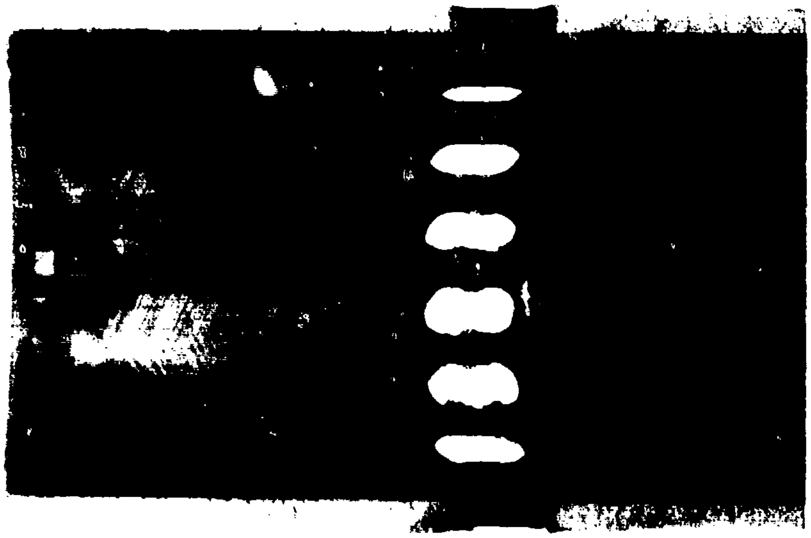


3–RIGHT THRUST

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L

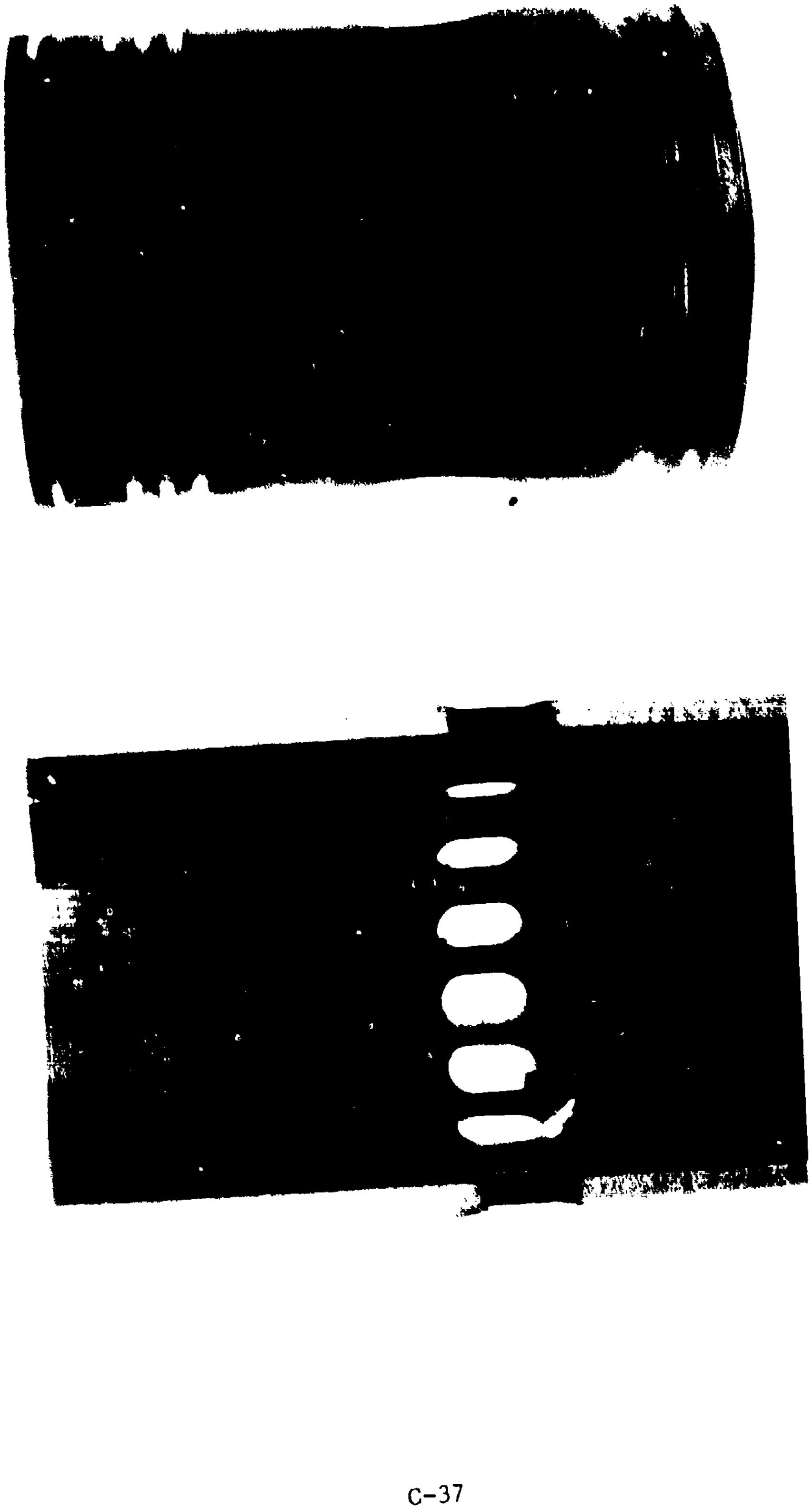




3—RIGHT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

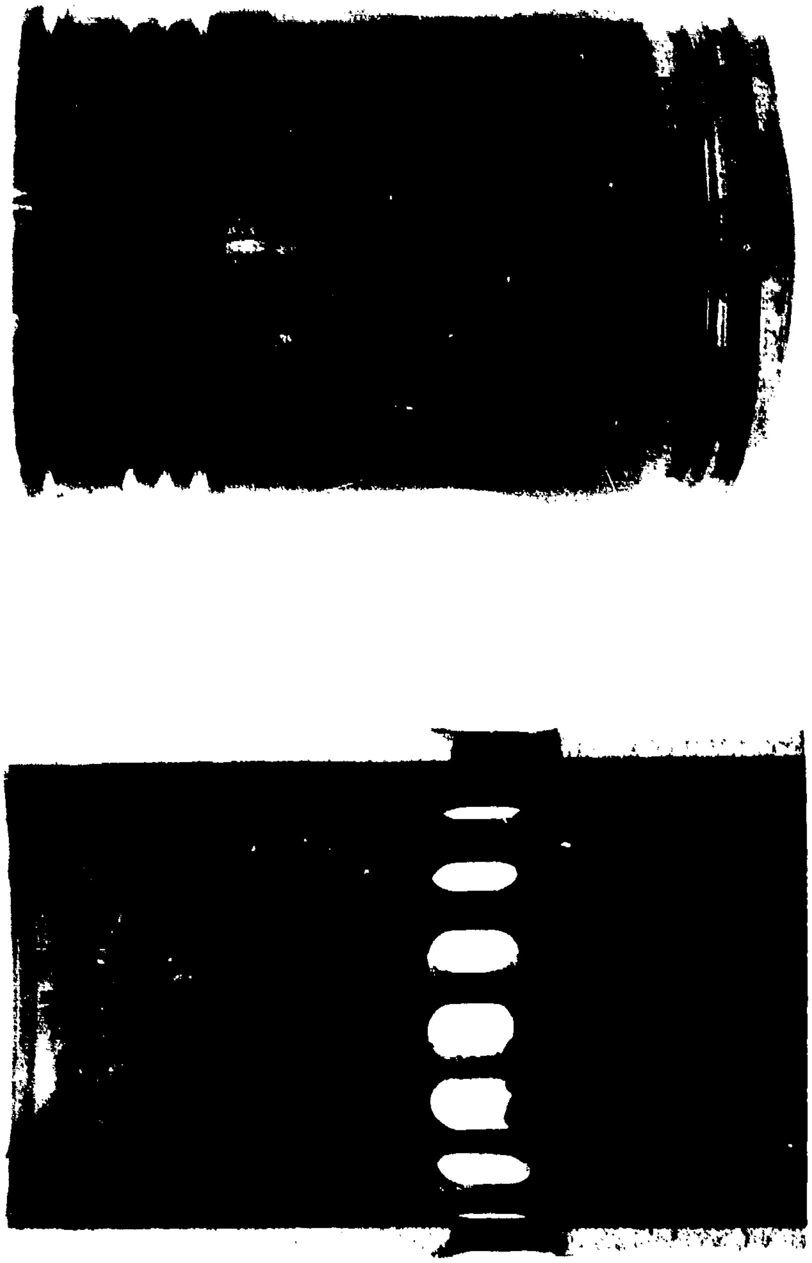
TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L



1—LEFT THRUST

CONDITION OF PISTON AND CYLINDER LINER

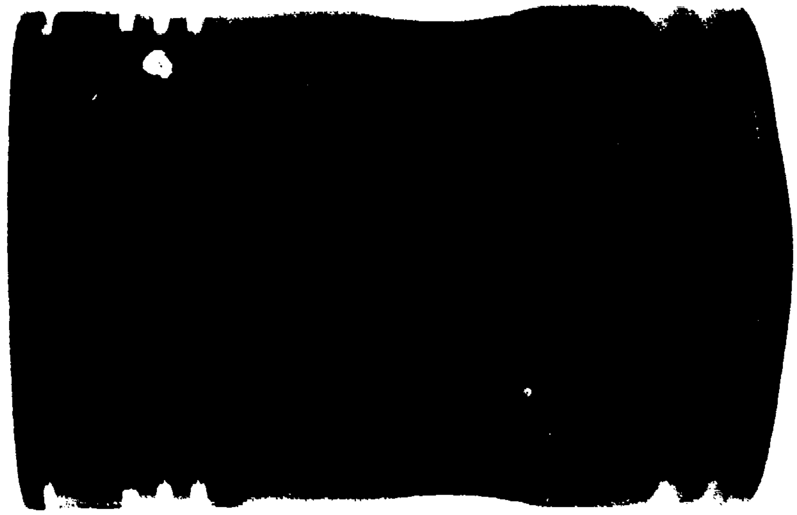
TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L

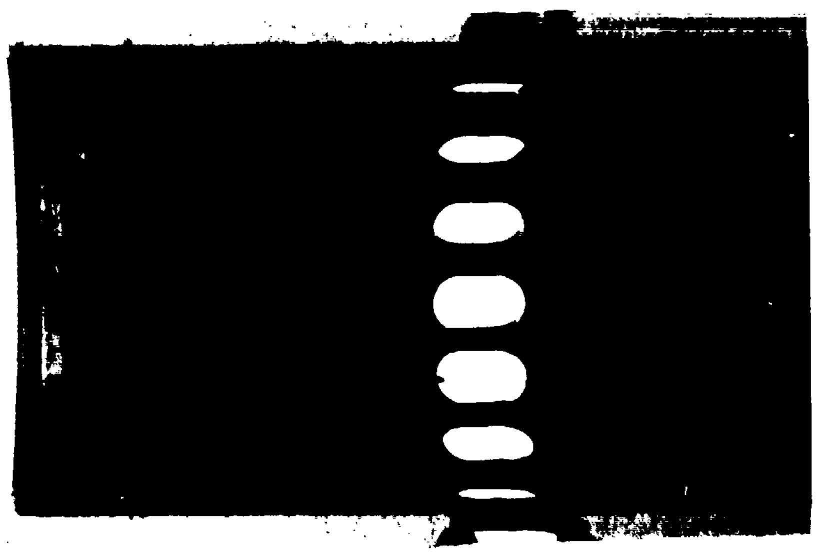


1—LEFT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 240 HOURS   TEST NO.: CI5136206-5   LUBRICANT: AL-6947-L

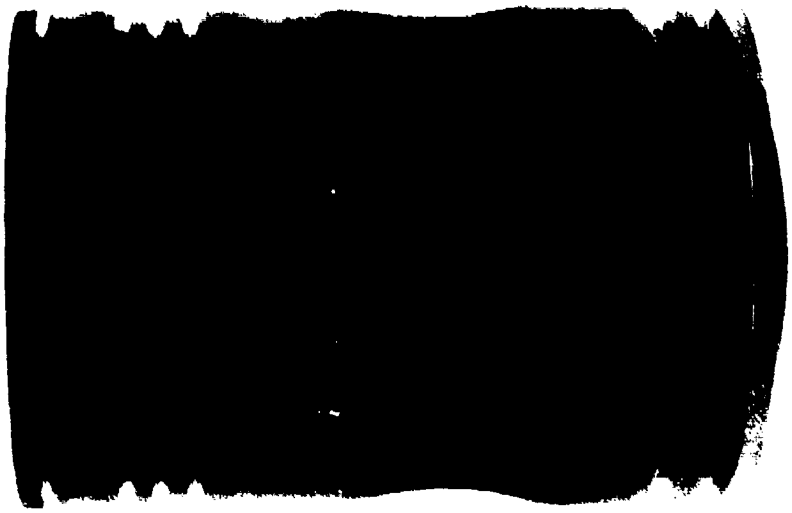


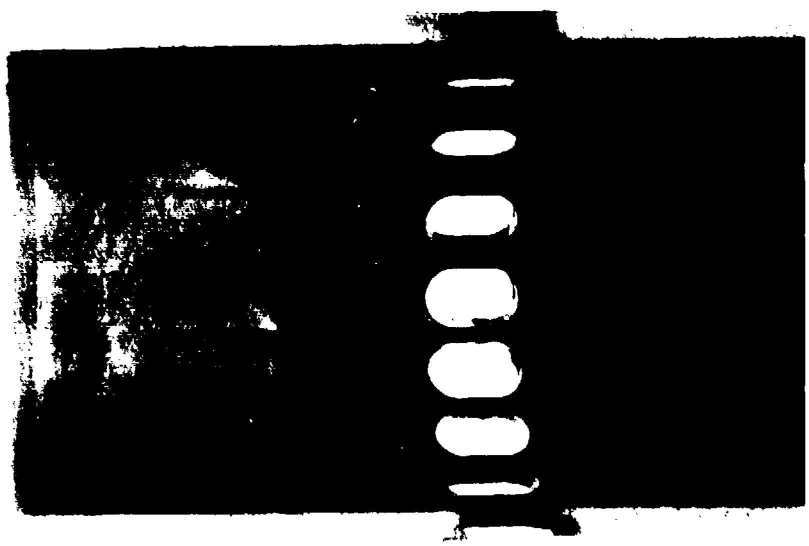


2—LEFT THRUST

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L

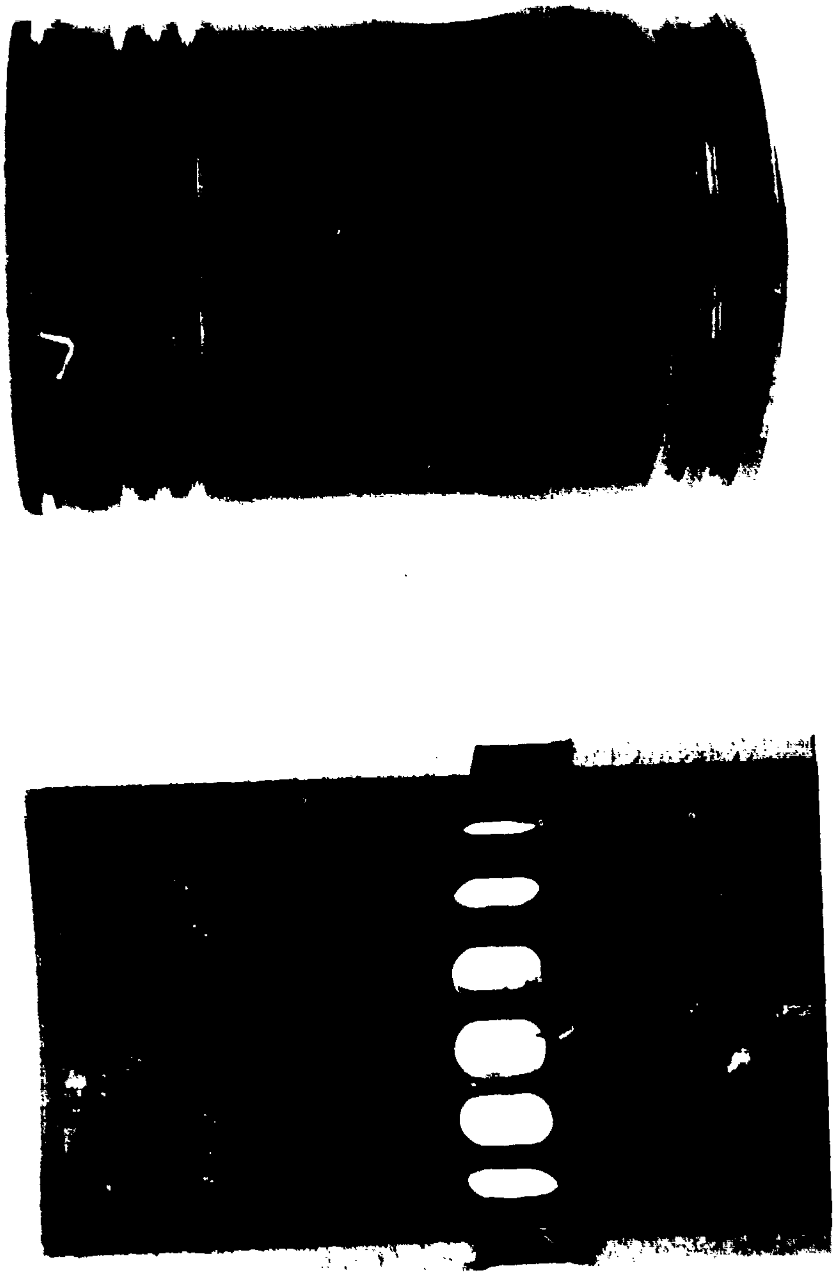




2—LEFT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

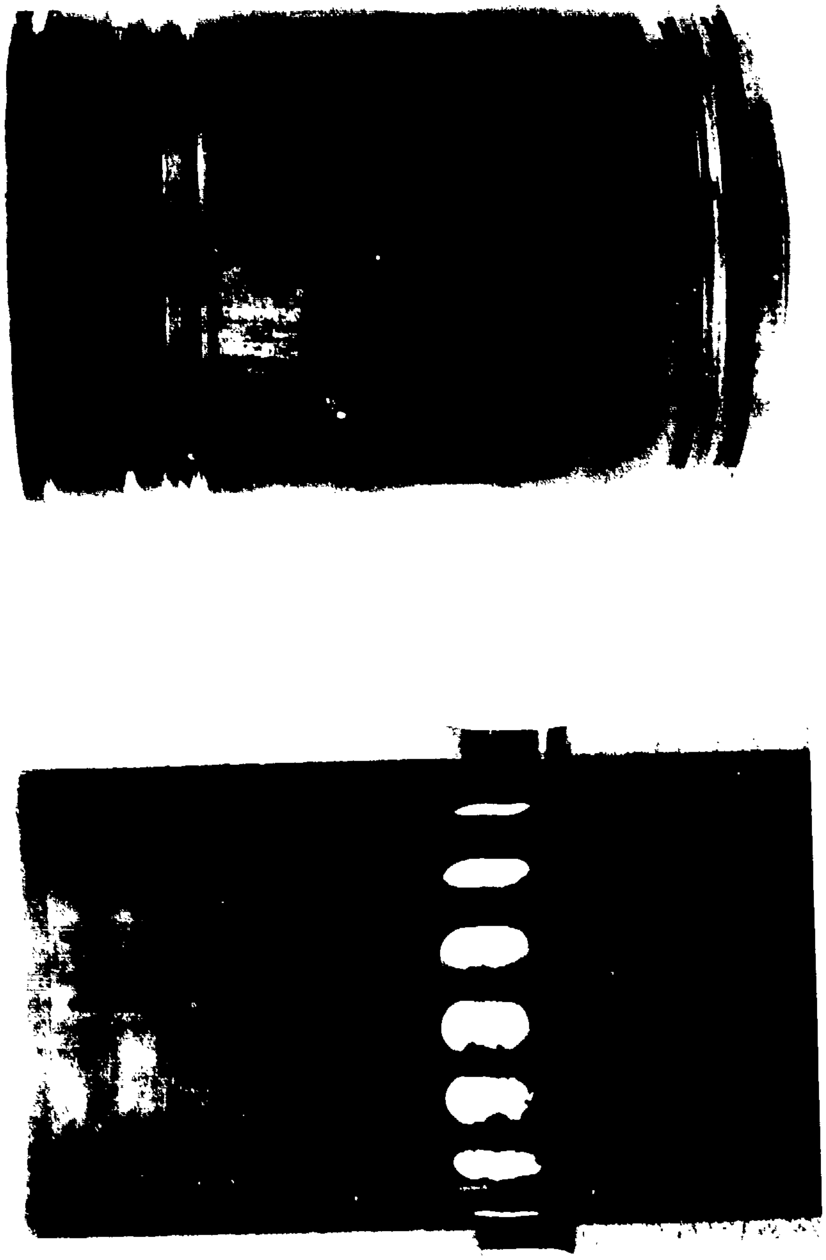
TEST TIME: 240 HOURS   TEST NO.: CI5136206-5   LUBRICANT: AL-6947-L



3—LEFT THRUST

CONDITION OF PISTON AND CYLINDER LINER

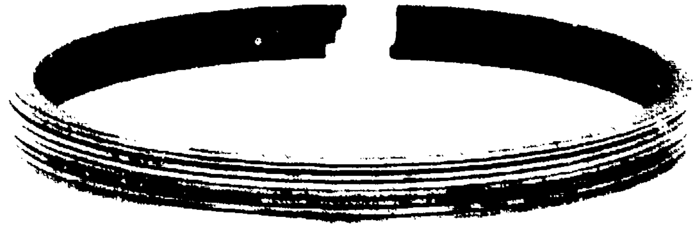
TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L



3—LEFT ANTI-THRUST

CONDITION OF PISTON RING FACE

TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L



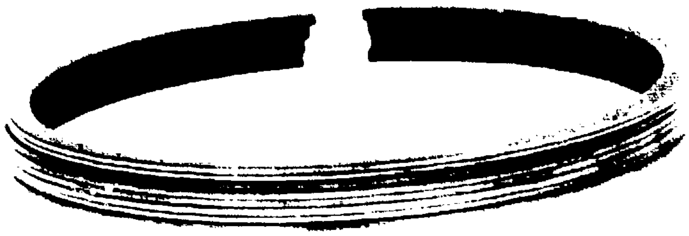
1–RIGHT

2–RIGHT

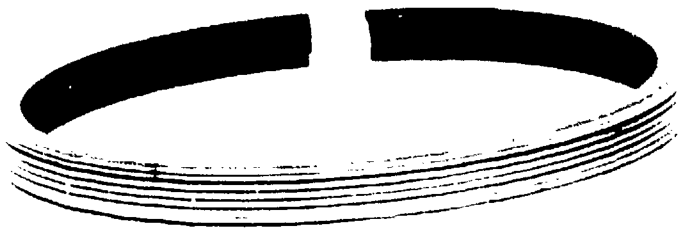
3–RIGHT

CONDITION OF PISTON RING FACE

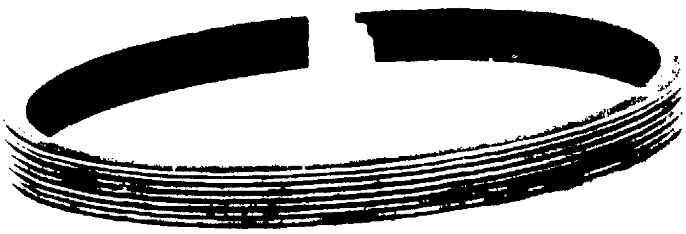
TEST TIME: 240 HOURS   TEST NO.: CI5136206-5   LUBRICANT: AL-6947-L



1–LEFT



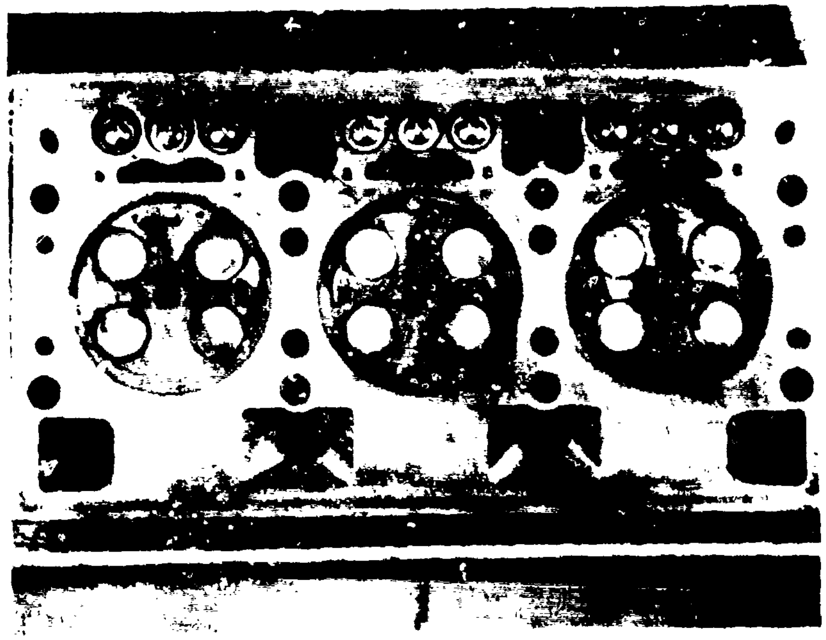
2–LEFT



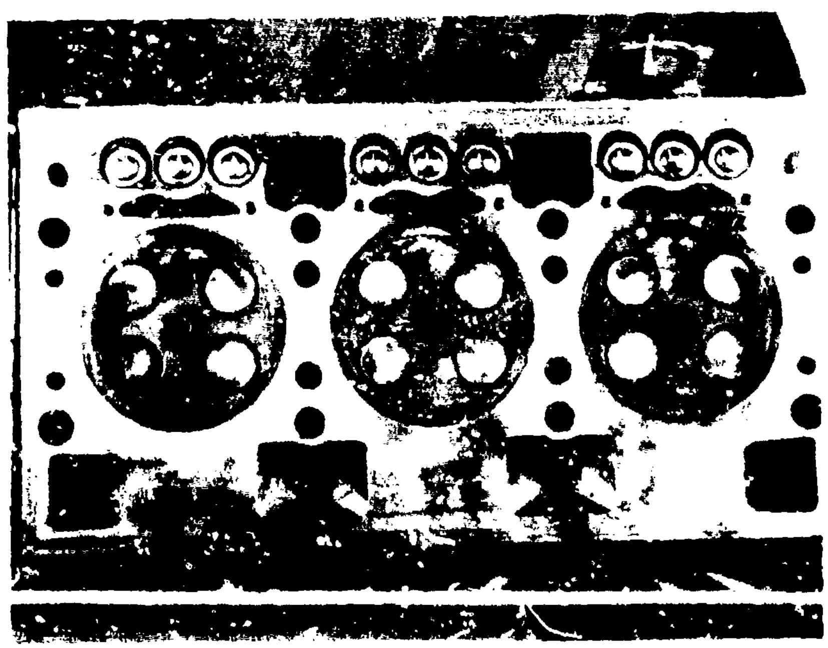
3–LEFT

CONDITION OF CYLINDER HEADS

TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L



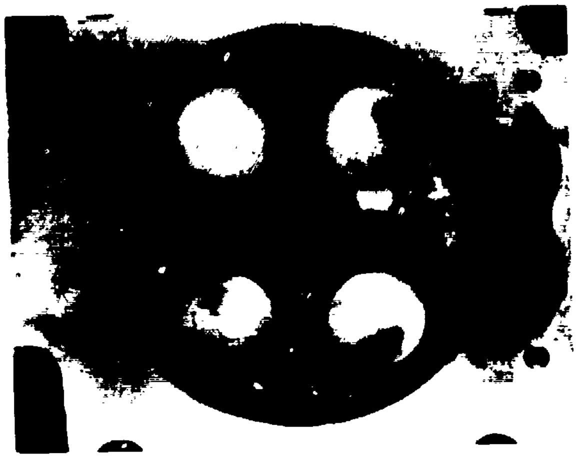
3L 2L 1L



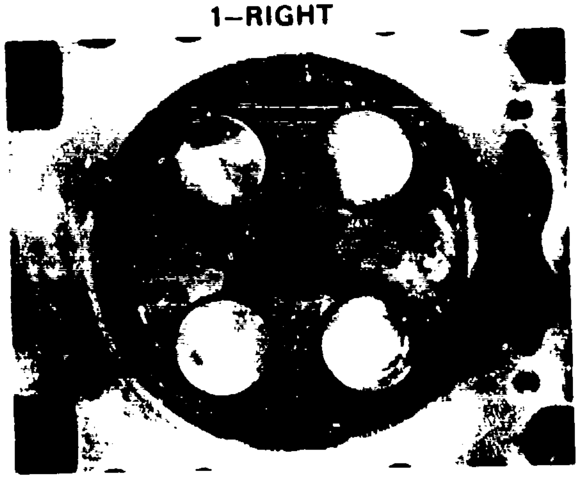
IR 2R 3R

CONDITION OF CYLINDER HEADS

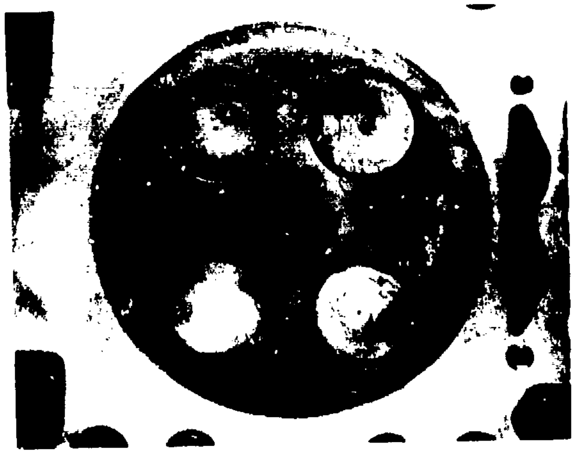
TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-8947-L



1–RIGHT



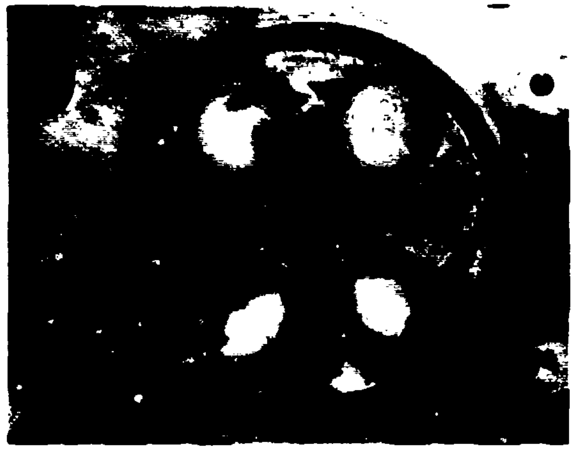
2–RIGHT



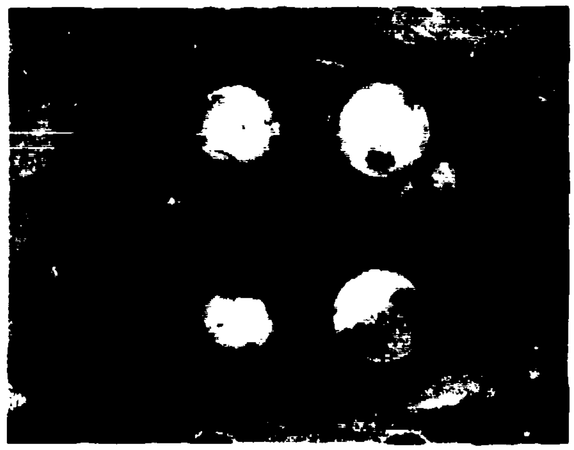
3–RIGHT

CONDITION OF CYLINDER HEADS

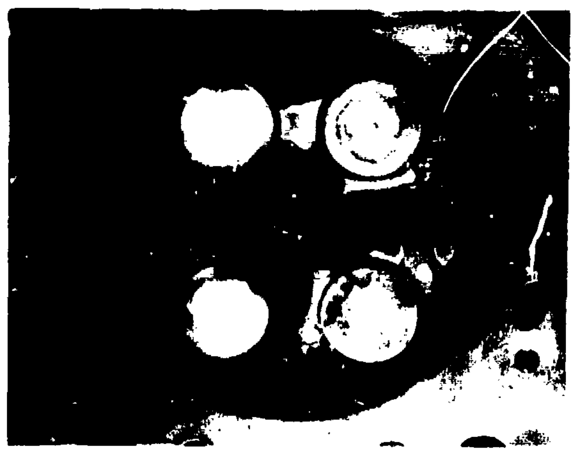
TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L



1–LEFT



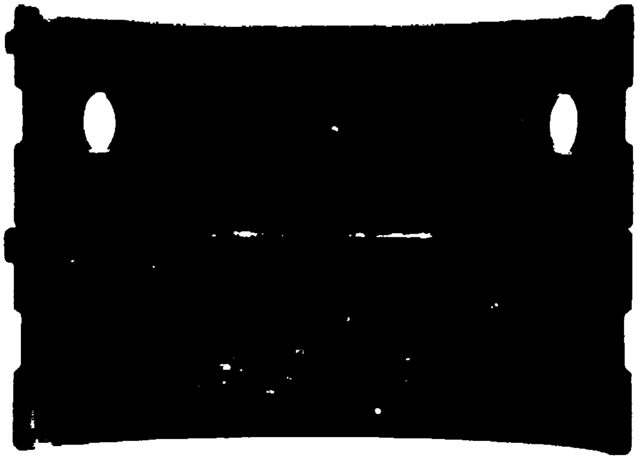
2–LEFT



3–LEFT

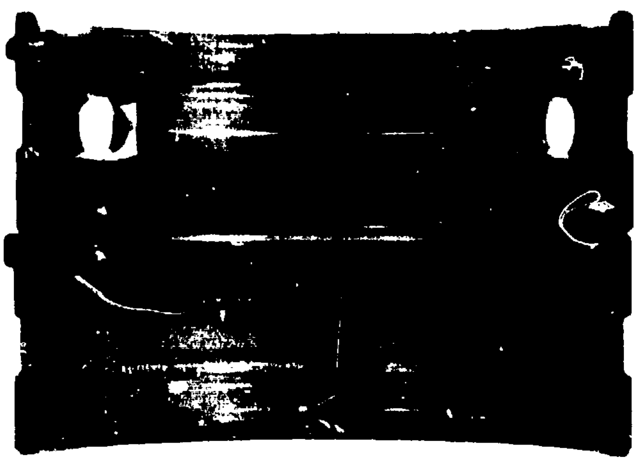
CONDITION OF ROD BEARINGS

TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L



1–RIGHT

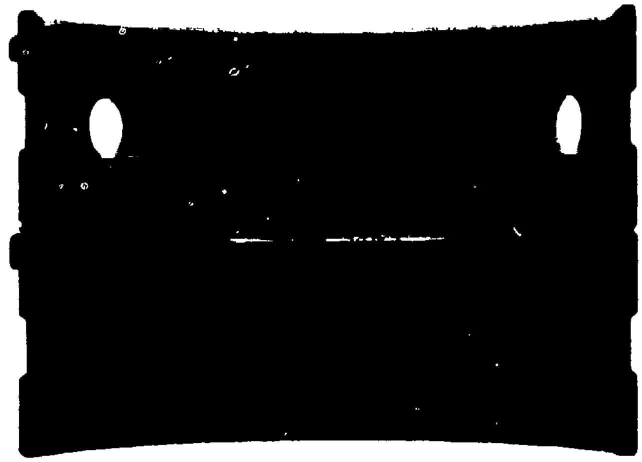
2–RIGHT



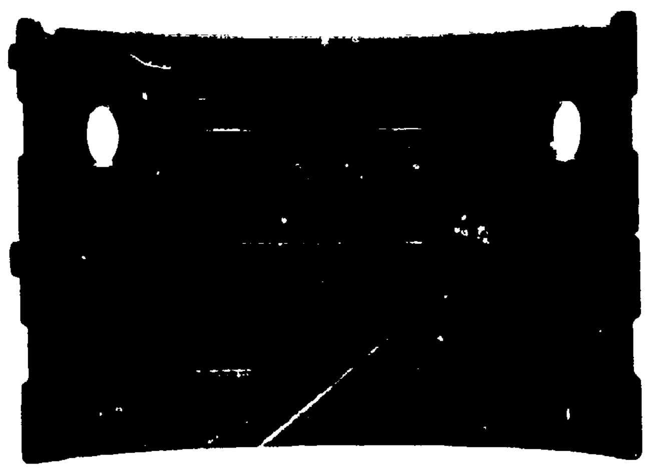
3 RIGHT

CONDITION OF ROD BEARINGS

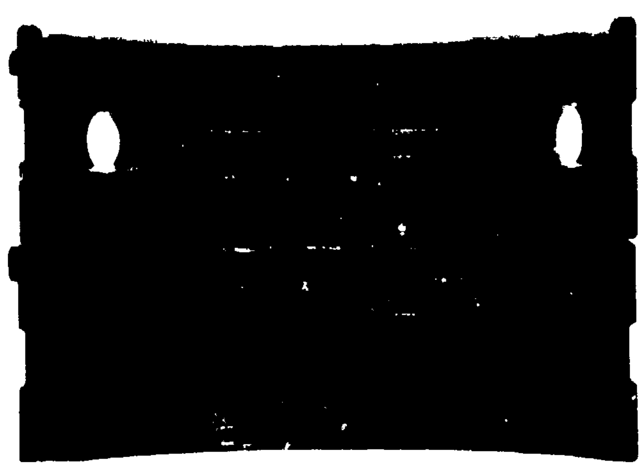
TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: **AL-6947-L**



1–LEFT



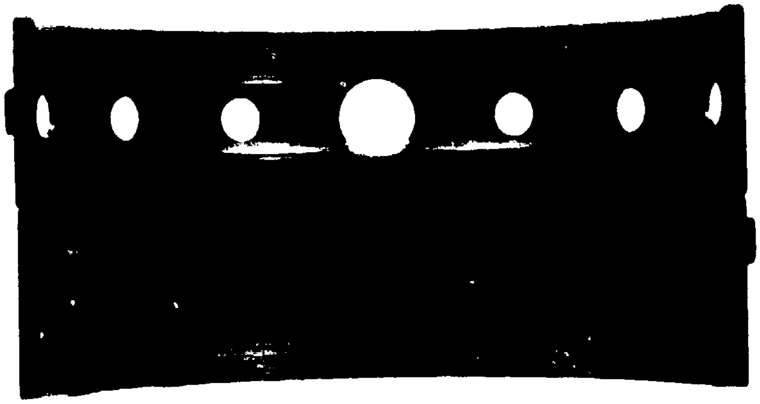
2–LEFT



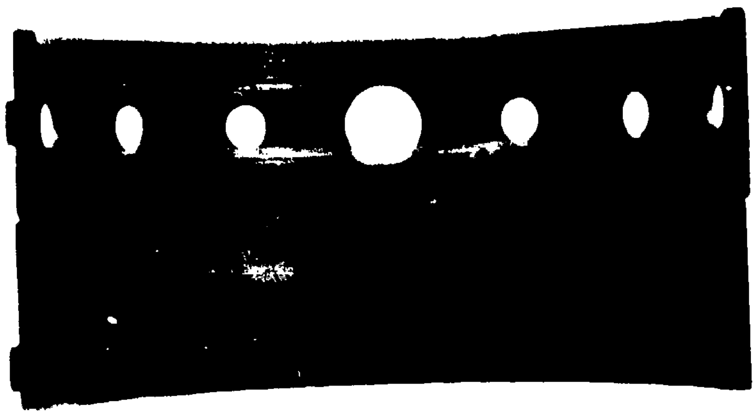
3–LEFT

CONDITION OF MAIN BEARINGS

TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L



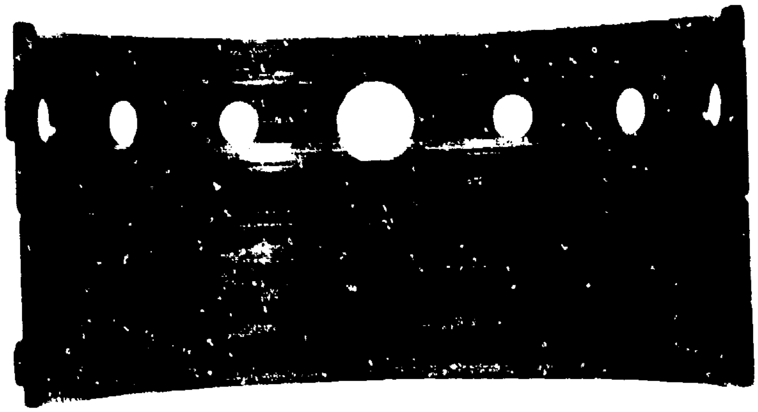
NO. 1



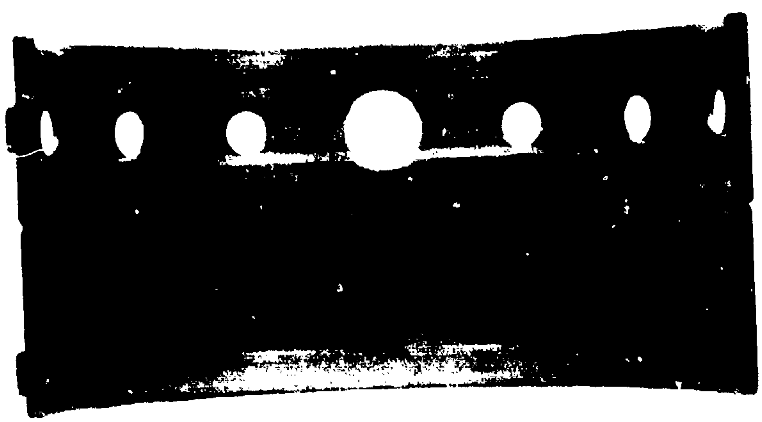
NO. 2

CONDITION OF MAIN BEARINGS

TEST TIME: 240 HOURS TEST NO.: CI5136206-5 LUBRICANT: AL-6947-L



NO. 3



NO. 4

APPENDIX D

ENGINE-LUBRICANT COMPATIBILITY TEST #6
240-HOUR TRACKED-VEHICLE CYCLE
USING 6V-53T DIESEL ENGINE

ENGINE-LUBRICANT COMPATIBILITY TEST
240-HOUR TRACKED-VEHICLE CYCLE
USING 6V53T DIESEL ENGINE

Test Lubricant: AL-7235-8531-L
Engine Test Number: CI 5136206-6
Date Completed: 30 July 1979

Conducted for

U.S. Army Mobility Equipment Research and Development Command
Energy and Water Resources Laboratory
Fort Belvoir, Virginia

By

U.S. Army Fuels and Lubricants Research Laboratory
Southwest Research Institute
San Antonio, Texas 78284

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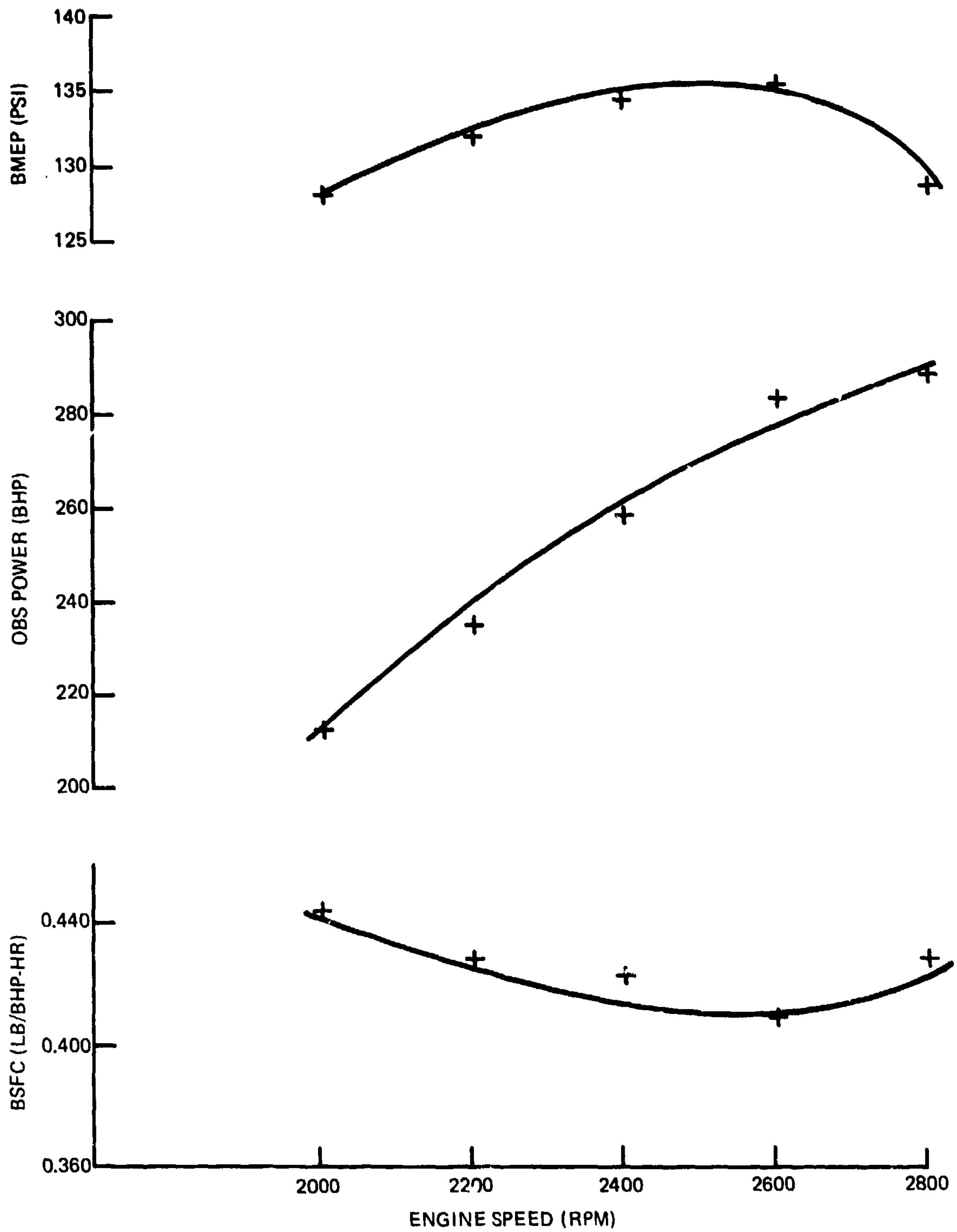
6V53T
BUILD-UP ENGINE MEASUREMENTS
CI 5136206-6

Measurements	Inches Min	Max	Avg	Spec Limits (1)
Crankshaft main bearing clearance	0.0040	0.0040	0.0040	0.0016-0.0046
Camshaft bearing clearance				
Left cam	0.0050	0.0051	0.0050	0.0080 max.
Right cam	0.0045	0.0047	0.0046	0.0080 max.
Connecting rod bearing clearance	0.0026	0.0031	0.0029	0.0016-0.0046
Crankshaft end-play	-	-	0.005	0.004 -0.011
Oil pump				
Between rotors	-	-	0.0070	0.004 -0.011
Outer rotor/housing	-	-	0.0030	0.001 -0.0035
Cylinder liner block bore				
Taper	0.0000	0.0002	0.0001	0.0015 max
Out-of-round	0.0000	0.0004	0.0002	0.0015 max
Inside diameter	4.3573	4.3577	4.3576	4.3595 max
Cylinder Liners(installed)				
Taper	0.0000	0.0008	0.0005	0.0020 max (2)
Out-of-round	0.0000	0.0004	0.0002	0.0030 max (2)
Inside diameter	3.8750	3.8761	3.8757	3.8752-3.8767
Piston to liner fit	0.0071	0.0087	0.0081	0.0061-0.0095
Piston diameter	3.8672	3.8682	3.8676	3.8669-3.8691
Fire ring				
End gap	0.028	0.035	0.032	0.020 -0.046
Side clearance	0.003	0.003	0.003	0.003 -0.006
No. 1 compression ring				
End gap	0.023	0.028	0.025	0.020 -0.046
Side clearance	0.005	0.008	0.006	0.007 -0.010
No. 2 & No. 3 compression ring				
End gap	0.020	0.028	0.024	0.020 -0.046
Side clearance	0.003	0.006	0.005	0.005 -0.010
Oil rings				
End gap	0.011	0.020	0.013	0.010 -0.025
Side clearance	0.002	0.005	0.003	0.0015-0.0055

(1)Limits on new parts unless maximum wear limit specified.
(2)Wear limits with new liners in a used block.

6V53T FULL LOAD PERFORMANCE
BEFORE TEST

TEST NO.: CI 5136206-6 LUBRICANT: AL-7235-8531-L



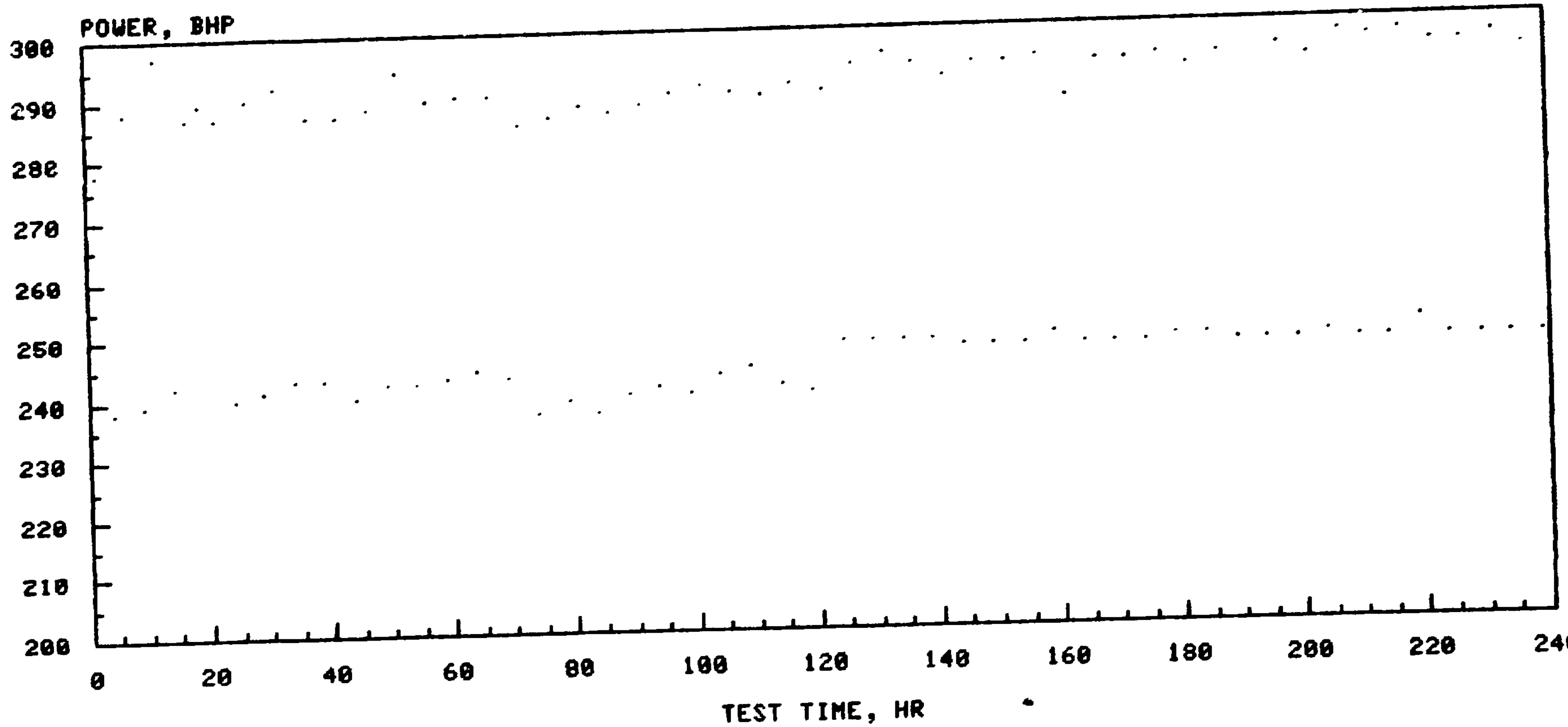
6V53T ENDURANCE TEST
SUMMARY OF OPERATING DATA

TEST NO.: CI 5136206-6 LUBRICANT: AL-7235-8531-L

	2200 RPM			2800 RPM		
	Avg	Min	Max	Avg	Min	Max
Engine Speed, rpm	2206	2185	2275	2804	2796	2812
Load, lb	454	440	468	427	415	439
Obs Power, bhp	244	234	260	292	283	301
Fuel Rate, lb/hr	100.6	99.6	101.6	121.3	119.4	123.2
BSFC, lb/bhp-hr	0.412	0.391	0.426	0.415	0.409	0.422
Temperatures, °F						
Jacket In	150	140	160	146	139	153
Jacket Our	162	154	170	156	150	162
Oil Sump	246	242	250	250	246	254
Inlet Air (Compressor)	97	90	104	97	90	104
Airbox	242	230	254	285	267	303
Exhaust Before Turbo	1127	1090	1164	1117	1087	1143
Exhaust After Turbo	946	919	973	953	933	981
Fuel at Filter	90	88	92	93	88	98
Pressures, psi						
Compressor Discharge	8.4	7.9	8.9	11.5	10.9	12.1
Blower Discharge	10.5	9.5	11.5	16.9	16.2	17.6
Exhuast Before Turbo	8.8	8.4	9.2	12.7	12.1	13.3
Oil Consumption (lb/hr avg for 240 hr)	0.682					

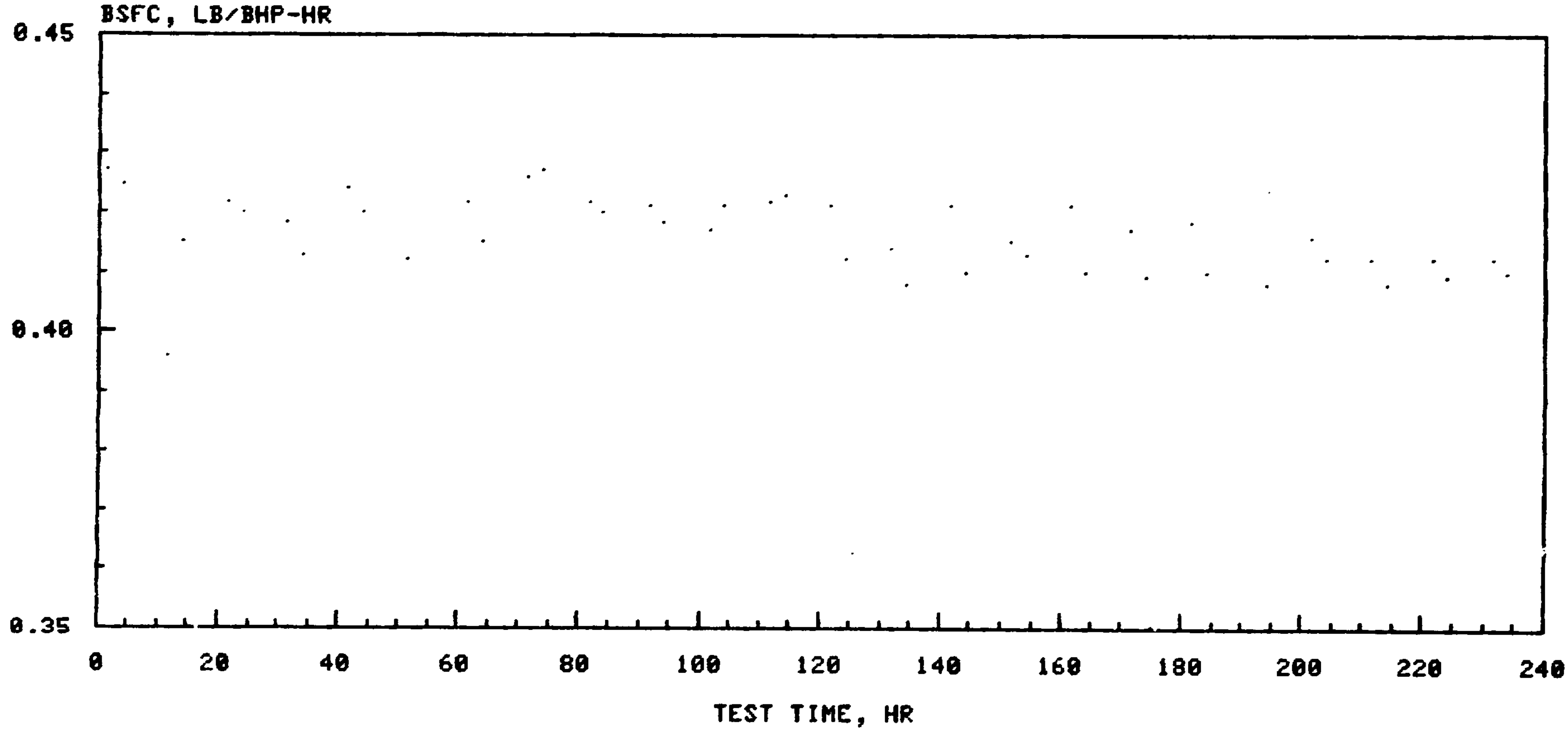
6V53T ENDURANCE TEST - 240 HR TRACKED

Test No.: CI 5136206-6 Oil: AL-7235-8531-L



6V53T ENDURANCE TEST - 240 HR TRACKED

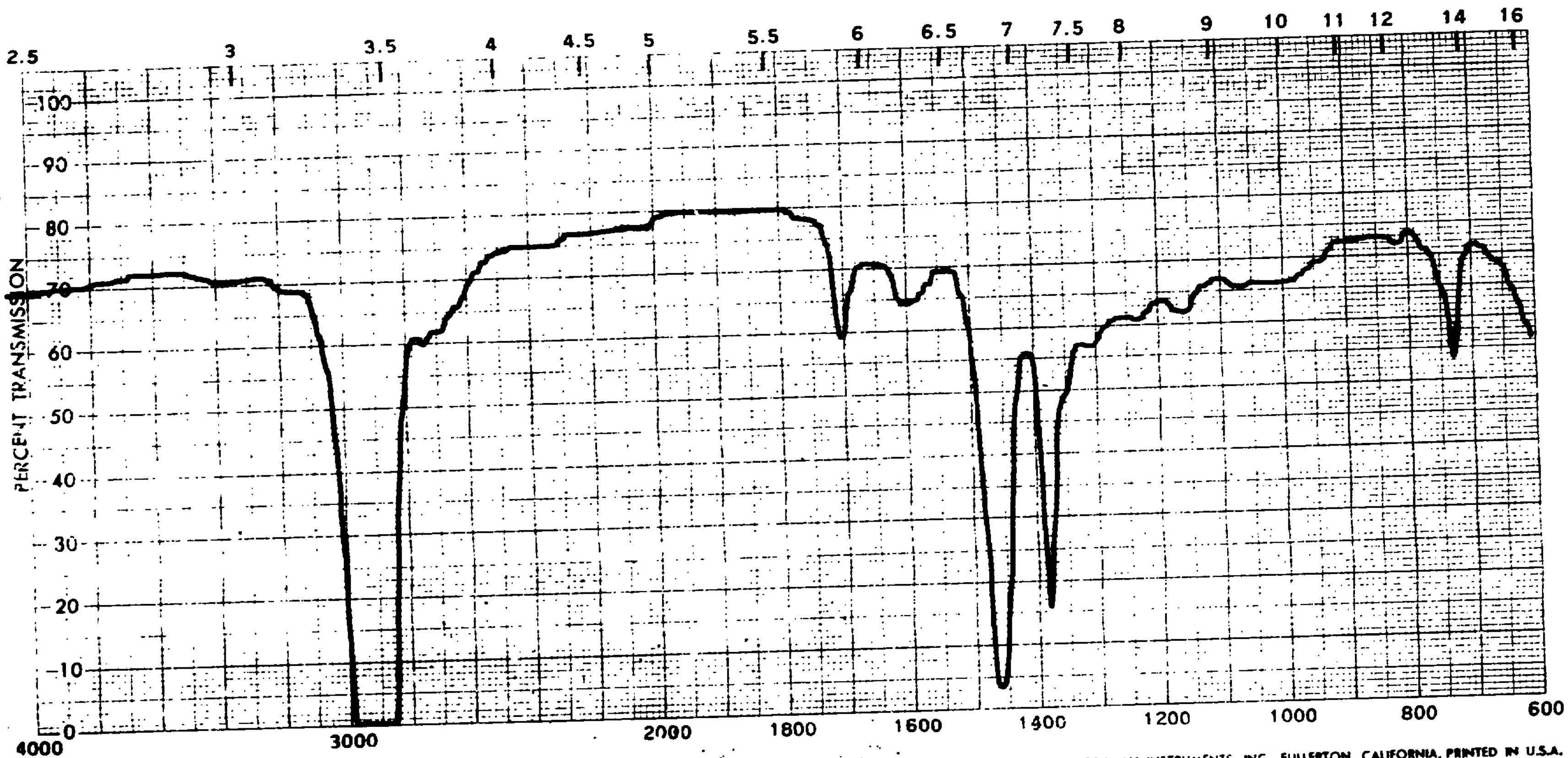
Test No.: CI 5136206-6 Oil: AL-7235-8531-L



LUBRICANT ANALYSIS
6V53T - CI5136206-6
LUBRICANT: AL-7235-8531-L
FUEL: 1-H CAT

Property	ASTM Test Method	New	TEST HOUR 20	40	60	80	100	120	140	160	180	200	220	240
Cold Cranking Simulator @ -29°C, cP	D 2602	-						14100						14200
Cold Cranking Simulator @ -18°C, cP	D 2602	1760						2820						2900
K.Vis @40°C, cSt	D 445	66.4	66.2	68.5	69.6	72.6	70.4	71.7	65.7	66.9	68.9	69.8	70.6	70.7
K.Vis @100°C, cSt	D 445	10.5	10.0	10.2	10.3	10.6	10.4	10.6	10.0	10.1	10.2	10.3	10.4	10.4
TAN	D 664	2.1	3.05	3.93	4.15	5.10	3.55	4.60	3.50	4.28	4.10	3.25	3.35	3.40
TBN	D 664	-	5.24	5.02	4.62	4.43	4.0	3.8	4.4	4.2	4.2	4.1	4.1	4.2
TBN	D 2896	10.3			-			8.92			-			9.06
Insolubles, %														
Pentane B	D 893	0.01			0.03			0.09			0.04			0.05
Toluene B	D 893	-			0.02			0.04			0.04			0.04
Flash Point, °C	D 92	202						220						224
Pour Point, °C	D 97	-31						-29						-26
Gravity, °API @60°F	D 287	29.2						27.8						27.3
Carbon Residue, wt %	D 524	1.24						1.99						1.99
Sulfated Ash, wt %	D 874	1.09						1.37						1.34
Wear Metals by XRF														
Iron, ppm		-	66	87	93	456	244	423	93	145	186	193	191	164
Copper, ppm		-	15	25	22	65	50	42	-	-	15	20	15	20

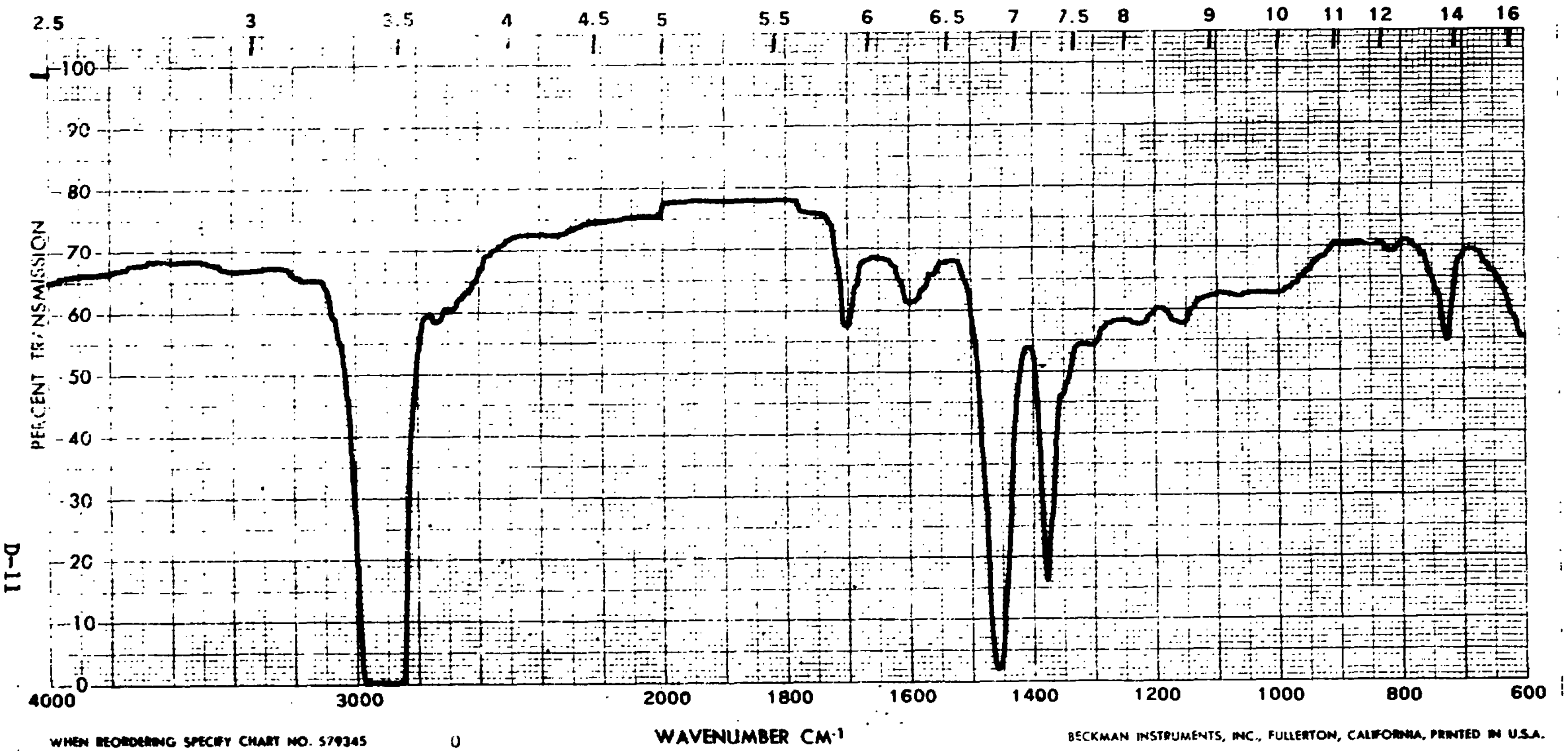
- = Not determined



WHEN REORDERING SPECIFY CHART NO. 579345

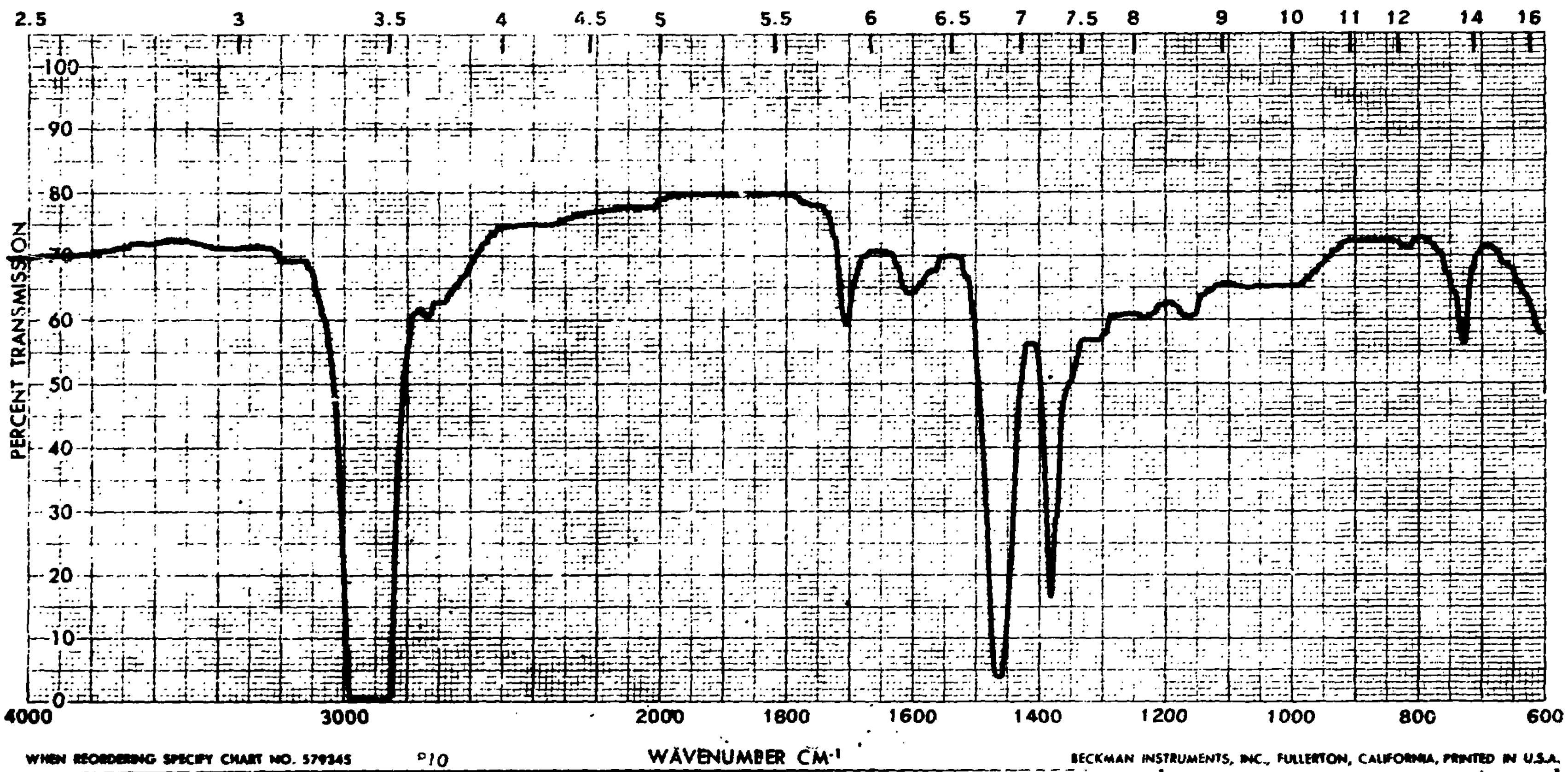
BECKMAN INSTRUMENTS, INC., FULLERTON, CALIFORNIA, PRINTED IN U.S.A.

SPECTRUM NO. 1733	ORIGIN	LEGEND	REMARKS
SAMPLE AL-7235-L		1.	
60-hr	PURITY	2.	
	PHASE	DATE 8-13-79	
	THICKNESS 0.025	OPERATOR D.B.	



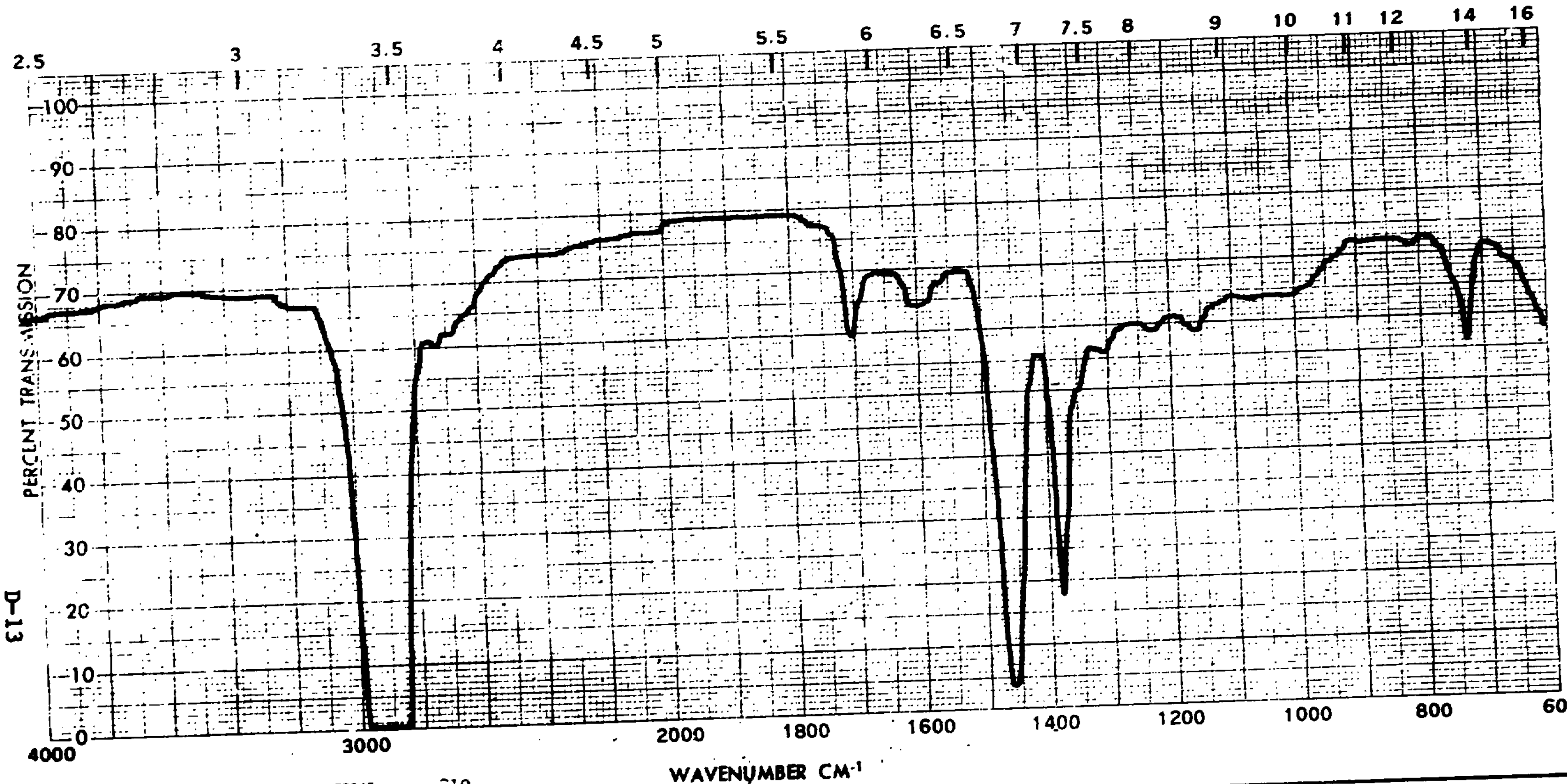
WHEN REORDERING SPECIFY CHART NO. 579345

SPECTRUM NO. 1734	ORIGIN	LEGEND	REMARKS
SAMPLE AL-7235-L		1.	
120 hr	PURITY	2.	
	PHASE	DATE 8-13-79	
	THICKNESS 0.025	OPERATOR D.B.	



WHEN REORDERING SPECIFY CHART NO. 579345 °10 BECKMAN INSTRUMENTS, INC., FULLERTON, CALIFORNIA, PRINTED IN U.S.A.

SPECTRUM NO. 1735	ORIGIN	LEGEND	REMARKS
SAMPLE AL-7235-L		1.	
180 hr	PURITY	2.	
	PHASE	DATE 8-13-79	
	THICKNESS 0.025	OPERATOR D.B.	



WHEN REORDERING SPECIFY CHART NO. 579345

210

SPECTRUM NO. 1736

SAMPLE AL-7235-L

240 hr

ORIGIN

PURITY

PHASE

THICKNESS 0.025

LEGEND

1.

2.

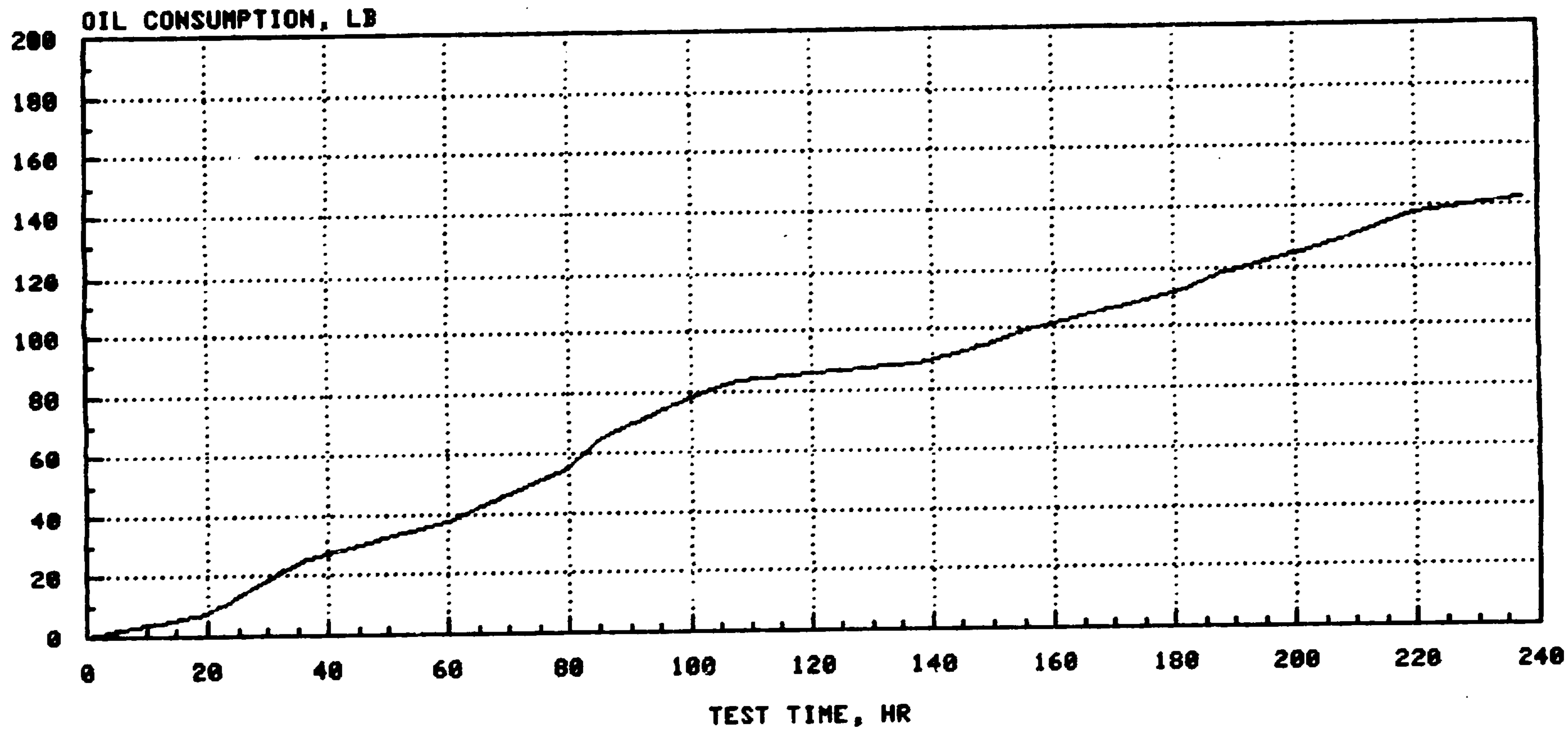
DATE 8-13-79

OPERATOR D.B.

REMARKS

6V53T ENDURANCE TEST - 240 HR TRACKED

Test No.: CI 5136206-6 Oil: AL-7235-8531-L



WEAR MEASUREMENTS
TEST NO. CI 5136206-6
LUBRICANT: AL-7235-8531-L
TEST HOURS: 240

Cylinder No.		Cylinder Liner ID: Perpendicular to Crankshaft Top	Perpendicular Middle	Perpendicular Bottom	Parallel to Crankshaft Top	Parallel Middle	Parallel Bottom
1L	Before	3.8753	3.8757	3.8761	3.8756	3.8756	3.8761
	After	3.8795	3.8772	3.8761	3.8767	3.8765	3.8759
	Change	0.0042	0.0015	0.0000	0.0011	0.0009	-0.0002
2L	Before	3.8755	3.8757	3.8761	3.8755	3.8756	3.8759
	After	3.8790	3.8770	3.8762	3.8779	3.8764	3.8756
	Change	0.0035	0.0013	0.0001	0.0024	0.0008	-0.0003
3L	Before	3.8758	3.8758	3.8761	3.8756	3.8758	3.8763
	After	3.8784	3.8771	3.8760	3.8766	3.8767	3.8764
	Change	0.0026	0.0013	-0.0001	0.0010	0.0009	0.0001
1R	Before	3.8750	3.8752	3.8757	3.8754	3.8755	3.8758
	After	3.8781	3.8773	3.8762	3.8787	3.8766	3.8758
	Change	0.0031	0.0021	0.0005	0.0033	0.0011	0.0000
2R	Before	3.8758	3.8755	3.8757	3.8753	3.8756	3.8759
	After	3.8745	3.8771	3.8759	3.8763	3.8767	3.8758
	Change	-0.0013	0.0016	0.0002	0.0010	0.0011	-0.0001
3R	Before	3.8753	3.8754	3.8757	3.8753	3.8755	3.8759
	After	3.8780	3.8780	3.8757	3.8716	3.8772	3.8765
	Change	0.0027	0.0026	0.0000	0.0023	0.0017	0.0006

WEAR MEASUREMENTS
ENGINE NUMBER 5136206-6
LUBRICANT: AL-7235-8531-L
TEST HOURS: 240

Piston No.		Piston Ring Gap, inches 1	2	3	4	5	6	7
1L	Before	0.035	0.025	0.025	0.025	0.020	0.011	0.011
	After	0.041	0.024	0.026	0.027	0.030	0.028	0.027
	Change	0.006	-0.001	0.001	0.002	0.010	0.017	0.016
2L	Before	0.028	0.023	0.023	0.021	0.020	0.011	0.011
	After	0.036	0.027	0.033	0.028	0.075	0.084	0.082
	Change	0.008	0.004	0.010	0.007	0.055	0.063	0.071
3L	Before	0.034	0.025	0.028	0.020	0.020	0.011	0.011
	After	0.039	0.029	0.029	0.024	0.033	0.024	0.025
	Change	0.005	0.004	0.001	0.004	0.013	0.013	0.014
1R	Before	0.031	0.020	0.020	0.030	0.015	0.012	0.011
	After	0.033	0.023	0.024	0.031	0.029	0.029	0.025
	Change	0.002	0.003	0.004	0.001	0.014	0.017	0.014
2R*	Before	0.035	0.026	0.022	0.020	0.016	0.011	0.011
	After	0.038	0.030	0.026	0.023	0.063	0.090	Broken
	Change	0.003	0.004	0.004	0.003	0.047	0.079	---
2R**	Before	0.042	0.031	0.040	0.035	0.022	0.019	0.019
	After	0.047	0.032	0.039	0.036	0.028	0.025	0.026
	Change	0.005	0.001	-0.001	0.001	0.006	0.006	0.007
3R	Before	0.028	0.028	0.028	0.028	0.013	0.014	0.013
	After	0.040	0.031	0.030	0.034	0.033	0.028	0.027
	Change	0.012	0.003	0.002	0.006	0.020	0.014	0.014

* Failed first cylinder assembly at 120 hours.
**Second cylinder assembly.

WEAR MEASUREMENTS
ENGINE NO. 5136206-6
LUBRICANT: AL-7235-8531-L
TEST HOURS: 240

Cylinder No.		Rod Bearing Journal AA	Rod Bearing Journal BB	Rod Bearing F	Rod Bearing R
1L	Before	2.7495	2.7495	2.7525	2.7525
	After	2.7495	2.7495	2.7521	2.7522
	Change	0.0000	0.0000	-0.0004	-0.0003
2L	Before	2.7493	2.7493	2.7522	2.7522
	After	2.7494	2.7494	2.7525	2.7523
	Change	0.0001	0.0001	0.0003	0.0001
3L	Before	2.7493	2.7493	2.7524	2.7523
	After	2.7493	2.7493	2.7521	2.7521
	Change	0.0000	0.0000	-0.0003	-0.0002
1R	Before	2.7495	2.7495	2.7521	2.7521
	After	2.7494	2.7494	2.7525	2.7524
	Change	-0.0001	-0.0001	0.0004	0.0003
2R	Before	2.7493	2.7493	2.7524	2.7524
	After	2.7493	2.7493	2.7523	2.7521
	Change	0.0000	0.0000	-0.0001	0.0003
3R	Before	2.7493	2.7493	2.7524	2.7524
	After	2.7493	2.7494	2.7522	2.7521
	Change	0.0000	0.0001	-0.0002	-0.0003

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-7235-8531-L

RATER E. Lyons DATE 8-1-79
LABORATORY TEST NUMBER CI 5136206-6
STAND NO. 5 ENGINE NO. 6V53T 5136206
FUEL 1-H CAT

PISTON NO. 1-Right

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	300.35

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00			15	15.00					95	95.00								
CARBON	MHC	0.75			85	63.75							15	11.25	10	7.50				
CARBON	MC	0.50	25	12.50			50	25.00												
CARBON	LC	0.25											25	6.25	40	10.00				
CARBON	VLC	0.15	45	6.75							5	0.75	25	3.75			10	1.50		
	CARBON RATING		19.25		78.75		25.00				95.75		21.35		17.50		1.50			
LACQUER	BL	0.100	30	3.00			50	5.00	50	5.00			35	3.50	50	5.00	80	8.00	100	7.50
LACQUER	DBrL	0.075							50	3.75										
LACQUER	AL	0.050															10	0.50		
LACQUER	LAL	0.025																		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING		3.00				5.00		8.75				3.50		5.00		8.50		7.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		22.25		78.75		30.00		8.75		95.75		24.85		22.50		10.00		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked Cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-7235-8531-L

RATER E. Lyons DATE 8-1-79
LABORATORY TEST NUMBER CI 5136206-6
STAND NO. 5 ENGINE NO. 6V53T 5136206
FUEL 1-H CAT

PISTON NO. 2-Right

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	342.75

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00			15	15.00					95	95.00	90	90.00						
CARBON	MHC	0.75			85	63.75														
CARBON	MC	0.50																		
CARBON	LC	0.25					40	10.00	25	6.25			10	2.50	50	12.50				
CARBON	VLC	0.15	100	15.00			10	1.50			5	0.75								
	CARBON RATING		15.00		78.75		11.50		6.25		95.75		92.50		12.50					
LACQUER	BL	0.100					50	5.00	75	7.50					50	5.00	10	1.00		
LACQUER	DBrL	0.075																	100	7.50
LACQUER	AL	0.050															90	4.50		
LACQUER	LAL	0.025																		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING						5.00		7.50						5.00		5.50		7.50	
CLEAN		0																		
ZONAL RATING																				
LOCATION FACTOR																				
WEIGHTED RATING			15.00		78.75		16.50		13.75		95.75		92.50		17.50		5.50		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked Cycle
TEST HOURS 85.5
TEST LABORATORY AFLRL
LUBRICANT AL-7235-L

RATER E. Lyons DATE 8-1-79
LABORATORY TEST NUMBER CI 5136206-6
STAND NO. 5 ENGINE NO. 6V53T 5136206
FUEL 1-H CAT

PISTON NO. 2-Right (Failed)

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	272.125

		GROOVES								LANDS								UNDER-CROWN	
		NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
DEPOSIT TYPE	DEPOSIT FACTOR	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON HC	1.00			100	100.00					90	90.00	60	60.00						
CARBON MHC	0.75																		
CARBON MC	0.50									10	5.00								
CARBON LC	0.25	100	25.00			10	2.50					25	6.25	45	11.25				
CARBON VLC	0.15											15	2.25						
CARBON RATING		25.00		100.00		2.50				95.00		14.50		11.25					
LACQUER BL	0.100					90	9.00									5	0.50	100	10.00
LACQUER DBrL	0.075																		
LACQUER AL	0.050																		
LACQUER LAL	0.025							100	2.50					55	1.375				
LACQUER VLAL	0.010															95	0.950		
LACQUER RL	0.001																		
LACQUER RATING						9.00		2.50						1.375		1.00		10.00	
CLEAN	0																		
ZONAL RATING																			
LOCATION FACTOR																			
WEIGHTED RATING		25.00		100.00		11.50		2.50		95.00		14.50		12.625		1.00		10.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked Cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-7235-8531-L

RATER E. Lyons DATE 8-1-79
LABORATORY TEST NUMBER CI 5136206-6
STAND NO. 5 ENGINE NO. 6V53T 5136206
FUEL 1-H CAT

PISTON NO. 3-Right

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	319.125

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00											20	20.00						
CARBON	MHC	0.75			100	75.00	10	7.50			100	75.00								
CARBON	MC	0.50					90	45.00							60	30.00				
CARBON	LC	0.25											50	12.50	40	10.00				
CARBON	VLC	0.15	100	15.00									30	4.50			30	4.50		
CARBON	CARBON RATING		15.00		75.00		52.50				75.00		37.00		40.00		4.50			
LACQUER	BL	0.100							20	2.00							60	6.00		
LACQUER	DBrL	0.075															5	0.375	100	7.50
LACQUER	AL	0.050							80	4.00							5	0.25		
LACQUER	LAL	0.025																		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
LACQUER	LACQUER RATING								6.00								6.625		7.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		15.00		75.00		52.50		6.00		75.00		37.00		40.00		11.125		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked Cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-7235-8531-L

RATER E. Lyons DATE 8-1-79
LABORATORY TEST NUMBER CI 5136206-6
STAND NO. 5 ENGINE NO. 6V53T 5136206
FUEL 1-H CAT

PISTON NO. 1-Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	345.60

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00									90	90.00	90	90.00						
CARBON	MHC	0.75			100	75.00									50	37.50				
CARBON	MC	0.50																		
CARBON	LC	0.25	55	13.75			10	2.50							10	2.50				
CARBON	VLC	0.15	45	6.75							10	1.50	10	1.50	10	1.50				
	CARBON RATING		20.50		75.00		2.50				91.50		91.50		41.50					
LACQUER	BL	0.100					90	9.00							20	2.00	5	0.50		
LACQUER	DBrL	0.075																	100	7.50
LACQUER	AL	0.050													10	0.50				
LACQUER	LAL	0.025							100	2.50							10	0.25		
LACQUER	VLAL	0.010															85	0.85		
LACQUER	RL	0.001																		
	LACQUER RATING						9.00		2.50						2.50		1.60		7.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		20.50		75.00		11.50		2.50		91.50		91.50		44.00		1.60		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked Cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-7235-8531-L

RATER E. Lyons DATE 8-1-79
LABORATORY TEST NUMBER CI 5136206-6
STAND NO. 5 ENGINE NO. 6V53T 5136206
FUEL 1-H CAT

PISTON NO. 2-Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	271.50

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00											80	80.00						
CARBON	MHC	0.75			100	75.00					25	18.75								
CARBON	MC	0.50					20	10.00												
CARBON	LC	0.25									75	18.75	20	5.0	80	20.00				
CARBON	VLC	0.15	100	15.00			30	4.50							20	3.00				
	CARBON RATING		15.00		75.00		14.50				37.50		85.00		23.00					
LACQUER	BL	0.100															15	1.50		
LACQUER	DBrL	0.075					50	3.75											100	7.50
LACQUER	AL	0.050							100	5.00							65	3.25		
LACQUER	LAL	0.025															20	0.50		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING						3.75		5.00								5.25		7.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		15.00		75.00		18.25		5.00		37.50		85.00		23.00		5.25		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked Cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-7235-8531-L

RATER E. Lyons DATE 8-1-79
LABORATORY TEST NUMBER CI 5136206-6
STAND NO. 5 ENGINE NO. 6V53T 5136206
FUEL 1-H CAT

PISTON NO. 3-Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	305.50

DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON HC	1.00			50	50.00					95	95.00	15	15.00						
CARBON MHC	0.75			50	37.50									20	15.00				
CARBON MC	0.50											75	37.50						
CARBON LC	0.25	25	5.25			15	3.75							60	15.00				
CARBON VLC	0.15	75	11.25							5	0.75	10	1.50						
CARBON RATING		16.50		87.50		3.75				95.75		49.00		30.00					
LACQUER BL	0.100													10	1.00	50	5.00		
LACQUER DBrL	0.075															20	1.50	100	7.50
LACQUER AL	0.050					85	4.25									10	0.50		
LACQUER LAL	0.025							100	2.50					10	0.25	20	0.50		
LACQUER VLAL	0.010																		
LACQUER RL	0.001																		
LACQUER RATING						4.25		2.50						1.25		7.50		7.50	
CLEAN	0																		
ZONAL RATING																			
LOCATION FACTOR																			
WEIGHTED RATING		16.50		37.50		8.00		2.50		95.75		49.00		31.25		7.50		7.50	

*WEIGHTED TOTAL DEPOSITS

RATING DATA SHEET
CI 5136206-6

Test Run at AFLRL
Test Lubricant: AL-7235-8531-L
Test Fuel: CAT 1-H
Test No.: CI 5136206-6
Test Stand: 5
Engine No.: 6V53T 5136206
Test Hours: 240
Date Started: 26 June 1979
Date Completed: 30 July 1979

A. Cylinder Liner Ratings

Intake Port Plugging

Cylinder No.	Restriction,%
1 L	<1
2 L	1
3 L	1
1 R	2
2 R	<1
3 R	3
Average	1

Scuffing, Glazing and Lacquer*

Cylinder No.	Thrust	Anti-Thrust	Total	Glazing,%	Lacquer,%
1 L	25	5	15	5	95
2 L	30	10	20	10	90
3 L	50	10	30	10	90
1 R	10	40	25	2	98
2 R	75	5	40	2	98
3 R	80	60	70	0	100
Average	45	22	33	5	95

*Ring Travel Area

B. Piston Ratings

Ring Sticking and Condition

Cylinder No.	Ring Fire	No.1	No.2	No.3
1 L	5%P 1%B	F 65%B	F 80%B	F 75%B
2 L	F 5%B	F 95%B	F 90%B	F 70%B
3 L	F x 15%B	F 85%B	F 90%B	F 75%B
1 R	F 15%B	F 70%B	F 85%B	F 60%B
2 R	F 25%B	F 80%B	F 80%B	F 80%B
3 R	F x 70%B	F 95%B	F 100%B	F 50%B

* Rings broken, + collapsed, x partially collapsed

Ring Groove Carbon Filling and Oil Groove Lacquer

Cylinder No.	Groove Filling,% Fire	No.1	No.2	No.3	Oil Groove Lacquer Upper	Lower
1 L	10	90	2	0	3.0	3.0
2 L	5	85	5	0	3.0	3.0
3 L	10	95	2	0	3.0	3.0
1 R	15	85	10	0	3.0	3.0
2 R	10	85	5	0	3.0	3.0
3 R	5	60	40	1	3.0	3.0

Cylinder No.	Land Description
1 L	Normal
2 L	Normal
3 L	Normal
1 R	Normal
2 R	Normal
3 R	Normal

Skirt

Cylinder No.	Side Thrust	Anti-Thrust
1 L	5.8 Lt. Scuff and Scratches	5.8 Lt. Scratches
2 L	6.0 Lt. Scuff and Scratches	5.5 Lt. Scuff and Scratches
3 L	6.5 Scuff and Lt. Scratches	6.0 Lt. Scratches
1 R	6.0 Lt. Scratches	6.0 Lt. Scuff and Scratches
2 R	7.0 Plate Melt and Scuff	6.0 Lt. Scratches
3 R	6.0 Scuff and Scratch	5.8 Lt. Scuff and Scratches

RATING DATA SHEET - CONTINUED
CI 5136206-6

C. Other Ratings

Combustion Chambers

Cylinder No.	Description	Cylinder No.	Description
1 L	80% AHC	1 R	30% AHC
2 L	75% AHC	2 R	90% AHC
3 L	80% AHC	3 R	80% AHC

Valve Covers, Oil Pan and Cylinder Head Deck

Covers	Clean
Pan	Clean
Deck	Clean

Remarks

No. 2 R Piston and Liner Removed at 85.5 hours.
A New Set Was Installed, and the Test was Finished.

D. Interim Inspections

Zero Test Hours	Inspection
1 L	Normal
2 L	Normal
3 L	Normal
1 R	Normal
2 R	Normal
3 R	Normal

40 Test Hours	Inspection
1 L	Normal
2 L	Normal
3 L	Normal
1 R	Normal
2 R	Normal
3 R	Normal

60 Test Hours	Inspection
1 L	Fire Ring Black, Scuffed and Glazed Thrust Side of Liner
2 L	Normal
3 L	Normal
1 R	Normal
2 R	Normal
3 R	Normal

RATING DATA SHEET - CONTINUED
CI 5136206-6

D. Interim Inspections (Cont'd)

80 Test Hours	Inspection
1 L	Fire ring black, lightly burned; Light to medium scuffing of liner thrust side
2 L	Normal
3 L	Normal
1 R	Normal
2 R	Normal
3 R	Normal

120 Test Hours	Inspection
1 L	Top ring burning, medium glazing to scuffing of liner
2 L	Top land with medium carbon deposits, Light to Medium Lacquer or Glazing of liner
3 L	Normal
1 R	Fire ring face black, lightly burned; Cylinder liner has light to medium glazing
2 R	Normal
3 R	Cylinder liner medium glazing

140 Test Hours	Inspection
1 L	Normal
2 L	Normal
3 L	Normal
1 R	Normal
2 R	Normal
3 R	Normal

160 Test Hours	Inspection
1 L	No change
2 L	No change
3 L	No change
1 R	No change
2 R	No change
3 R	No change

180 Test Hours	Inspection
1 L	No change
2 L	No change
3 L	No change
1 R	No change
2 R	No change
3 R	No change

D. Interim Inspections (Cont'd)

200 Test Hours	Inspection
1 L	No change
2 L	No change
3 L	No change
1 R	No change
2 R	No change
3 R	No change

RATING DATA SHEET
CI 5136206-6
FAILED CYLINDER 2-RIGHT

Test Run at AFLRL
Test Lubricant: AL-7235-L
Test Fuel: CAT 1-H
Test No.: CI 5136206-6
Test Stand: 5
Engine No.: 6V53T 5136206
Test Hours: 85.5 for Failed Cylinder
Date Started: 26 June 1979
Date Completed: 30 July 1979

A. Cylinder Liner Ratings

Intake Port Plugging

Cylinder No.	Restriction, %
2 R	<1%

Scuffing, Glazing and Lacquer*

Cylinder No.	Thrust	Anti-Thrust	Total	Glazing,%	Lacquer,%
2 R	95	15	55	5	95

* Ring Travel Area.

B. Piston Ratings

Ring Sticking and Condition

Cylinder No.	Ring Fire	Ring No.1	Ring No.2	Ring No. 3
2 R	30% C.S., 30%B P, X, 55%	F 100%B	F 100%B	F 100%B

X = Partially collapsed
CS = Cold Stuck
F = Free
B = Burned

RATING DATA SHEET - CONTINUED
CI 5136206-6
FAILED CYLINDER 2-RIGHT

B. Piston Ratings (Cont'd)

Ring Groove Carbon Filling and Oil Groove Lacquer

	Groove Filling,%				Oil Groove Lacquer	
Cylinder No.	Fire	No.1	No.2	No.3	Upper	Lower
2 R	5%	90%	2%	<1%	3.0	3.0

Land Description

Cylinder No.	
2 R	Start of Plate Melt on fourth land - Rest Normal

Skirt

	Side	
Cylinder No.	Thrust	Anti-Thrust
2 R	100% Scuff and Burn	5.5 Light Scratches

RING STICKING

Test No. CI-6

Engine Model 6V53T　　Serial No. 5136206　　Date 8-1-79

Fuel 1-H CAT　　Lubricant AL-7235-8531-L　　Observer E Lyons

Ring No.	Piston Number 1L	2L	3L	1R	2R	3R
1	5% P	F	F	F	F	F
2	F	F	F	F	F	F
3	F	F	F	F	F	F
4	F	F	F	F	F	F

Indicate by letter — Free or Sluggish, or by number and letter -- percent Pinched (cold stuck) or percent Hot stuck (Pages 6 and 7 of Manual).

RING STICKING

Test No. CI-6(85.5 Hours, Failed Cylinder No. 2-Right)

Engine Model 6V53T Serial No. 5136206 Date 8-1-79

Fuel 1-H CAT Lubricant AL-7235-L Observer E. Lyons

Piston Number

Ring No.	1L	2L	3L	1R	2R	3R
1					30% C.S. 30% P PARTIALLY COLLAPSED	
2						
3						
4						

Indicate by letter — Free or Sluggish, or by number and letter — percent Pinched (cold stuck) or percent Hot stuck (Pages 6 and 7 of Manual).

PISTON GROOVE INSIDE DIAMETER—% RING SUPPORTING CARBON

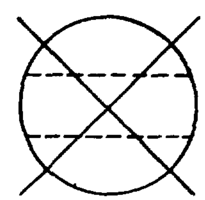
Test No. CI-6

Engine Model 6V53T   Serial No. 5136206   Date 8-1-79

Fuel 1-H CAT   Lubricant AL-7235-8531-L   Observer E. Lyons

Piston Ring	Quadrant	Piston Number					
		1L	2L	3L	1R	2R	3R
1	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
2	1	0	10	90	0	5	0
	2	75	5	100	70	5	10
	3	0	40	10	5	100	10
	4	0	0	0	0	5	0

1 Thrust Side

4 Front  2 Rear

3 Anti-Thrust Side

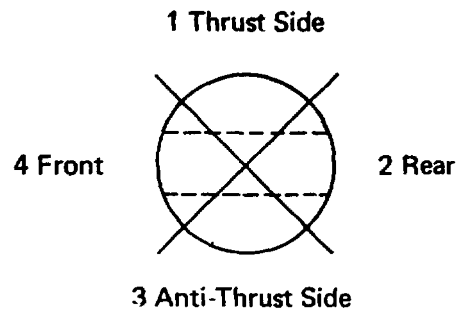
PISTON GROOVE INSIDE DIAMETER—% RING SUPPORTING CARBON

Test No. CI-6 (85.5 Hours, Failed Cylinder No. 2-Right)

Engine Model 6V53T Serial No. 5136206 Date 8-1-79

Fuel 1-H CAT Lubricant AL-7235-8531-L Observer E. Lyons

Piston Ring	Quadrant	Piston Number					
		1L	2L	3L	1R	2R	3R
1	1					0	
	2					0	
	3					0	
	4					0	
2	1					95	
	2					10	
	3					100	
	4					95	



VALVE DEPOSITS

Test No. CI-6

Engine Model 6V53T   Serial No. 5136206   Date 8-1-79

Fuel 1-H CAT   Lubricant AL-7235-8531-L   Observer E. Lyons

		Cylinder Number											
		1L		2L		3L		1R		2R		3R	
Head*	INT	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ
	EXH	1 0 0 %	A H	C----	----	----	----	----	----	----	----	----	----
Face	INT	¼ A H	C -	1 0 0	- 9	L A C	Q U E	R----	----	----	----	----	----
	EXH	----	----	----	----	----	----	----	----	----	----	----	----
Tulip†	INT	1 0 0	A H C	- 1	0 0 -	9 L A	C Q U E	R --	----	----	----	----	----
	EXH	----	----	----	----	----	----	----	----	----	----	----	----
Stem	INT	N U M	B E R	9 L A	C Q U E	R -	C L E A	N----	----	----	----	----	----
	EXH	----	----	----	----	----	----	----	----	----	----	----	----

*Carbon and Ash: Use Volume Factor Technique (Pages 5 and 40 through 47 of Manual).
†Use Chart, Page 21—Indicate H, M, or S, (Page 5).
Lacquer: Pages 4, 36 and 37.

EXHAUST VALVE SURFACE CONDITIONS

Test No. CI-6

Engine Model 6V53T Serial No. 5136206 Date 8-1-79

Fuel 1-H CAT Lubricant AL-7235-8531-L Observer E. Lyons

	1L	2L	3L	1R	2R	3R
Freeness in Guide	F			(All Free)		
Head	N			(All Normal)		
Face	N			(All Normal)		
Seat	N			(All Normal)		
Stem	N			(All Normal)		
Tip	N			(All Normal)		

See Pages 1, 2, 16 through 23, and 54 through 65 of Manual.

TAPPETS, CAMS, AND ROCKER ARMS

Test No. CI-6

Engine Model 6V53T Serial No. 5136206 Date 8-1-79

Fuel 1-H CAT Lubricant AL - 7235-8531-L Observer E. Lyons

			Cylinder Number					
			1L	2L	3L	1R	2R	3R
Tappet Deposit		INT						
		EXH						
Tappet Surface Condition		INJ						
		INT						
		EXH						
Cam Lobes								
Rocker Arms	Tip	INT						
		EXH						
	Bushing	INT						
		EXH						
	Shaft	INT						
		EXH						

NORMAL

Lacquer: Pages 4, 36 and 37 of Manual.
See Pages 1, 2, 16 through 23, and 54 through 65.

SURFACE CONDITION

Test No. CI-6

Engine Model 6V53T Serial No. 5136206 Date 8-1-79

Fuel 1-H CAT Lubricant AL-7235-8531-L Observer E. Lyons

Bearing No.	1	2	3	4	5	6	7
Main—Bearing	Scratched Babbitt Removed	Same	Same	Scratched	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX
—Journal	N	N	N	N	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX
Rod—Bearing	*L I G H T	S C R A T	C H E S----	----------	----------	----------	
—Journal	N	N	N	N	N	N	
Piston Pin	N	N	N	N	N	N	
Bushing	A L L B U R O D B U	S H I N G S S H I N G S	I N P I N O R M A	S T O N S L--------	W O R N A ----------	T T O P ----------	

Note surface condition. See pages 1, 2, 16 through 23 and 54 through 65 of Manual.

*No. 1-Left has a deep scratch on to half.

SURFACE CONDITION

Test No. CI-6 (85.5 Hours, Failed Cylinder No. 2-Right)

Engine Model 6V53T   Serial No. 5136206   Date 8-1-79

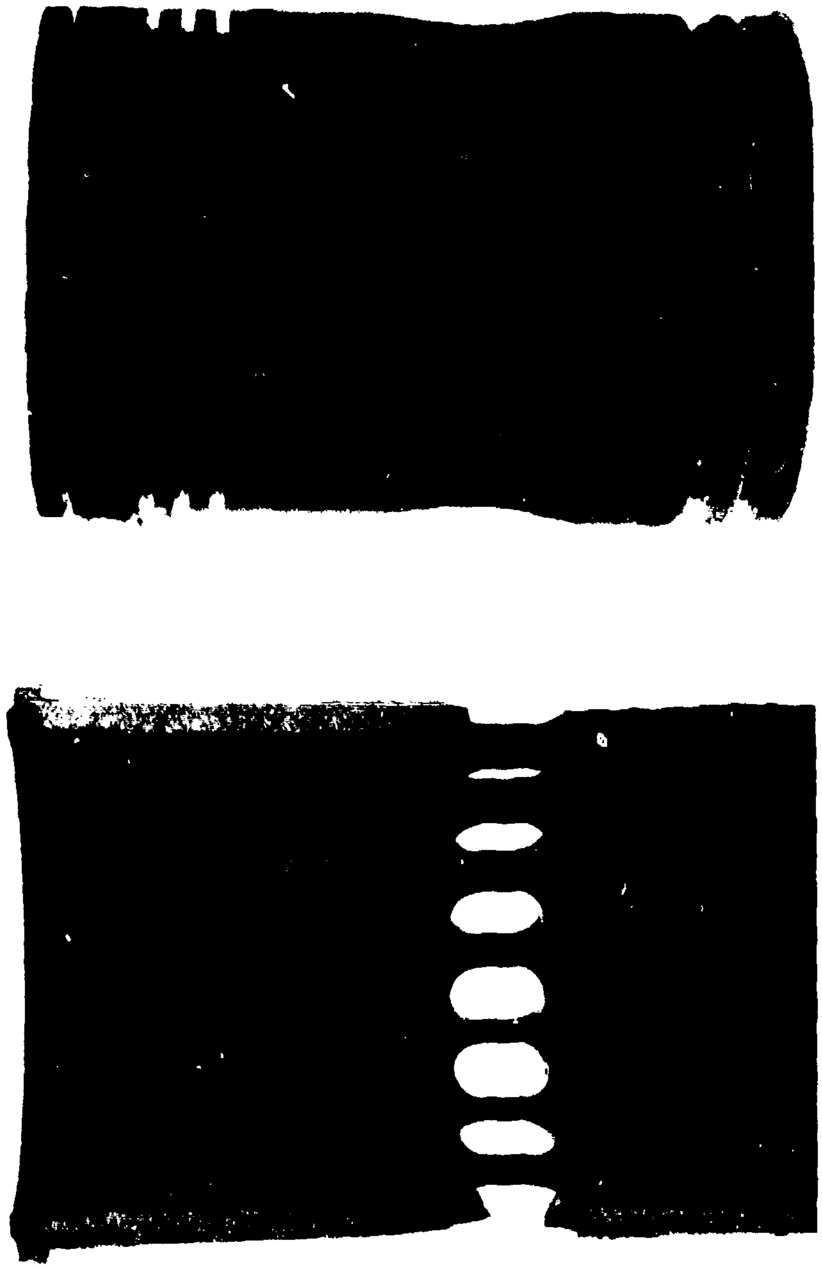
Fuel 1-H CAT   Lubricant AL-7235-L   Observer E. Lyons

Bearing No.	1	2	3	4	5	6	7
Main—Bearing							
—Journal							
Rod—Bearing							
—Journal							
Piston Pin	R2 WORN AND SCUFFED ON PISTON BEARING SURFACE						
Bushing	WORN HEAVY ON TOP						

Note surface condition. See pages 1, 2, 16 through 23 and 54 through 65 of Manual.

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 240 HOURS   TEST NO.: CI 5136206-6   LUBRICANT: AL-7235-8531-L



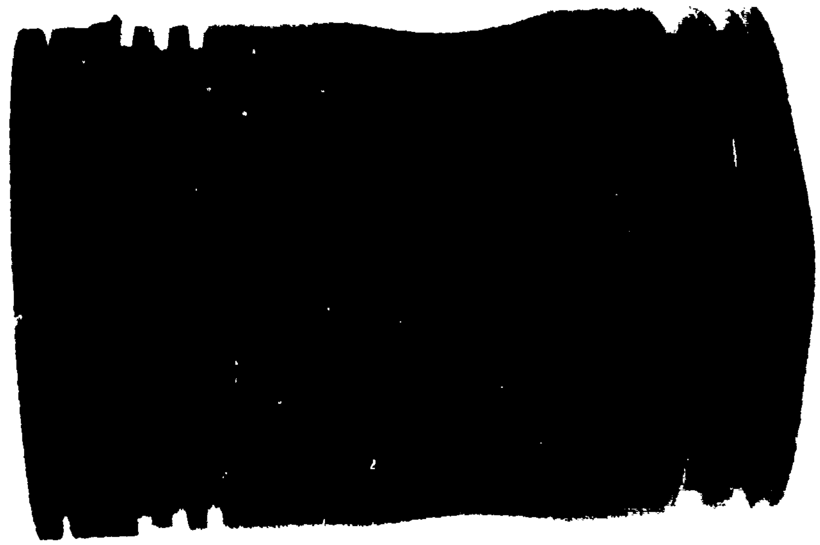
1-RIGHT THRUST

CONDITION OF PISTON AND CYLINDER LINER

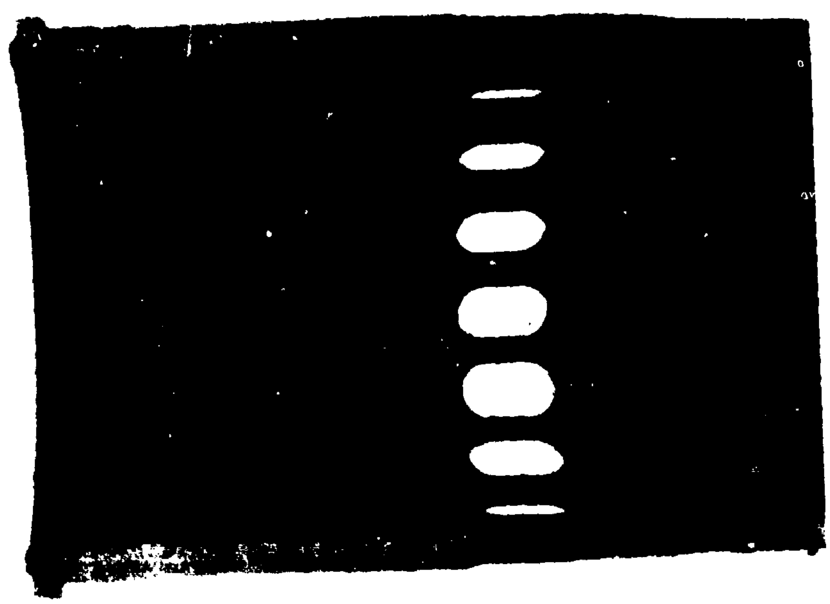
TEST TIME: 120 HOURS

TEST NO.: CI 5136206-6

LUBRICANT: AL-7235-8531-L



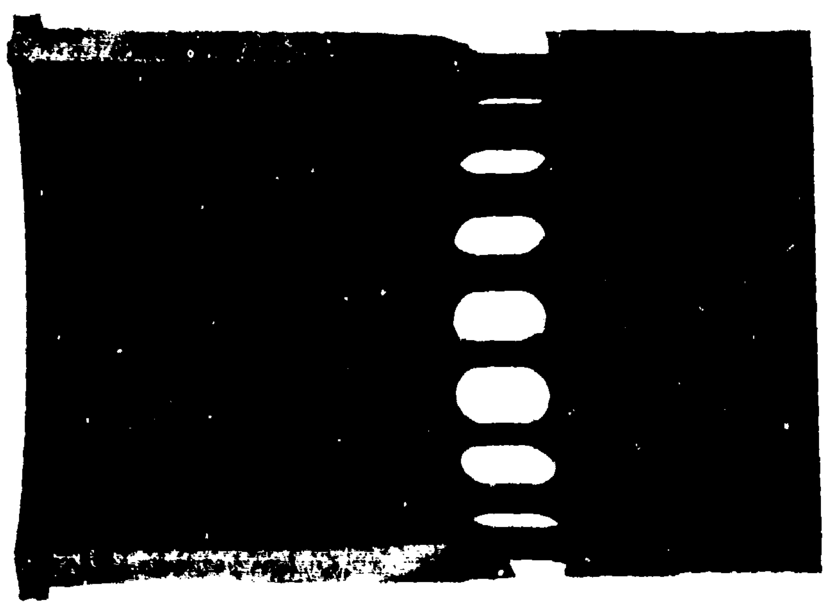
1-RIGHT ANTI-THRUST



CONDITION OF PISTON AND CYLINDER LINER

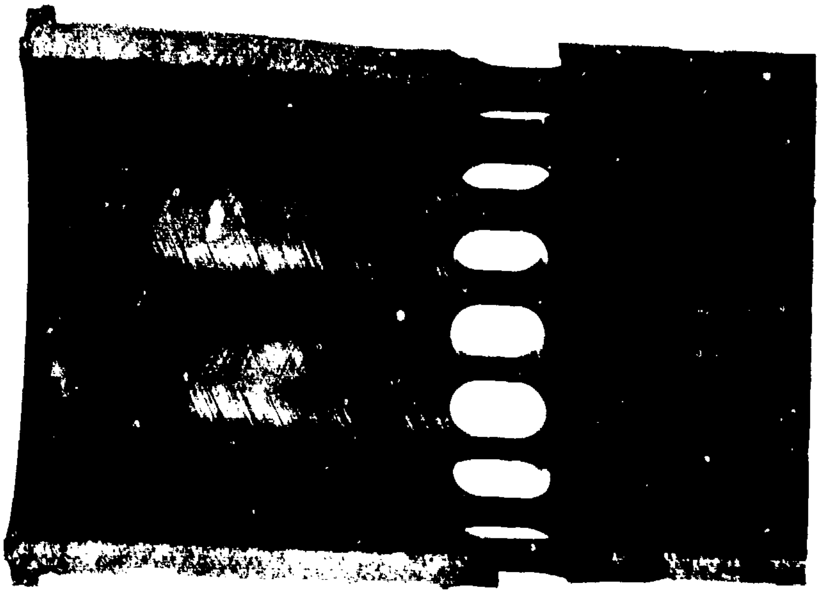
TEST TIME: 120 HOURS TEST NO.: CI 5136206-6 LUBRICANT: AL-7235-8531-L

2-RIGHT THRUST



CONDITION OF PISTON AND CYLINDER LINER

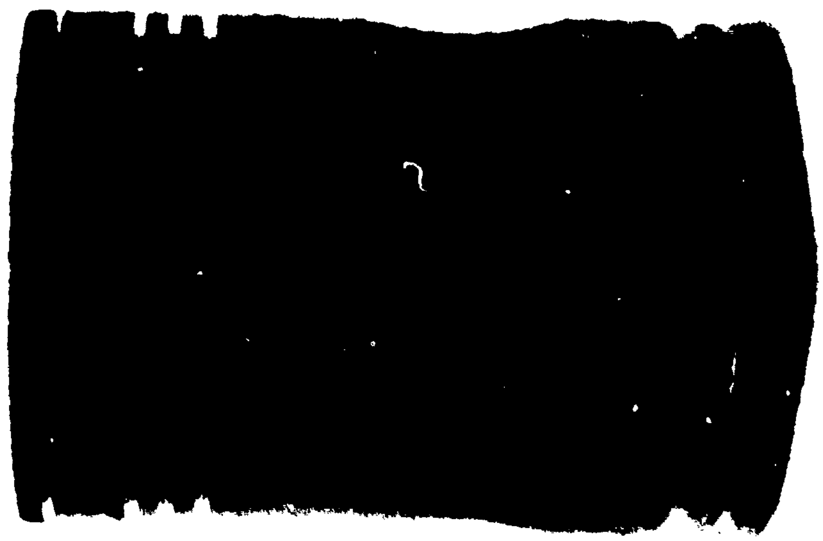
TEST TIME: 120 HOURS   TEST NO.: CI 5136206-6   LUBRICANT: AL-7235-8531-L

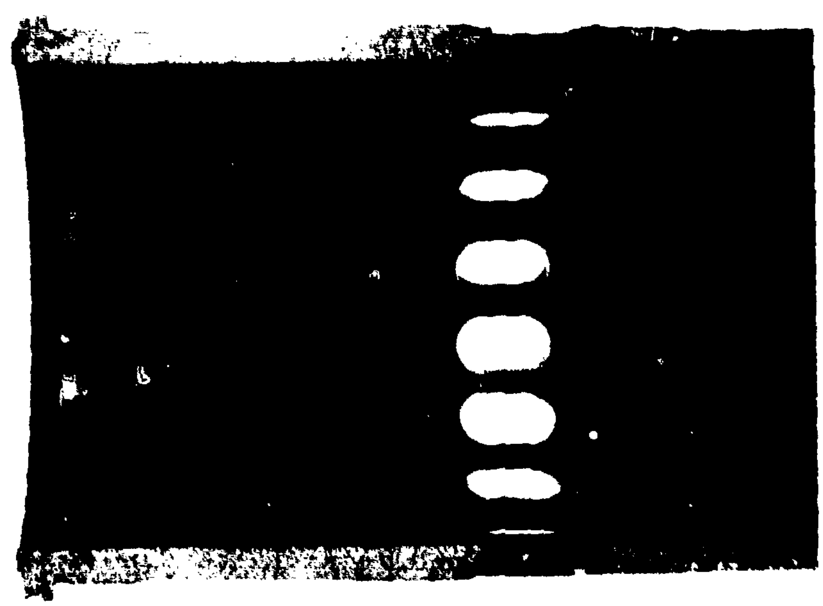


2-RIGHT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 120 HOURS   TEST NO.: CI 5136206-6   LUBRICANT: AL-7235-8531-L

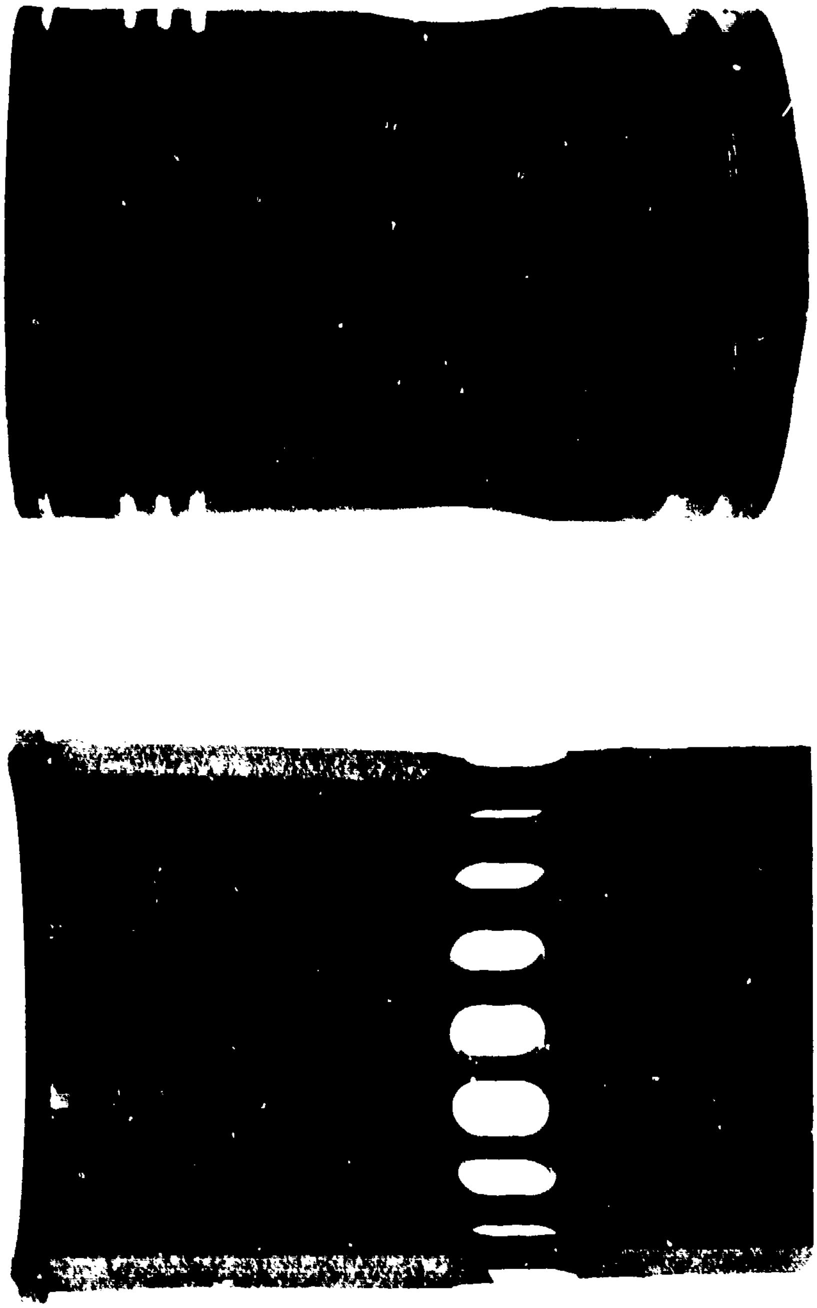




3-RIGHT THRUST

CONDITION OF PISTON AND CYLINDER LINER

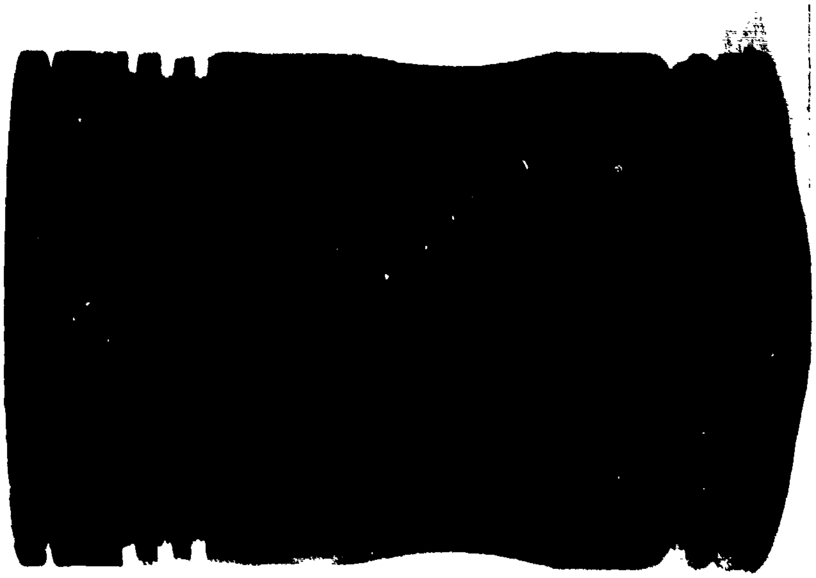
TEST TIME: 120 HOURS | TEST NO.: CI 5136206-6 | LUBRICANT: AL-7235-8531-L



3-RIGHT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 240 HOURS TEST NO.: CI 5136206-6 LUBRICANT: AL-7235-8531-L

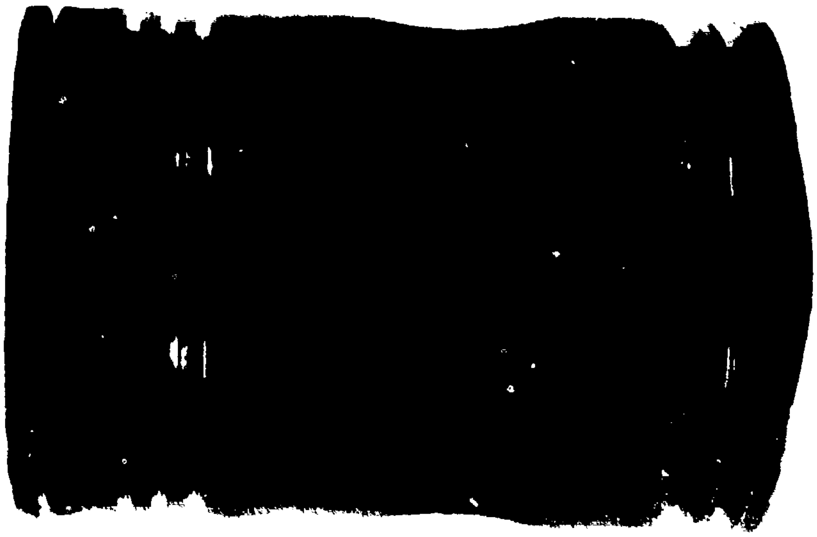


1-LEFT THRUST

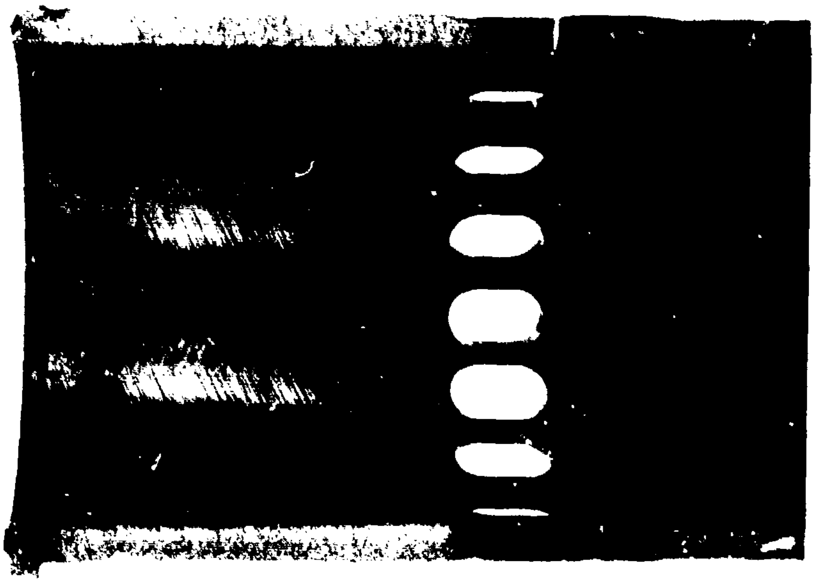
1 – LT CYLINDER PHOTO MISSING OR NOT TAKEN

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 120 HOURS TEST NO.: CI 5136206-6 LUBRICANT: AL-7235-8531-L



1-LEFT ANTI-THRUST

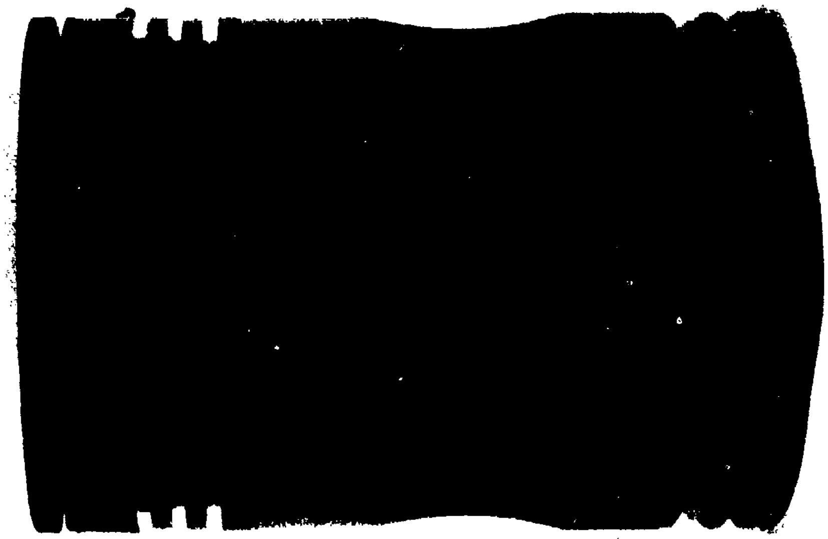


CONDITION OF PISTON AND CYLINDER LINER

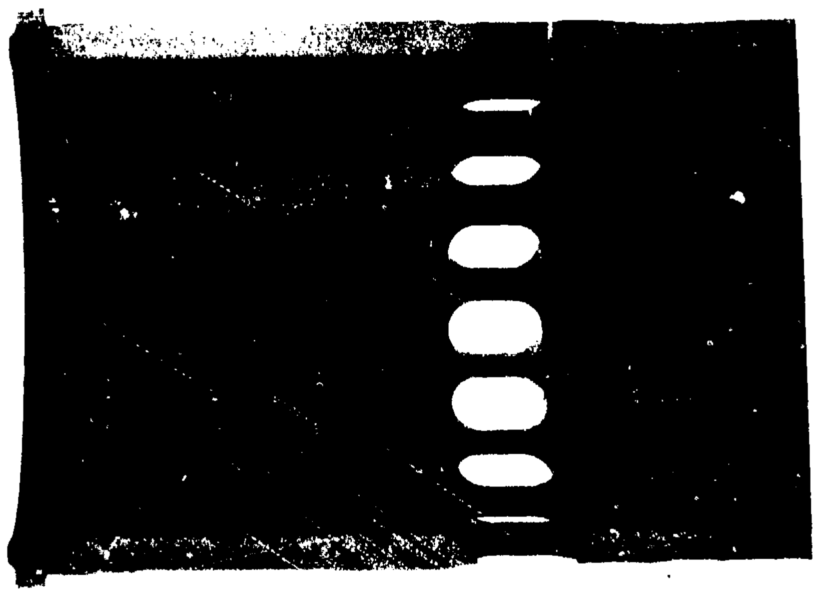
TEST TIME: 120 HOURS

TEST NO.: CI 5136206-6

LUBRICANT: AL-7235-8531-L



2-LEFT THRUST

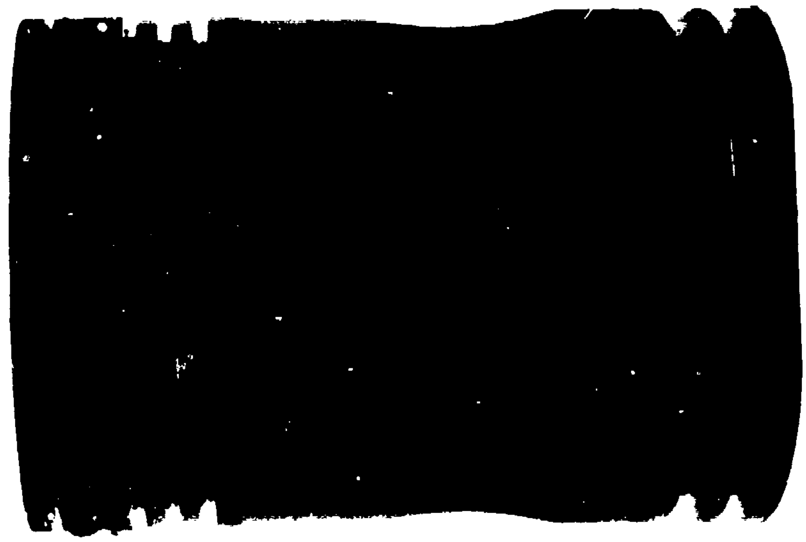


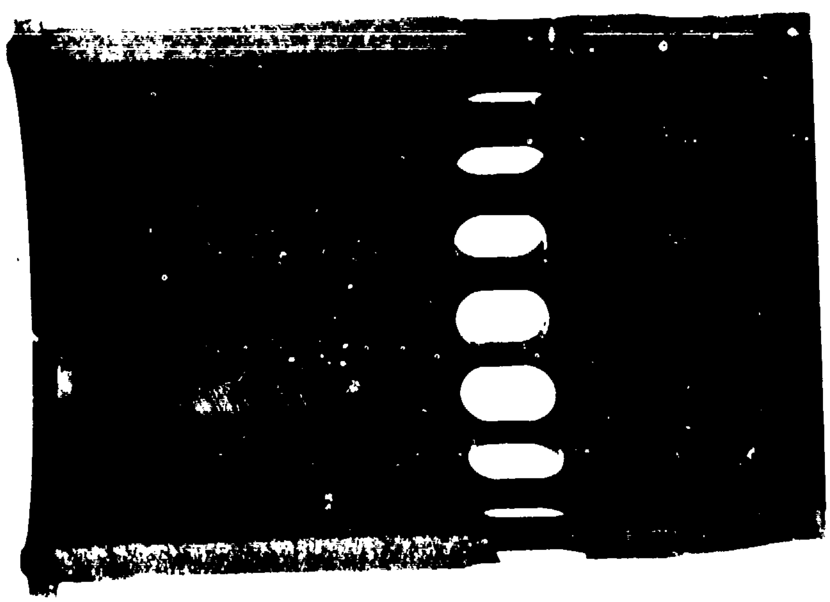
CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 120 HOURS

TEST NO.: CI 5136206-6

LUBRICANT: AL-7235-8531-L





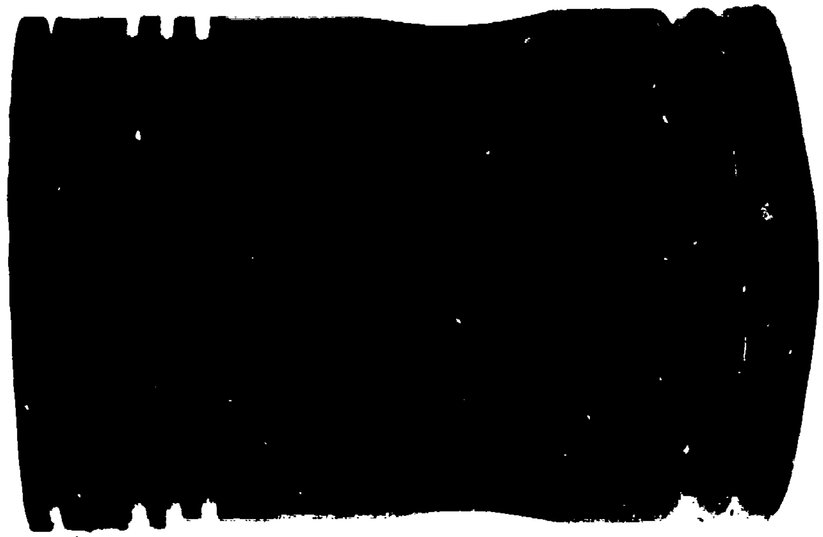
2-LEFT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

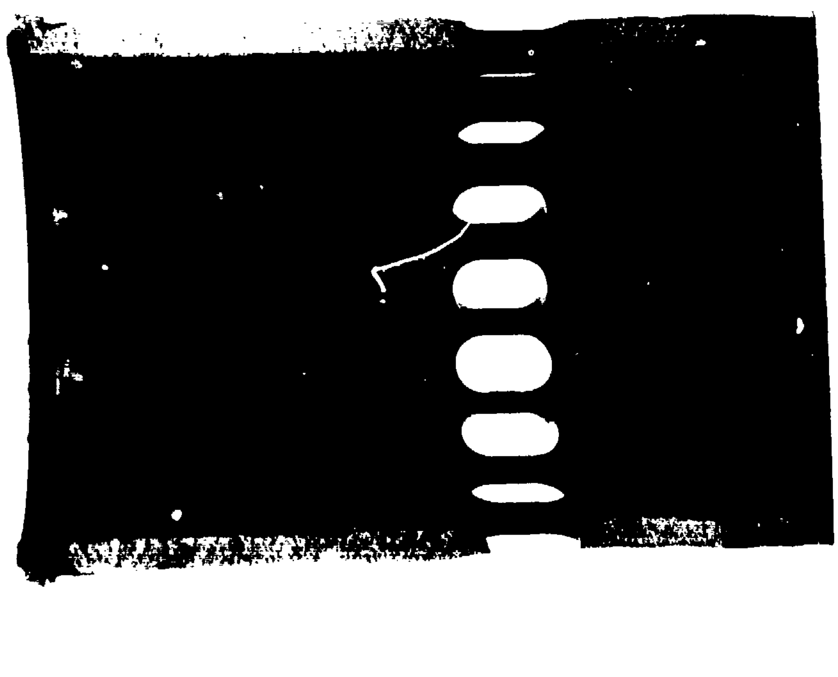
TEST TIME: 120 HOURS

TEST NO.: CI 5136206-6

LUBRICANT: AL-7235-8531-L

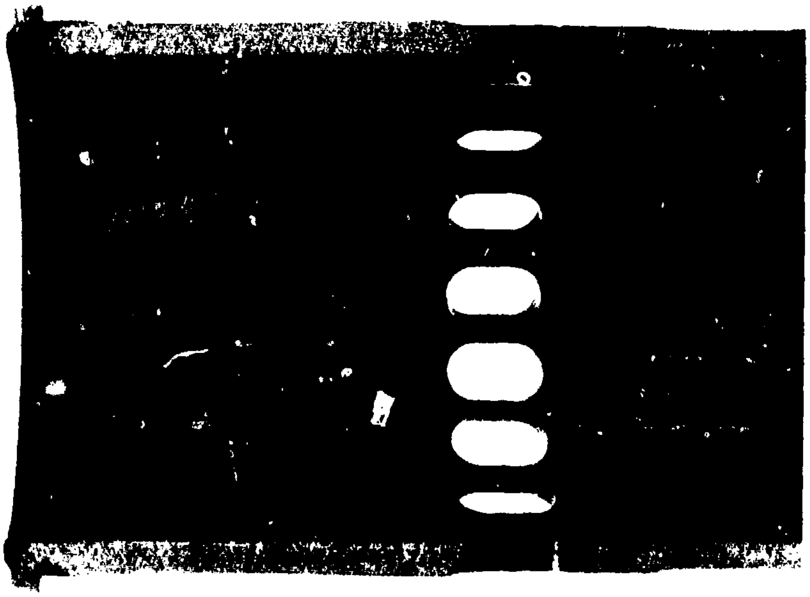


3-LEFT THRUST



CONDITION OF PISTON AND CYLINDER LINER

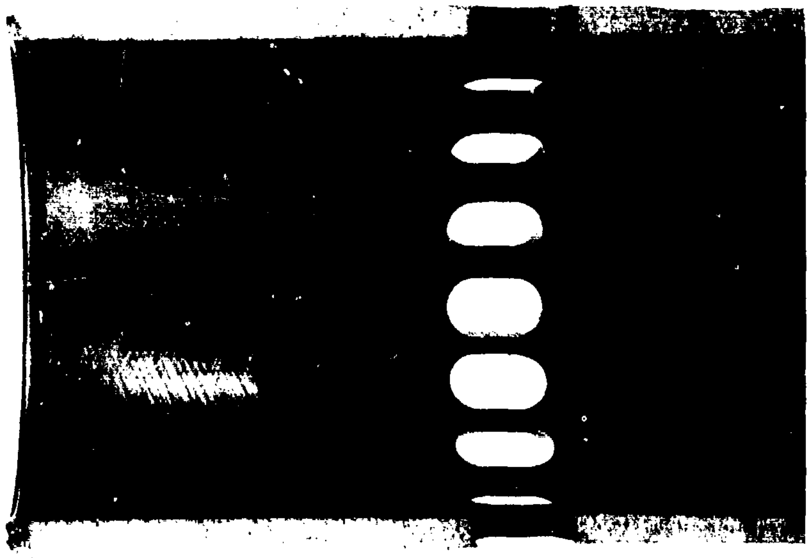
TEST TIME: 120 HOURS TEST NO.: CI 5136206-6 LUBRICANT: AL-7235-8531-L



3-LEFT ANTI-THRUST

CONDITION OF FAILED PISTON AND CYLINDER

TEST TIME: 120 HOURS | TEST NO.: CI 5136206-6 | LUBRICANT: AL-7235-L



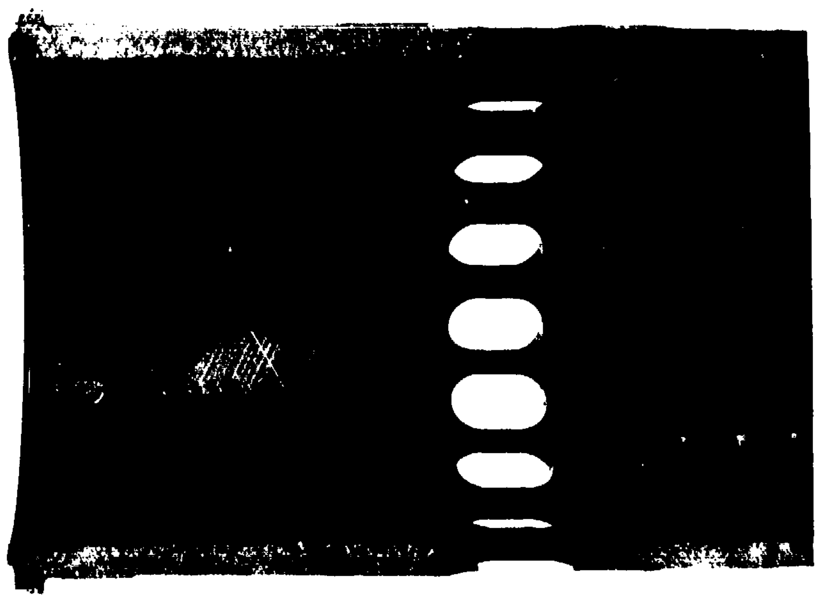
2-RIGHT THRUST

CONDITION OF FAILED PISTON AND CYLINDER

TEST TIME: 120 HOURS

TEST NO.: CI 5136206-6

LUBRICANT: AL-7235-L



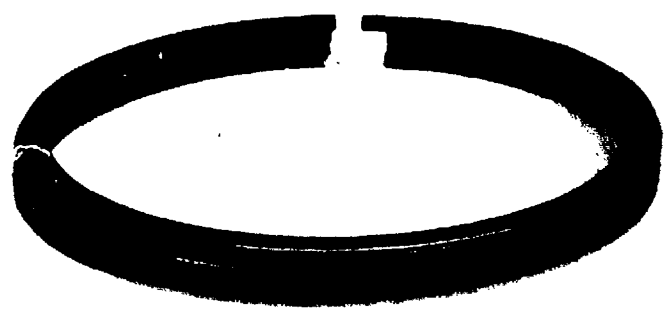
2-RIGHT ANTI-THRUST

CONDITION OF RING FACES

TEST TIME: 240 HOURS | TEST NO.: CI5136206-6 | LUBRICANT: AL-7235-8531-L

1-RIGHT

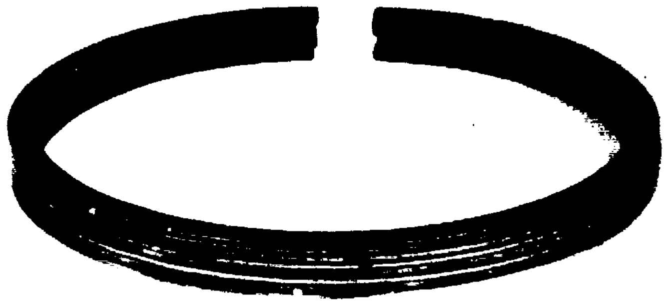
2-RIGHT



3-RIGHT

CONDITION OF RING FACES

TEST TIME: 240 HOURS TEST NO.: CI5136206-6 LUBRICANT: AL-7235-8531-L



1-LEFT

2-LEFT

3-LEFT

CONDITION OF FAILED RING FACES

TEST TIME: 120 HOURS

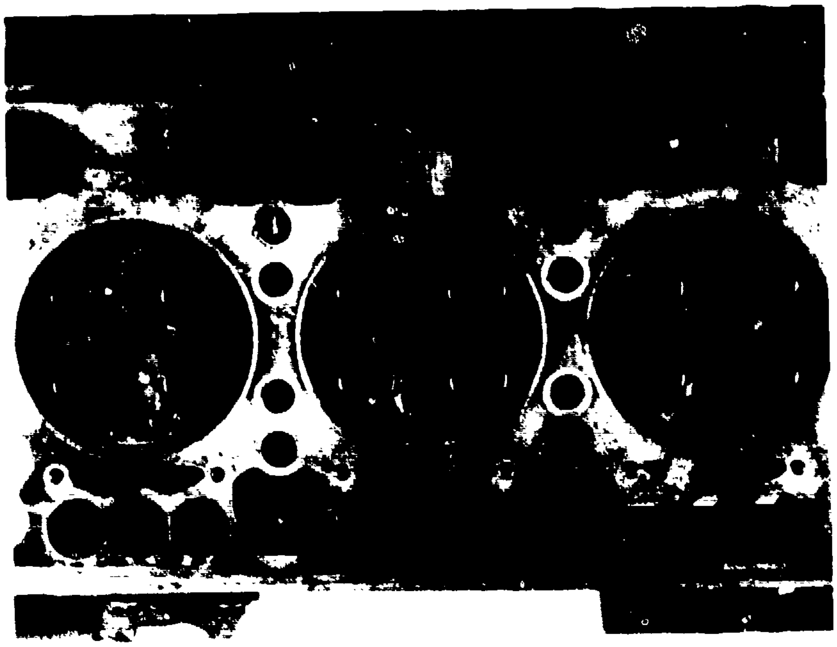
TEST NO.. CI 5136206-6

LUBRICANT: AL-7235-L

2-RIGHT

CONDITION OF CYLINDER HEADS

TEST TIME: 240 HOURS | TEST NO.: CI 5136206-6 | LUBRICANT: AL-7235-8531-L



1L 2L 3L

3R 2R 1R

CONDITION OF CYLINDER HEADS

TEST TIME: 240 HOURS

TEST NO.: CI 5136206-6

LUBRICANT: AL-7235-8531-L

1-RIGHT

2-RIGHT

3-RIGHT

CONDITION OF CYLINDER HEADS

TEST TIME: 240 HOURS

TEST NO.: CI 5136206-6

LUBRICANT: AL-7235-8531-L

1-LEFT

2-LEFT

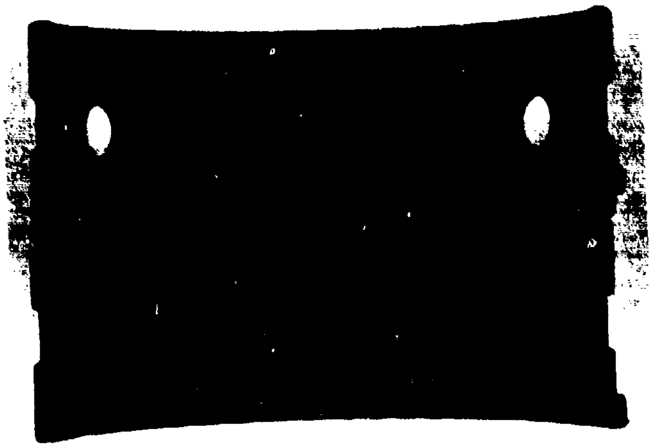
3-LEFT

CONDITION OF ROD BEARINGS

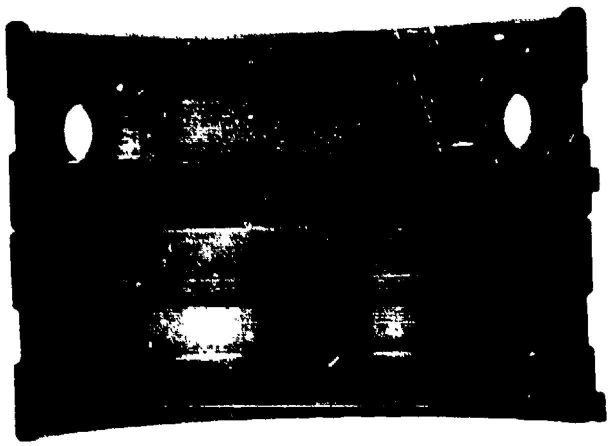
TEST TIME: 240 HOURS

TEST NO.: CI 5136206-6

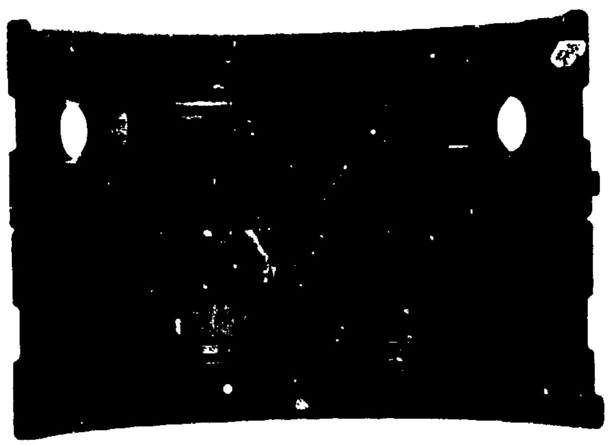
LUBRICANT: AL-7235-8531-L



1-RIGHT



2-RIGHT



3-RIGHT

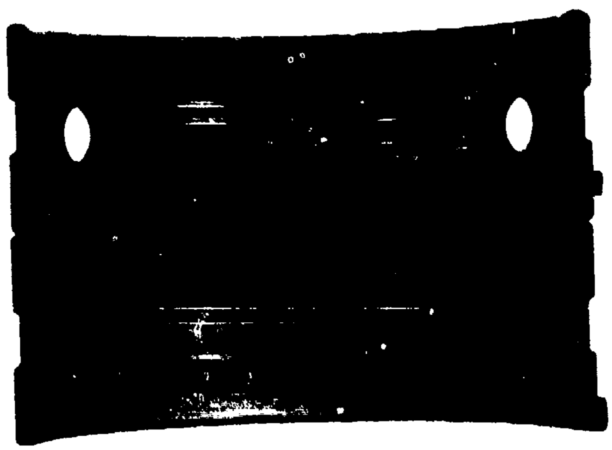
CONDITION OF ROD BEARINGS

TEST TIME: 240 HOURS

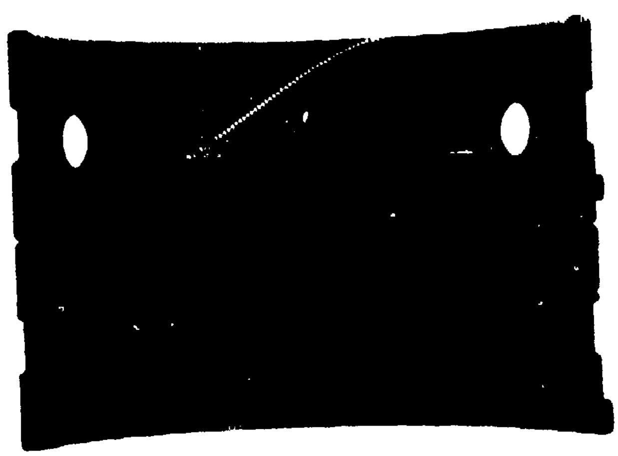
TEST NO.: CI 5136206-6

LUBRICANT: AL-7235-8531-L

1-LEFT



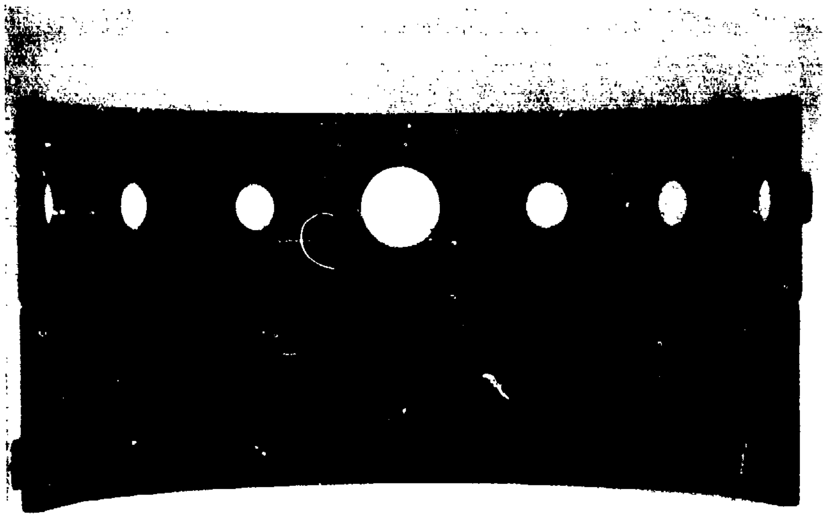
2-LEFT



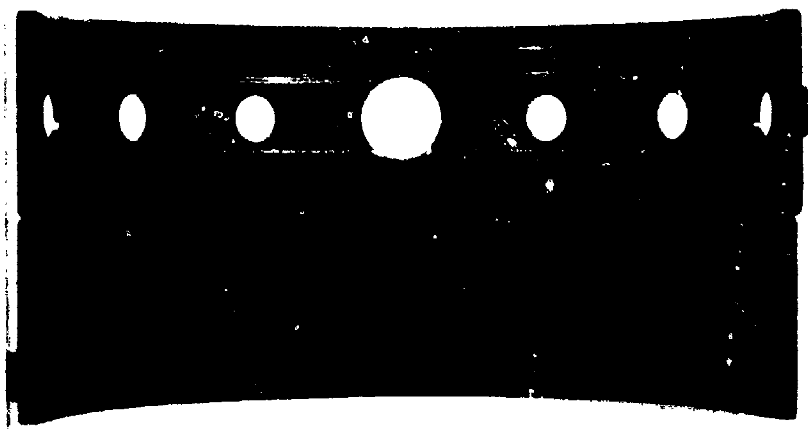
3-LEFT

CONDITION OF MAIN BEARINGS

TEST TIME: 240 HOURS | TEST NO.: CI 5136206-6 | LUBRICANT: AL-7235-8531-L



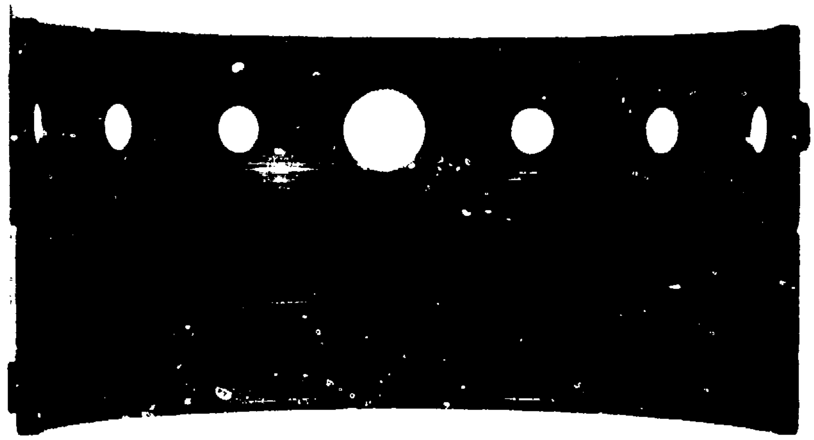
NO. 1



NO. 2

CONDITION OF MAIN BEARINGS

TEST TIME: 240 HOURS TEST NO.: CI 5136206-6 LUBRICANT: AL-7235-8531-L



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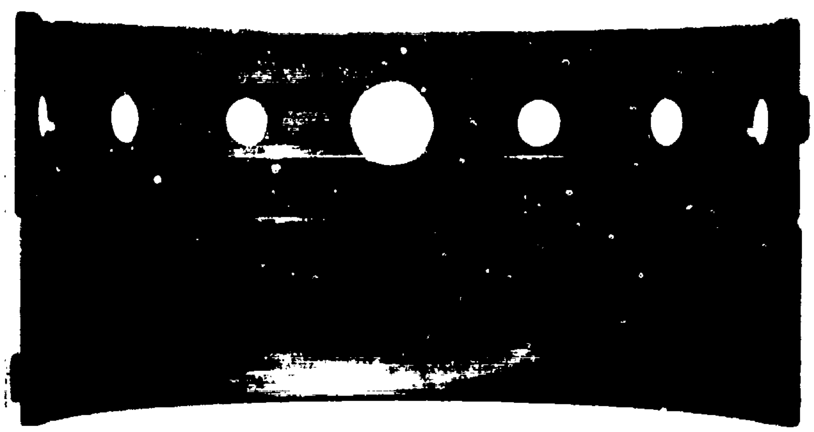
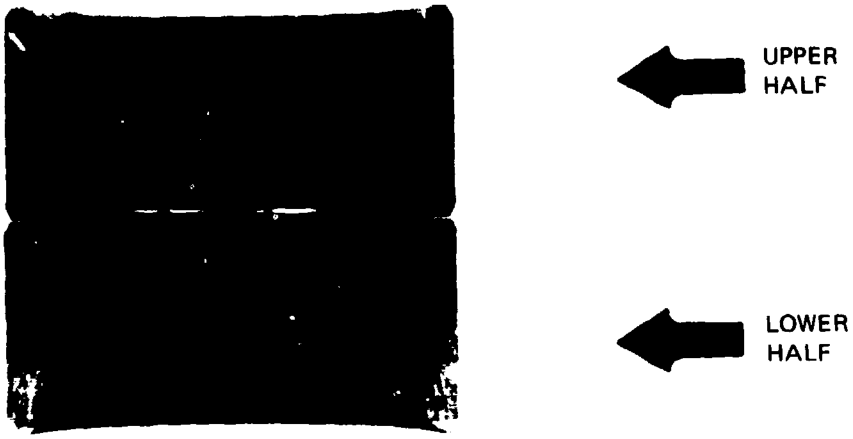


NO. 4

CONDITION OF FAILED PISTON PIN BUSHING

TEST TIME: 120 HOURS TEST NO.: CI 5136206-6 LUBRICANT: AL-7235-L



2-RIGHT

APPENDIX E

ENGINE-LUBRICANT COMPATIBILITY TEST #7

240-HOUR TRACKED-VEHICLE CYCLE

USING 6V-53T DIESEL ENGINE

ENGINE-LUBRICANT COMPATIBILITY TEST
240-HOUR TRACKED-VEHICLE CYCLE
USING 6V53T DIESEL ENGINE

Test Lubricant: AL-8406-L
Engine Test Number: CI5136206-7
Date Completed: 31 August 1979

Conducted for

U.S. Army Mobility Equipment Research and Development Command
Energy and Water Resources Laboratory
Ft. Belvoir, Virginia

by

U.S. Army Fuels and Lubricants Research Laboratory
Southwest Research Institute
San Antonio, Texas 78284

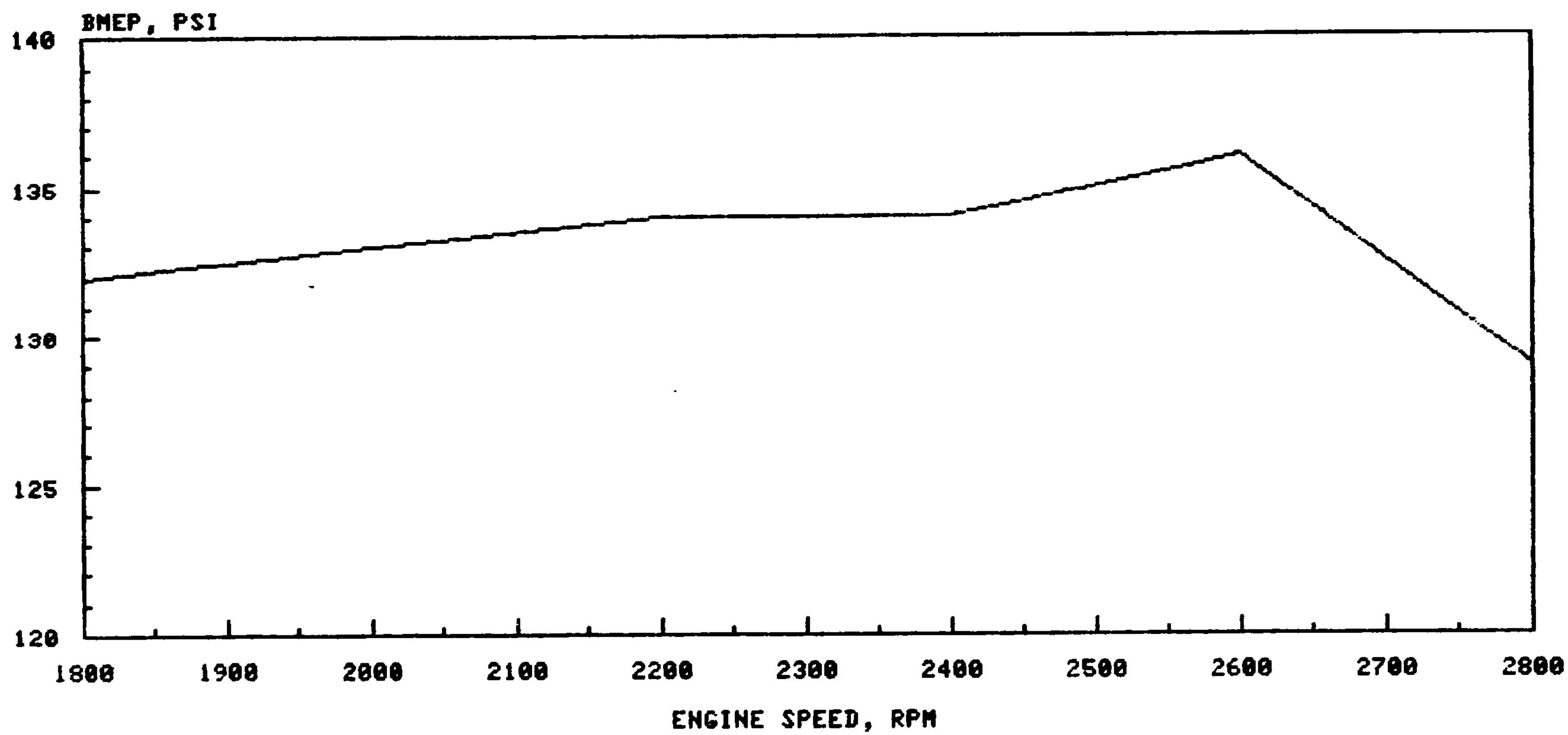
PRECEDING PAGE BL[illegible]

6V53T
BUILD-UP ENGINE MEASUREMENTS
CI5136206-7

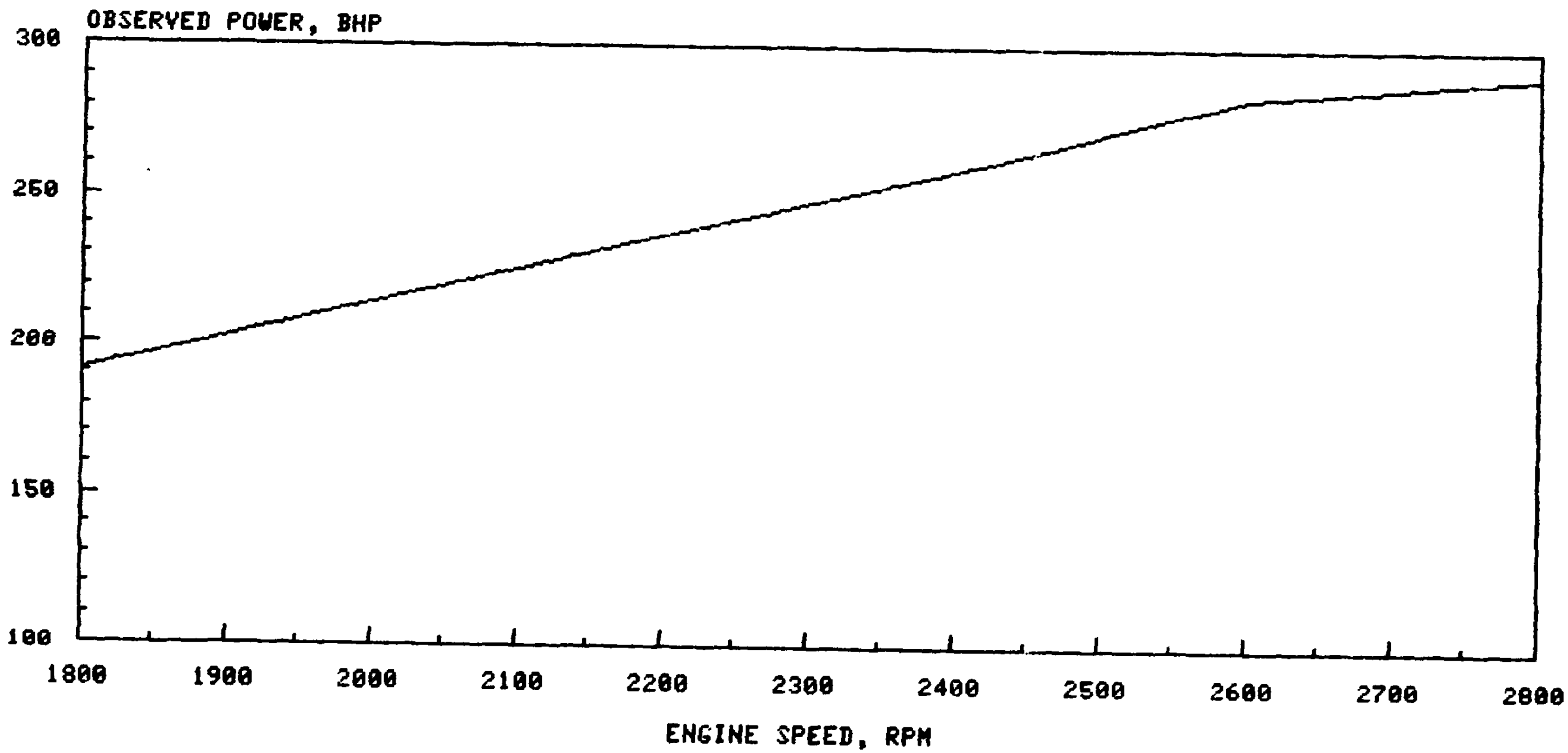
Measurements	Inches			
	Min	Max	Avg	Spec. Limits (1)
Connecting rod bearing clearance	0.0026	0.0034	0.0030	0.0016-0.0046
Cylinder Liner block bore				
Taper	0.0001	0.0005	0.0002	0.0015 max
Out-of-round	0.0000	0.0006	0.0003	0.0015 max
Inside diameter	4.3571	4.3578	4.3575	4.3595 max
Cylinder Liners (installed)				
Taper	0.0002	0.0008	0.0004	0.0020 max (2)
Out-of-round	0.0000	0.0007	0.0002	0.0030 max (2)
Inside diameter	3.8753	3.8764	3.8759	3.8752-3.8767
Piston to liner fit	0.0073	0.0084	0.0077	0.0060-0.0095
Piston Diameter	3.8664	3.8685	3.8675	3.8669-3.8691
Fire Ring				
End gap	0.026	0.034	0.031	0.020-0.046
Side clearance	0.003	0.004	0.003	0.003-0.006
No. 1 Compression Ring				
End gap	0.030	0.040	0.033	0.020-0.046
Side clearance	0.008	0.009	0.009	0.007-0.010
No. 2 & No. 3 Compression Ring				
End gap	0.029	0.037	0.031	0.020-0.046
Side clearance	0.006	0.007	0.006	0.005-0.010
Oil rings				
End gap	0.017	0.023	0.019	0.010-0.025
Side clearance	0.003	0.003	0.003	0.0015-0.0055

(1) Limits on new parts unless maximum wear limit specified.
(2) Wear limits with new liners in a used block.

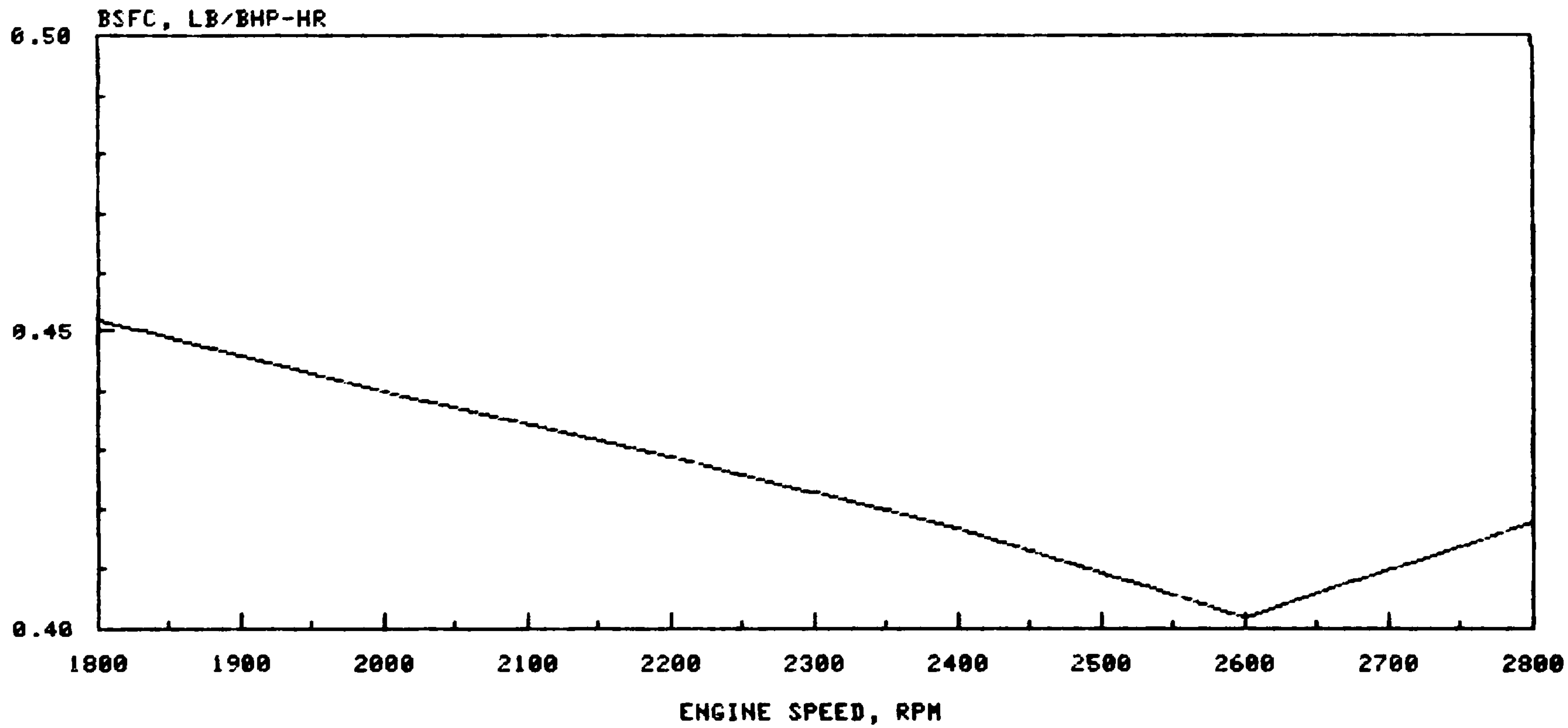
6V53T ENDURANCE TEST-240 HR TRACKED
Test No. CI5136206-7 Lubricant: AL-8406-L



6V53T ENDURANCE TEST-240 HR TRACKED
Test No. CI5136206-7 Lubricant: AL-8406-L



6V53T ENDURANCE TEST-240 HR TRACKED
Test No. CI5136206-7 Lubricant: AL-8406-7



6V53T ENDURANCE TEST
SUMMARY OF OPERATING DATA

Test No.: CI5136206-7

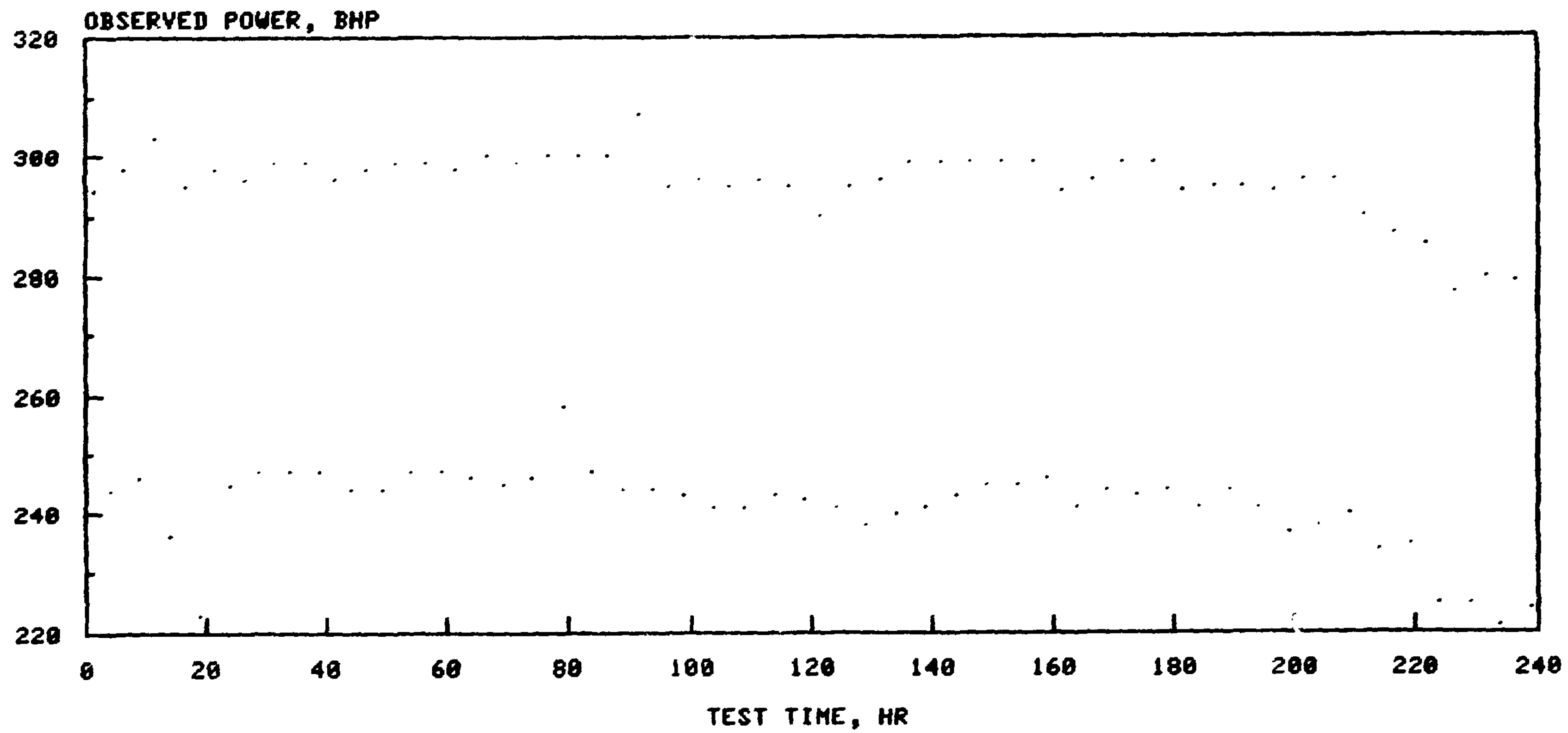
Lubricant: AL-8406-L

	2200 RPM			2800 RPM		
	Avg	Min	Max	Avg	Min	Max
Engine Speed, rpm	2204	1997	2201	2803	2793	2813
Load, lb	450	424	476	433	416	450
Obs. Power, bhp	242	207	256	296	283	309
Fuel Rate, lb/hr	99.0	93.8	104.2	121.9	118.8	125.0
BSFC, lb/bhp-hr	.409	.407	.453	.412	0.405	0.420
Temperatures, °F						
Jacket In	151	145	157	141	137	145
Jacket Out	165	159	171	155	152	158
Oil Sump	247	242	252	247	2[illegible]2	252
Inlet Air (Compressor)	97	88	106	99	90	108
Airbox	235	222	248	277	251	303
Exhaust before Turbo	1128	1022	1234	1127	1011	1243
Exhaust after Turbo	953	886	1020	950	877	1023
Fuel at filter	90	86	94	92	89	95
Pressures, psi						
Compressor Discharge	8.2	7.5	8.9	11.3	10.3	12.3
Blower Discharge	10.1	9.3	10.9	16.9	16.1	17.6
Exhaust Before Turbo	8.7	8.0	9.4	12.8	12.1	13.5
Oil Consumption (lb/hr avg for 240 hr)	0.455					

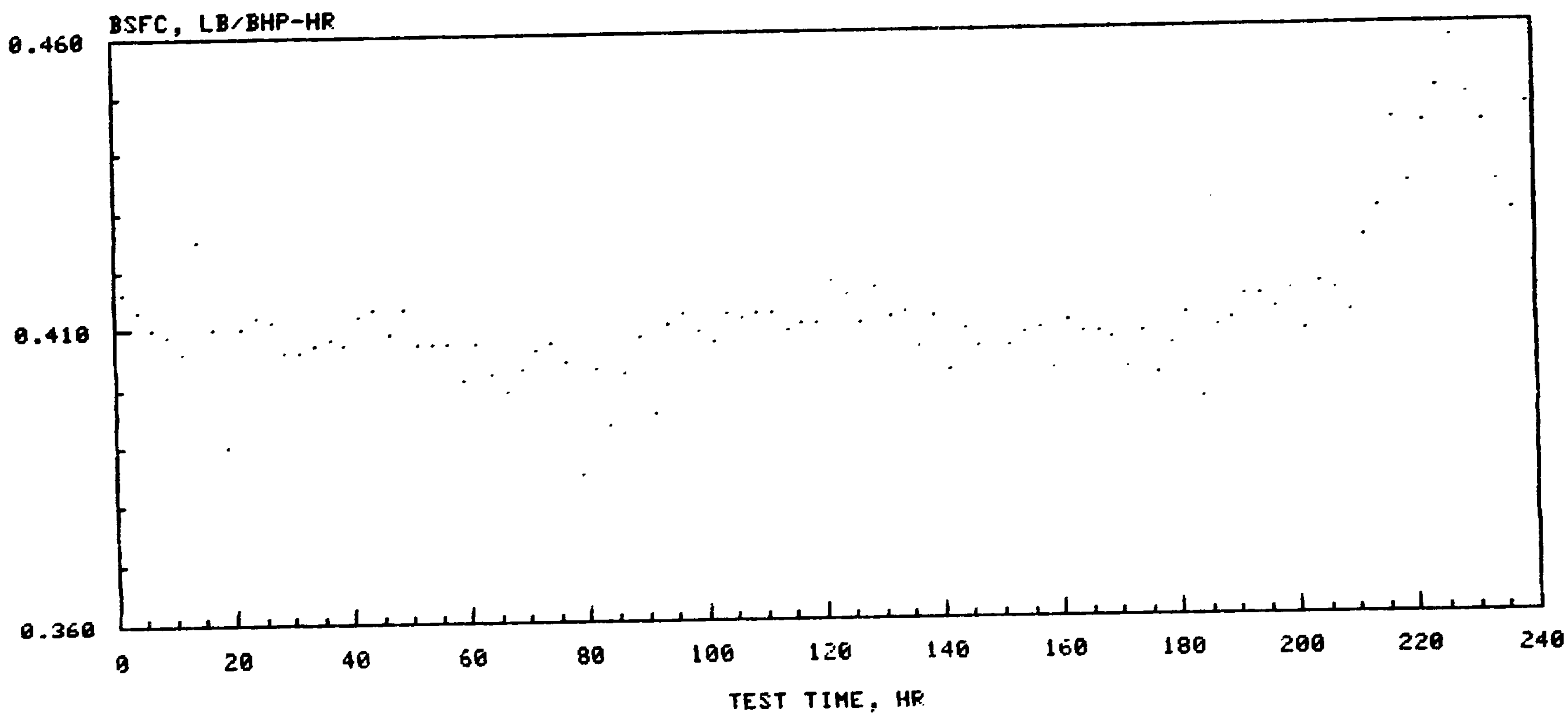
Unscheduled Shutdowns

1. At 0.5 hours-stopped engine to replace broken oil line; added 20.64 lb oil
2. At 2.5 hours-stopped engine to replace other broken line; added 13.48 lb oil.

6V53T ENDURANCE TEST-240 HR TRACKED
Test No. CI5136206-7 Lubricant: AL-8406-L



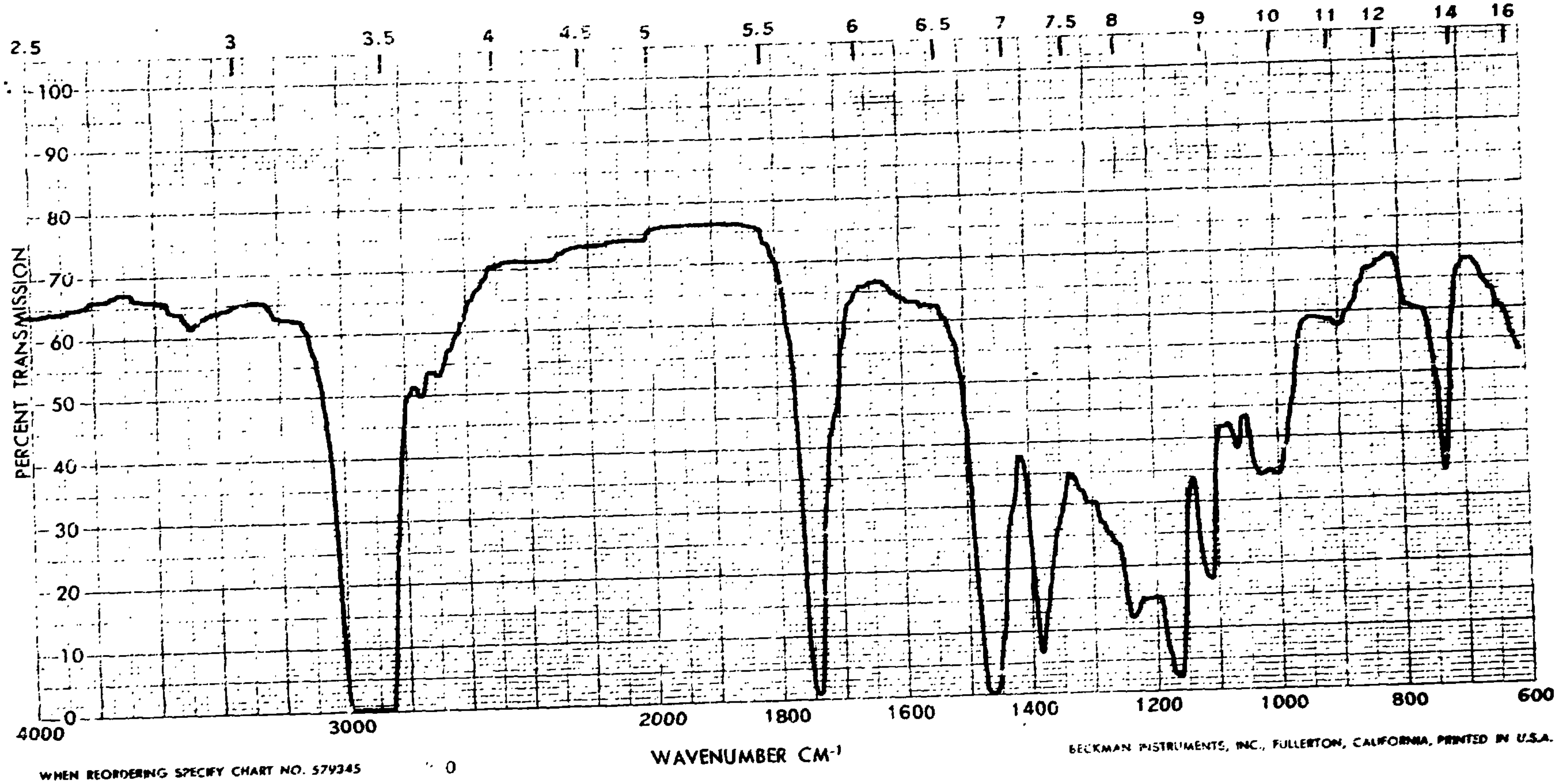
6V53T ENDURANCE TEST-240 HR TRACKED
Test No. CI5136206-7 Lubricant: AL-8406-L



LUBRICANT ANALYSIS
6V53T - CI5136206-7
LUBRICANT: AL-8406-L
FUEL. 1-H CAT

Property	ASTM Test Method	TEST HOUR New	20	40	60	80	100	120	140	160	180	200	220	240
Cold Cranking Simulator @ -29°C, cP	D 2602	-												4000
Cold Cranking Simulator @ -18°C, cP	D 2602	1600												1400
K. Vis. @40°C, cSt	D 445	56.0		54.1		54.7		57.4		53.9		54.5		57.0
K. Vis. @100°C, cSt	D 445	10.0		9.53		9.57		9.72		9.51		9.53		9.53
TAN	D 664	3.0		2.65		2.63		2.56		2.61		2.56		2.50
TBN	D 664	6.3		2.17		2.16		2.11		2.13		2.10		2.15
TBN	D 2896	7.1												
Insolubles, %														
Pentane B	D 893	0.04		0.02		0.04		0.03		0.03		0.03		0.06
Toluene B	D 893	0.02		0.02		0.03		0.03		0.02		0.02		0.06
Flash Point, °C	D 92	224						218						216
Pour Point, °C	D 97	-45						-42						-45
Gravity, °API @60°F	D 287	31.2						30.6						29.4
Carbon Residue, wt %	D 524	1.07						1.53						2.71
Sulfated Ash, wt %	D 874	1.05						1.27						1.24
Millipore Insolubles, wt %		-		0.07		0.08		0.04		0.03		0.06		0.10
Wear Metals by XRF														
Iron, ppm		-	51	85	93	93	87	107	44	56	64	85	164	202

- = Not determined.



SPECTRUM NO. 1745

SAMPLE AL-8406-L

60 hr

ORIGIN

PURITY

PHASE

THICKNESS .025

LEGEND

1.

2.

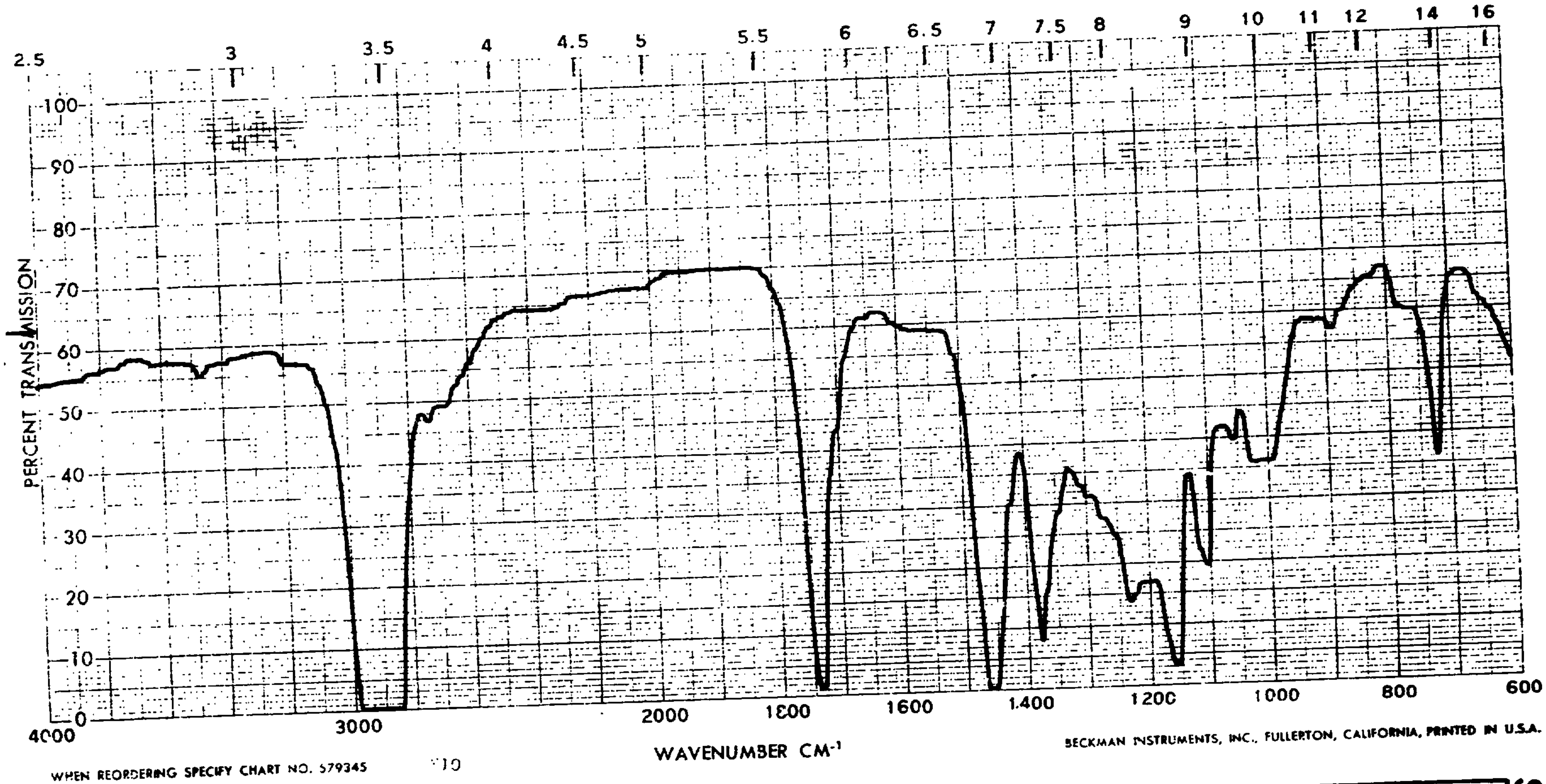
DATE 10-3-79

OPERATOR T.W.

REMARKS

SPECTRUM NO.

SAMPLE



SPECTRUM NO. 1746

SAMPLE AL-8406-L

120 hr

ORIGIN

PURITY

PHASE

THICKNESS .025

LEGEND

1.

2.

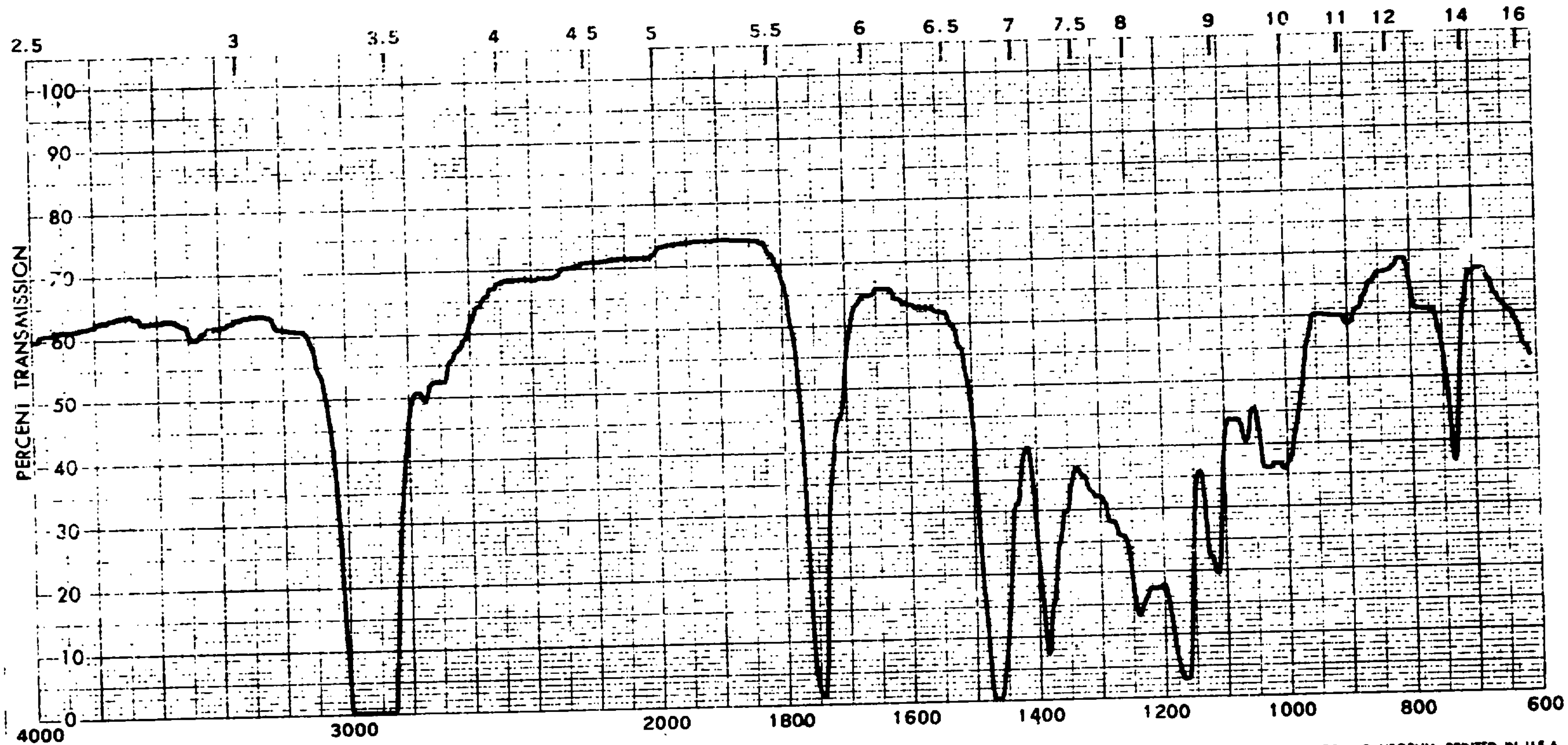
DATE 10-3-79

OPERATOR T.W.

REMARKS

SPECTRUM NO.

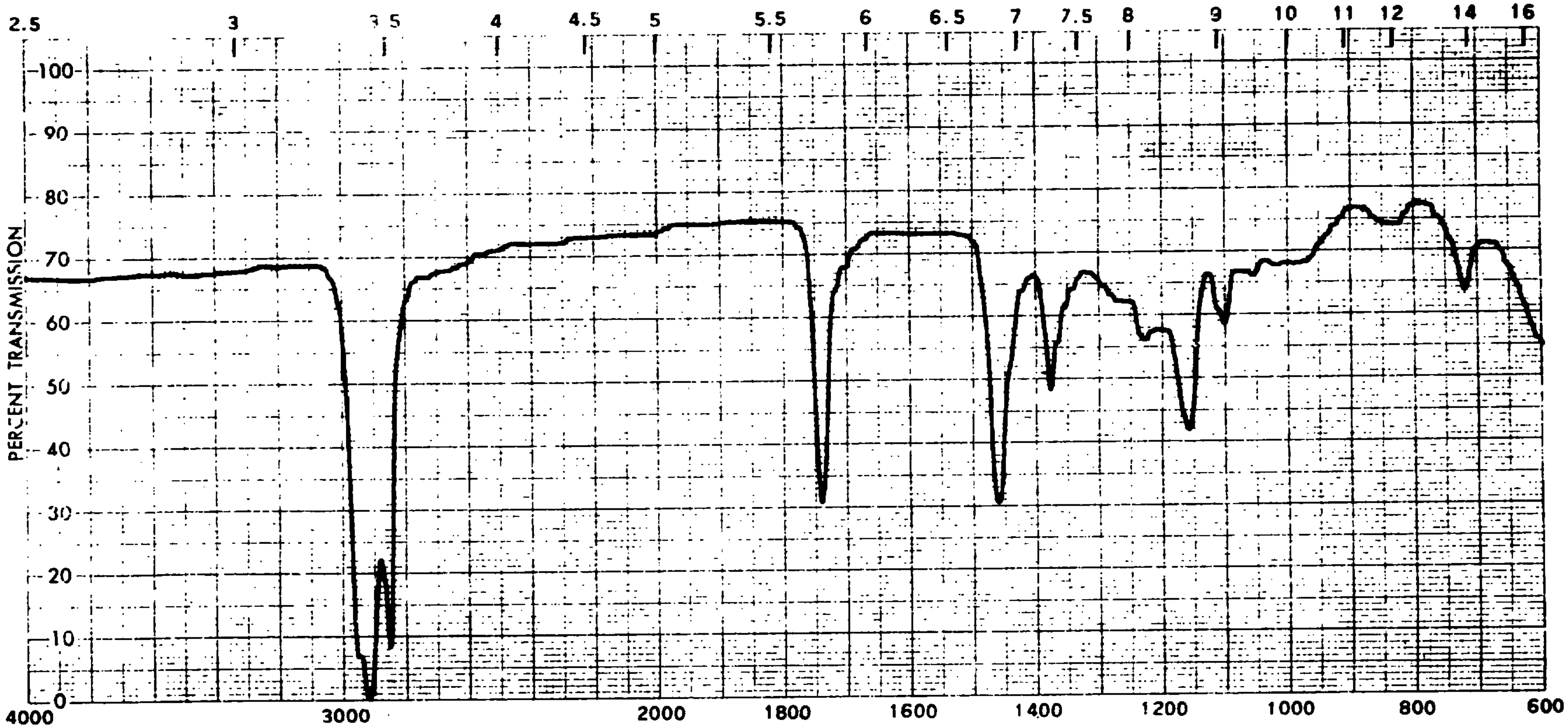
SAMPLE



WHEN REORDERING SPECIFY CHART NO. 579345

SPECTRUM NO. 1747	ORIGIN	LEGEND	REMARKS
SAMPLE AL-8406-L		1.	
180 hr	PURITY	2.	
	PHASE	DATE 10-3-79	
	THICKNESS .025	OPERATOR T.W.	

SPECTRUM NO.
SAMPLE



WHEN REORDERING SPECIFY CHART NO. 579345

BECKMAN INSTRUMENTS, INC., FULLERTON, CALIFORNIA, PRINTED IN U.S.A.

SPECTRUM NO. 1748

SAMPLE AL-8406-L

240 hr

ORIGIN

PURITY

PHASE

THICKNESS .025

LEGEND

1.

2.

DATE 10-3-79

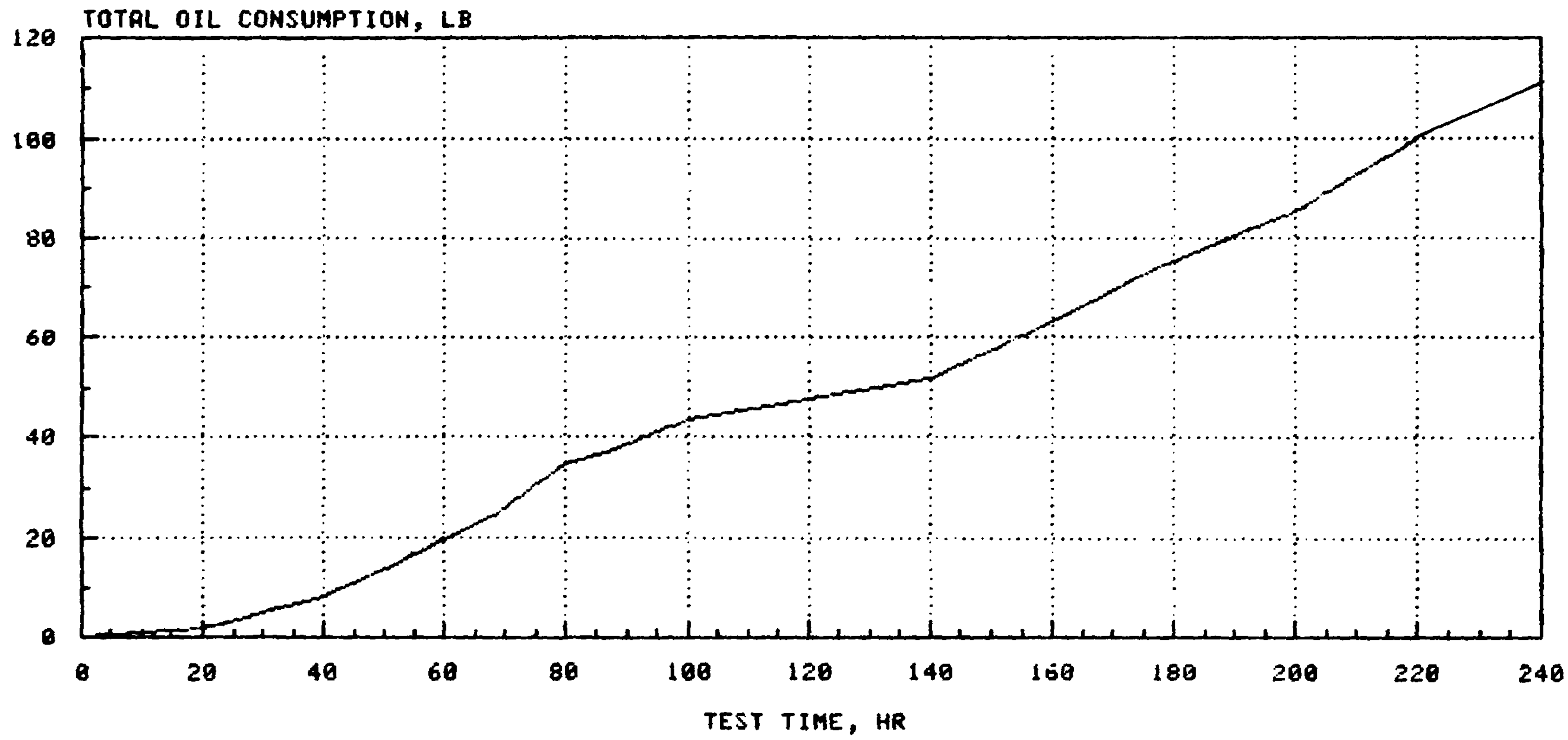
OPERATOR T.W.

REMARKS

SPECTRUM NO.

SAMPLE

6V53T ENDURANCE TEST-240 HR TRACKED
Test No. CI5136206-7 Lubricant: AL-8406-L



WEAR MEASUREMENTS
TEST NO.: CI5136206-7
LUBRICANT: AL-8406-L
TEST HOURS: 240

Cylinder No.		Cylinder Liner ID, Inches: Perpendicular to Crankshaft Top	Middle	Bottom	Parallel to Crankshaft Top	Middle	Bottom
1L	Before	3.8758	3.8758	3.8758	3.8758	3.8758	3.8760
	After	3.8768	3.8780	3.8764	3.8758	3.8757	3.8764
	Change	0.0010	0.0022	0.0006	0.0000	-0.0001	0.0004
2L	Before	3.8761	3.8761	3.8763	3.8762	3.8762	3.8764
	After	3.8810	3.8793	3.8778	3.8781	3.8772	3.8768
	Change	0.0049	0.0032	0.0015	0.0019	0.0010	0.0004
3L	Before	3.8756	3.8758	3.8759	3.8757	3.8758	3.8761
	After	3.8768	3.8768	3.8769	3.8759	3.8759	3.8768
	Change	0.0012	0.0010	0.0010	0.0002	0.0001	0.0007
1R	Before	3.8758	3.8757	3.8761	3.8754	3.8759	3.8761
	After	3.8763	3.8775	3.8772	3.8759	3.8775	3.8767
	Change	0.0005	0.0018	0.0011	0.0005	0.0016	0.0006
2R	Before	3.8755	3.8761	3.8763	3.8757	3.8761	3.8764
	After	3.8768	3.8764	3.8768	3.8758	3.8759	3.8764
	Change	0.0013	0.0003	0.0005	0.0001	-0.0002	0.0000
3R	Before	3.8758	3.8758	3.8764	3.8764	3.8760	3.8758
	After	3.8772	3.8776	3.8770	3.8757	3.8758	3.8768
	Change	0.0014	0.0018	0.0006	-0.0007	-0.0002	0.0010
Average	Changes	0.0017	0.0017	0.0009	0.0003	0.0004	0.0005
Overall Average	Changes	0.0009					

WEAR MEASUREMENTS
ENGINE NO.: 5136206-7
LUBRICANT: AL-8406-L
TEST HOURS: 240

Piston No.	Piston Ring End Gap, inches 1	2	3	4	5	6	7
1L Before	0.034	0.033	0.029	0.030	0.021	0.019	0.018
After	0.043	0.030	0.030	0.029	0.034	0.029	0.027
Change	0.009	-0.003	0.001	-0.001	0.013	0.010	0.009
2L Before	0.026	0.030	0.029	0.031	0.021	0.018	0.017
After	0.035	0.030	0.031	0.033	0.032	0.026	0.027
Change	0.009	0.000	0.002	0.002	0.011	0.008	0.010
3L Before	0.027	0.031	0.030	0.028	0.021	0.018	0.017
After	0.029	0.033	0.034	0.028	0.035	0.026	0.026
Change	0.002	0.002	0.004	0.000	0.014	0.008	0.009
1R Before	0.030	0.032	0.033	0.034	0.022	0.018	0.017
After	0.035	0.035	0.032	0.034	0.034	0.026	0.027
Change	0.005	0.003	-0.001	0.000	0.012	0.008	0.010
2R Before	0.035	0.040	0.029	0.030	0.023	0.019	0.020
After	0.037	0.036	0.028	0.031	0.035	0.029	0.030
Change	0.002	-0.004	-0.001	0.001	0.012	0.010	0.010
3R Before	0.031	0.031	0.029	0.037	0.022	0.020	0.018
After	0.037	0.033	0.029	0.038	0.035	0.030	0.028
Change	0.006	0.002	0.000	0.001	0.013	0.010	0.010
Average Change	0.006	0.000	0.001	0.001	0.013	0.009	0.010

RATING DATA SHEET
CI-7

Test Run at AFLRL
Test Lubricant: AL-8406-L
Test Fuel: 1-H CAT
Test No.: CI5136206-7
Test Stand: 5
Engine No.: 6V53T-5136206
Test Hours: 240
Date Started: 15 August 1979
Completed: 31 August 1979

A. Cylinder Liner Ratings

Intake Port Plugging

Cylinder No.	Restriction, %
1 L	05
2 L	10
3 L	02
1 R	01
2 R	01
3 R	01
Average	03

Scuffing, Glazing and Lacquer*

Cylinder No.	Scuffing, % Thrust	Scuffing, % Anti-Thrust	Scuffing, % Total	Glazing, %	Lacquer, %
1 L	05	05	05	20	80
2 L	95	75	85	05	95
3 L	15	05	10	10	90
1 R	05	05	05	15	85
2 R	10	10	10	15	85
3 R	10	20	15	20	80
Average	23	20	22	14	86

*Ring Travel Area.

RATING DATA SHEET - CONTINUED
CI-7

B. Piston Ratings

Ring Sticking and Condition

Cylinder No.	Ring			
	Fire	No. 1	No. 2	No. 3
1 L	F 10%B	F 1%B	F 0%B	F 0%B
2 L	X F 100%B	F 100%B	F 100%B	F 100%B
3 L	F 100%B	F 5%B	F 5%B	F 5%B
1 R	F 30%B	F 0%B	F 0%B	F 0%B
2 R	5%P 15%B	F 0%B	F 0%B	F 0%B
3 R	F 50%B	F 0%B	F 0%B	F 1%B

X = Partially Collapsed

Ring Groove Carbon Filling and Oil Groove Lacquer

Cylinder No.	Groove Filling, %				Oil Groove Lacquer	
	Fire	No. 1	No. 2	No. 3	Upper	Lower
1 L	5	75	<1	<1	4	4
2 L	5	90	85	10	4	4
3 L	5	95	5	<1	4	4
1 R	5	45	<1	<1	4	4
2 R	5	60	2	<1	4	4
3 R	5	70	5	<1	4	4

Land Description

Cylinder No.	Description
1 L	Normal
2 L	Normal
3 L	Normal
1 R	Normal
2 R	Normal
3 R	Normal

Skirt

Cylinder No.	Side	
	Thrust	Anti-Thrust
1 L	6.0 Scratches and Plate Melt	5.8 Scratches and Lt. Scuff
2 L	6.2 Scuff and Plate Melt	6.0 Scuff and Plate Melt
3 L	5.5 Lt. Scratches	6.0 Lt. Scratches
1 R	6.0 Lt. Scratches	5.7 Lt. Scratches
2 R	6.0 Lt. Scratches	5.5 Lt. Scratches
3 R	5.5 Lt. Scratches and Lt. Scuff	6.2 Lt. Scratches

C. Other Ratings

Combustion Chambers

Cylinder No.	Description	Cylinder No.	Description
1 L	50% AHC	1 R	35% AHC
2 L	30% AHC	2 R	10%B 60% AHC
3 L	35% AHC	3 R	80% AHC

Valve Covers, Oil Pan and Cylinder Head Deck

Covers	¼ A Sludge
Pan	¼ A Sludge
Deck	¼ A Sludge

Remarks

The No. 2 Left Injector cam lobe and roller failed.
Nos. 2, 3 and 4 Main Bearings have some deep scratches and journals are a little rough.
No. 3-Right Cam Bearing spun on shaft and damaged shaft and maybe bore in block.

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-8406-L

RATER E. Lyons DATE 9-11-79
LABORATORY TEST NUMBER 7
STAND NO. 5 ENGINE NO. 6V53T-5136206
FUEL CAT 1-H

PISTON NO. 1-Right

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	260.25

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00									100	100.00	50	50.00						
CARBON	MHC	0.75																		
CARBON	MC	0.50			70	35.00							30	15.00						
CARBON	LC	0.25	100	25.00	30	7.50							20	5.00						
CARBON	VLC	0.15																		
	CARBON RATING		25.00		42.50						100.00		70.00							
LACQUER	BL	0.100													5	0.50				
LACQUER	DBrL	0.075																	100	7.50
LACQUER	AL	0.050					100	5.00							95	4.75				
LACQUER	LAL	0.025							100	2.50							100	2.50		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING						5.00		2.50						5.25		2.50		7.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		25.00		42.50		5.00		2.50		100.00		70.00		5.25		2.50		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-8406-L

RATER E. Lyons DATE 9-11-79
LABORATORY TEST NUMBER 7
STAND NO. 5 ENGINE NO. 6V53T-5136206
FUEL CAT 1-H

PISTON NO. 2-Right

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	276.50

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00			45	45.00					100	100.00	35	35.00						
CARBON	MHC	0.75																		
CARBON	MC	0.50			30	15.00							35	17.50						
CARBON	LC	0.25	100	25.00	25	6.25							30	7.50	10	2.50				
CARBON	VLC	0.15																		
	CARBON RATING		25.00		66.25						100.00		60.00		2.50					
LACQUER	BL	0.100													10	1.00				
LACQUER	DBrL	0.075																	100	7.50
LACQUER	AL	0.050					100	5.00							80	4.00	10	0.50		
LACQUER	LAL	0.025							100	2.50							90	2.25		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING						5.00		2.50						5.00		2.75			
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		25.00		66.25		5.00		2.50		100.00		60.00		7.50		2.75		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-8406-L

RATER E. Lyons DATE 9-11-79
LABORATORY TEST NUMBER 7
STAND NO. 5 ENGINE NO. 6V53T-5136206
FUEL CAT 1-H

PISTON NO. 3-Right

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	285.75

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00									50	50.00	15	15.00						
CARBON	MHC	0.75			70	52.50														
CARBON	MC	0.50	20	10.00	10	5.00					50	25.00	70	35.00	5	2.50				
CARBON	LC	0.25	80	20.00	20	5.00	100	25.00					15	3.75	95	23.75				
CARBON	VLC	0.15																		
CARBON	CARBON RATING		30.00		62.50		25.00				75.00		53.75		26.25					
LACQUER	BL	0.100																		
LACQUER	DBrL	0.075																	100	7.50
LACQUER	AL	0.050															30	1.50		
LACQUER	LAL	0.025							100	2.50							70	1.75		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
LACQUER	LACQUER RATING								2.50								3.25		7.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		30.00		62.50		25.00		2.50		75.00		53.75		26.25		3.25		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-8406-L

RATER E. Lyons DATE 9-11-79
LABORATORY TEST NUMBER 7
STAND NO. 5 ENGINE NO. 6V53T-5136206
FUEL CAT 1-H

PISTON NO. 1-Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	316.25

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES								LANDS								UNDER-CROWN	
			NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
			AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON	HC	1.00			10	10.00					90	90.00	90	90.00						
	MHC	0.75			90	67.50														
	MC	0.50													20	10.00				
	LC	0.25					5	1.25			10	2.50	10	2.50	10	2.50				
	VLC	0.15	100	15.00																
	CARBON RATING		15.00		77.50		1.25				92.50		92.50		12.50					
LACQUER	BL	0.100													25	2.50	5	0.50		
	DBrL	0.075					95	7.125											100	7.50
	AL	0.050													45	2.25				
	LAL	0.025							100	2.50							95	2.375		
	VLAL	0.010																		
	RL	0.001																		
	LACQUER RATING						7.125		2.50						5.00					
	CLEAN	0																		
	ZONAL RATING																2.875			
	LOCATION FACTOR																			
	WEIGHTED RATING		15.00		77.50		8.375		2.50		92.50		92.50		17.50		2.875		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-8406-L

RATER E. Lyons DATE 9-11-79
LABORATORY TEST NUMBER 7
STAND NO. 5 ENGINE NO. 6V53T-5136206
FUEL CAT 1-H

PISTON NO. 2-Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	391.25

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00					15	15.00							100	100.00				
CARBON	MHC	0.75																		
CARBON	MC	0.50			100	50.00	85	42.50	15	7.50	100	50.00	90	45.00						
CARBON	LC	0.25	100	25.00					85	21.25			10	2.50			100	25.00		
CARBON	VLC	0.15																		
CARBON	CARBON RATING		25.00		50.00		57.50		28.75		50.00		47.50		100.00		25.00			
LACQUER	BL	0.100																		
LACQUER	DBrL	0.075																	100	7.50
LACQUER	AL	0.050																		
LACQUER	LAL	0.025																		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
LACQUER	LACQUER RATING																		7.50	
CLEAN		0																		
ZONAL RATING																				
LOCATION FACTOR																				
WEIGHTED RATING			25.00		50.00		57.50		28.75		50.00		47.50		100.00		25.00		7.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Tracked cycle
TEST HOURS 240
TEST LABORATORY AFLRL
LUBRICANT AL-8406-L

RATER E. Lyons DATE 9-11-79
LABORATORY TEST NUMBER 7
STAND NO. 5 ENGINE NO. 6V53T-5136206
FUEL CAT 1-H

PISTON NO. 3-Left

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	324.25

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00			100	100.00							90	90.00						
CARBON	MHC	0.75																		
CARBON	MC	0.50									100	50.00			5	2.50				
CARBON	LC	0.25	100	25.00			20	5.00					10	2.50	95	23.75				
CARBON	VLC	0.15																		
CARBON	CARBON RATING		25.00		100.00		5.00				50.00		92.50		26.25					
LACQUER	BL	0.100					80	80.00												
LACQUER	DBrL	0.075							100	7.50									100	7.50
LACQUER	AL	0.050																		
LACQUER	LAL	0.025															100	2.50		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
LACQUER	LACQUER RATING						8.00		7.50								2.50			
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		25.00		100.00		13.00		7.50		50.00		92.50		26.25		2.50		7.50	

*WEIGHTED TOTAL DEPOSITS

RING STICKING

Test No. 7

Engine Model 6V53T Serial No. 5136206 Date 9-11-79

Fuel CAT 1-H Lubricant AL-8406-L Observer E. Lyons

Piston Number

Ring No.	1L	2L	3L	1R	2R	3R
1	F	Partially Collapsed	F	F	5%P	F
2	F	F	F	F	F	F
3	F	F	F	F	F	F
4	F	F	F	F	F	F

Indicate by letter – **F**ree or **S**luggish, or by number and letter – percent **P**inched (cold stuck) or percent **H**ot stuck (Pages 6 and 7 of Manual).

PISTON GROOVE INSIDE DIAMETER—% RING SUPPORTING CARBON

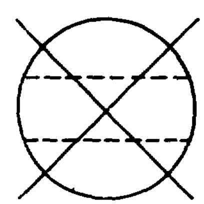
Test No. 7

Engine Mode! 6V53T | Serial No. 5136206 | Date 9-11-79

Fuel CAT 1-H | Lubricant AL-8406-L | Observer E. Lyons

Piston Ring	Quadrant	Piston Number					
		1L	2L	3L	1R	2R	3R
1	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
2	1	5	0	10	5	10	0
	2	40	0	90	0	80	15
	3	0	0	95	0	15	5
	4	0	0	100	0	0	0

1 Thrust Side

4 Front  2 Rear

3 Anti-Thrust Side

VALVE DEPOSITS

Test No. 7

Engine Model 6V53T | Serial No. 5136206 | Date 9-11-79

Fuel CAT 1-H | Lubricant AL-8406-L | Observer E. Lyons

		Cylinder Number											
		1L		2L		3L		1R		2R		3R	
Head*	INT	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ
	EXH	A L	L A	H C									
Face	INT	N O.	9	L A	C Q	U E	R						
	EXH												
Tulip†	INT	N O.	9	L A	C Q	U E	R &	L I	G H	T C	A R	B O	N
	EXH												
Stem	INT	N O.	9	L A	C Q	U E	R	T O	C L	E A	N		
	EXH												

*Carbon and Ash: Use Volume Factor Technique (Pages 5 and 40 through 47 of Manual).
†Use Chart, Page 21—Indicate H, M, or S, (Page 5).
Lacquer: Pages 4, 36 and 37.

EXHAUST VALVE SURFACE CONDITIONS

Test No. 7

Engine Model 6V53T   Serial No. 5136206   Date 9-11-79

Fuel CAT 1-H   Lubricant AL-8406-L   Observer E. Lyons

	1L	2L	3L	1R	2R	3R
Freeness in Guide	F	F	F	F	F	F
Head	N	N	N	N	N	N
Face	A FEW LIGHT PITS					
Seat	N	N	N	N	N	N
Stem	N	N	N	N	N	N
Tip	N	N	N	N	N	N

See Pages 1, 2, 16 through 23, and 54 through 65 of Manual.

F = FREE
N = NORMAL

TAPPETS, CAMS, AND ROCKER ARMS

Test No. 7

Engine Model 6V53T   Serial No. 5136206   Date 9-11-79

Fuel CAT 1-H   Lubricant AL-8406-L   Observer E. Lyons

			Cylinder Number					
			1L	2L	3L	1R	2R	3R
Tappet Deposit		INT						
		EXH	SOME SCRATCHES	INJECTOR ROLLER FAILED REST HAVE SCRATCHES	SOME SCRATCHES	NORMAL	NORMAL	NORMAL
Tappet Surface Condition		INJ						
		INT						
		EXH						
Cam Lobes								
Rocker Arms	Tip	INT	N O			N		
		EXH				O		
	Bushing	INT		R			R	
		EXH		M			M	
	Shaft	INT			A		A	
		EXH			L			L

Lacquer: Pages 4, 36 and 37 of Manual.
See Pages 1, 2, 16 through 23, and 54 through 65.

SURFACE CONDITION

Test No. 7

Engine Model 6V53T   Serial No. 5136206   Date 9-11-79

Fuel CAT 1-H   Lubricant AL-8406-L   Observer E. Lyons

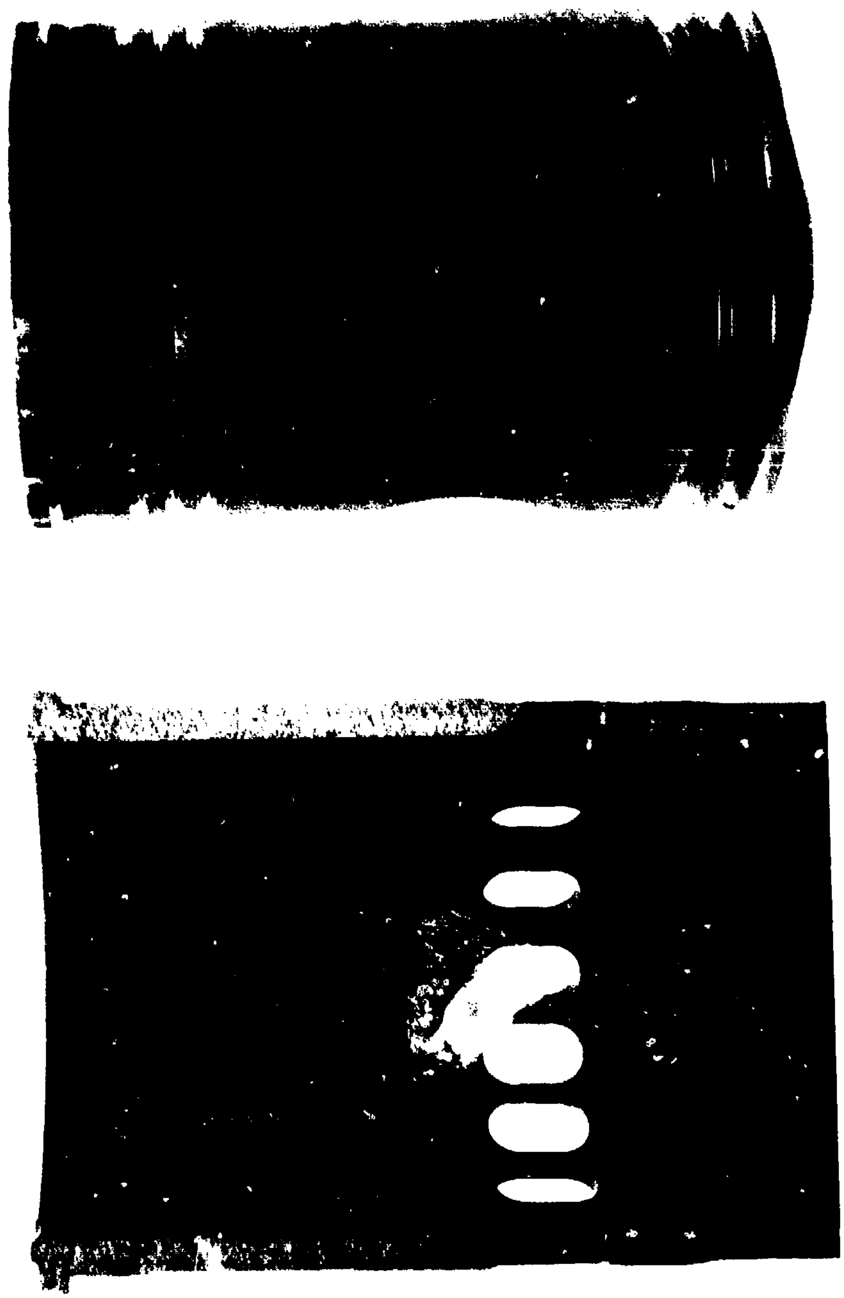
Bearing No.	1	2	3	4	5	6	7
Main–Bearing	Lt. Scratches	Copper Showing	Scratched Babbit Goen	Copper Showing			
–Journal	N	SOME ROUGH SPOTS					
Rod–Bearing	ALL HAVE SOME SCRATCHES AND NORMAL WEAR PATTERNS						
–Journal	N	N	N	N	N	N	
Piston Pin	N	N	N	N	N	N	
Bushing	N	N	N	N	N	N	

Note surface condition. See pages 1, 2, 16 through 23 and 54 through 65 of Manual.

N = NORMAL

CONDITION OF PISTON AND CYLINDER LINER

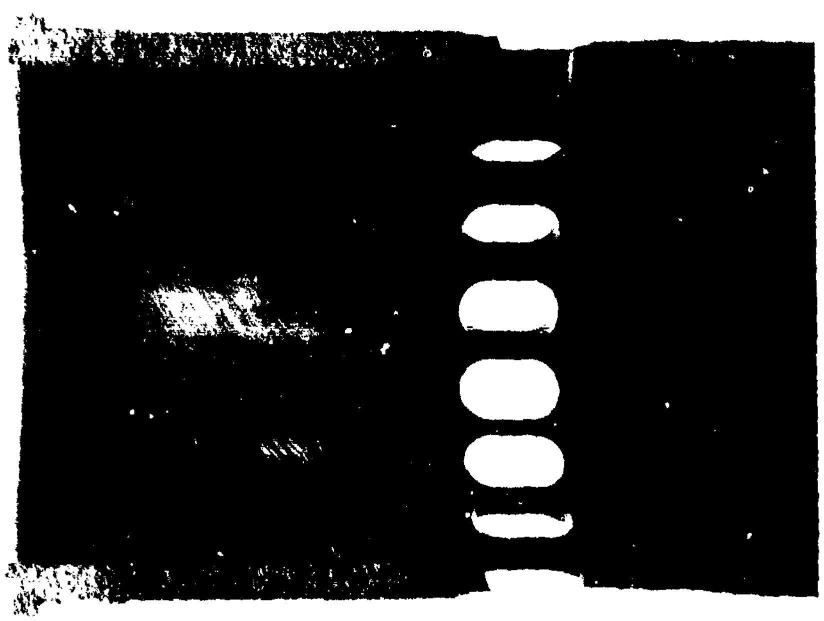
TEST TIME: 240 HOURS   TEST: 7   LUBRICANT: AL-8406-L



1-RIGHT THRUST

CONDITION OF PISTON AND CYLINDER LINER

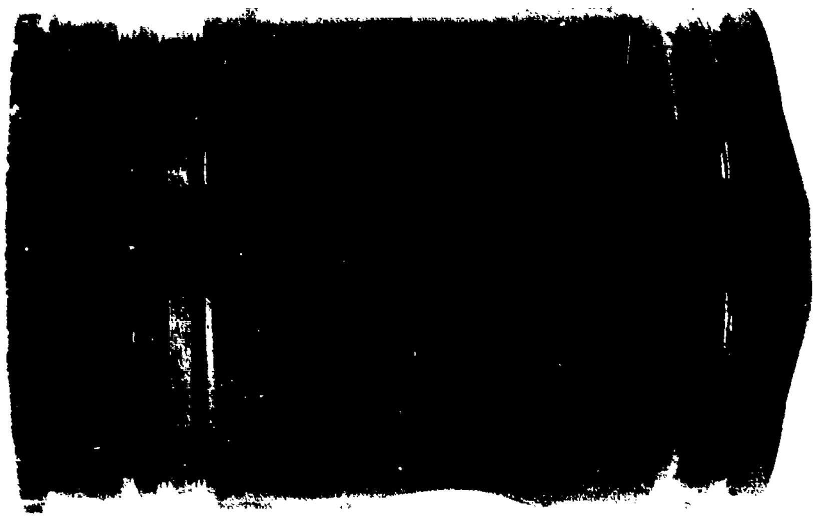
TEST TIME: 240 HOURS TEST: 7 LUBRICANT: AL-8406-L

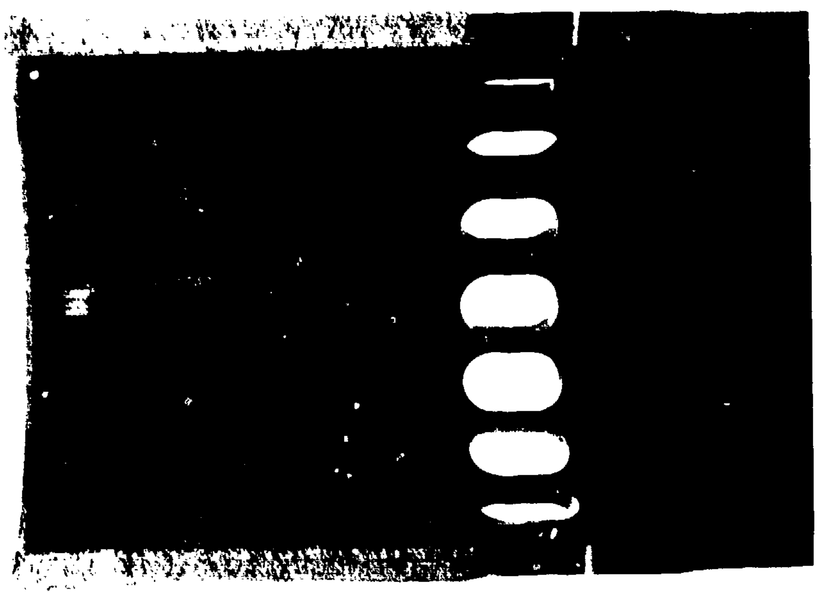


1-RIGHT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 240 HOURS TEST: 7 LUBRICANT: AL-8406-L

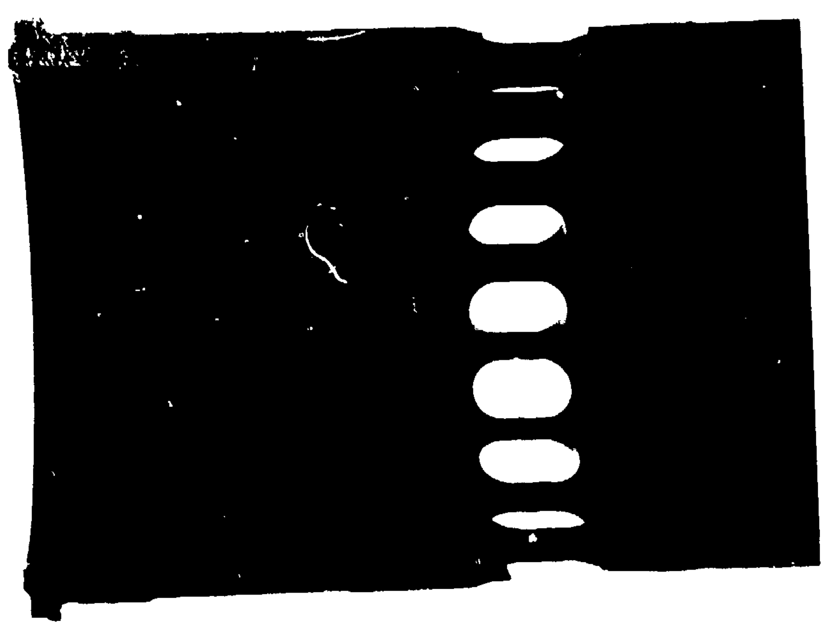




2-RIGHT THRUST

CONDITION OF PISTON AND CYLINDER LINER

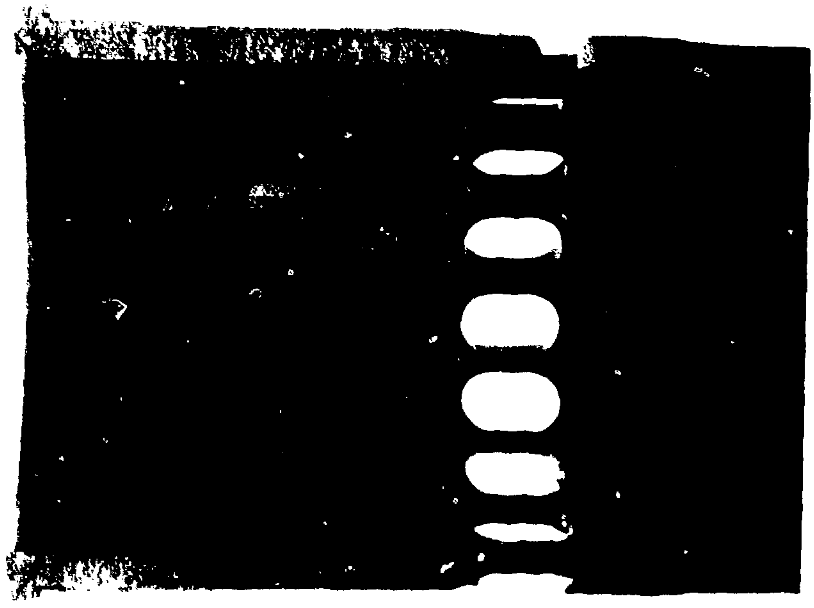
TEST TIME: 240 HOURS   TEST: 7   LUBRICANT: AL-8406-L



2-RIGHT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

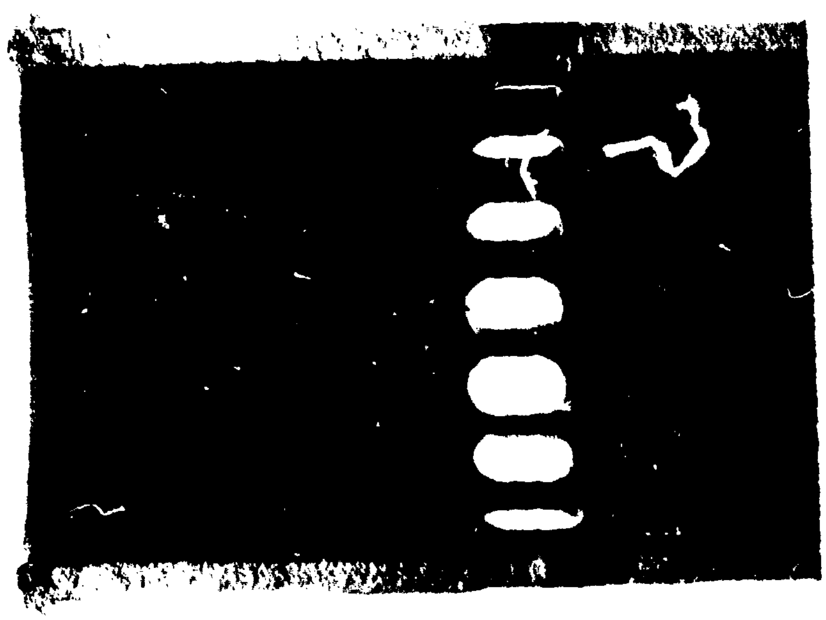
TEST HOURS: 240 HOURS TEST: 7 LUBRICANT: AL-8406-L



3-RIGHT THRUST

CONDITION OF PISTON AND CYLINDER LINER

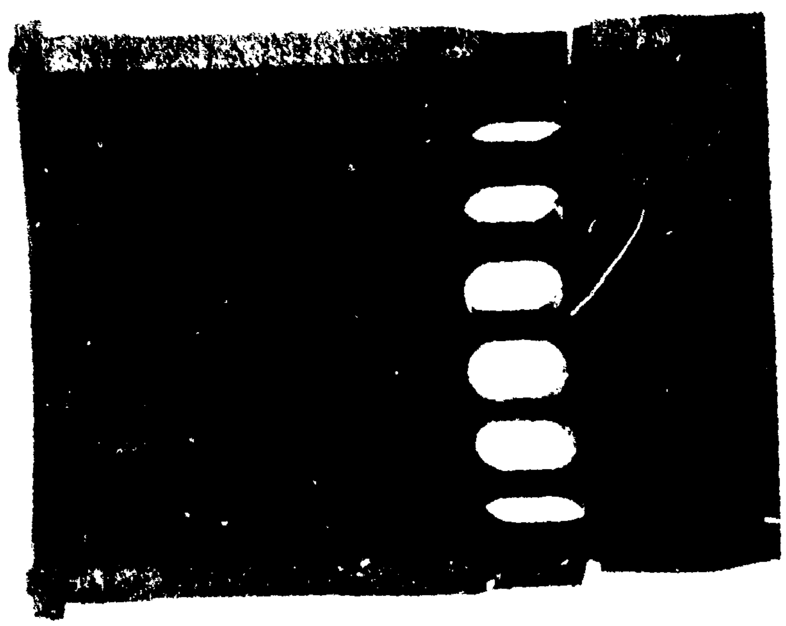
TEST TIME: 240 HOURS TEST: 7 LUBRICANT: AL-8406-L



3-RIGHT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

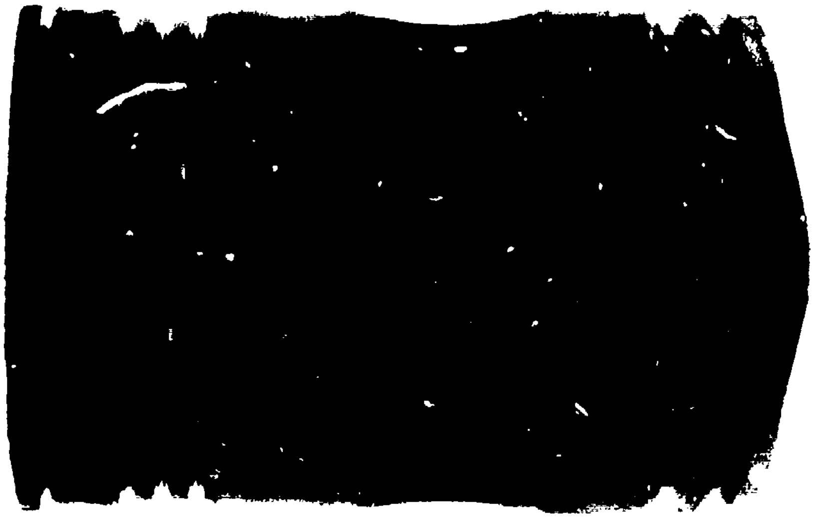
TEST TIME: 240 HOURS TEST: 7 LUBRICANT: AL-8406-L

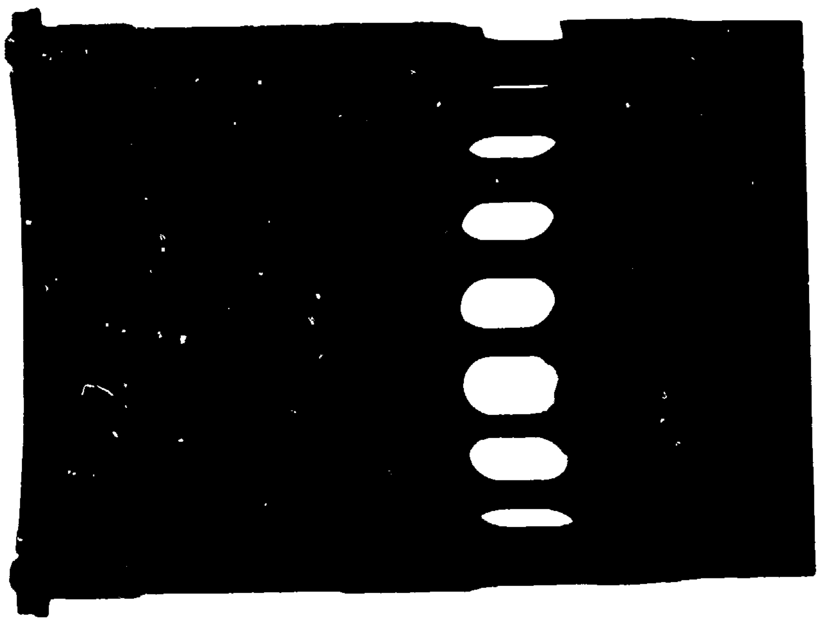


1-LEFT THRUST

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 240 HOURS TEST: 7 LUBRICANT: AL-8406-L



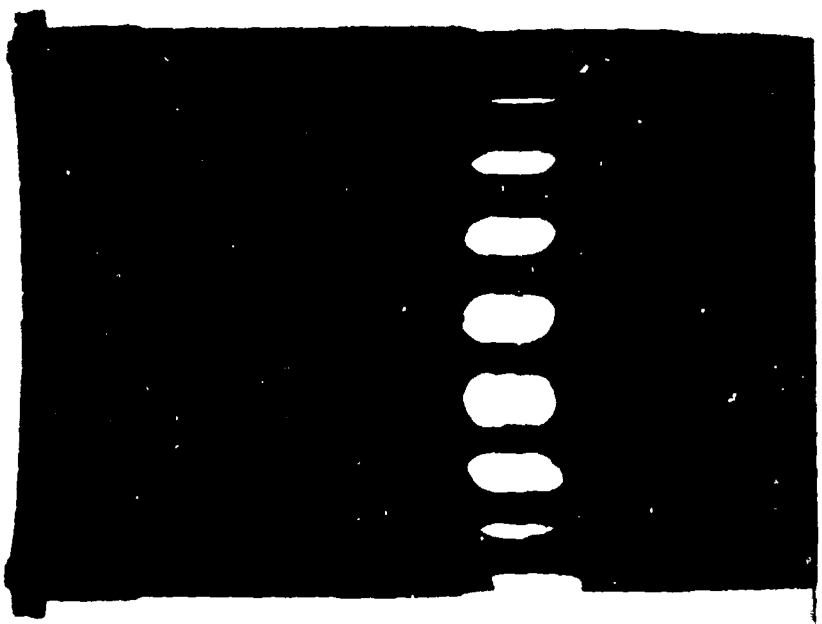


1-LEFT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

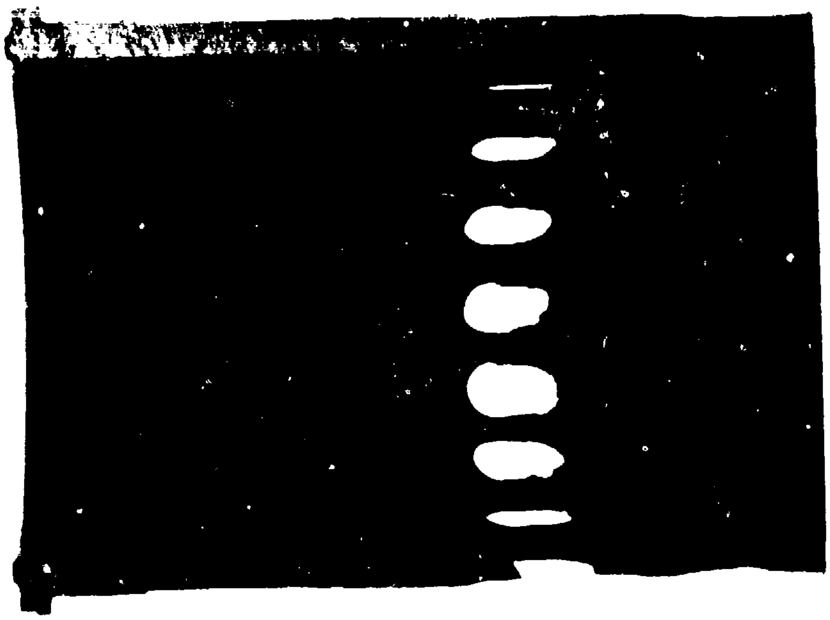
TEST TIME: 240 HOURS TEST: 7 LUBRICANT: AL-8406-L

2-LEFT THRUST



CONDITION OF PISTON AND CYLINDER LINER

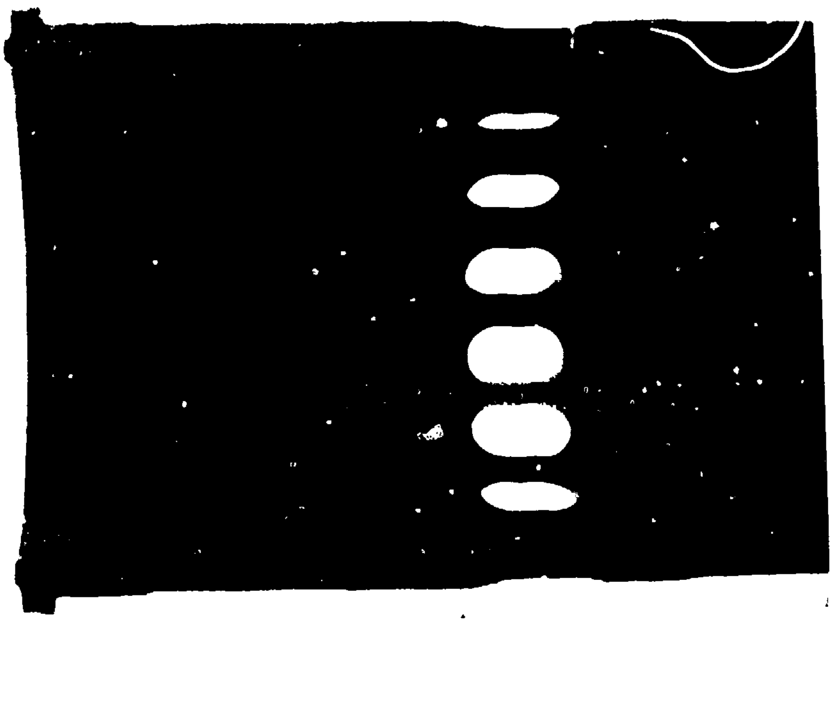
TEST TIME: 240 HOURS TEST: 7 LUBRICANT: AL-8406-L



2-LEFT ANTI-THRUST

CONDITION OF PISTON AND CYLINDER LINER

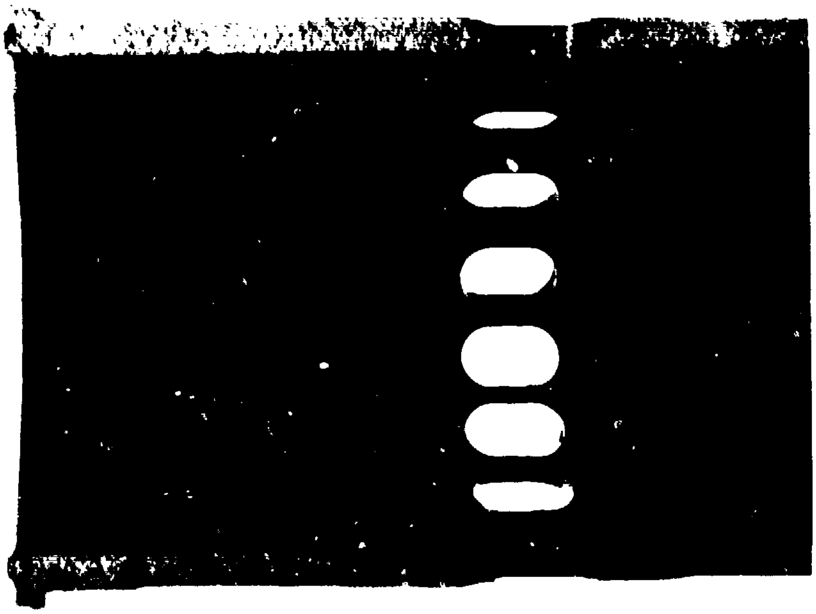
TEST TIME: 240 HOURS TEST: 7 LUBRICANT: AL-8406-L



3-LEFT THRUST

CONDITION OF PISTON AND CYLINDER LINER

TEST TIME: 240 HOURS TEST; 7 LUBRICANT; AL-8406-L



3-LEFT ANTI-THRUST

CONDITION OF PISTON RING FACE

TEST TIME: 240 HOURS TEST: 7 LUBRICANT: AL-8406-L

1-RIGHT

2-RIGHT

3-RIGHT

CONDITION OF PISTON RING FACE

TEST TIME: 240 HOURS TEST: 7 LUBRICANT: AL-8406-L

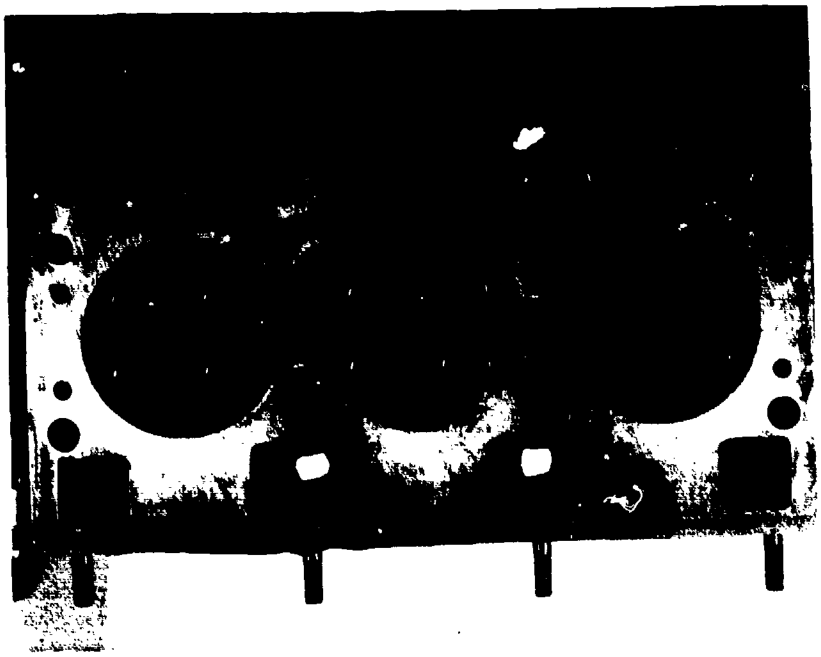
1-LEFT

2-LEFT

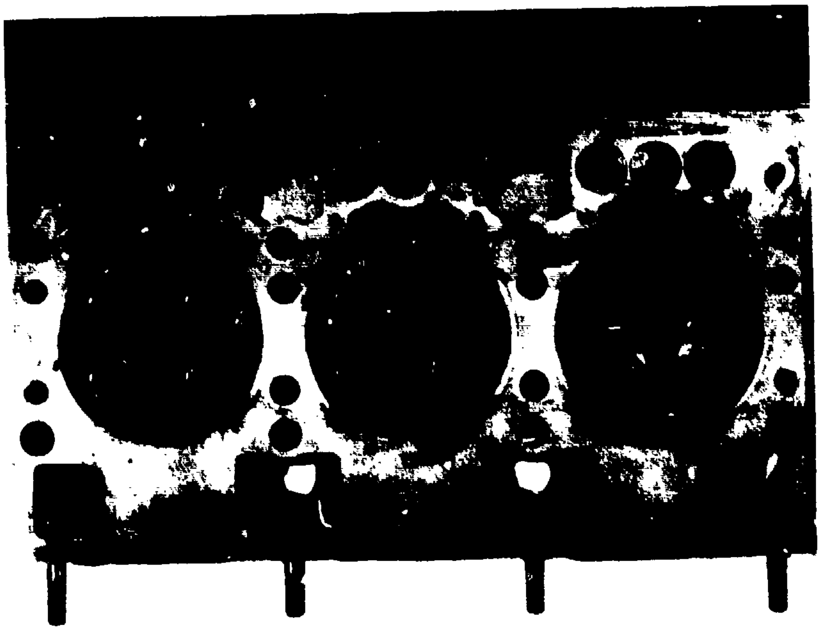
3-LEFT

CONDITION OF CYLINDER HEADS

TEST TIME: 240 HOURS | TEST: 7 | LUBRICANT: AL-8406-L



3L 2L 1L



1R 2R 3R

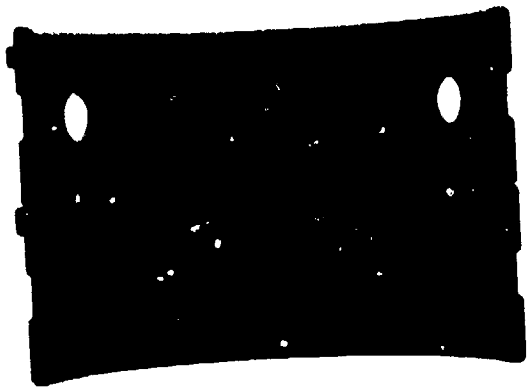
CONDITION OF ROD BEARINGS

TEST TIME: 240 HOURS

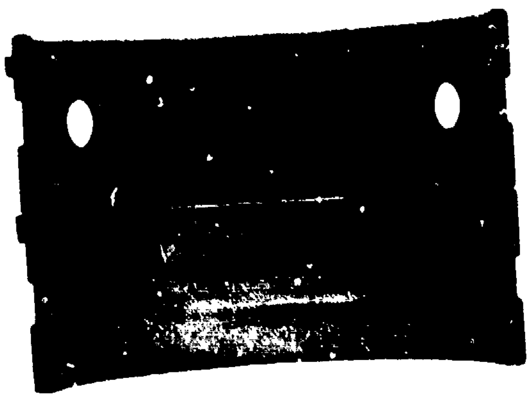
TEST: 7

LUBRICANT: AL-8406-L

1-RIGHT



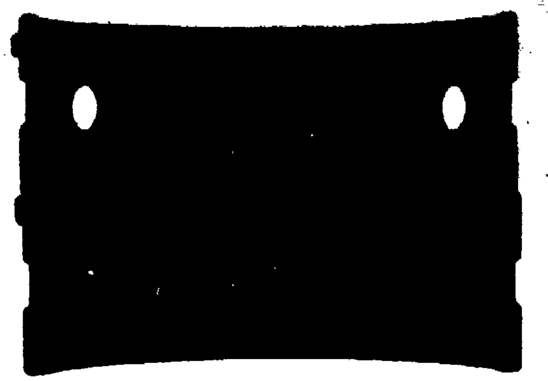
2-RIGHT



3-RIGHT

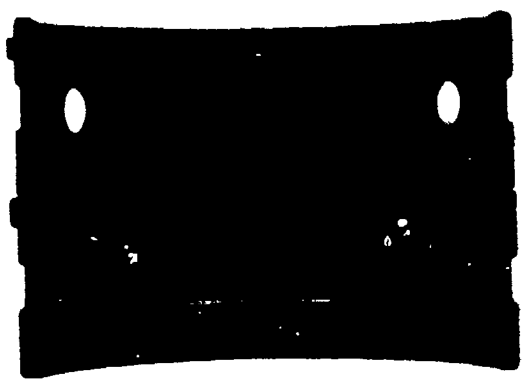
CONDITION OF ROD BEARINGS

TEST TIME: 240 HOURS TEST: 7 LUBRICANT: AL-8406-L



1-LEFT

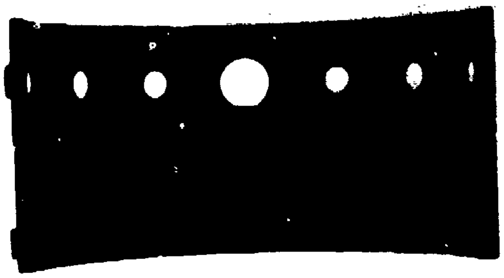
2-LEFT



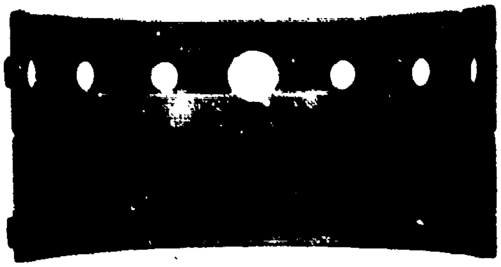
3-LEFT

CONDITION OF MAIN BEARINGS

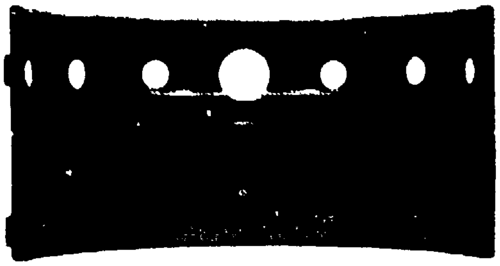
TEST TIME: 240 HOURS   TEST: 7   LUBRICANT: AL-8406-L



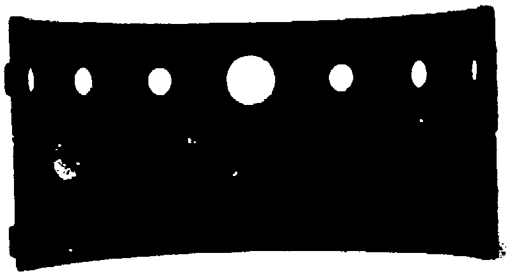
No. 1



No. 2



No. 3



No. 4

CONDITION OF NO. 2 LEFT FUEL INJECTION CAM FOLLOWER AND CAM LOBE

TEST TIME: 240 HOURS TEST: 7 LUBRICANT: AL-8406-L

CAM FOLLOWER

CAM LOBE

APPENDIX F

ENGINE-LUBRICANT COMPATIBILITY TEST #8

240-HOUR TRACKED-VEHICLE CYCLE

USING 6V-53T DIESEL ENGINE

ENGINE-LUBRICANT COMPATIBILITY TEST
240-HOUR TRACKED-VEHICLE CYCLE
USING 6V-53T DIESEL ENGINE

Test Lubricant: AL-7172-1
Test Fuel: Caterpillar 1-H
Engine Test Number: 8
Date Completed: 14 May 1980

Conducted for

U.S. Army Mobility Equipment Research and Development Command
Energy and Water Resources Laboratory
Fort Belvoir, Virginia

by

U.S. Army Fuels and Lubricants Research Laboratory
Southwest Research Institute
San Antonio, Texas 78284

PRECEDING PAGE BL

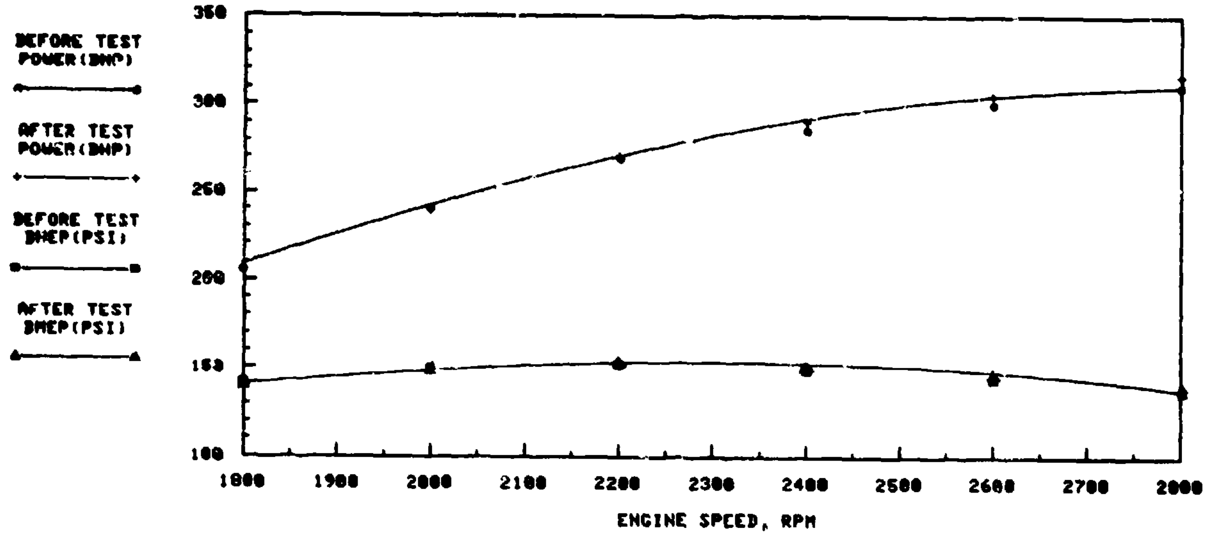
6V53T
TEST 8
ENGINE REBUILD MEASUREMENTS
Model Number: 5063-5397
Serial Number: 6D-178671

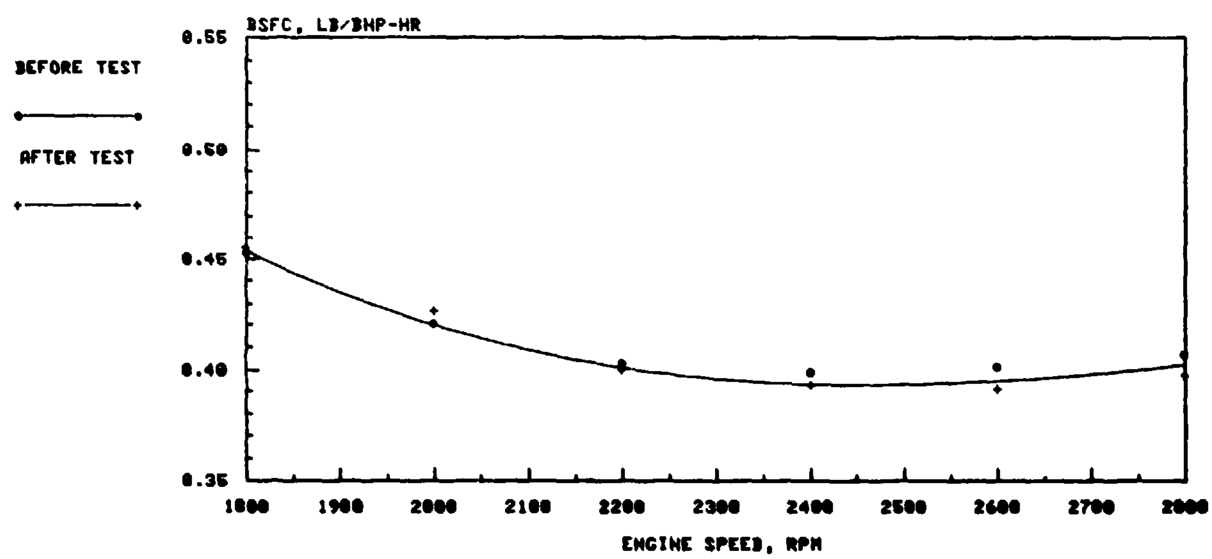
	Min	Max	Avg	Specified Limits*
Cylinder Block Bore				
Inside Diameter (bottom)	4.3563	4.3573	4.3571	4.3595 max
Out-of-Round	0.0001	0.0010	0.0003	0.0015 max
Taper	0.0001	0.0004	0.0002	0.0015 max
Cylinder Liners (installed)				
Inside Diameter	3.8750	3.8761	3.8755	3.8752-3.8767
Out-of-Round	0.0000	0.0004	0.0002	0.0020 max
Taper	0.0001	0.0009	0.0004	0.0010 max
Piston Diameter (@ skirt)	3.8673	3.8679	3.8676	3.8669-3.8691
Piston Skirt to Cylinder Liner Clearance	0.0073	0.0089	0.0079	0.0061-0.0098
Compression Rings				
Gap (Fire)	0.032	0.036	0.034	0.020-0.046
Gap (others)	0.025	0.036	0.029	0.020-0.036
Ring-to-Groove Clearance				
Top (Fire)	0.003	0.004	0.004	0.003-0.006
No. 1	0.007	0.008	0.008	0.007-0.010
No. 2 and No. 3	0.006	0.007	0.007	0.005-0.008
Oil Control Rings				
Gap	0.018	0.021	0.020	0.010-0.025
Ring-to-Groove Clearance	0.002	0.003	0.003	0.0015-0.0055
Connecting Rod Bearing-to-Journal Clearance	0.0024	0.0033	0.0026	0.0011-0.0041
Main Bearing-to-Journal Clearance	0.0040	0.0042	0.0041	0.0011-0.0041
Camshaft Bearing-to-Shaft Clearance	0.0047	0.0051	0.0049	0.0045-0.0060

*All measurements are in inches.

6V-53T 240 HOUR TRACKED VEHICLE CYCLE

BEFORE AND AFTER TEST @ PERFORMANCE DATA





6V-53T
240 HOUR TRACKED VEHICLE CYCLE ENDURANCE TEST
TEST 8
OPERATING CONDITIONS SUMMARY
Lubricant: AL-7172-L Fuel: Caterpillar 1-H

	Maximum Power Mode (2800 rpm)		Maximum Torque Mode (2200 rpm)	
	Mean	Standard* Deviation	Mean	Standard Deviation
Engine Speed, rpm	2805	2	2206	3
Torque, Ft-lb (N-m)	567(769)	14(19)	635(861)	9(12)
Fuel Consumption, lb/hr (kg/hr)	121.3(55.07)	2.6(1.18)	105.8(48.03)	1.3(0.59)
Observed Power, Bhp (kW)	303(226)	6(4)	267(199)	4(3)
BSFC, lb/Bhp-hr (g/kW-hr)	.400(243)	0.002(1)	.396(241)	0.003(2)
Temperatures, °F (°C)				
Exhaust before turbo	1031(554)	20(11)	1071(577)	26(14)
Exhaust after turbo	866(463)	14(8)	902(483)	12(7)
Water Jacket Inlet	155(68)	1(1)	155(68)	1(1)
Water Jacket Outlet	170(77)	1(1)	170(77)	1(1)
Oil Sump	237(114)	2(1)	229(109)	2(1)
Fuel at Filter	94(34)	3(2)	92(33)	2(1)
Inlet Air (at compressor)	95(35)	6(3)	93(34)	5(3)
Airbox	293(145)	8(4)	241(116)	5(3)
Pressures				
Exhaust before turbo, psi (kPa)	14.9(103)	0.3(2)	10.1(70)	0.3(2)
Exhaust after turbo, in. Hg (kPa)	2.8(9.5)	0.1(0.3)	1.8(6.1)	0.1(.3)
Compressor Discharge, psi (kPa)	14.6(101)	0.4(3)	11.0(76)	0.3(2)
Blower Discharge, psi (kPa)	19.6(135)	0.5(3)	12.2(84)	0.4(3)
Oil Gallery, psi (kPa)	57(393)	1(7)	46(317)	1(7)
Intake Vacuum, in. H_2O (Pa)	7.6(1890)	0.2(50)	4.7(1170)	0.1(20)
Ambient Conditions (both modes of operation)				
Dry Bulb Temperature, °F (°C)	78(26)	5(3)		
Wet Bulb Temperature, °F (°C)	73(23)	4(2)		
Barometric Pressure, in. Hg (kPa)	28.87(97.87)	0.23(0.78)		

*68% of the values for a given variable occur within ± 1 standard deviation of the mean; 95% occur within ± 2 standard deviations.

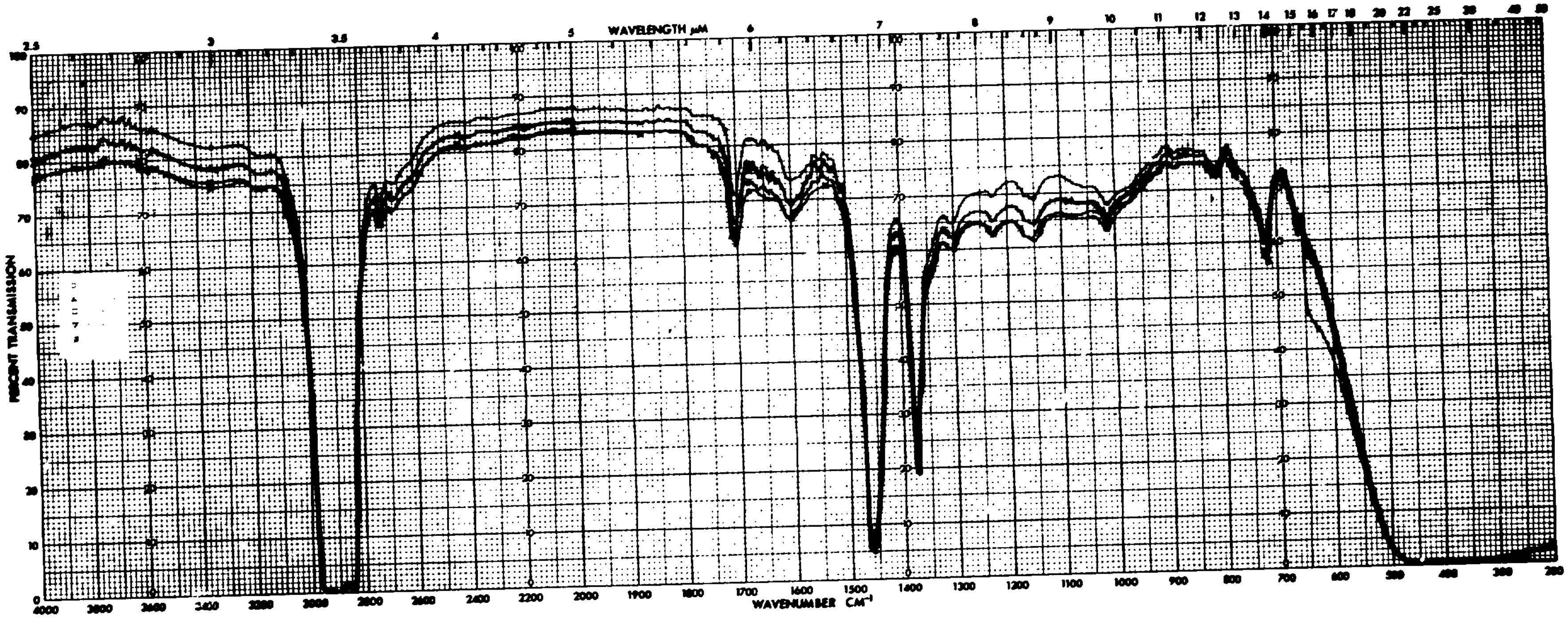
6V-53T
TEST 8
LUBRICANT ANALYSIS

Lubricant: AL-7172-L

	ASTM Test Method	Test Time, Hours 0	60	120	180	240
Apparent Viscosity at -29°C (-20°F), cP	D 2602	22770	39580	43950	39580	39580
Apparent Viscosity at -18°C (0°F), cP	D 2602	4150	6380	6940	6380	6710
Kinematic Viscosity at 40° (104°F), cSt	D 445	112.8	112.5	116.8	111.9	115.3
Kinematic Viscosity at 100°C (212°F), cSt	D 445	14.8	13.9	14.2	14.0	13.7
Viscosity Index	D 2270	135	124	122	125	117
Total Acid Number, mg KOH/g	D 664	1.9	2.4	2.9	2.9	3.5
Total Base Number, mg KOH/g	D 664	8.2	5.9	6.4	6.5	6.4
Pentane B Insolubles, wt%	D 893	0.02	0.04	0.11	0.05	0.06
Toluene B Insolubles, wt%	D 893	0.01	0.04	0.09	0.05	0.05
Flash Point, °C (°F)	D 92	210(410)	222(432)	228(442)	220(428)	222(432)
Density at 16°C (60°F), gm/ml	D 287	0.885	0.891	0.893	0.886	0.893
Carbon Residue, wt %	D 524	1.3	1.6	1.8	1.8	1.9
Sulfated Ash, wt %	D 874	1.0	1.2	1.3	1.1	1.3

6V-53T
TEST 8

Lubricant: AL-7172-L



6V-53T
TEST 8
Lubricant: AL-7172-L

TOTAL OIL CONSUMPTION AND WEAR METALS BY XRF

Test Time, Hours	Total Oil Consumed, lb (kg)	Wear Metals,+ ppm Fe(Iron)	Cu(Copper)
20	13.6(6.17)	46	20
33	19.1(8.66)	-++	-
40	29.1(13.20)	53	18
53	33.3(15.10)	-	-
60	42.5(19.28)	67	19
75.5	48.1(21.82)	-	-
80	56.3(25.54)	70	23
95.5	61.5(27.90)	-	-
100	67.4(30.57)	62	21
112.5	74.2(33.66)	-	-
120	86.9(39.42)	71	24
133	92.7(42.05)	-	-
140	100.0(45.36)	33	ND*
145.5	107.4(48.72)	-	-
155.5	112.0(50.80)	-	-
160	115.4(52.34)	39	16
170.5	122.6(55.61)	-	-
180	125.4(56.88)	41	ND
190	132.9(60.28)	-	-
195	138.5(62.82)	-	-
200	139.6(63.32)	35	ND
210	146.7(66.54)	-	-
220	150.9(68.45)	53	ND
230	161.7(73.35)	-	-
240	173.8(78.83)	56	20

Average Oil Consumption Rate: 0.72 lb/hr (0.33 kg/hr)

+No other wear metals detected.
++Oil samples for wear metal analysis not taken at these times.
*Not Detected.

6V-53T
TEST 8
Lubricant: AL-7172-L

WEAR MEASUREMENTS

Cylinder Liner Bore Diameter Change*

Cylinder Number

	1L		2L		3L	
	T-AT**	F-B	T-AT	F-B	T-AT	F-B
Top	+0.0012	+0.0004	+0.0014	+0.0006	+0.0024	+0.0008
Middle	+0.0014	+0.0011	+0.0017	+0.0021	+0.0010	+0.0014
Bottom	+0.0009	+0.0008	+0.0008	+0.0009	+0.0005	+0.0007

Cylinder Number

	1R		2R		3R	
	T-AT	F-B	T-AT	F-B	T-AT	F-B
Top	+0.0013	+0.0009	+0.0010	+0.0010	+0.0016	+0.0008
Middle	+0.0012	+0.0014	+0.0017	+0.0006	+0.0017	+0.0014
Bottom	+0.0005	+0.0008	+0.0012	+0.0007	+0.0009	+0.0004

Average Change

	T-AT	F-B
Top	+0.0015	+0.0008
Middle	+0.0015	+0.0013
Bottom	+0.0008	+0.0007

Overall Average Change: +0.0011 inches.

Piston Ring End Gap Change

Ring Number	1L	2L	3L	1R	2R	3R	Average Change
1	+0.001	+0.002	+0.006	-0.001	+0.001	+0.001	+0.002
2	0.000	+0.001	+0.002	+0.002	+0.001	0.000	+0.001
3	+0.001	+0.002	0.000	+0.001	+0.001	0.000	+0.001
4	0.000	0.000	+0.001	0.000	0.000	0.000	0.000
5	+0.007	+0.006	+0.006	+0.007	+0.006	+0.008	+0.007
6	+0.006	+0.006	+0.007	+0.007	+0.008	+0.007	+0.007
7	+0.004	+0.007	+0.005	+0.007	+0.003	+0.004	+0.005

Overall Average Change: +0.003.

*All dimensions given are in inches.
**T-AT = Thrust-Antithrust Direction; F-B = Front-Back Direction.

6V-53T
TEST 8
Lubricant: AL-7172-L

POST TEST ENGINE CONDITION AND DEPOSITS

A. Cylinder Liner

	Cylinder Number 1L	2L	3L	1R	2R	3R	Average
Intake Port Plugging, % restriction	1	1	1	1	1	1	1
Liner Scuffing, % Area							
Thrust	15	5	5	5	10	30	12
Anti-Thrust	40	0	2	3	10	10	11
Total	28	3	4	4	10	20	11
						Overall:	11
Liner Glazed, % Area	5	5	10	10	15	10	9
Liner Lacquer, % Area	65	65	80	70	85	65	72

B. Pistons

	1L	2L	3L	1R	2R	3R	Average
Ring Face Burn, % Area							
Fire Ring	2	12	65	1	6	5	15
No. 1	1	0	85	1	20	12	20
No. 2	0	0	60	1	7	8	13
No. 3	0	0	55	2	10	20	15
						Overall:	16
Ring Groove Carbon, % Filling							
Fire Ring	15	5	20	10	5	10	11
No. 1	60	70	80	85	90	80	78
No. 2	5	5	10	5	5	15	8
No. 3	0	0	5	0	0	0	1
						Overall:	25
Piston Skirt Deposit Rating ** **(Demerit)**							
Thrust	6.5 LS*	6.7 LSC	6.7 LSC	6.5 MSC	6.2 SC,PM	6.5 SC,PM	6.5 -
Anti-Thrust	6.0 LS	6.0 LS	6.0 LSC	6.0 LS	6.2 LS,SC	6.2 S,PM	6.1 -
						Overall:	6.3

*L = light, S = scratches, SC = scuffing, M = medium, PM = plating melted.
**0 = least, 9 most.

6V-537
TEST 8
Lubricant: AL-7172-L

POST TEST ENGINE CONDITION AND DEPOSITS

B. Pistons (continued)

	Cylinder Number						
	1L	2L	3L	1R	2R	3R	Average
Oil Control Ring Grooves (Demerit)							
Upper	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lower	4.0	4.0	4.0	4.0	4.0	4.0	4.0
						Overall:	4.0
Piston Groove Inside Diameter, % Ring Supporting Carbon							
No. 1	0	0	0	0	0	0	0
No. 2	20	34	29	30	55	66	42
						Overall:	21
Piston WTD* Rating	375	371	378	334	365	364	365
Ring Sticking							
No. 1	F	F	F	F	F	5%-P	
No. 2	F	F	F	F	F	F	
No. 3	F	F	F	F	F	F	
No. 4	F	F	F	F	F	F	
Piston Oil Drain Holes	----------	----------	----------	100% Open	----------	----------	----------

C. Exhaust Valves

Deposits	
Head	AHC**
Face	all have carbon buildup causing leaking
Tulip	AHC to No. 9+ Lacquer
Stem	No. 9 Lacquer to Clean
Surface Condition	
Freeness in Guide	Free
Head	Normal
Face	Leaking
Seat	Normal
Stem	Worn at Top
Tip	Tip

*CRC Weighted Total Deposits Rating (0 = least, 900 = most).
**HC = Hard Carbon; the number-letter prefix indicates carbon depth, with ¼A = least through the alphabet to J = most.
+The higher the number, the darker the lacquer (0 = lightest, 9 = darkest).

6V-53T
TEST 8
Lubricant: AL-7172-L

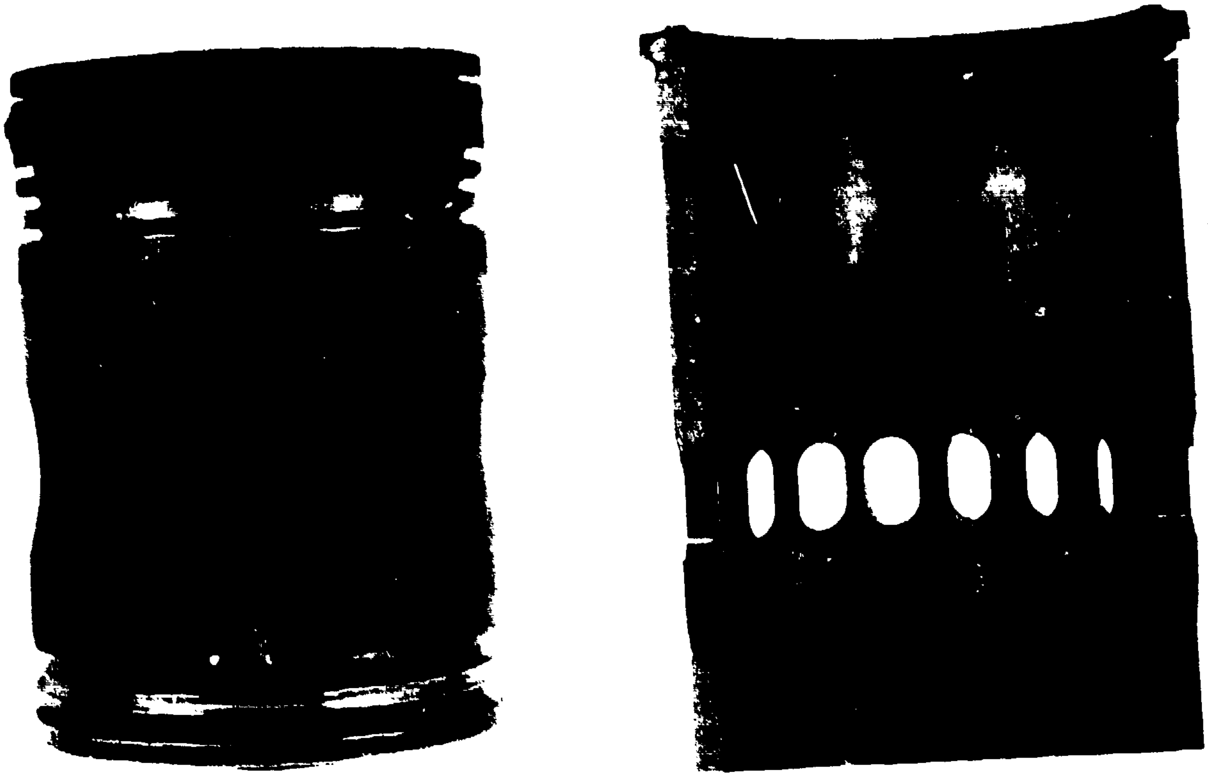
POST TEST ENGINE CONDITION AND DEPOSITS

D. Other Ratings

	Cylinder Number						
	1L	2L	3L	1R	2R	3R	Average
Tappets, Cams, and Rocker Arms							
Tappet Deposit	Clean						
Tappet Surface Condition	Normal						
Cam Lobes	N*	N	SCR	N	N	N	N
Rocker Arms							
Tip	Normal						
Bushing	Normal						
Shaft	Normal						
Bearing Surface Condition							
Main Bearings	Not Removed						
Main Journals	Not Removed						
Rod Bearings	Normal						
Rod Journals	Normal						
Piston Pin	N	LG	N	LG	MG	LG	LG
Pin Bushing	N	N	N	N	MG	N	N
Combustion Chamber Deposits	10% B 75% A 15% ½A	5% B 70% A 25% ½A	80% A 20% ½A	5% B 90% A 5% ½A	90% A 10% ½A	10% B 80% A 10% ½A	
Exhaust Port Deposits	½ AHC						
Valve Covers, Cylinder Head Decks, and Oil Pan	Clean						

* N = Normal, SCR = Scratched.

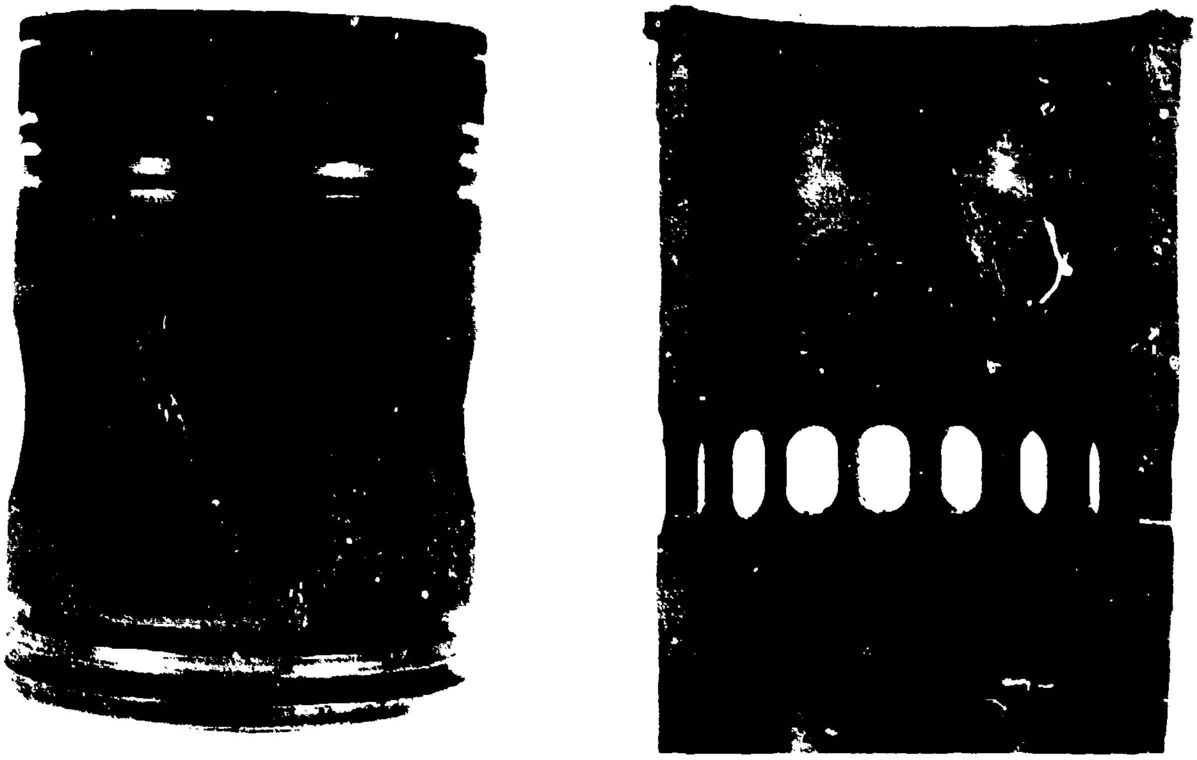
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 8
Lubricant: AL-7172-L



1 - Left Thrust*

*Cylinder 1-Left had the most scuffing.

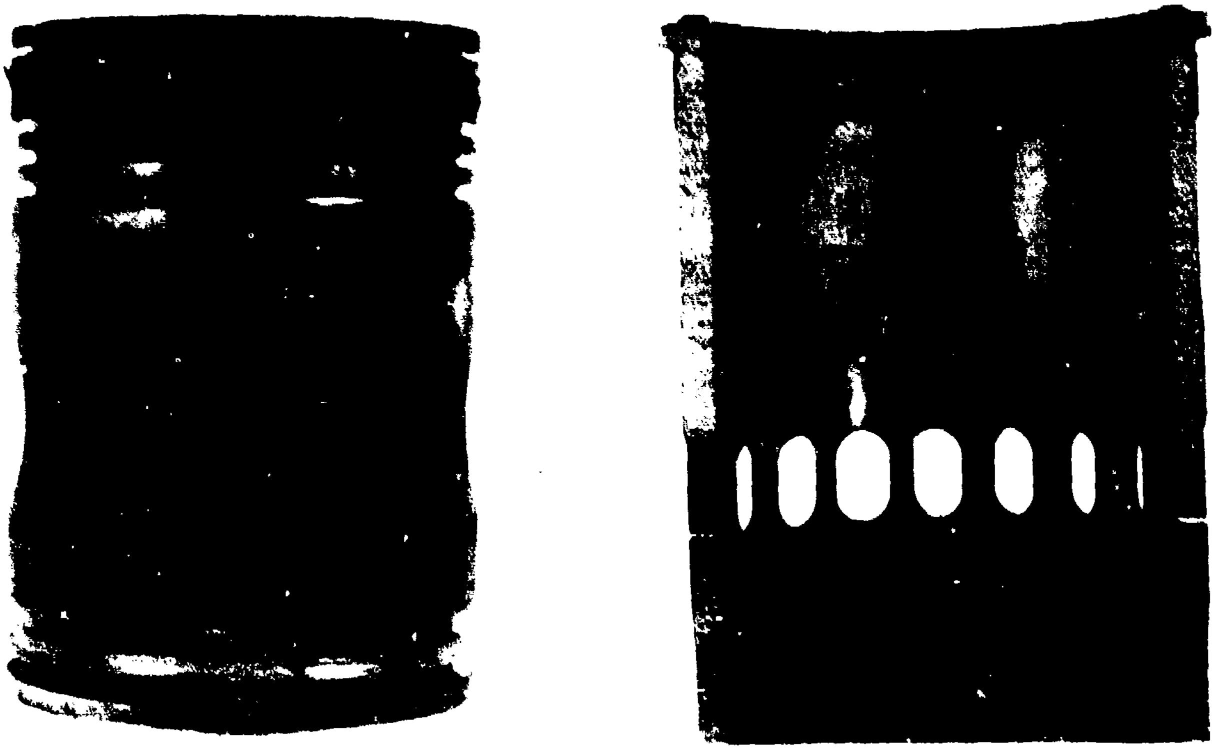
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 8
Lubricant: AL-7172-L



1 - Left Anti-Thrust*

*Cylinder 1-Left had the most scuffing.

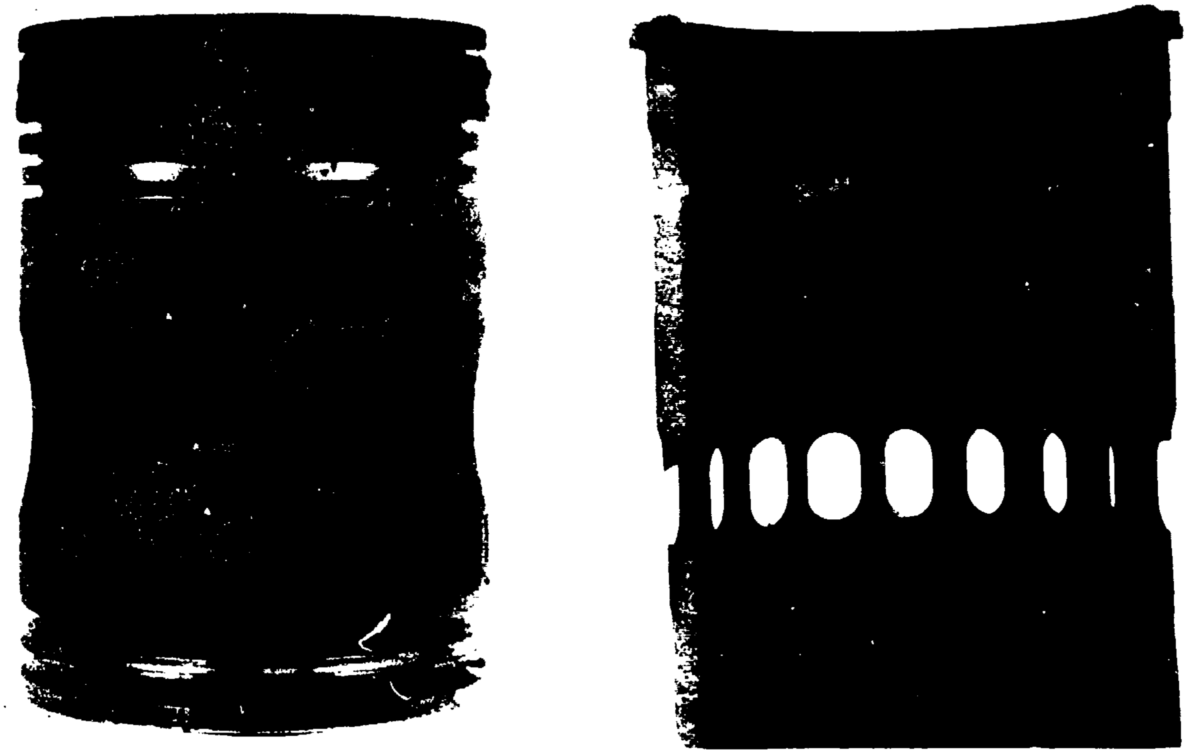
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 8
Lubricant: AL-7172-L



2 - Left Thrust*

*Cylinder 2 Left had the least scuffing.

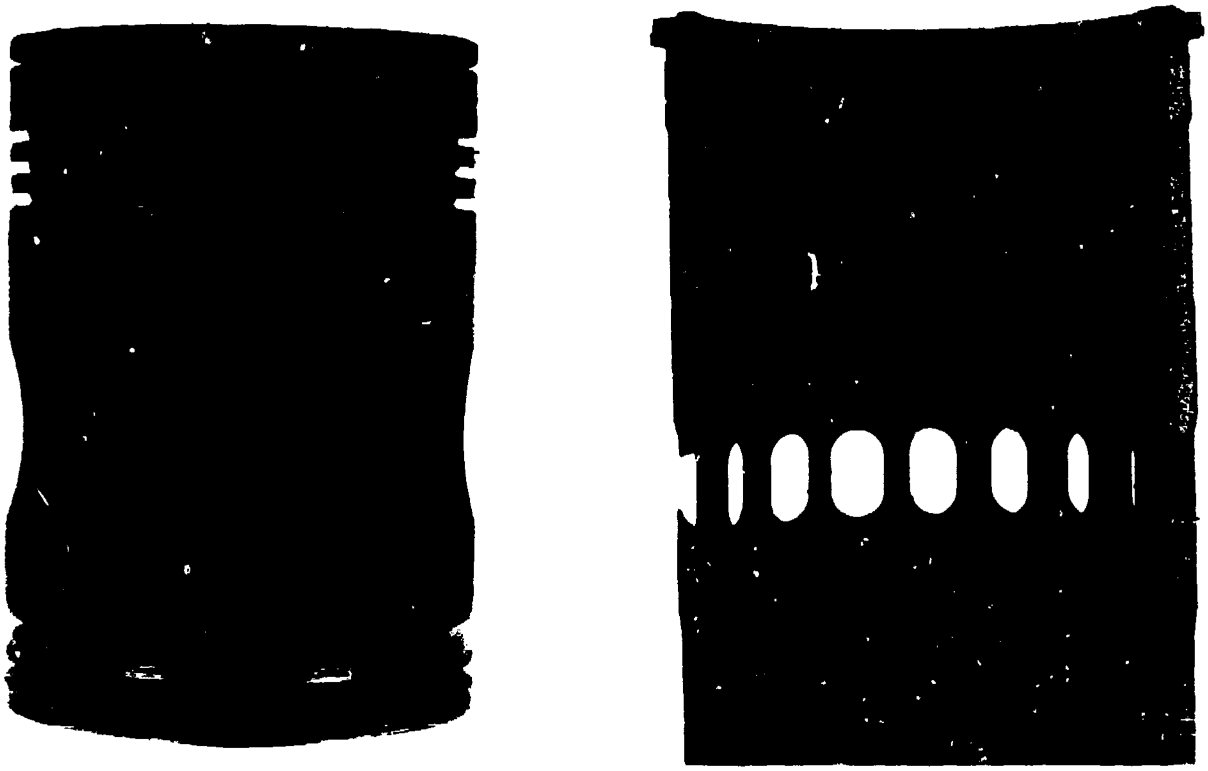
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 8
Lubricant: AL-7172-L



2 - Left Anti-Thrust*

*Cylinder 2-Left had the least scuffing.

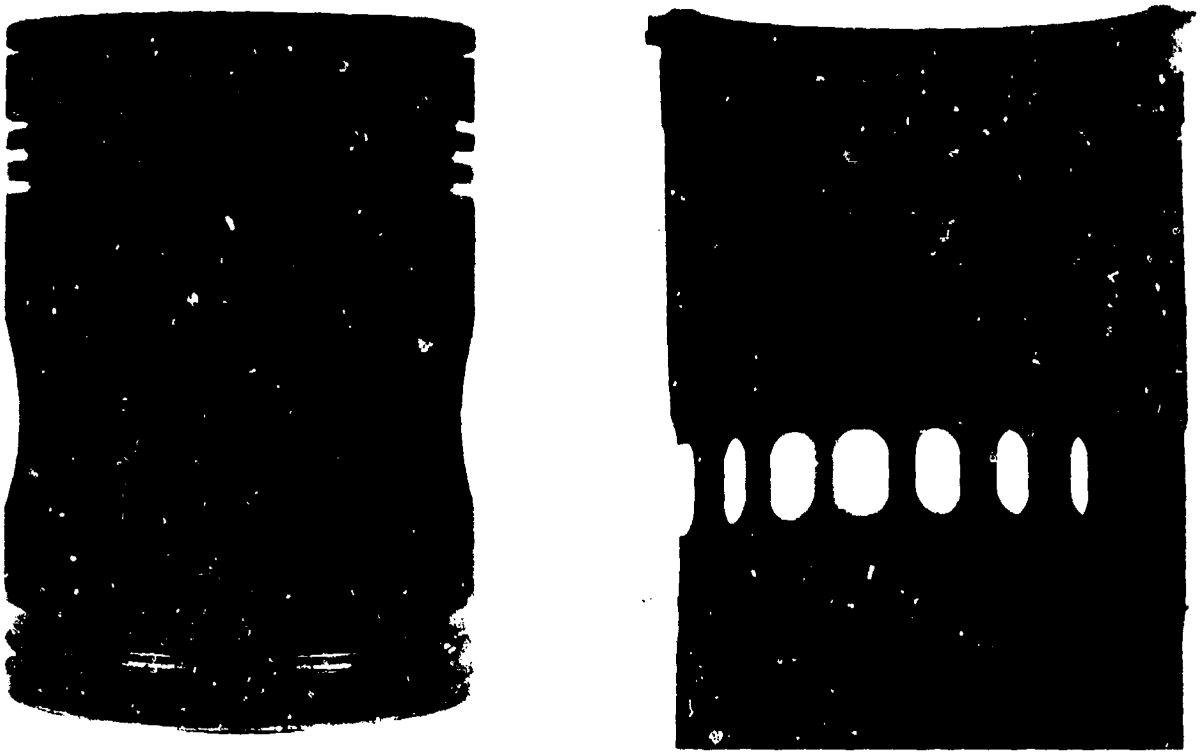
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 8
Lubricant: AL-7172-L



3 - Left Thrust*

*Piston 3-Left had the highest Weighted Total Deposits (WTD) rating.

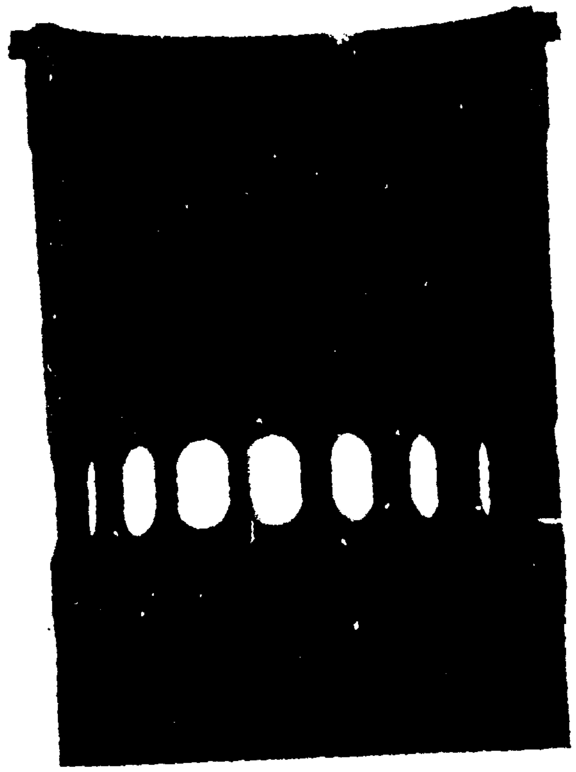
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 8
Lubricant: AL-7172-L



3 - Left Anti-Thrust*

*Piston 3-Left had the highest Weighted Total Deposits (WTD) rating.

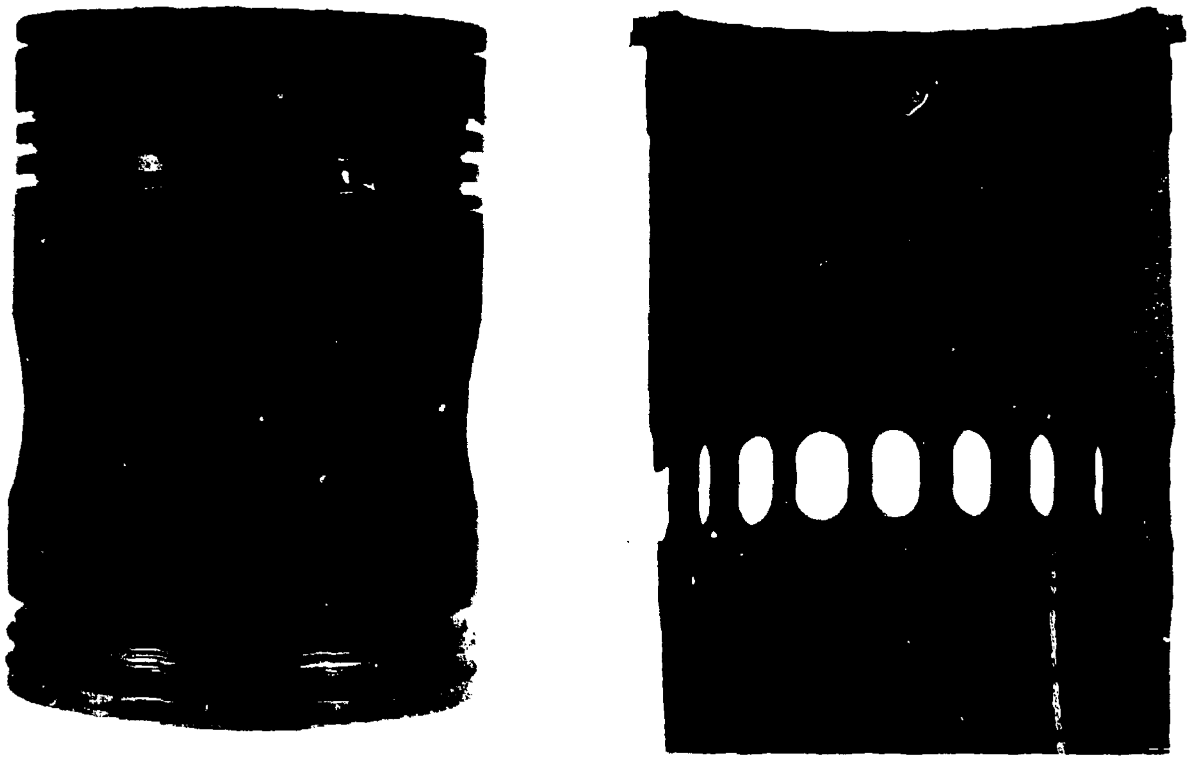
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 8
Lubricant: AL-7172-L



1 - Right Thrust*

*Piston 1-Right had the lowest Weighted Total Deposits (WTD) rating.

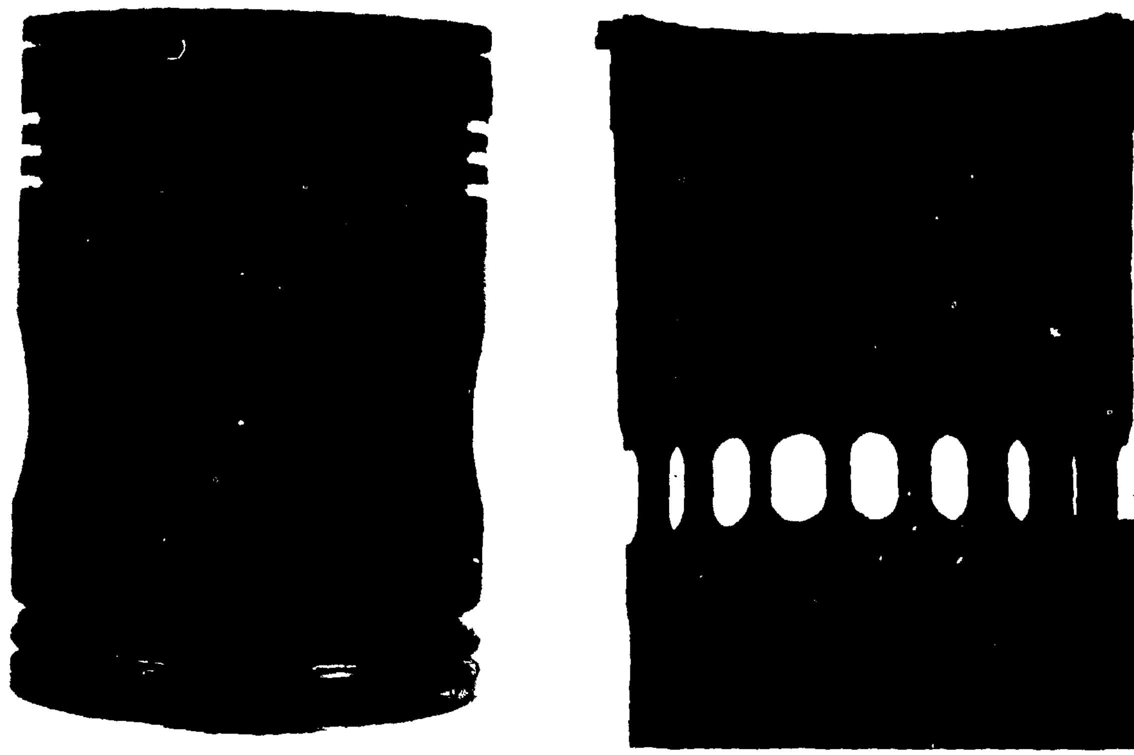
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 8
Lubricant: AL-7172-L



1 - Right Anti-Thrust*

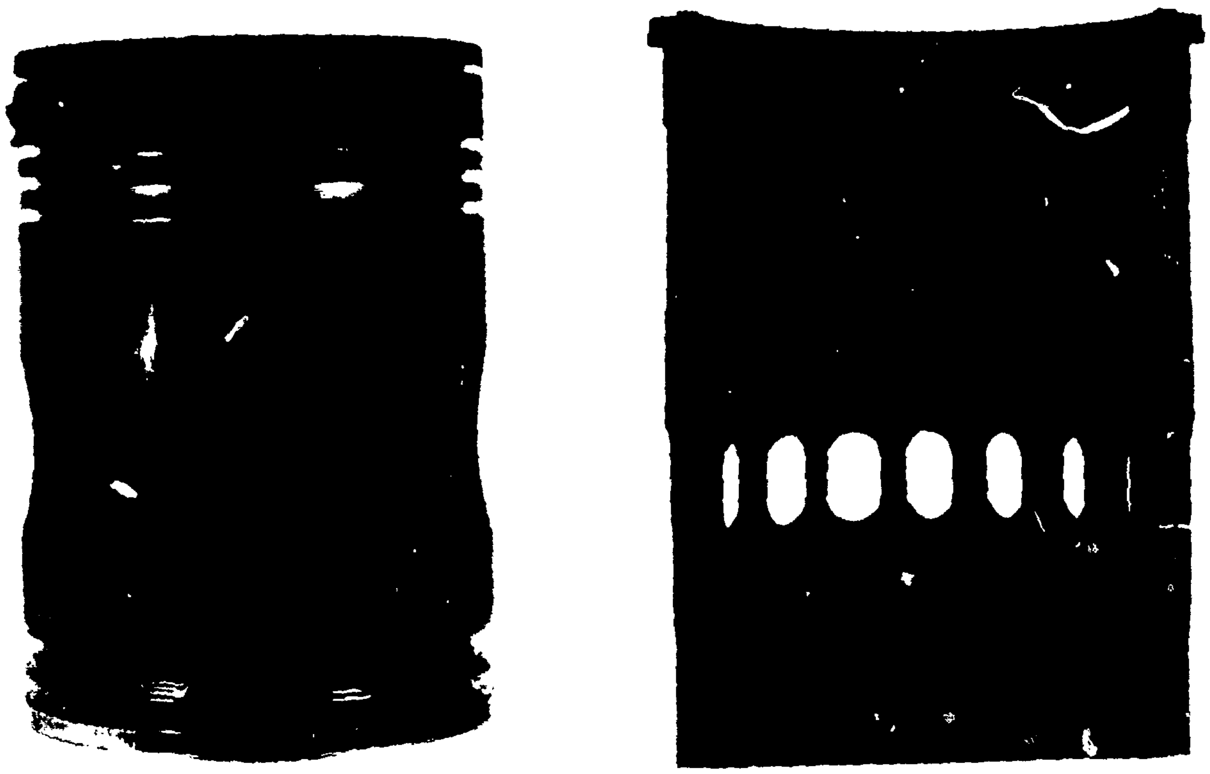
*Piston 1-Right had the lowest Weighted Total Deposits (WTD) rating.

CONDITION OF PISTON AND CYLINDER
6V-53T   TEST 8
Lubricant: AL-7172-L



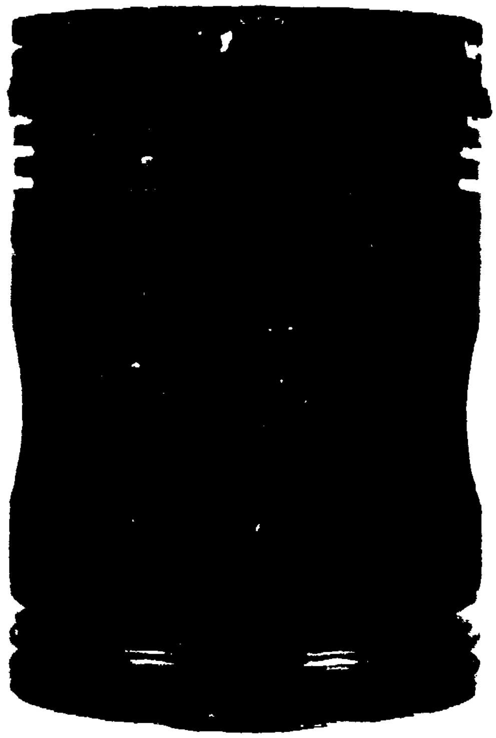
2 - Right Thrust

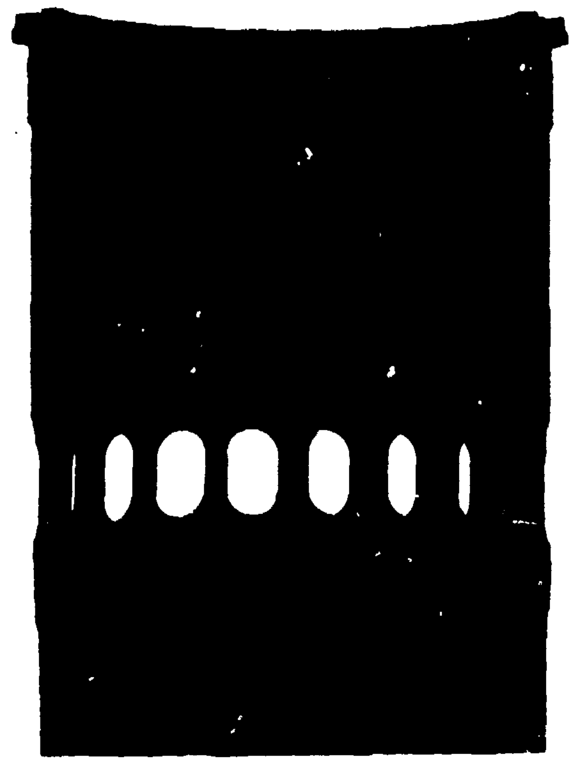
CONDITION OF PISTON AND CYLINDER
6V-53T   TEST 8
Lubricant: AL-7172-L



2 - Right Anti-Thrust

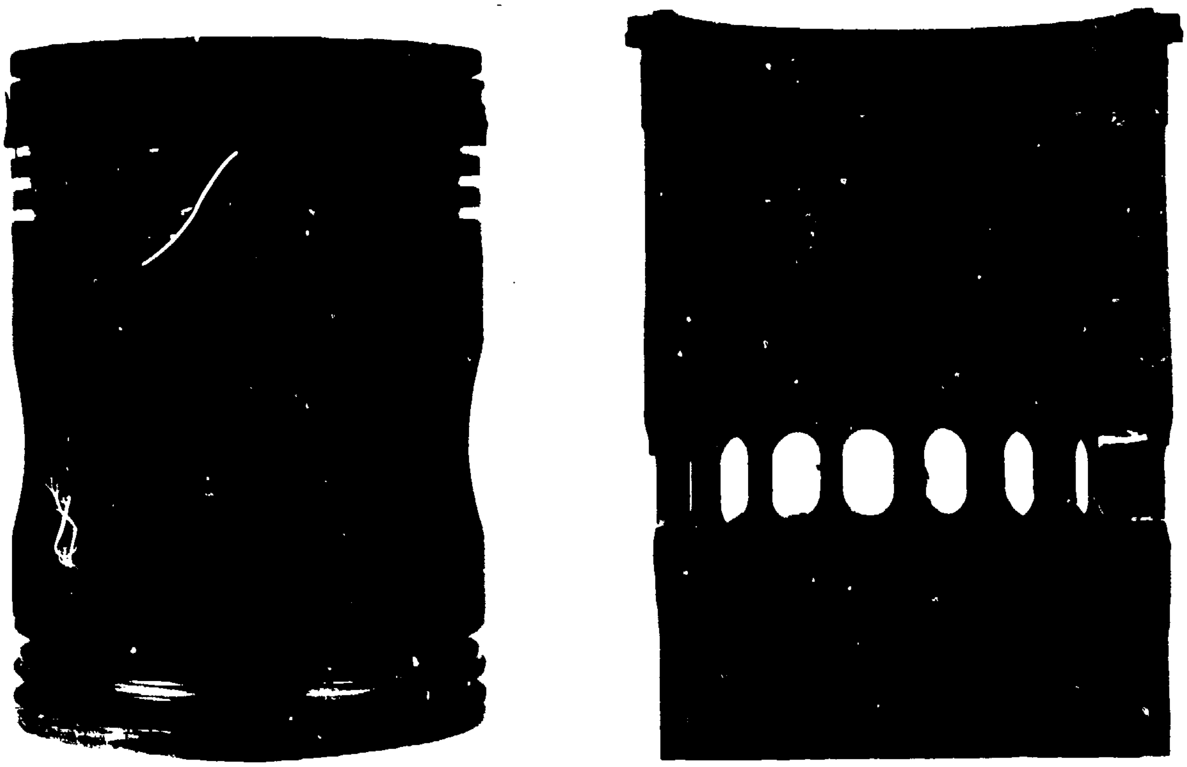
CONDITION OF PISTON AND CYLINDER
6V-53T   TEST 8
Lubricant: AL-7172-L





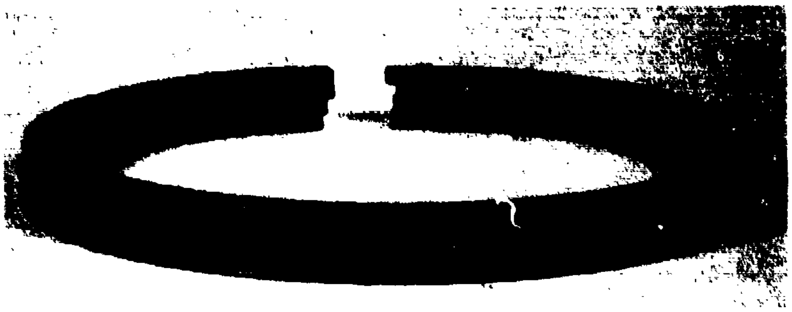
3 - Right Thrust

CONDITION OF PISTON AND CYLINDER
6V-53T TEST 8
Lubricant: AL-7172-L



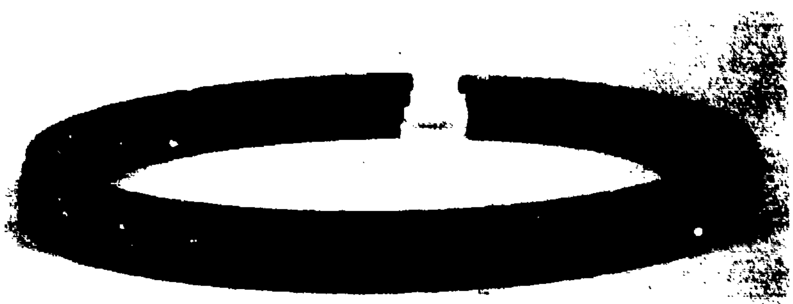
3 - Right Anti-Thrust

CONDITION OF PISTON RINGS
6V-53T TEST 8
Lubricant: AL-7172-L



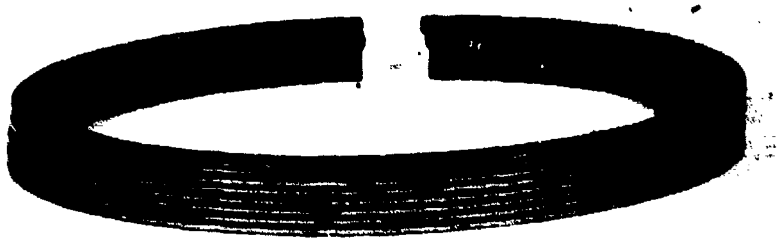
1 - Left

2 - Left



3 - Left

CONDITION OF PISTON RINGS
6V-53T TEST 8
Lubricant: AL-7172-L

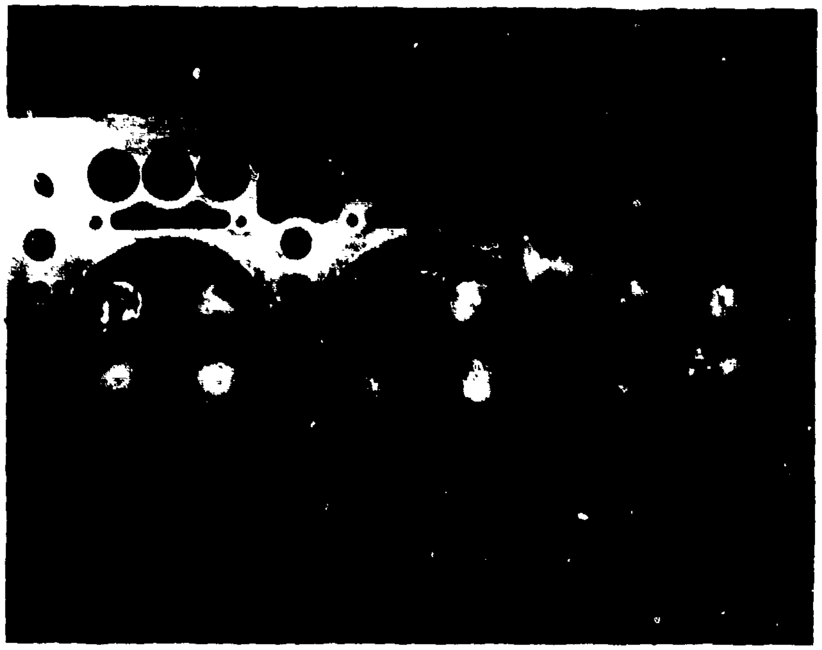


1 - Right

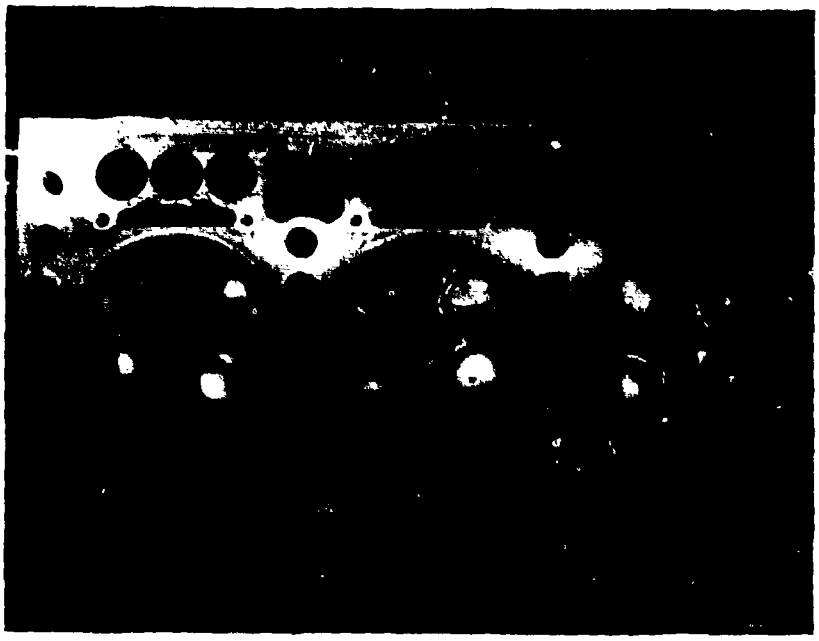
2 - Right

3 - Right

CONDITION OF CYLINDER HEADS
6V-53T TEST 8
Lubricant: AL-7172-L



3 - Left 2 - Left 1- Left



1 - Right 2 - Right 3 - Right

APPENDIX G

ENGINE-LUBRICANT COMPATIBILITY TEST #9
240-HOUR TRACKED-VEHICLE CYCLE
USING 6V-53T DIESEL ENGINE

ENGINE-LUBRICANT COMPATIBILITY TEST
240-HOUR TRACKED-VEHICLE CYCLE
USING 6V-53T DIESEL ENGINE

Test Lubricant: AL-9249-L
Test Fuel: Caterpillar 1-H
Engine Test Number: 9
Date Completed: 10 June 1980

Conducted by

U.S. Army Mobility Equipment Research and Development Command
Energy and Water Resources Laboratory
Ft. Belvoir, Virginia

by

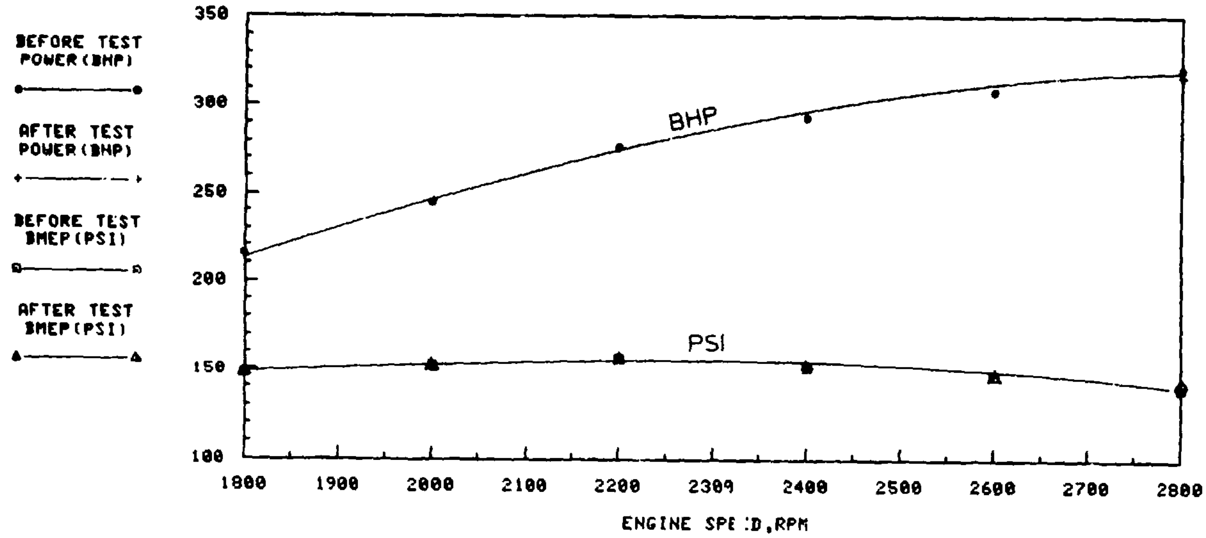
U.S. Army Fuels and Lubricants Research Laboratory
Southwest Research Institute
San Antonio, Texas 78284

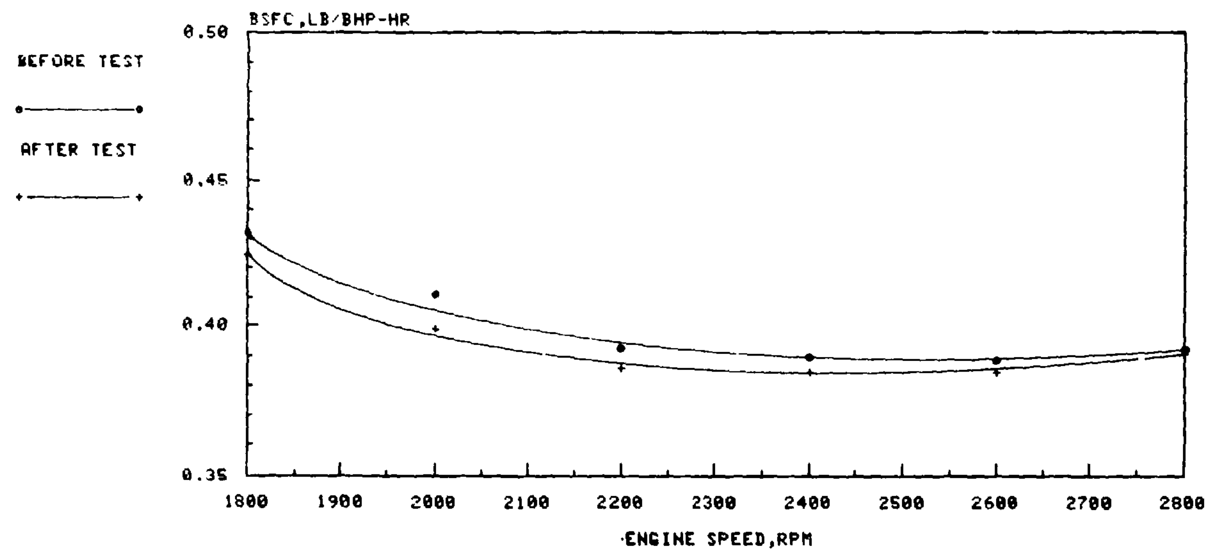
6V-53T
TEST 9
ENGINE REBUILD MEASUREMENTS
Model Number: 5063-5397
Serial Number: 6D-178671

	Min	Max	Avg	Specified Limits
Cylinder Block Bore				
Inside Diameter (bottom)	4.3570	4.3577	4.3572	4.3595 max
Out-of-Round	0.0000	0.0009	0.0003	0.0015 max
Taper	0.0000	0.0003	0.0002	0.0015 max
Cylinder Liners (installed)				
Inside Diameter	3.8755	3.8767	3.8760	3.8752-3.8767
Out-of-Round	0.0000	0.0008	0.0003	0.0020 max
Taper	0.0004	0.0010	0.0007	0.0010 max
Piston Diameter (at skirt)	3.8673	3.8678	3.8675	3.8669-3.3691
Piston Skirt to Cylinder Liner Clearance	0.0079	0.0092	0.0086	0.0061-0.0098
Compression Rings				
Gap (Fire)	0.0300	0.0350	0.0340	0.0200-0.0360
Gap (Others)	0.0200	0.0390	0.0300	0.0200-0.0360
Ring-to-Groove Clearance				
Top (Fire)	0.0030	0.0030	0.0030	0.0030-0.0060
No. 1	0.0070	0.0070	0.0070	0.0070-0.0100
No. 2 and 3	0.0050	0.0070	0.0060	0.0050-0.0080
Oil Control Rings				
Gap	0.0170	0.0200	0.0180	0.0100-0.0250
Ring-to-Groove Clearance	0.0020	0.0030	0.0020	0.0015-0.0055
Piston Pin				
Pin-to- Piston Bushing Clearance	0.0029	0.0031	0.0031	0.0025-0.0034
Pin-to- Conn. Rod Bushing Clearance	0.0013	0.0014	0.0014	0.0010-0.0019
Connecting Rod Bearing-to-Journal Clearance	0.0019	0.0022	0.0021	0.0011-0.0041
Main Bearing-to-Journal Clearance	Bearings not rebuilt or measured this test			0.0010-0.0040
Camshaft Bearing-to-shaft Clearance	Bearings not rebuilt or measured this test			0.0045-0.0060

6V-53T 240 HOUR TRACKED VEHICLE CYCLE

BEFORE AND AFTER TEST 9 PERFORMANCE DATA





6V-53T
240-HOUR TRACKED VEHICLE CYCLE ENDURANCE TEST
TEST 9
OPERATING CONDITIONS SUMMARY
Lubricant: AL-2949-L Fuel: Caterpillar 1-H

	Maximum Power Mode (2800 rpm)		Maximum Torque Mode (2200 rpm)	
	Mean	Standard Deviation*	Mean	Standard Deviation
Engine Speed, rpm	2802	2	2203	3
Torque, Ft-lb (N-m)	592(803)	3(4)	657(891)	3(4)
Fuel Consumption, lb/hr (kg/hr)	123.9(56.25)	0.7(0.32)	106.7(48.44)	0.5(0.23)
Observed Power, Bhp (kW)	316(236)	2(1)	276(206)	1(1)
BSFC, lb/Bhp-hr (g/kW-hr)	0.392(238)	0.001(1)	0.387(235)	0.001(1)
Temperatures, °F (°C)				
Exhaust before turbo	992(533)	16(9)	1027(289)	15(8)
Exhaust after turbo	832(444)	8(4)	859(459)	8(4)
Water Jacket Inlet	158(70)	4(2)	155(68)	1(1)
Water Jacket Outlet	172(78)	3(2)	170(77)	1(1)
Oil Sump	238(114)	3(2)	227(108)	1(1)
Fuel at Filter	92(33)	1(1)	89(32)	1(1)
Inlet Air (at compressor)	93(34)	5(3)	93(34)	5(3)
Airbox	292(144)	5(3)	239(115)	1(1)
Pressures				
Exhaust before turbo, psi (kPa)	15.1(104)	0.2(1)	10.1(70)	0.1(1)
Exhaust after turbo, in. Hg (kPa)	2.9(9.8)	0.1(0.3)	1.9(6.4)	0.1(0.3)
Compressor Discharge, psi (kPa)	14.8(102)	0.2(1)	11.1(76)	0.2(1)
Blower Discharge, psi (kPa)	20.0(138)	0.2(1)	12.2(84)	0.2(1)
Oil Gallery, psi (kPa)	47(324)	1(7)	43(296)	1(7)
Intake Vacuum, in. H_2O (kPa)	7.8(1.94)	0.1(0.02)	4.7(1.17)	0.1(0.02)
Ambient Conditions (both modes of operation)				
Dry Bulb Temperature, °F (°C)	82(28)	4(3)		
Wet Bulb Temperature, °F (°C)	79(26)	3(2)		
Barometric Pressure, in. Hg (kPa)	29.14(98.78)	0.20(0.68)		

*68% of the values for a given variable occur within ± 1 standard deviation of the mean; 95% occur within ± 2 standard deviations.

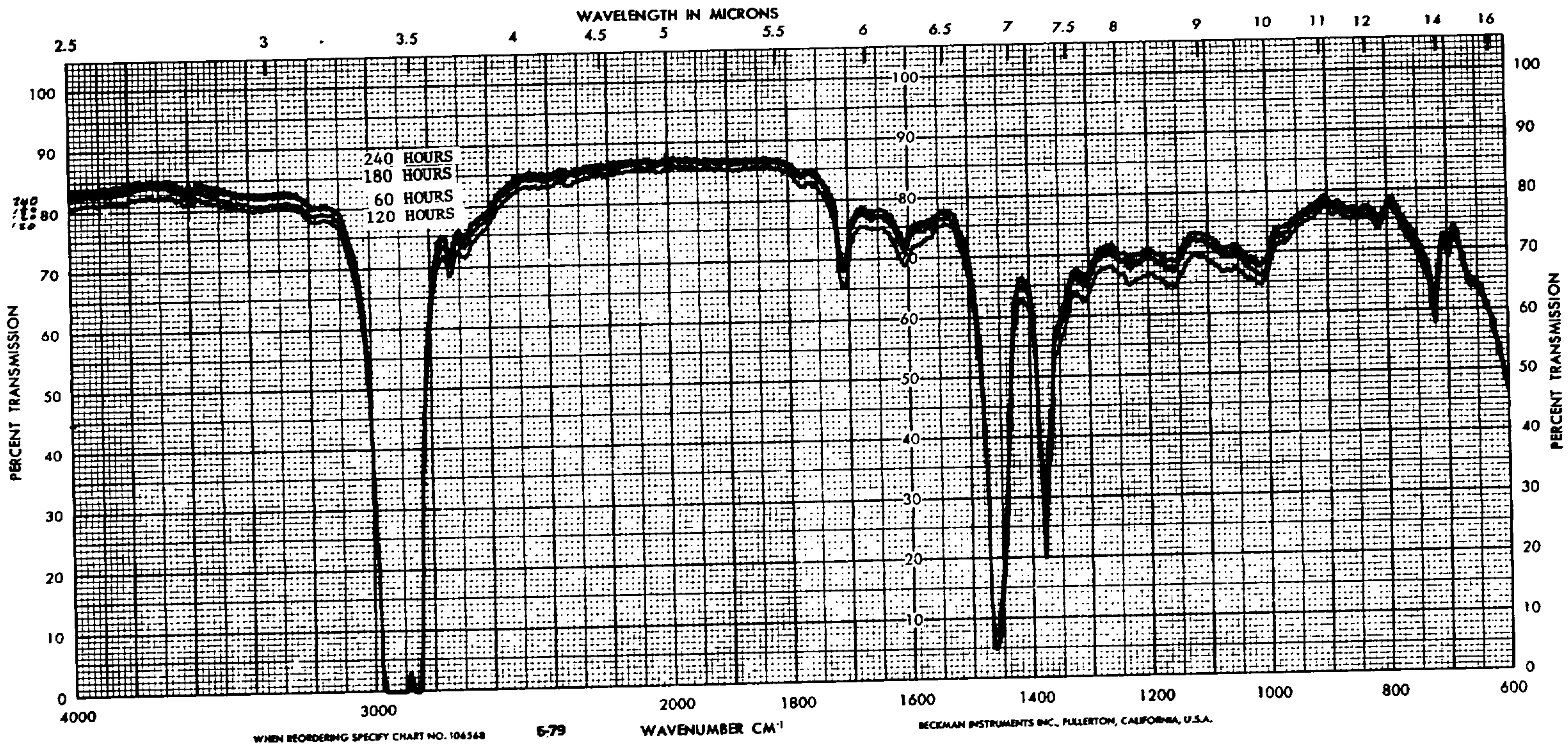
6V-53T
TEST 9
LUBRICANT ANALYSIS

Lubricant: AL-9249-L

	ASTM Test Method	Test time, Hours: 0	60	120	180	240
Apparent Viscosity at -29°C (-20°F), cP	D 2602	23000	43000	52000	30500	43000
Apparent Viscosity at -18°C (0°F), cP	D 2602	3900	6800	8700	6600	7800
Kinematic Viscosity at 40°C (104°F), cSt	D 445	96.7	120.0	127.5	118.3	122.1
Kinematic Viscosity at 100°C (212°F), cSt	D 445	13.9	15.5	16.2	15.6	15.5
Viscosity Index	D 2270	146	136	135	138	138
Total Acid Number, mg KOH/g	D 664	3.3	3.5	3.9	3.7	3.8
Total Base Number, mg KOH/g	D 664	6.5	4.7	4.4	4.9	4.6
Pentane B Insolubles, wt%	D 893	0.0	0.04	0.08	0.06	0.08
Toluene B Insolubles, wt%	D 893	0.0	0.04	0.08	0.06	0.08
Flash Point, °C (°F)	D 92	209(408)	218(424)	218(424)	218(424)	220(428)
Density at 16°C (60°F), gm/ml	D 287	0.88	0.88	0.89	0.89	0.89
Carbon Residue, wt%	D 524	1.2	1.7	1.9	1.8	1.9
Sulfated Ash, wt%	D 874	1.0	1.1	1.0	1.0	1.3

INFRARED SPECTRUM
6V-53T
TEST 9

Lubricant: AL-9294-L



6V-53T
TEST 9
Lubricant: AL-9249-L

TOTAL CONSUMPTION AND WEAR METALS BY XRF

Test Time, Hours	Total Oil Consumed, lb (kg)	Wear Metals,+ ppm Fe Fe	Cu
20	11.2(5.1)	37	ND*
30	19.4(8.8)	-++	-
40	22.6(10.3)	49	ND
50.5	33.1(15.0)	-	-
60	38.5(17.5)	57	ND
68	45.7(20.7)	-	-
80	52.7(23.9)	58	ND
93	59.5(27.0)	-	-
100	66.5(30.2)	55	ND
110	73.6(33.4)	-	-
120	86.0(39.0)	59	ND
130	93.4(42.3)	-	-
140	96.8(43.9)	28	ND
150	104.3(47.3)	-	-
160	110.1(49.9)	46	ND
170	117.6(53.3)	-	-
180	123.1(55.9)	54	ND
190	127.7(57.9)	-	-
200	136.3(61.8)	54	ND
213	143.7(65.2)	-	-
220	150.1(68.1)	71	10
233	157.1(71.2)	-	-
240	170.8(77.5)	59	ND

Average Oil Consumption Rate: 0.71 lb/hr (0.32 kg/hr)

+No other wear metals detected.
++Oil samples for wear metal analysis not taken at these times.
*Not detected.

6V-53T
TEST 9
Lubricant: AL-9249-L

WEAR MEASUREMENTS

Cylinder Liner Bore Diameter Change*

	Cylinder Number					
	1L		2L		3L	
	T-AT**	F-B	T-AT	F-B	T-AT	F-B
Top	+0.0001	-0.0002	+0.0004	-0.0002	+0.0004	-0.0007
Middle	+0.0006	-0.0001	+0.0004	+0.0003	+0.0007	+0.0008
Bottom	+0.0001	+0.0004	+0.0004	+0.0002	-0.0001	+0.0006

	Cylinder Number					
	1R		2R		3R	
	T-AT	F-B	T-AT	F-B	T-AT	F-B
Top	+0.0002	+0.0002	+0.0003	-0.0003	+0.0006	-0.0001
Middle	+0.0007	-0.0001	+0.0007	+0.0006	+0.0006	+0.0002
Bottom	+0.0003	+0.0004	+0.0003	-0.0001	+0.0003	+0.0005

	Average Change	
	T-AT	F-B
Top	+0.0003	-0.0005
Middle	+0.0006	+0.0003
Bottom	+0.0002	+0.0003

Overall Average Change: +0.0002 inch

Piston Ring End Gap Change

Ring Number	1L	2L	3L	1R	2R	3R	Average Change
1	+0.004	+0.001	+0.002	+0.004	+0.002	-0.003	+0.002
2	0.000	+0.001	+0.002	+0.005	+0.003	+0.001	+0.002
3	0.000	+0.001	+0.001	+0.003	+0.002	+0.001	+0.001
4	[illegible].002	+0.003	+0.001	+0.003	0.000	+0.003	+0.002
5	+0.009	+0.008	+0.010	+0.010	+0.009	Broke	+0.009
6	+0.005	+0.008	+0.004	+0.008	+0.005	+0.004	+0.006
7	+0.008	+0.004	+0.008	+0.005	+0.006	+0.006	+0.006

Overall Average Change: +0.004 in.

*All dimensions given are in inches.

**T-AT = Thrust-Antithrust Direction; F-B = Front-Back Direction.

6V-53T
TEST 9
Lubricant: AL-9249-L

POST TEST ENGINE CONDITION AND DEPOSITS

A. Cylinder Liner

	Cylinder Number						
	1L	2L	3L	1R	2R	3R	Average
Intake Port Plugging, % restriction	<1	<1	<1	<1	<1	<1	<1
Liner Scuffing, % Area							
Thrust	5	5	5	10	60	5	15
Anti-Thrust	2	2	5	10	20	5	7
Total	4	4	5	10	40	5	11
						Overall:	11
Liner Glazed, % Area	15	10	15	20	10	10	13
Liner Lacquer, % Area	85	90	85	80	90	90	87

B. Pistons

	1L	2L	3L	1R	2R	3R	Average
Ring Face Burn, % Area							
Fire Ring	1	3	1	5	20	1	5
No. 1	0	2	1	45	75	55	30
No. 2	0	0	0	60	90	25	29
No. 3	0	0	0	35	40	5	13
						Overall:	19
Ring Groove Carbon, % Filling							
Fire Ring	15	20	15	25	30	25	22
No. 1	70	75	85	90	85	95	83
No. 2	0	5	0	5	5	0	3
No. 3	0	0	0	0	0	0	0
						Overall:	27
Piston Skirt Deposit Rating (Demerit)**							
Thrust	5.0 LS*	5.5 LS	5.0 LPM,LS	5.2 LSC,LS	5.5 L to MSC	5.5 N	5.3
Anti-Thrust	5.0 LS	5.2 LS	5.5 LS	5.0 LSC	5.0 LS	5.5 LS	5.2
						Overall:	5.3

*L = Light, S = Scratches, PM = Plating Melted, N = Normal, SC = Scuffing
**0 = least, 9 = most

6V-53T
TEST 9
Lubricant: AL-9249-L

POST TEST ENGINE CONDITION AND DEPOSITS

B. Pistons (continued)

	Cylinder Number						
	1L	2L	3L	1R	2R	3R	Average
Oil Control Ring Grooves (Demerit)							
Upper	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lower	4.0	4.0	4.0	4.0	4.0	4.0	4.0
						Overall:	4.0
Piston Groove Inside Diameter, % Ring Supporting Carbon							
No. 1	0	0	0	0	0	0	0
No. 2	53	99	19	48	56	93	61
						Overall:	31
Piston WTD* Rating	319	369	351	352	353	350	349
Ring Sticking							
No. 1	5%-P**	F	S	F	F	F	
No. 2	F	F	S	F	F	F	
No. 3	F	F	F	F	F	F	
No. 4	F	F	F	F	F	F	
Piston Oil Drain Holes	<——— 100% OPEN ———>						

C. Exhaust Valves

	1L	2L	3L	1R	2R	3R
Deposits						
Head	<—— AHC+ to soot ——>					
Face	<—— 1/4 AHC to No. 9++ lacquer —>					
Tulip	<—— AHC to No. 9 lacquer ——>					
Stem	<—— 1/4 AHC to clean ——>					
Surface Condition						
Freeness in Guide	F	F	F	F	F	F
Head	N	N	N	N	N	N
Face	<— light pitting with some leakage —>					
Seat	<——— light pitting ———>					
Stem	N	N	N	N	N	N
Tip	N	N	N	N	N	N

*CRC Weighted Total Deposits (0 = least, 900 = most)
**P = Pinched, F = Free, S = Stuck
+HC = Hard Carbon; the number-letter prefix indicates carbon depth with 1/4A = least to J = most.
++ = The higher the number, the darker the lacquer. (0 - lightest, 9 = darkest

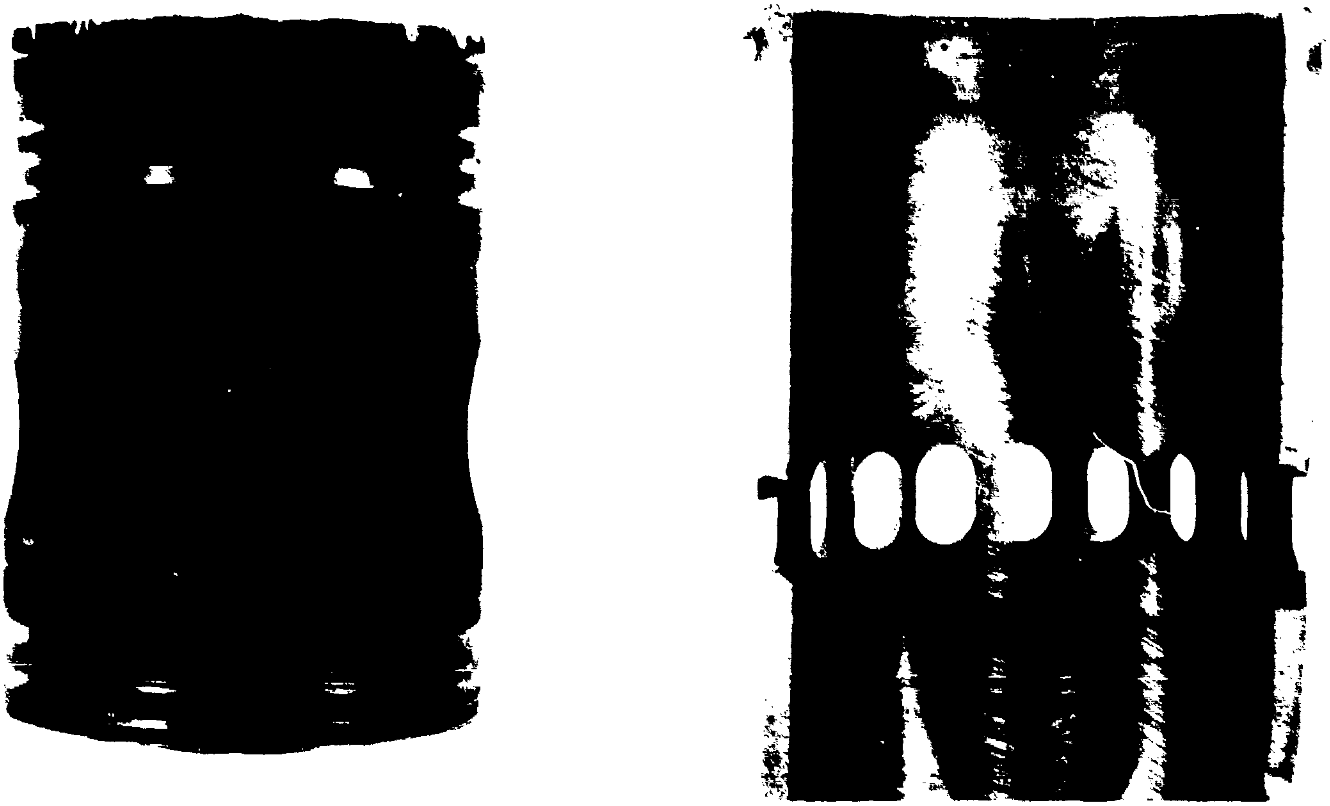
6V-53T
TEST 9
Lubricant: AL-9249-L

POST TEST ENGINE CONDITION AND DEPOSITS

C. Other Ratings

	Cylinder Number						
	1L	2L	3L	1R	2R	3R	Average
Tappets, Cams, Rocker Arms							
Tappet Deposit	< clean >						
Tappet Surface Condition	< normal >						
Cam Lobes	< normal >						
Rocker Arms							
Tip	< normal >						
Bushing	< normal >						
Shaft	< normal >						
Bearing Surface Condition							
Main Bearings and Main Journals	#1 and #2 main bearings and journals inspected and found to be in excellent condition						
Rod Bearings	< normal >						
Rod Journals	< normal >						
Piston Pin	lt. bluing	< normal >					
Pin Bushing	< some wear on all >						
Combustion Chamber Deposits							
(AHC)	85%	80%	80%	90%	85%	80%	83%
(1/4 AHC)	15%	20%	20%	10%	15%	20%	17%
Valve Covers, Cylinder Head Decks, and Oil Pan	< clean >						

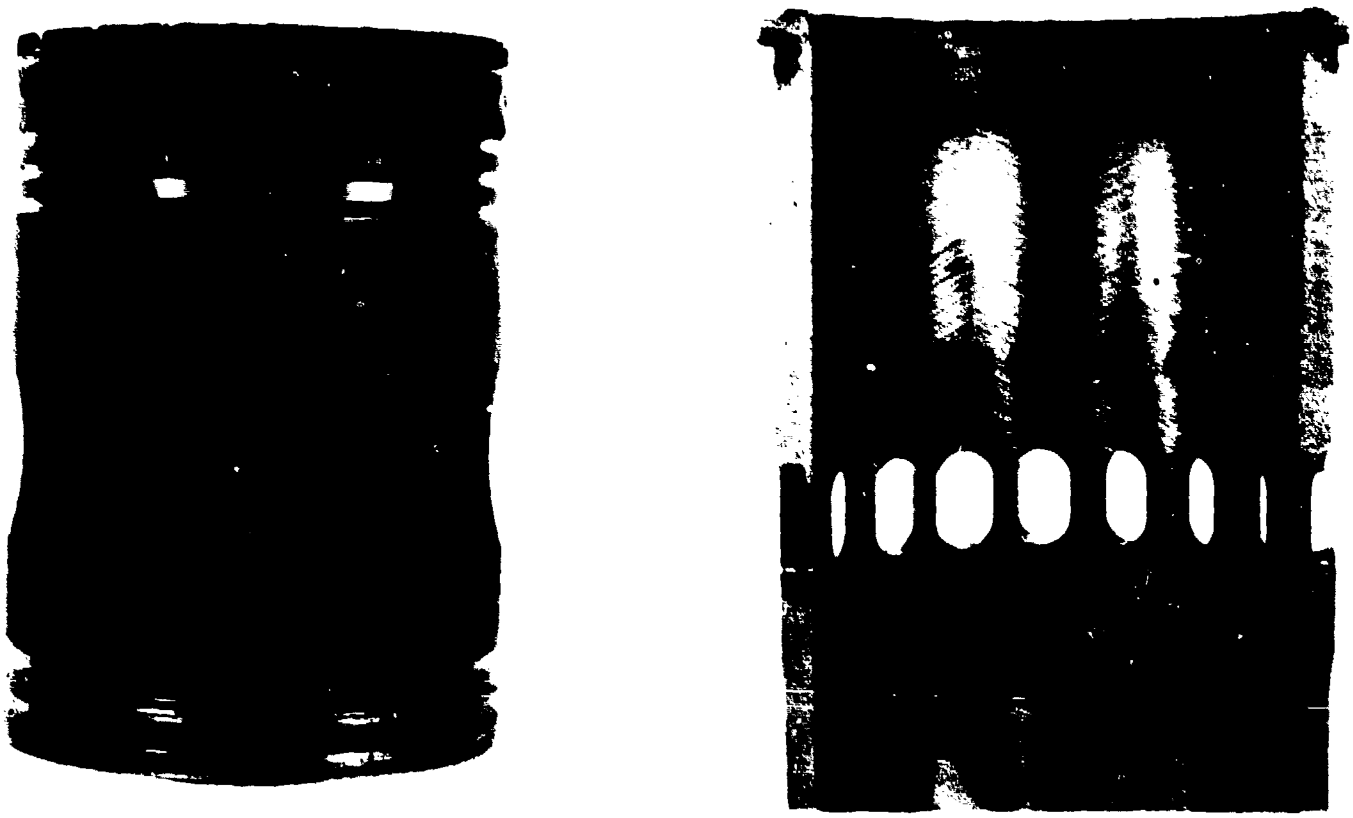
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 9
Lubricant: AL-9249-L



1-Left Thrust*

*Cylinders 1-Left and 2-Left had the least scuffing
Piston 1-Left had the lowest Weighted Total Deposits (WTD) rating

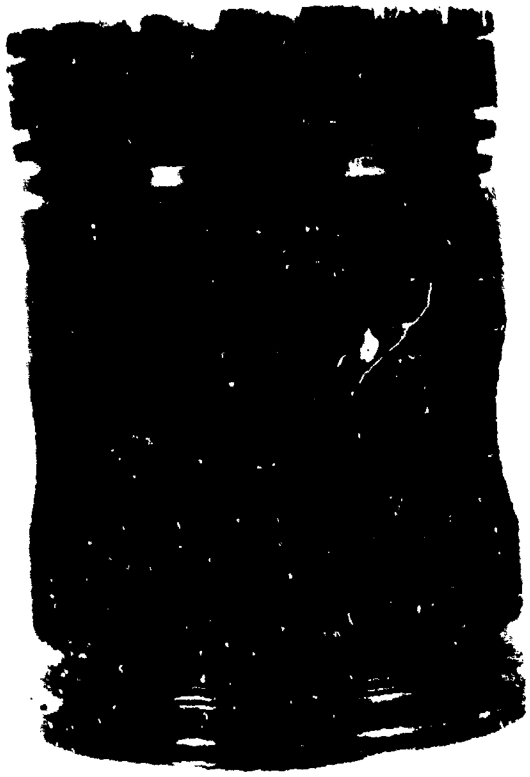
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 9
Lubricant: AL-9249-L

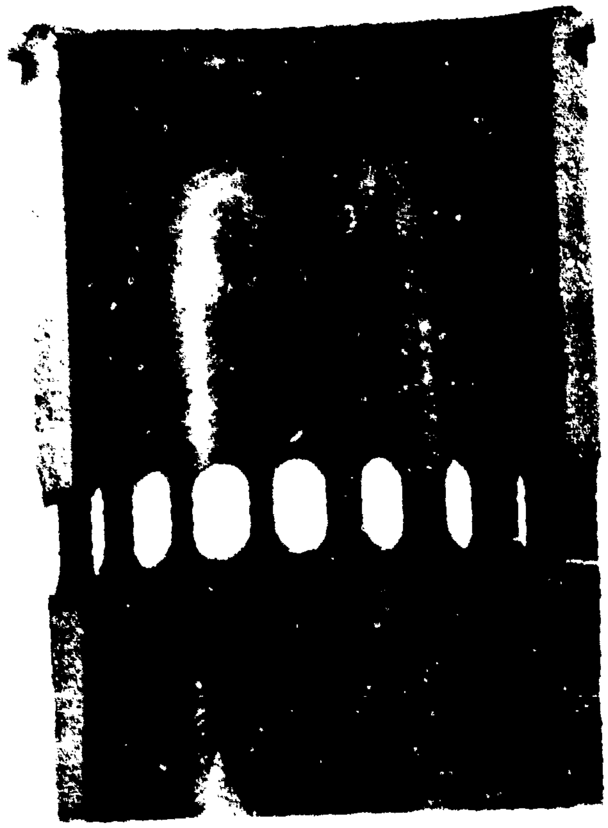


1-Left Anti-Thrust*

*Cylinders 1-Left and 2-Left had the least scuffing
Pistons 1-Left had the lowest Weighted Total Deposits (WTD) rating

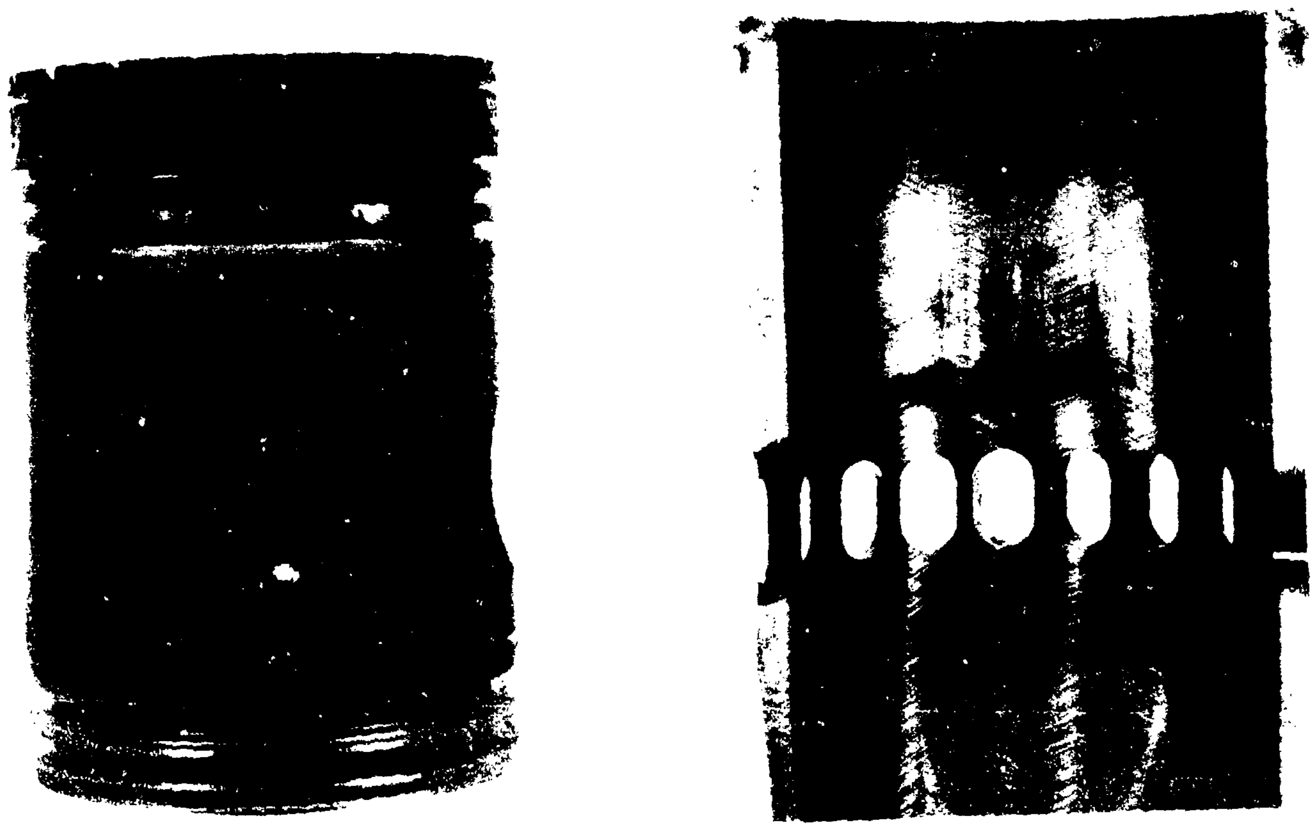
CONDITIONS OF PISTON AND CYLINDER
6V-53T TEST 9
Lubricant: AL-9249-L





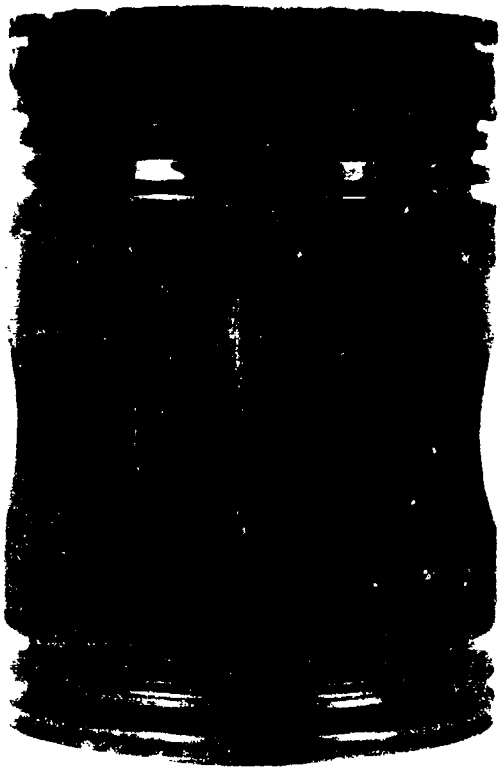
2-Left Thrust

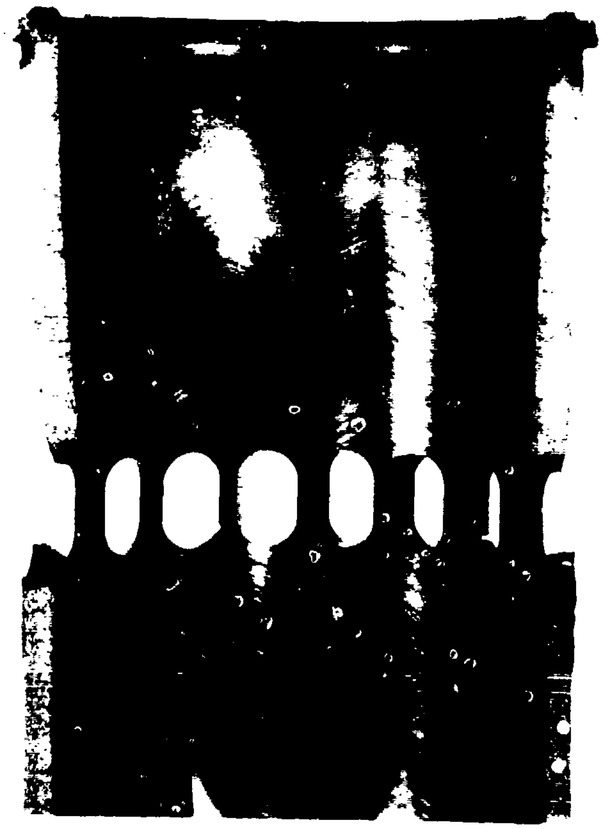
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 9
Lubricant: AL-9249-L



2-Left Anti-Thrust

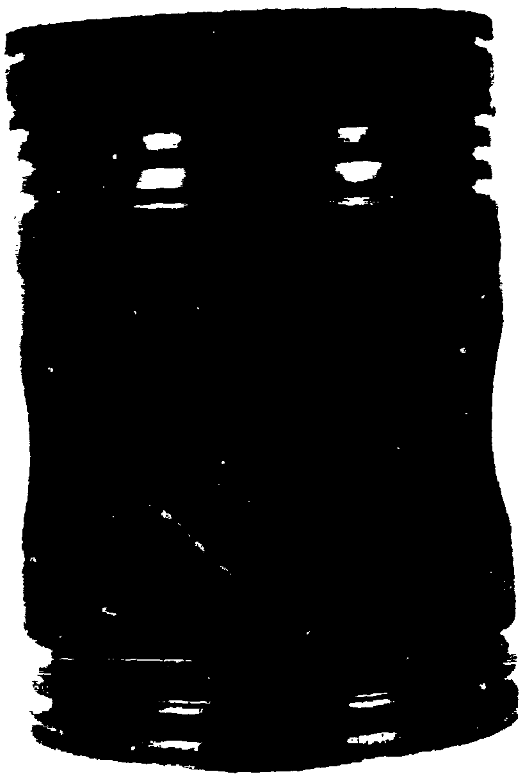
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 9
Lubricant: AL-9249-L

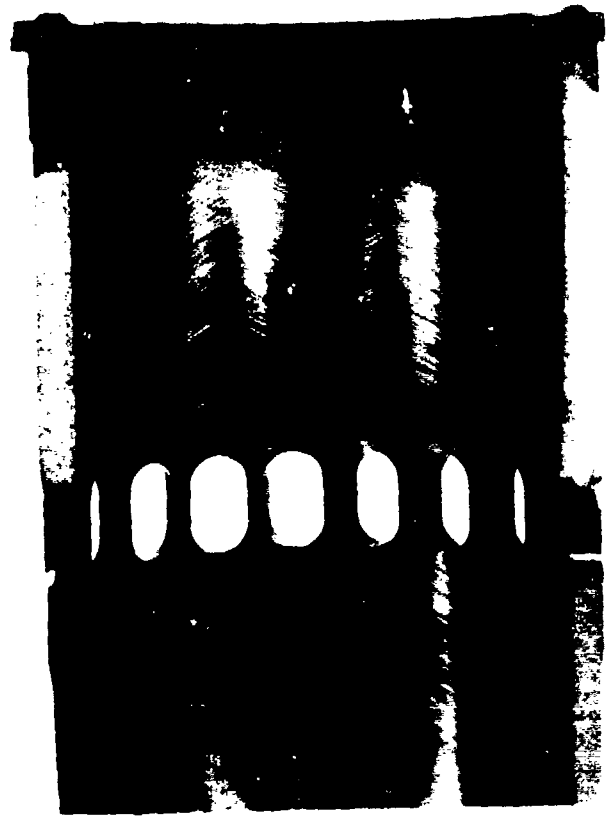




3-Left Thrust

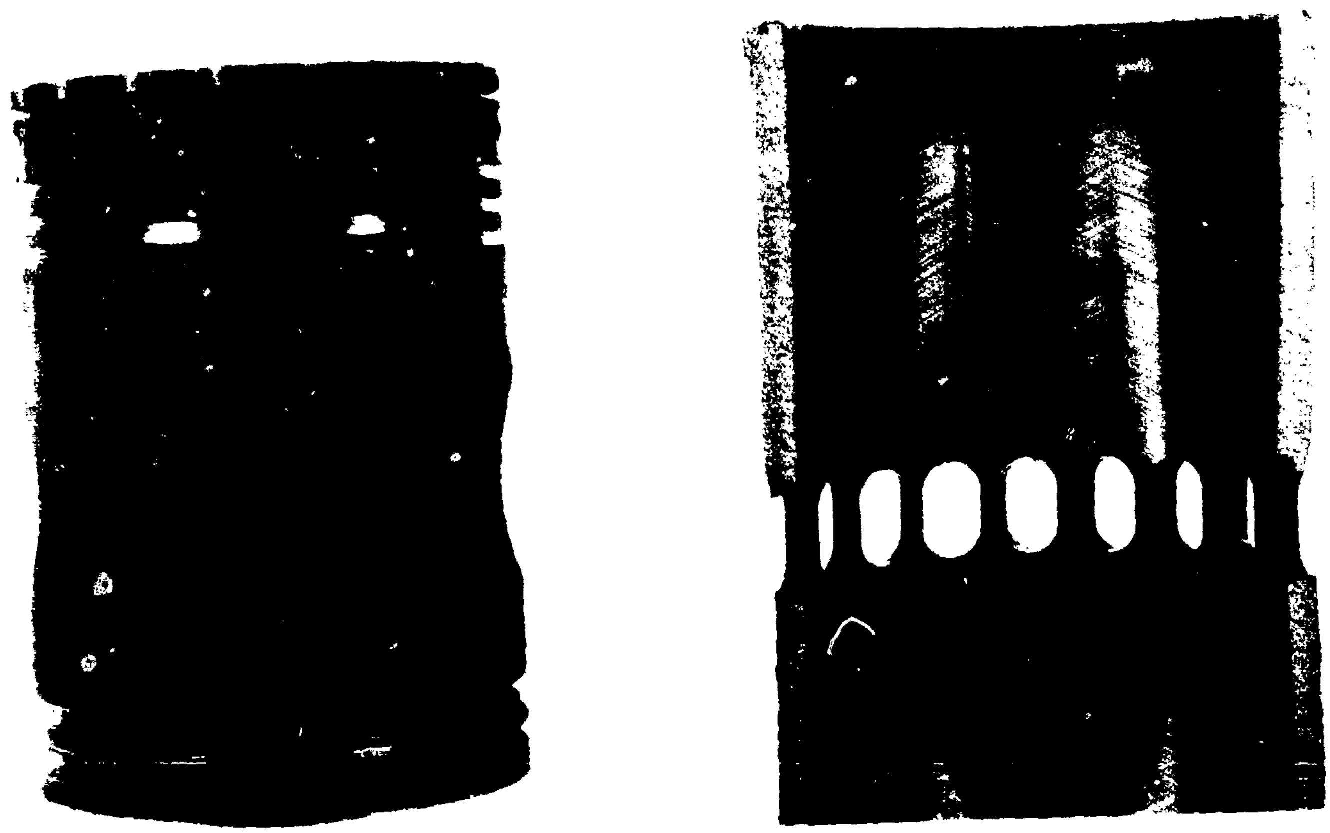
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 9
Lubricant: AL-9249-L





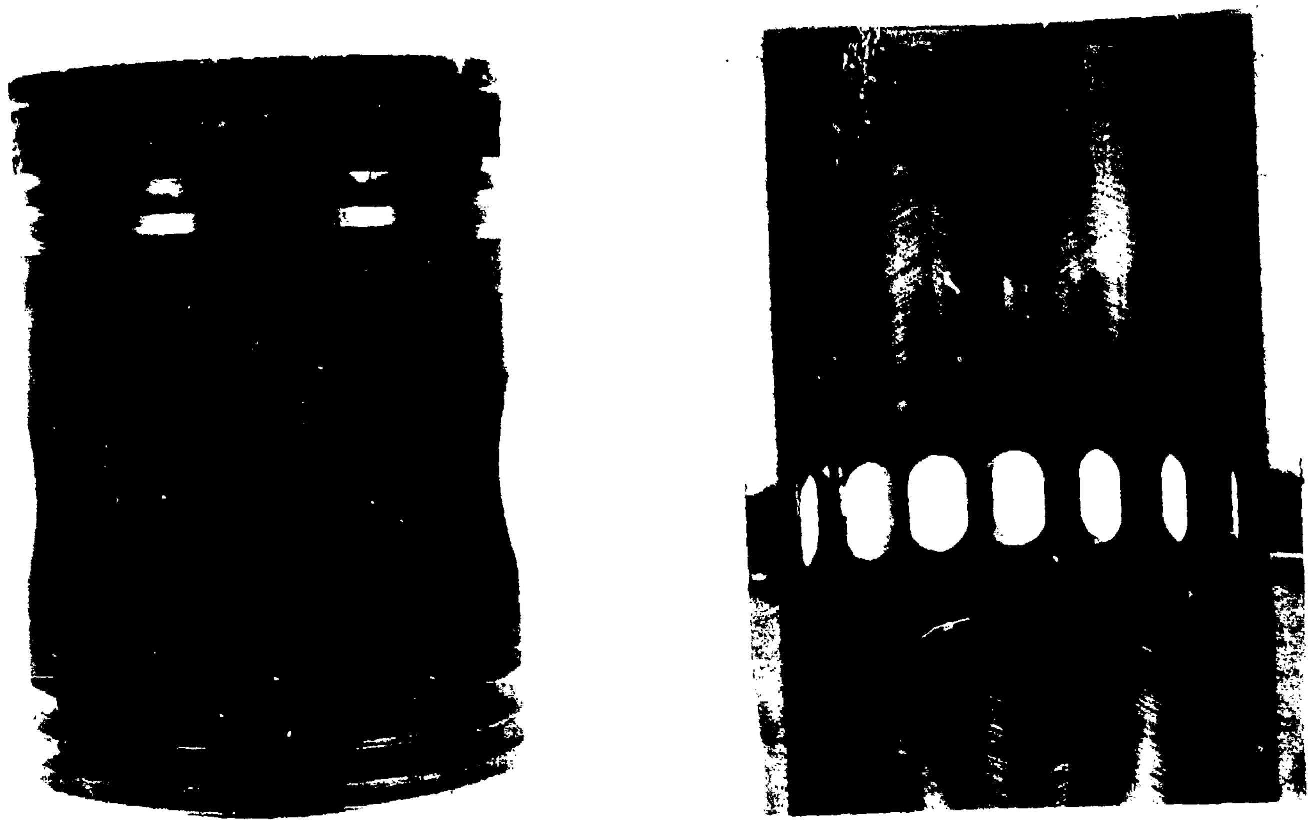
3-Left Anti-Thrust

CONDITION OF PISTON AND CYLINDER
6V-53T TEST 9
Lubricant: AL-9249-L



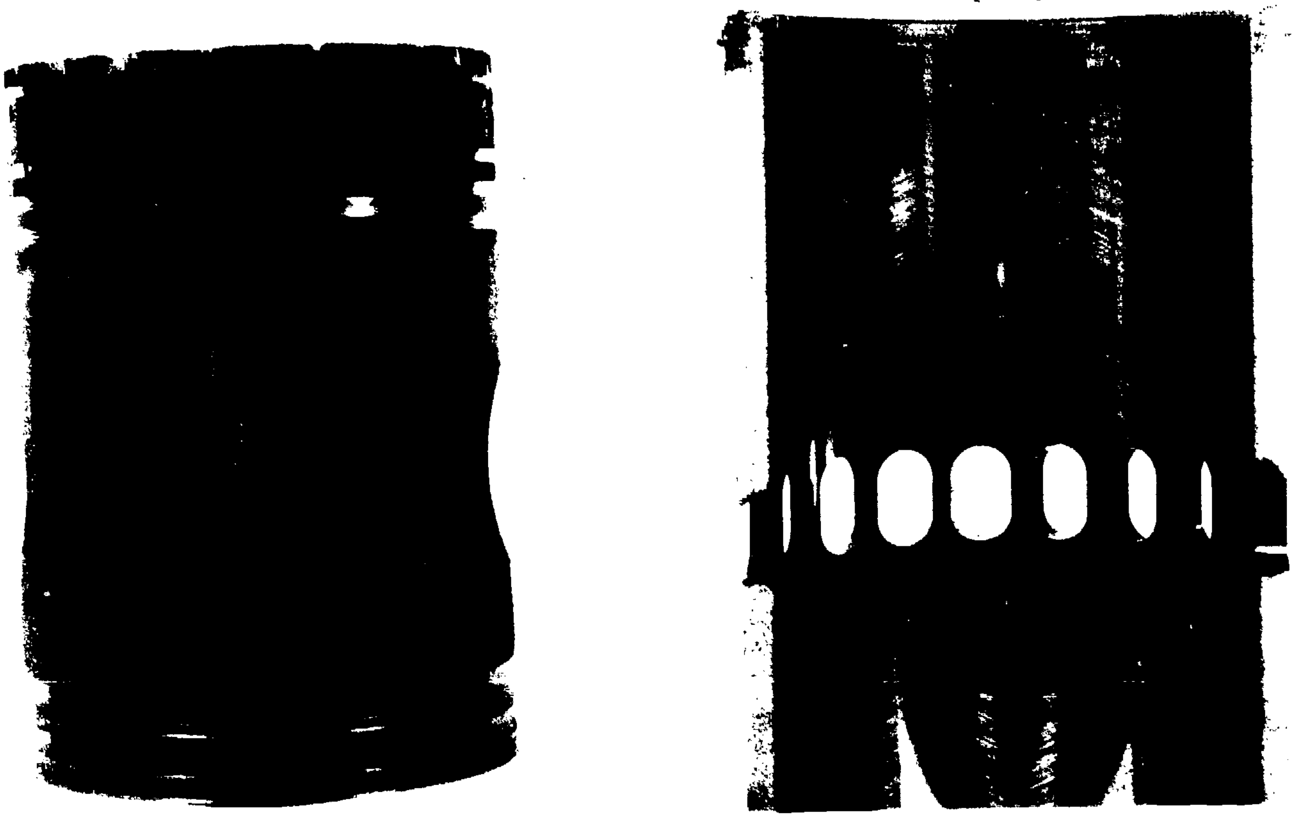
1-Right Thrust

CONDITION OF PISTON AND CYLINDER
6V-63T TEST 9
Lubricant: AL-9249-L



1-Right Anti-Thrust

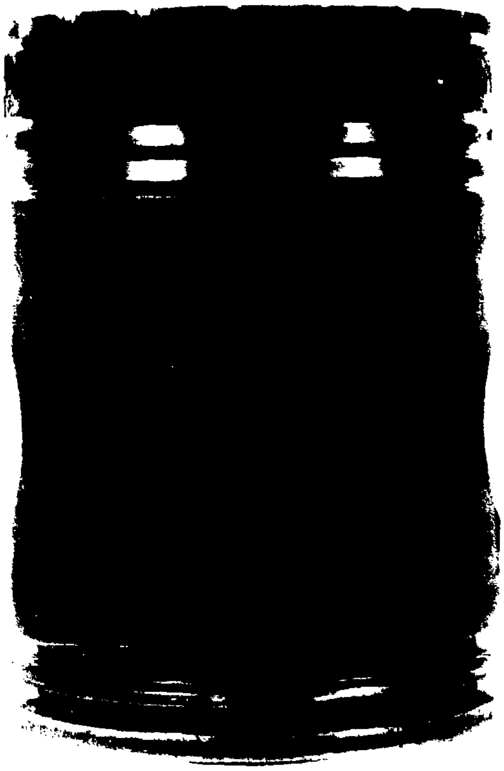
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 9
Lubricant: AL-9249-L

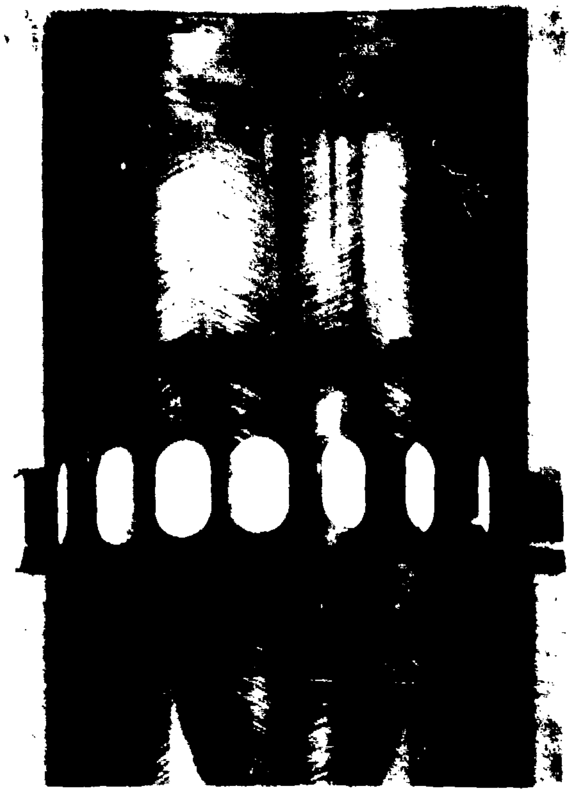


2-Right Thrust*

*Cylinder 2-Right had the most scuffing
Piston 2-Right had the highest Weighted Total Deposits (WTD) rating

CONDITION OF PISTON AND CYLINDER
6V-53T TEST 9
Lubricant: AL-9249-L

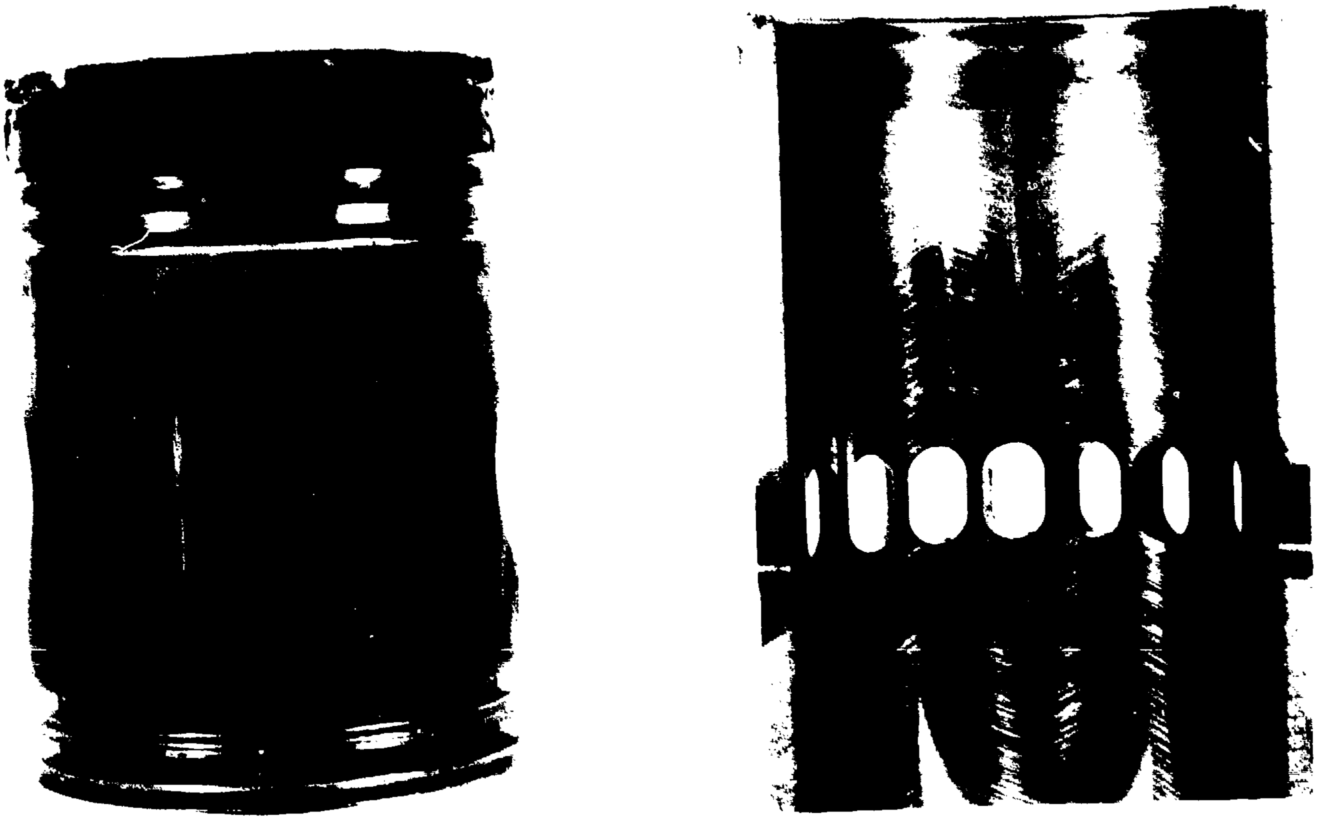




2-Right Anti-Thrust*

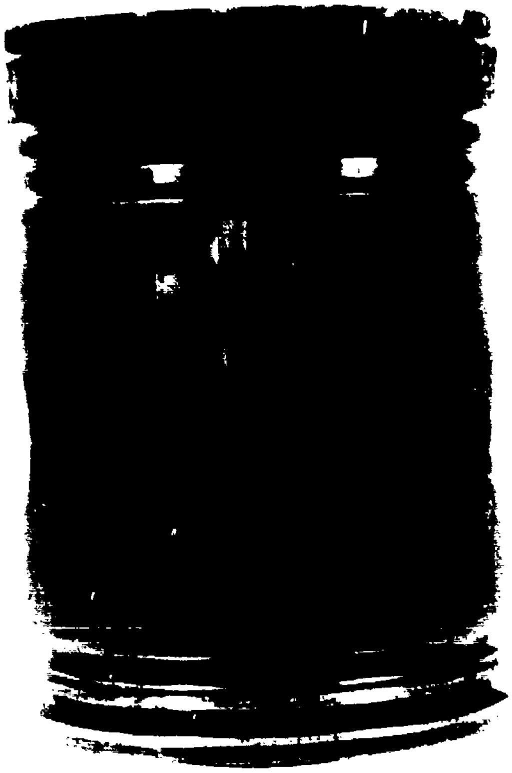
*Cylinder 2-Right had the most scuffing
Piston 2-Right had the highest Weighted Total Deposits (WTD) rating

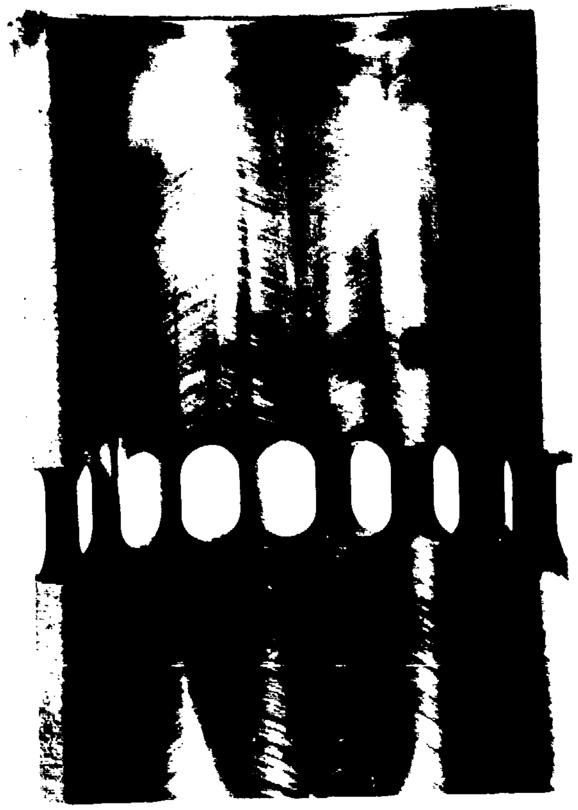
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 9
Lubricant: AL-9249-L



3-Right Thrust

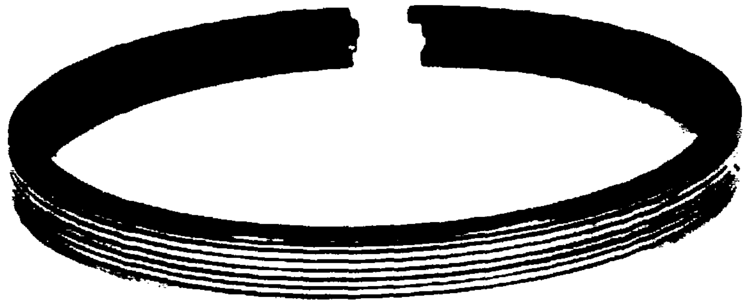
CONDITION OF PISTON AND CYLINDER
6V-53T TEST 9
Lubricant: AL-9249-L



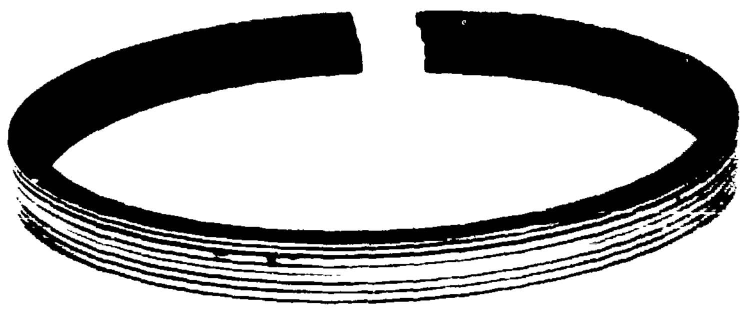


3-Right Anti-Thrust

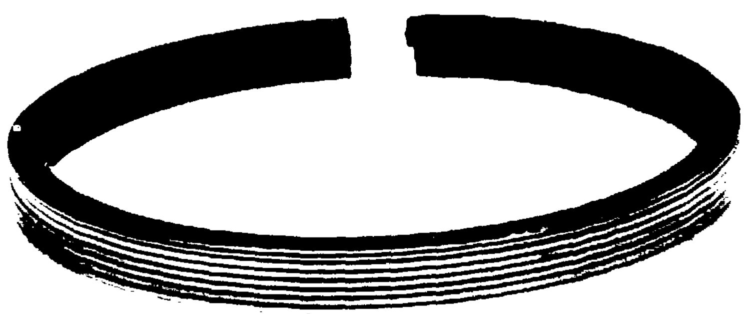
CONDITION OF PISTON RINGS
6V-53T TEST 9
Lubricant: AL-9249-L



1-Left



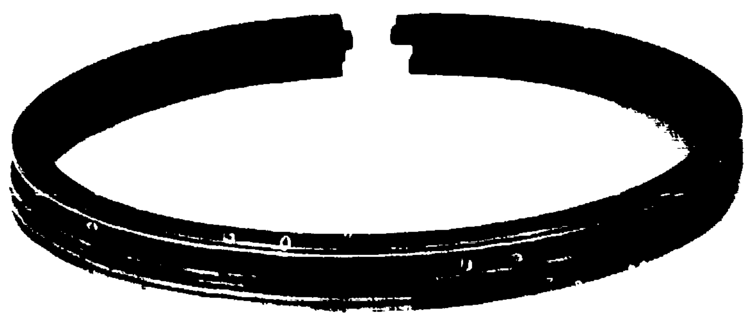
2-Left



3-Left

CONDITION OF PISTON RINGS
6V-53T TEST 9
Lubricant: AL-9249-L

1-Right



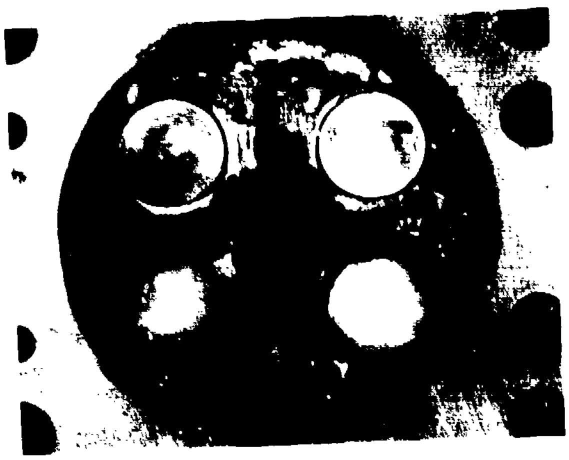
2-Right

3-Right

CONDITION OF CYLINDER HEADS
6V-53T TEST 9
Lubricant: AL-9249-L

1-Left

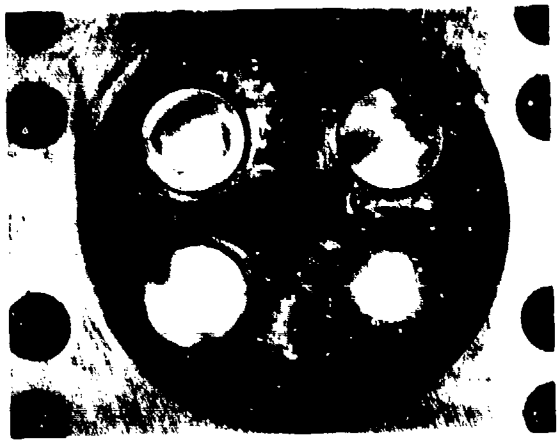
2-Left



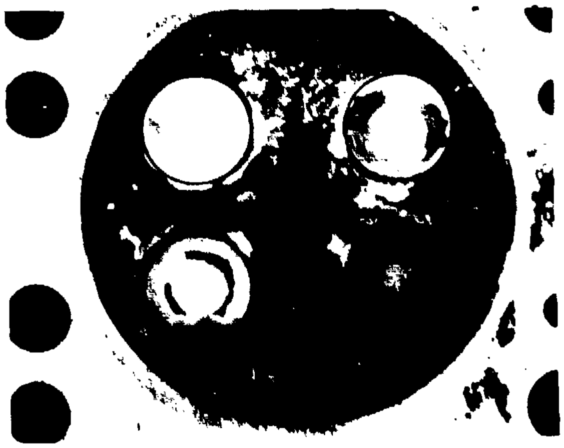
3-Left

CONDITION OF CYLINDER HEADS
6V-53T TEST 9
Lubricant: AL-9249-L

1-Right



2-Right



3-Right

APPENDIX H

ENGINE-LUBRICANT COMPATIBILITY TEST #1

210-HOUR WHEELED-VEHICLE CYCLE

USING LD 465 DIESEL ENGINE

ENGINE-LUBRICANT COMPATIBILITY TEST
210-HOUR WHEELED-VEHICLE CYCLE
USING LD 465 DIESEL ENGINE

Test Lubricant: AL-6855-L
Test Fuel: AL-7791-F
Engine Test Number: 1
Date Completed: 15 December 1978

Conducted for

U.S. Army Mobility Equipment Research and Development Command
Energy and Water Resources Laboratory
Fort Belvoir, Virginia

by

U.S. Army Fuels & Lubricants Research Laboratory
Southwest Research Institute
San Antonio, Texas 78284

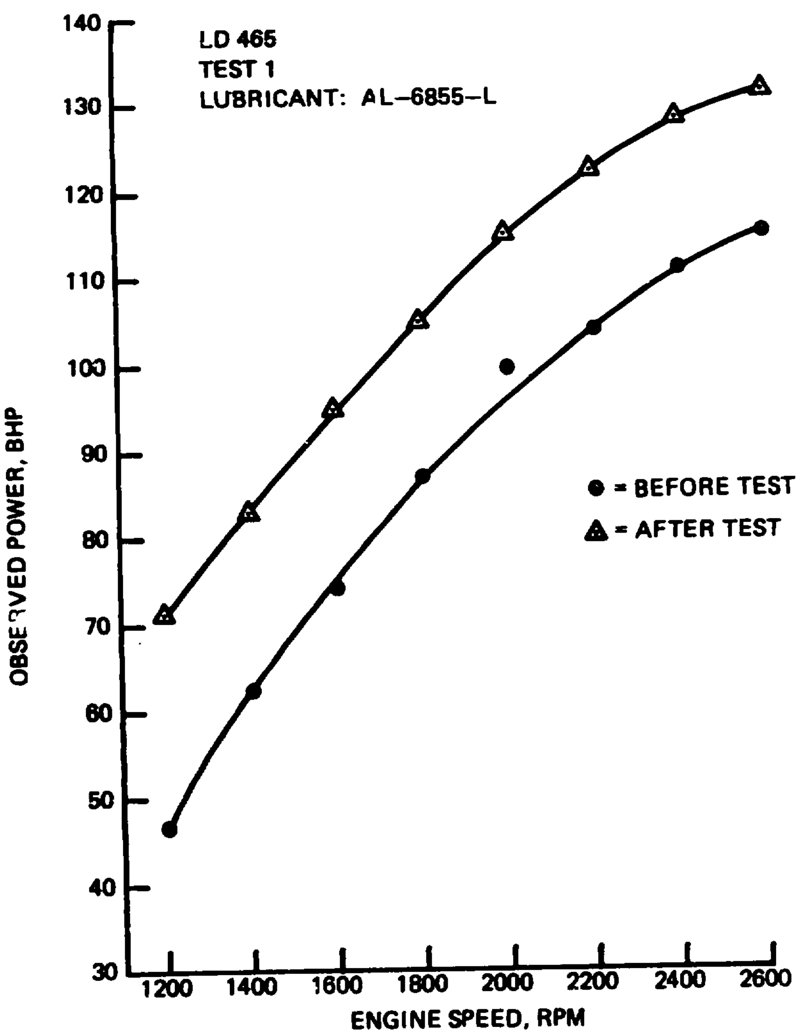
LD-465

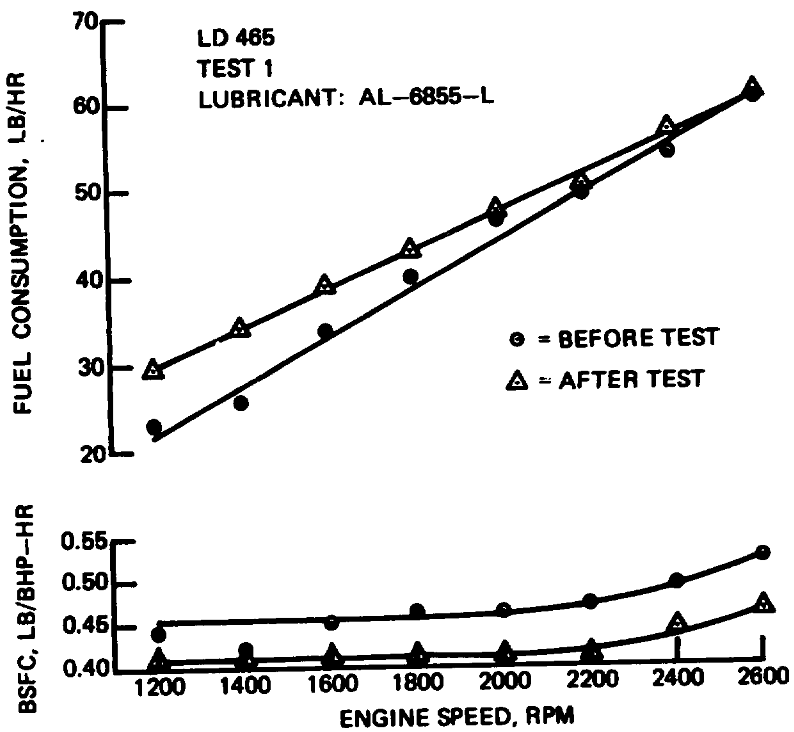
TEST 1

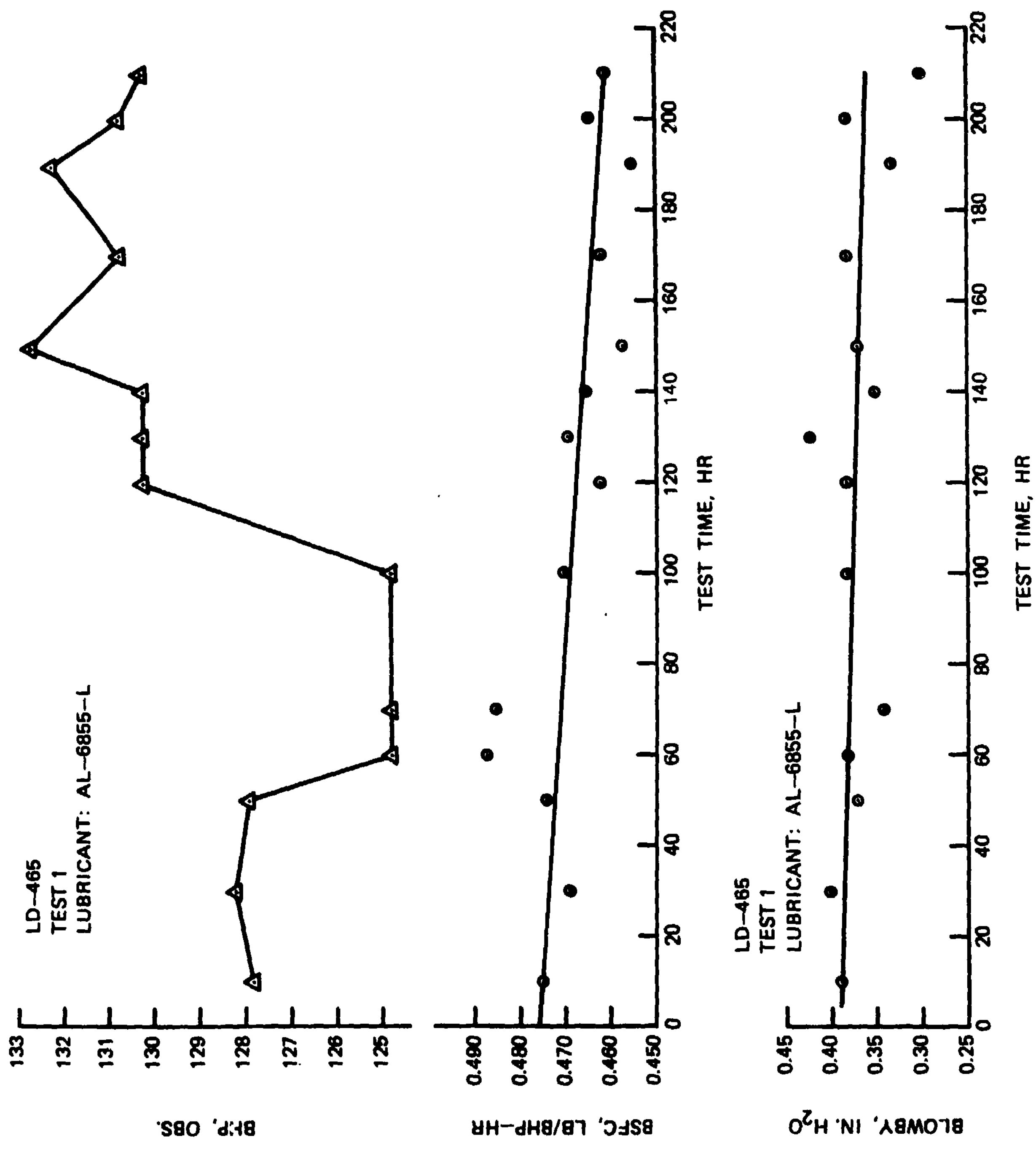
LUBRICANT: AL-6855-L

SUMMARY OF OPERATING DATA

	POWER MODE			IDLE MODE
	MIN	AVE	MAX	AVE
Engine Speed, rpm.	2599	2601	2606	836
Engine Torque, ft-lb	251	260	268	13
Fuel Consumption lb/hr	58.4	60.4	61.5	4.1
BHP (Observed)	124	129	133	2.1
BSFC (Observed)	.471	.468	.462	1.9
Temperatures, °F				
Exhaust Manifold	1250	1280	1330	163
Cooling Water In	167	170	174	97
Cooling Water Out	177	180	183	101
Oil Sump	210	216	223	122
Air In	70	94	128	75
Pressures				
Fuel Transfer Pump, psi	65	72	75	39
Oil Callery, psi	33	36	38	32
Intake Vacuum, in. H_2O	3.2	3.3	3.6	0.4
Exhaust Vacuum, in. Hg	0.8	1.1	1.6	0.0


LD 465
TEST 1
LUBRICANT: AL-6855-L
● = BEFORE TEST
△ = AFTER TEST
OBSERVED POWER, BHP
ENGINE SPEED, RPM
140
130
120
110
100
90
80
70
60
50
40
30
1200
1400
1600
1800
2000
2200
2400
2600


LD 465
TEST 1
LUBRICANT: AL-6855-L
● = BEFORE TEST
△ = AFTER TEST
FUEL CONSUMPTION, LB/HR
70
60
50
40
30
20
BSFC, LB/BHP-HR
0.55
0.50
0.45
0.40
1200
1400
1600
1800
2000
2200
2400
2600
ENGINE SPEED, RPM



LD-465
TEST 1
LUBRICANT: AL-6855-L
BHP, OBS.
133
132
131
130
129
128
127
126
125
BSFC, LB/BHP-HR
0.490
0.480
0.470
0.460
0.450
BLOWBY, IN. H_2O
0.45
0.40
0.35
0.30
0.25
0
20
40
60
80
100
120
140
160
180
200
220
TEST TIME, HR

LD-465
TEST 1
BUILD UP ENGINE MEASUREMENTS

	INCHES			
	MIN	MAX	AVE	SPECIFIED LIMITS
Cylinder Liners (Installed)				
Inside Diameter	4.5625	4.5646	4.5635	4.5630-4.5645
Out-Of-Round	.0001	.0022	.0006	.0015 Max
Piston Skirt Diameter	4.5559	4.5562	4.5560	4.5570-4.5580
#1 Ring				
End Gap	.025	.028	.026	.025-.035
#2 Ring				
End Gap	.025	.030	.027	.025-.035
#3 Ring				
End Gap	.020	.022	.021	.025-.035
Side Clearance	.0035	.0035	.0035	.0025-.0045
#4 Ring				
End Gap	.015	.022	.020	.013-.028
Side Clearance	.0010	.0015	.0015	.0010-.0035

LD-465
TEST 1
LUBRICANT: AL-6855-L

OIL CONSUMPTION (LB)

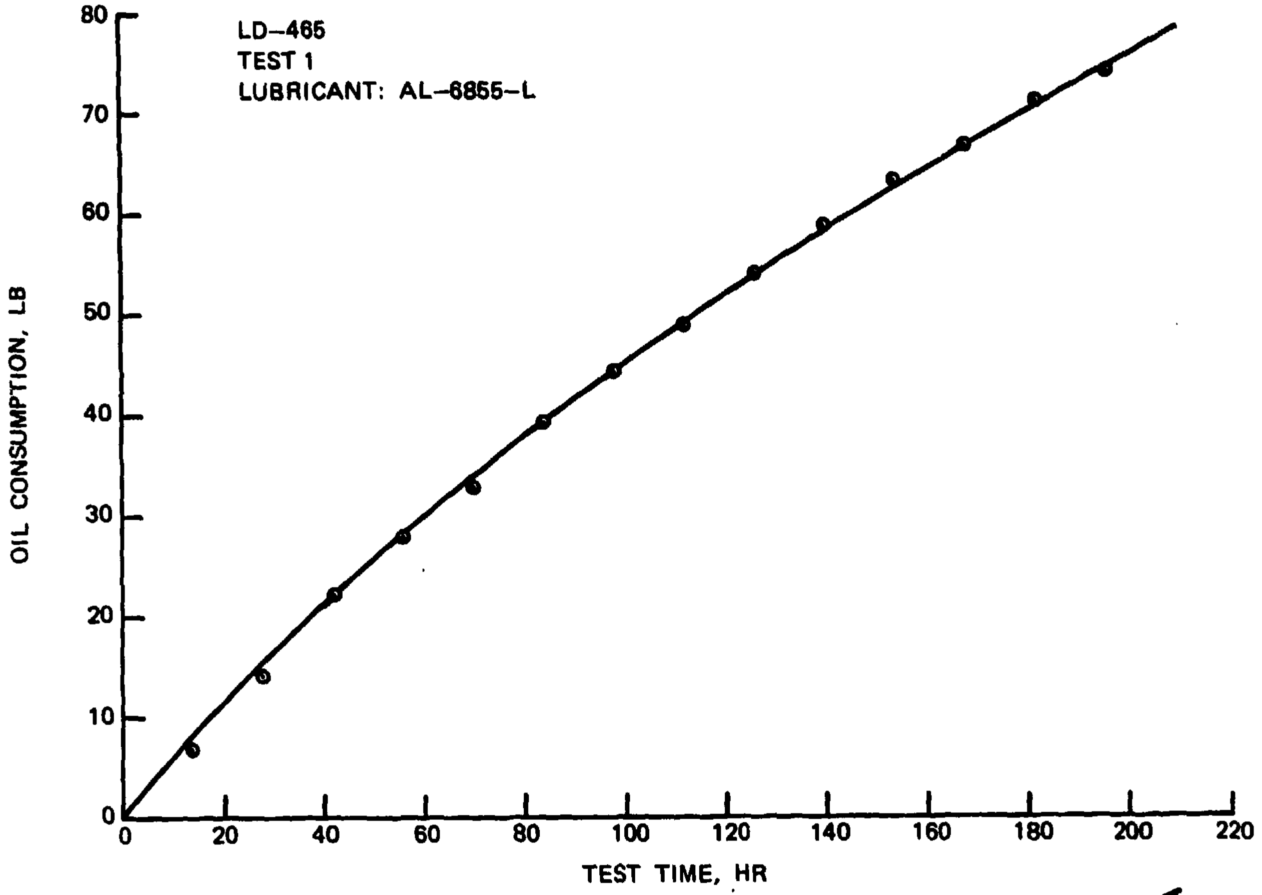
TEST HRS	OIL CONSUMED	TOTAL OIL CONSUMED
14	6.76	6.76
28	6.82	13.58
42	8.08	21.66
56	5.79	27.45
70	5.28	32.73
84	6.48	39.21
98	5.04	44.25
112	4.50	48.75
126	5.08	53.83
140	4.80	58.63
154	4.36	62.99
168	3.48	66.47
182	4.51	70.98
196	2.88	73.86

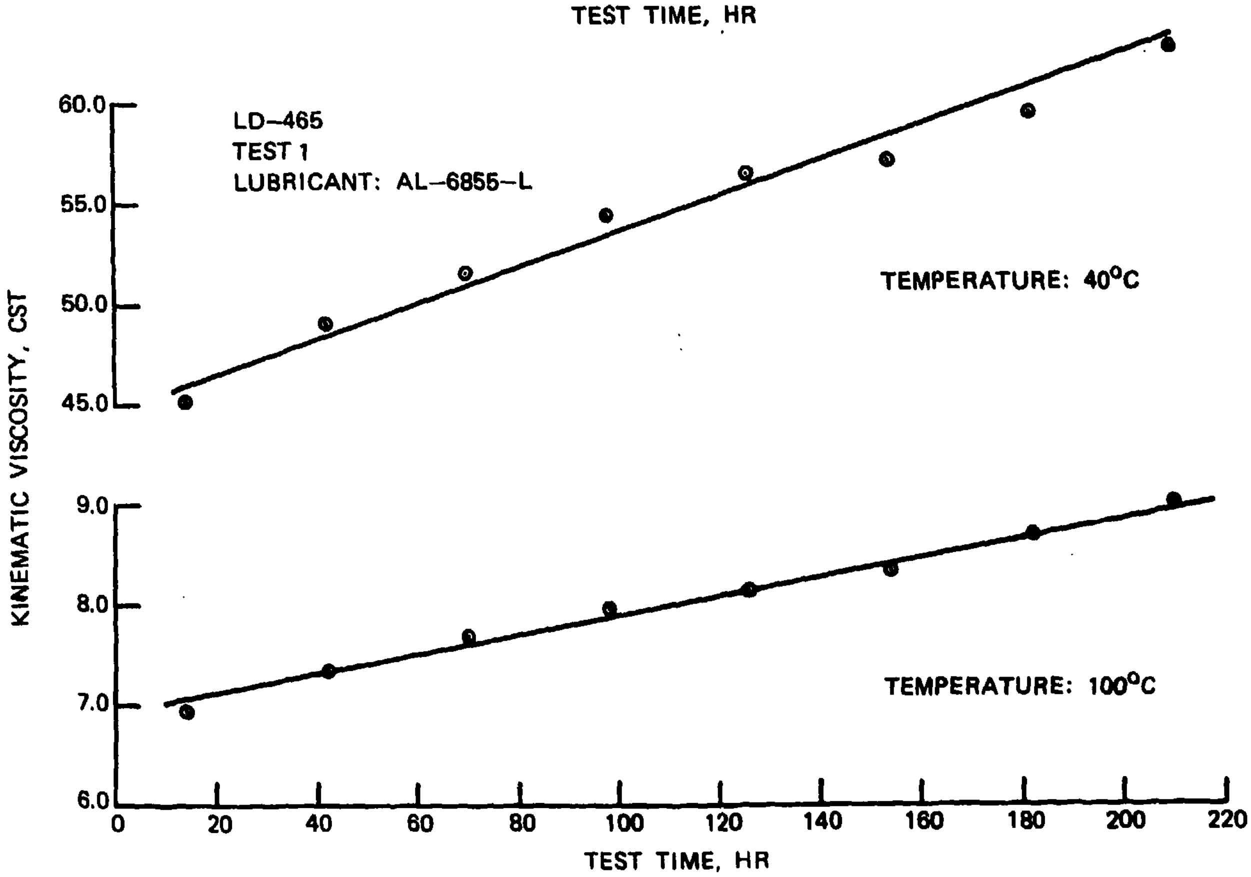
LD-465
TEST 1
LUBRICANT: AL-6855-L

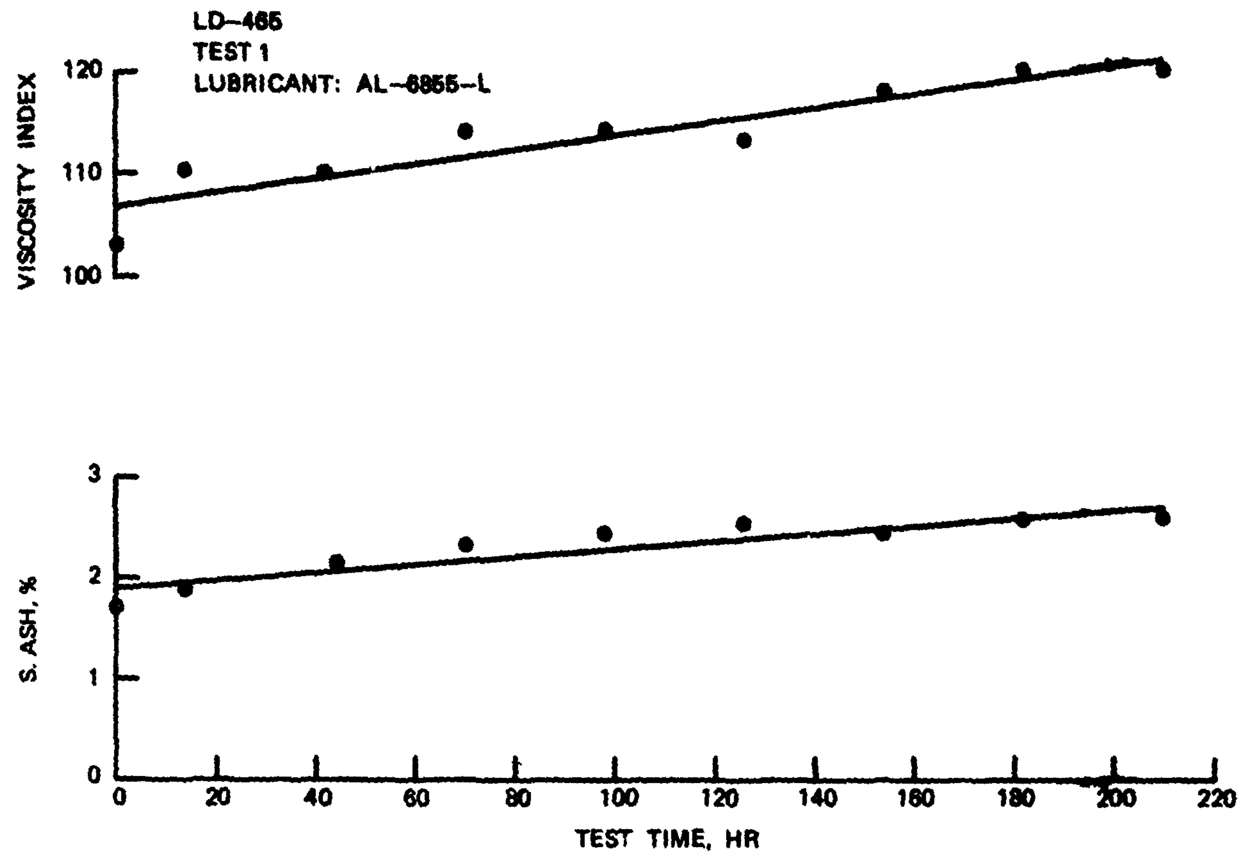
LUBRICANT ANALYSIS

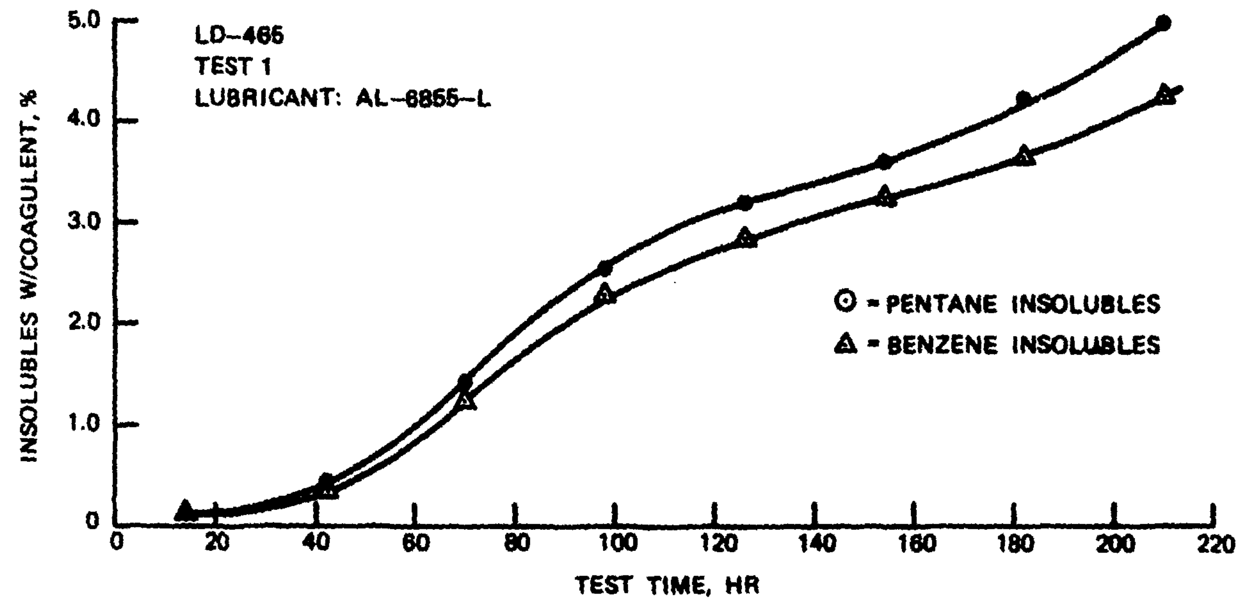
TEST TIME (HRS)

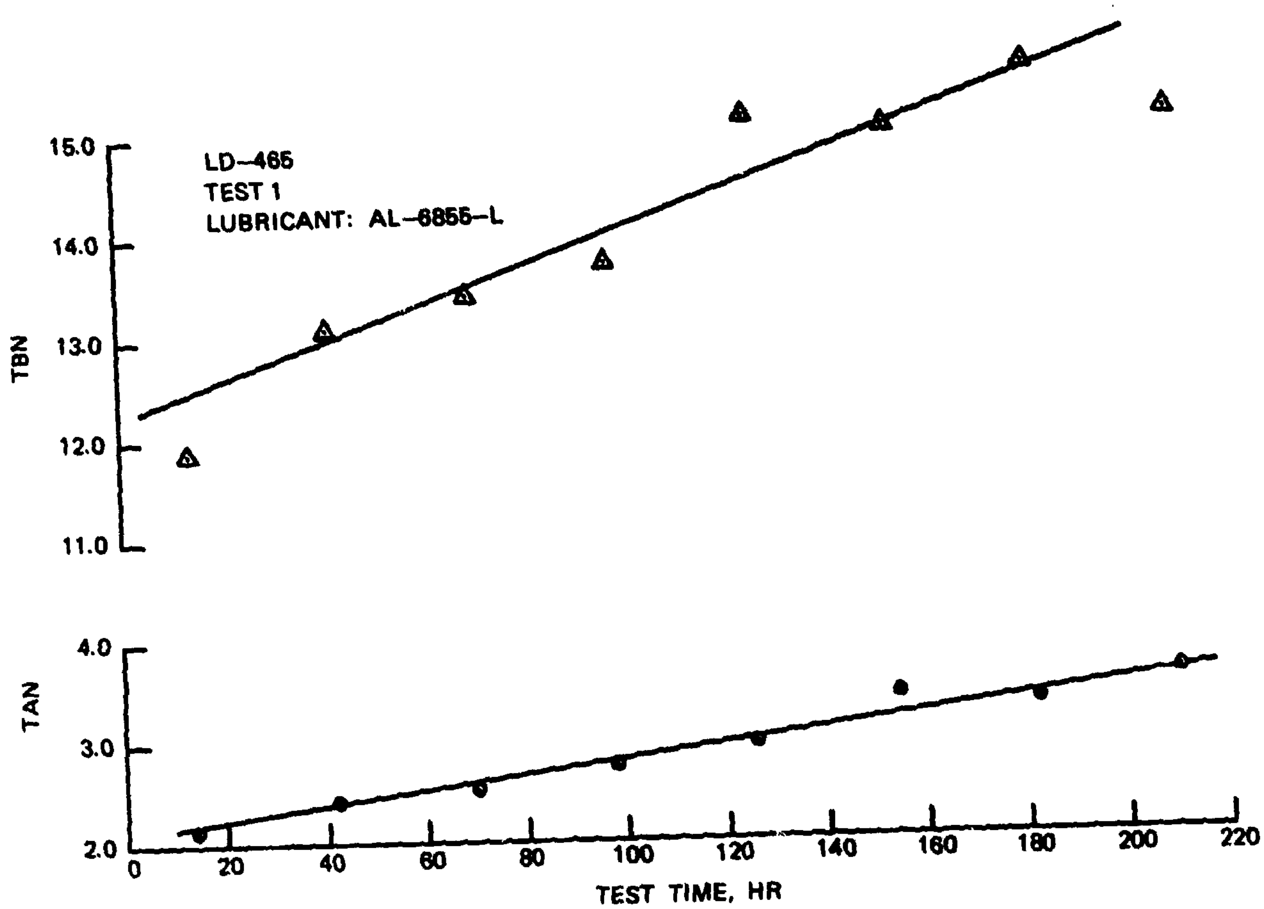
	ASTM TEST METHOD	NEW OIL	14	42	70	98	126	154	182	210
I.R. Trace No.		1128	1594	1595	1596	1597	1598	1599	1614	1615
K. Vis., (Cs) @ 40°C	D-445	45.2	45.10	49.09	51.48	54.28	56.38	57.0	59.4	62.6
K. Vis., (Cs) @ 100°C	D-445	6.5	6.94	7.33	7.68	6.95	8.14	8.34	8.68	9.0
V.I.	D-2270-74	103	110	110	114	114	113	118	120	120
TAN	D-664	2.5	2.14	2.40	2.50	2.71	2.93	3.38	3.31	3.55
TBN	D-2896	12.7	11.86	13.09	13.39	13.70	15.13	15.0	15.6	15.1
S. Ash, %	D-874	1.7	1.88	2.13	2.31	2.42	2.62	2.43	2.57	2.59
Pentane Insolubles, w/coag., %	D-893	.02	.14	.45	1.41	2.54	3.18	3.60	4.22	4.97
Benzene Insolubles, w/coag., %	D-893	.01	.13	.35	1.24	2.2	2.84	3.22	3.64	4.24
Fe (PPM) by XRF		N.D.	50	79	124	143	174	216	257	263

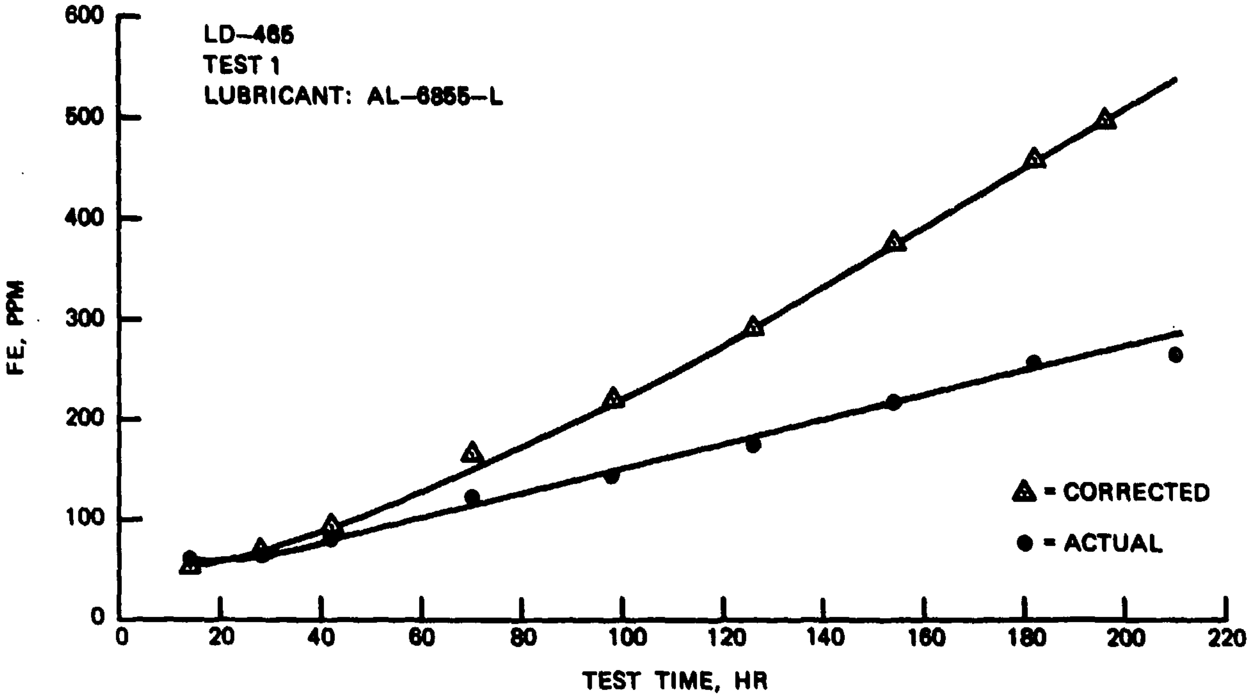

LD-465
TEST 1
LUBRICANT: AL-6855-L
OIL CONSUMPTION, LB
TEST TIME, HR
0
10
20
30
40
50
60
70
80
0 20 40 60 80 100 120 140 160 180 200 220

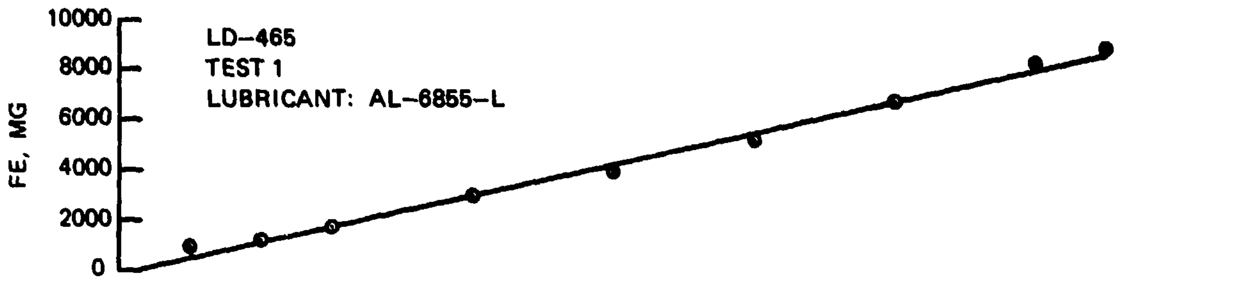

LD-465
TEST 1
LUBRICANT: AL-6855-L
TEMPERATURE: 40°C
TEMPERATURE: 100°C
KINEMATIC VISCOSITY, CST
TEST TIME, HR
45.0
50.0
55.0
60.0
6.0
7.0
8.0
9.0
0 20 40 60 80 100 120 140 160 180 200 220

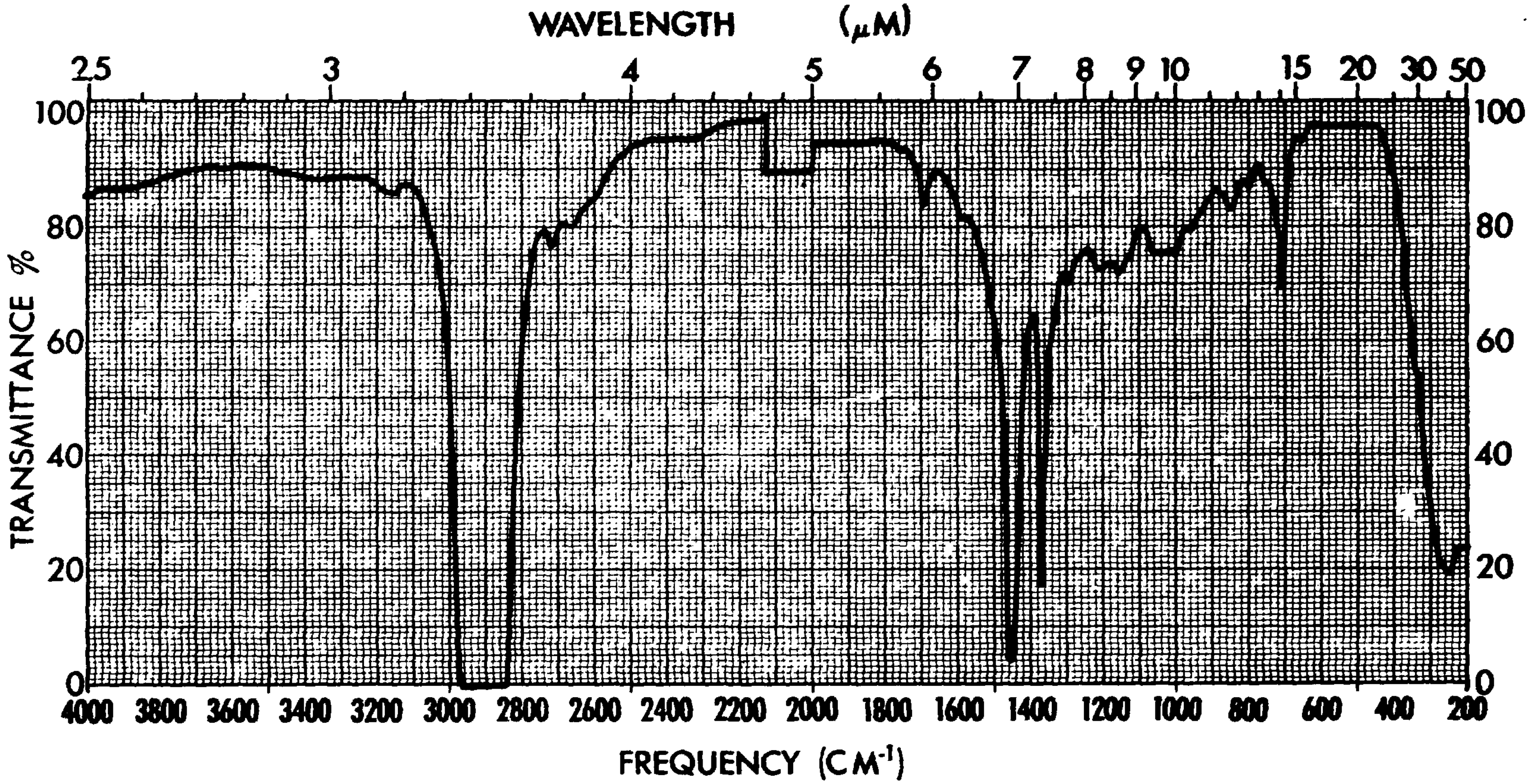

LD-465
TEST 1
LUBRICANT: AL-6855-L
VISCOSITY INDEX
120
110
100
S. ASH, %
3
2
1
0
0
20
40
60
80
100
120
140
160
180
200
220
TEST TIME, HR


LD-465
TEST 1
LUBRICANT: AL-6855-L
INSOLUBLES W/COAGULENT, %
5.0
4.0
3.0
2.0
1.0
0
⊙ = PENTANE INSOLUBLES
△ = BENZENE INSOLUBLES
0
20
40
60
80
100
120
140
160
180
200
220
TEST TIME, HR

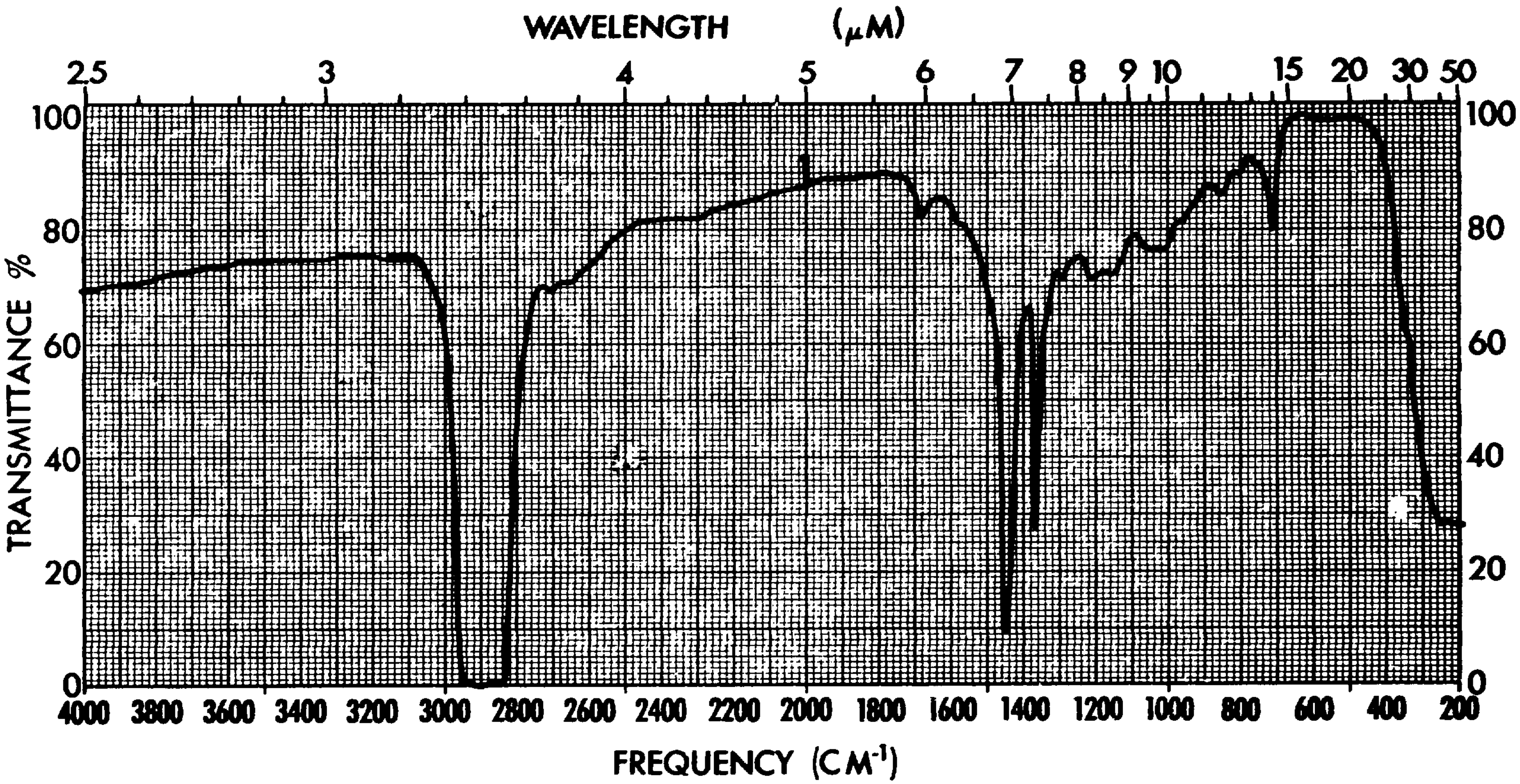

LD-465
TEST 1
LUBRICANT: AL-6855-L
TBN
15.0
14.0
13.0
12.0
11.0
TAN
4.0
3.0
2.0
0
20
40
60
80
100
120
140
160
180
200
220
TEST TIME, HR


LD-465
TEST 1
LUBRICANT: AL-6855-L
FE, PPM
TEST TIME, HR
▲ = CORRECTED
● = ACTUAL
0
100
200
300
400
500
600
0
20
40
60
80
100
120
140
160
180
200
220

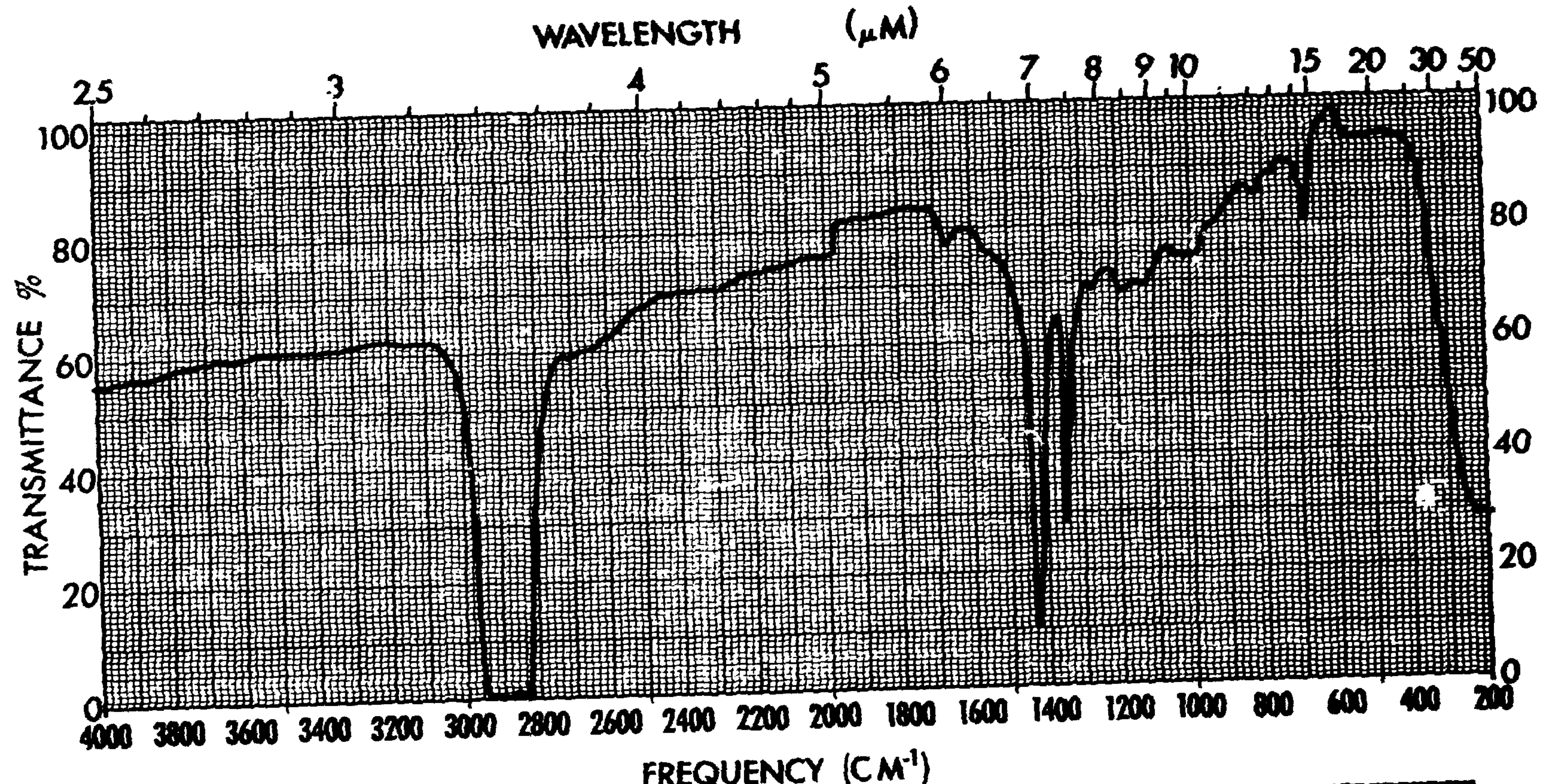

LD-465
TEST 1
LUBRICANT: AL-6855-L
FE, MG
0
2000
4000
6000
8000
10000



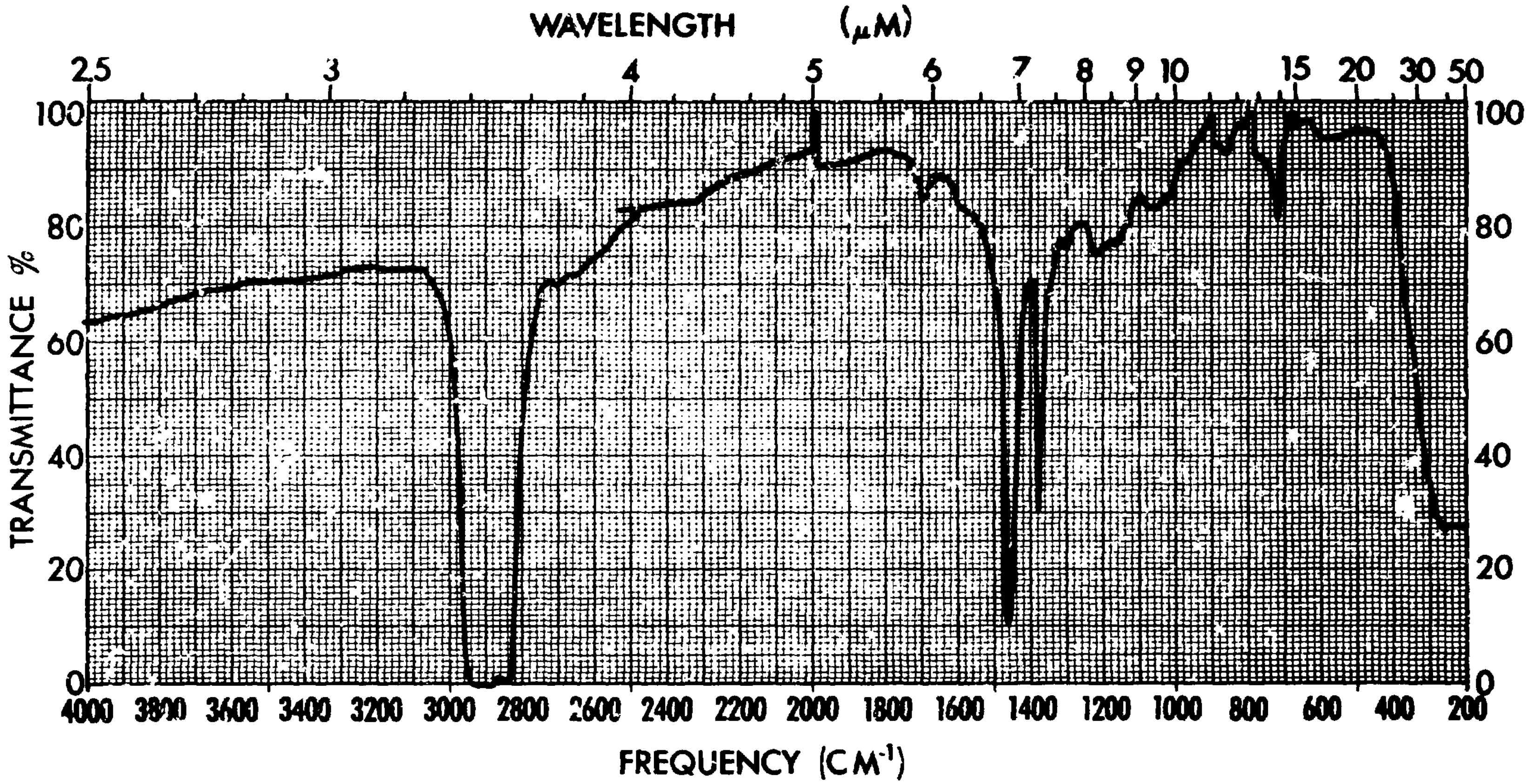
SPECTRUM NO. 1594	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6855-L		1.	
14 Hr	PURITY	2.	
Test 1	PHASE	DATE	
	THICKNESS 0.025	OPERATOR D. B.	



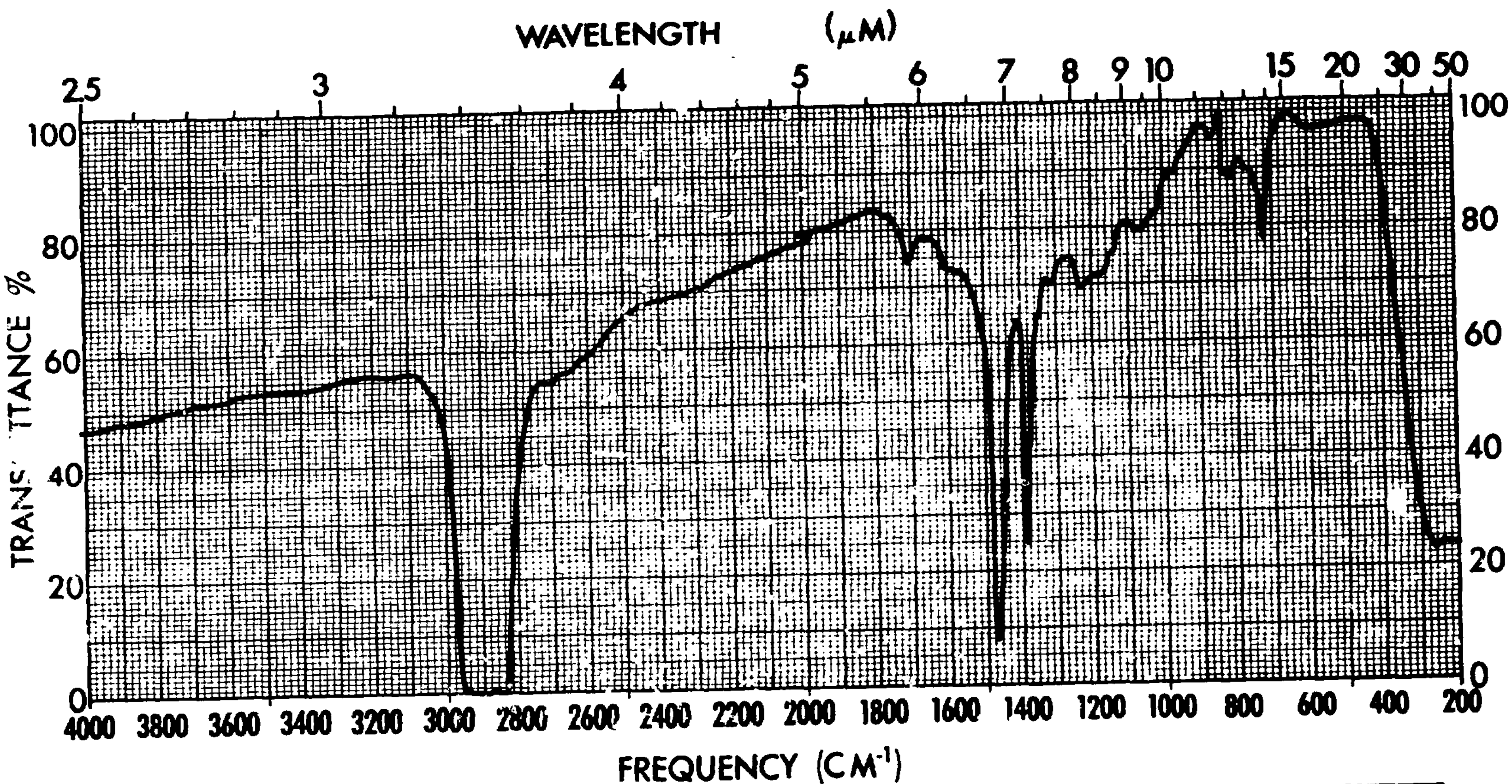
SPECTRUM NO. 159.5	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6855-L		1.	
42 HR	PURITY	2.	
TEST 1	PHASE	DATE 12-11-78	
	THICKNESS 0.025	OPERATOR KH	



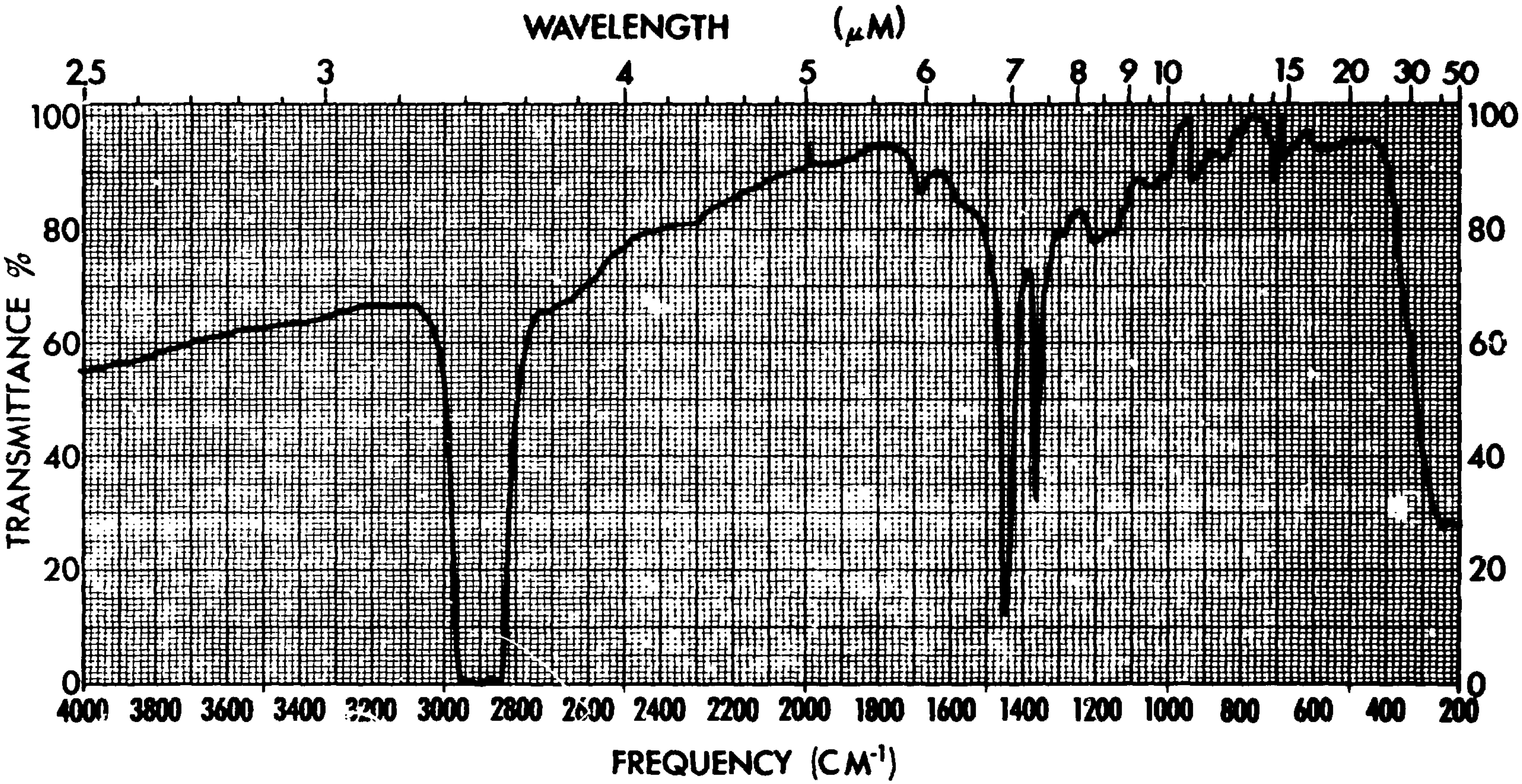
SPECTRUM NO. 1596	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6855-L		1.	
70 HR	PURITY	2.	
TEST 1	PHASE	DATE 12-11-78	
	THICKNESS 0.025	OPERATOR KH	



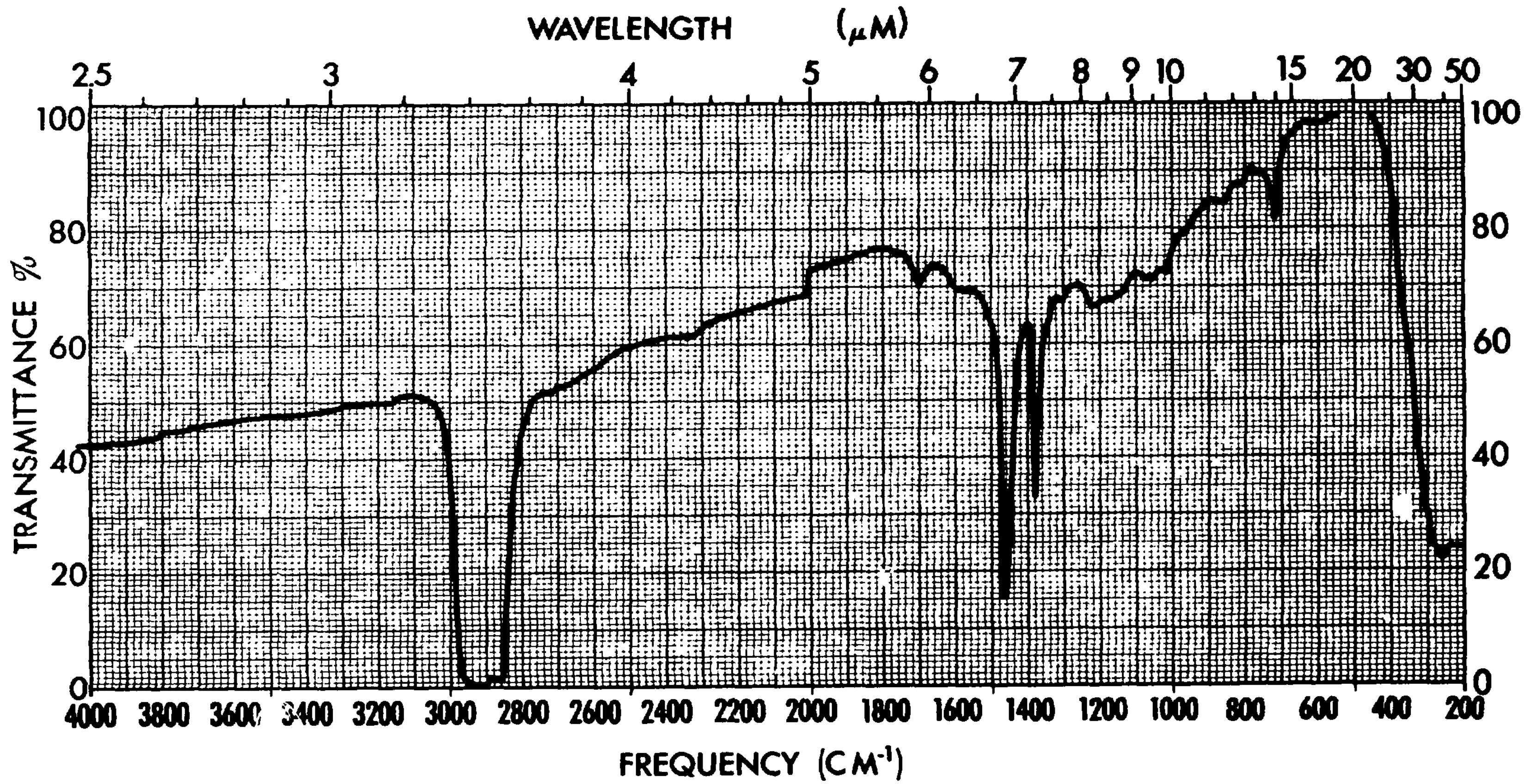
SPECTRUM NO. 1597	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6355-L		1.	
98 HR	PURITY	2.	
TEST 1	PHASE	DATE 12-11-78	
	THICKNESS 0.025	OPERATOR KH	



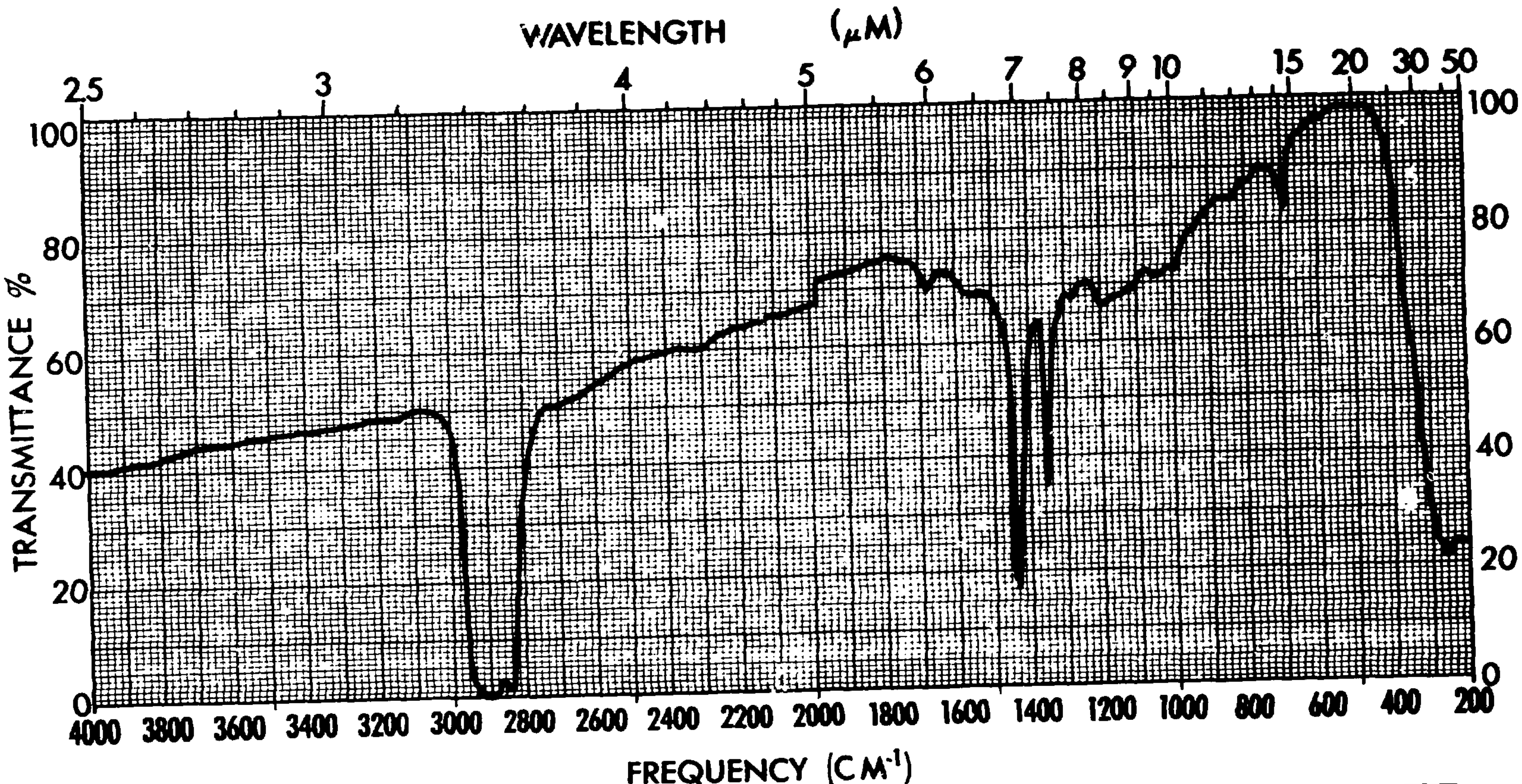
SPECTRUM NO. 1598	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6855-L		1.	
126 HR	PURITY	2.	
TEST 1	PHASE	DATE 12-11-78	
	THICKNESS 0.025	OPERATOR KH	



SPECTRUM NO. 1599	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6855-L		1.	
154 HR	PURITY	2.	
TEST 1	PHASE	DATE 12-12-78	
	THICKNESS 0.025	OPERATOR KH	



SPECTRUM NO. 1614	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6855-L		1.	
184 HR	PURITY	2.	
Test 1	PHASE	DATE 12-27-78	
	THICKNESS 0.015	OPERATOR KB	



SPECTRUM NO. 1615	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6855-L 210 HR TEST 1	PURITY	1.	
	PHASE	2.	
	THICKNESS 0.015	DATE 12-27-78	
		OPERATOR KB	

LD-465
TEST 1
LUBRICANT: AL-6855-L
WEAR MEASUREMENTS

CYLINDER LINER BORE DIAMETER (INCHES)

		LONGITUDINAL			TRANSVERSE		
		BEFORE	AFTER	CHANGE	BEFORE	AFTER	CHANGE
1.	TOP	4.5635	4.5638	.0003	4.5628	4.5628	.0000
	CENTER	4.5632	4.5628	-.0004	4.5638	4.5635	-.0003
	BOTTOM	4.5625	4.5624	-.0001	4.5646	4.5643	-.0003
2.	TOP	4.5633	4.5634	.0001	4.5639	4.5638	-.0001
	CENTER	4.5637	4.5633	-.0004	4.5641	4.5640	-.0001
	BOTTOM	4.5640	4.5635	-.0005	4.5638	4.5641	.0003
3.	TOP	4.5629	4.5629	.0000	4.5635	4.5635	.0000
	CENTER	4.5630	4.5627	-.0003	4.5636	4.5635	-.0001
	BOTTOM	4.5633	4.5630	-.0003	4.5638	4.5636	-.0002
4.	TOP	4.5633	4.5633	.0000	4.5635	4.5636	.0001
	CENTER	4.5634	4.5631	-.0003	4.5635	4.5633	-.0002
	BOTTOM	4.5634	4.5631	-.0003	4.5635	4.5634	-.0001
5.	TOP	4.5626	4.5629	.0003	4.5641	4.5643	.0002
	CENTER	4.5628	4.5627	-.0001	4.5639	4.5643	.0004
	BOTTOM	4.5633	4.5631	-.0002	4.5642	4.5642	.0000
6.	TOP	4.5636	4.5639	.0003	4.5635	4.5636	.0001
	CENTER	4.5636	4.5635	-.0001	4.5637	4.5635	-.0002
	BOTTOM	4.5638	4.5636	-.0002	4.5635	4.5634	-.0001

LD-465
TEST 1
LUBRICANT: AL-6855-L
WEAR MEASUREMENTS

Piston Ring End Gap (inches)

Ring Number*		Piston Number 1	2	3	4	5	6
1.	Before Test	.028	.025	.028	.025	.025	.025
	After Test	.024	.030	.028	.028	.025	.025
	Change	-.004	.005	.000	.003	.000	.000
2.	Before Test	.028	.025	.028	.028	.030	.025
	After Test	.030	.028	.028	.030	.028	.025
	Change	.002	.003	.000	.002	-.002	.000
3.	Before Test	.020	.021	.020	.021	.022	.021
	After Test	.025	.025	.022	.024	.025	.025
	Change	.005	.004	.002	.003	.003	.004
4.	Before Test	.019	.022	.020	.022	.020	.015
	After Test	.022	.022	.022	.022	.025	.024
	Change	.003	.000	-.002	.000	.005	.009

* From Top of Piston

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-6855-L

RATER E.L. DATE 12-20-78
LABORATORY TEST NUMBER 1
STAND NO. 6 ENGINE NO. LD 465-3904343
FUEL CAT 1-H

PISTON NO. 1

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	138.125

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	DEMERIT	NO. 2 AREA-%	DEMERIT	NO. 3 AREA-%	DEMERIT	NO. 4 AREA-%	DEMERIT	LANDS NO. 1 AREA-%	DEMERIT	NO. 2 AREA-%	DEMERIT	NO. 3 AREA-%	DEMERIT	NO. 4 AREA-%	DEMERIT	UNDER-CROWN AREA-%	DEMERIT
CARBON	HC	1.00																		
	MHC	0.75	10	7.50																
	MC	0.50	90	45.00							100	50.00	5	2.50						
	LC	0.25																		
	VLC	0.15																		
	CARBON RATING		52.50								50.00		2.50							
LACQUER	BL	0.100																		
	DBrL	0.075			100	7.50	100	7.50	100	7.50			75	5.625						
	AL	0.050																		
	LAL	0.025											20	.50					100	2.50
	VL	0.010													100	1.00	100	1.00		
	RL	0.001																		
	LACQUER RATING				7.50		7.50		7.50				5.125		1.00		1.00		2.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		52.50		7.50		7.50		7.50		50.00		8.625		1.00		1.00		2.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-6855-L

RATER E.L. DATE 12-20-78
LABORATORY TEST NUMBER 1
STAND NO. 6 ENGINE NO. LD 465-3904343
FUEL CAT 1-H

PISTON NO. 2

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	138.885

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00																		
CARBON	MHC	0.75	10	7.50							15	11.25								
CARBON	MC	0.50	90	45.00							60	30.00								
CARBON	LC	0.25									25	13.75	10	2.50						
CARBON	VLC	0.15																		
CARBON	CARBON RATING		52.50								55.00		2.50							
LACQUER	BL	0.100			60	6.00							15	1.50						
LACQUER	DBL	0.075			40	3.00	100	7.50					5	.375						
LACQUER	AL	0.050											70	3.50						
LACQUER	LAL	0.025													100	2.50			100	2.50
LACQUER	VLAL	0.010															100	1.00		
LACQUER	RL	0.001																		
LACQUER	LACQUER RATING				9.00		7.50		1.00				5.375		2.50		1.00		2.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		52.50		9.00		7.50		1.00		55.00		7.875		2.50		1.00		2.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-6855-L

RATER E.L. DATE 12-20-78
LABORATORY TEST NUMBER 1
STAND NO. 6 ENGINE NO. LD 465
FUEL CAT 1-H

PISTON NO. 3

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	117.25

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00																		
CARBON	MHC	0.75									10	7.50								
CARBON	MC	0.50									90	45.00								
CARBON	LC	0.25	100	25.00																
CARBON	VLC	0.15																		
	CARBON RATING		25.00								52.50									
LACQUER	BL	0.100			100	10.00	100	10.00					5	5.00						
LACQUER	DBrL	0.075																		
LACQUER	AL	0.050											95	7.75						
LACQUER	LAL	0.025							100	2.50					100	2.50	100	2.50	100	2.50
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING				10.00		10.00		2.50				9.75		2.50		2.50		2.50	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		25.00		10.00		10.00		2.50		52.50		9.75		2.50		2.50		2.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-6855-L

RATER E.L. DATE 12-20-78
LABORATORY TEST NUMBER 1
STAND NO. 6 ENGINE NO. 465-3904343
FUEL CAT 1-H

PISTON NO. 4

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	142.875

			GROOVES								LANDS								UNDER-CROWN	
	DEPOSIT TYPE	DEPOSIT FACTOR	NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
			AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON	HC	1.00																		
	MHC	0.75	15	11.25							10	7.50								
	MC	0.50	75	37.50							80	40.00								
	LC	0.25	10	2.50							10	2.50								
	VLC	0.15																		
	CARBON RATING		51.25								50.00									
LACQUER	BL	0.100											5	5.00	5	5.00				
	DBrL	0.075			100	7.50							85	6.375						
	AL	0.050											10	.50	95	4.75			100	5.00
	LAL	0.025					100	2.50	100	2.50							100	2.50		
	VLAL	0.010																		
	RL	0.001																		
	LACQUER RATING				7.50		2.50		2.50				11.875		9.75		2.50		5.00	
CLEAN		0																		
ZONAL RATING																				
LOCATION FACTOR																				
WEIGHTED RATING			51.25		7.50		2.50		2.50		50.00		11.875		9.75		2.50		5.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-6855-L

RATER E.L. DATE 12-20-78
LABORATORY TEST NUMBER 1
STAND NO. 6 ENGINE NO. 465-3904343
FUEL CAT 1-H

PISTON NO. 5

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	125.00

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00																		
CARBON	MHC	0.75	40	30.00							50	25.00								
CARBON	MC	0.50	60	30.00							50	12.50	10	2.50						
CARBON	LC	0.25																		
CARBON	VLC	0.15																		
CARBON	CARBON RATING		60.00								27.50		2.50							
LACQUER	BL	0.100																		
LACQUER	DBrL	0.075			100	7.50	100	7.50	100	7.50									100	5.00
LACQUER	AL	0.050											10	.50						
LACQUER	LAL	0.025											80	2.00	100	2.50	100	2.50		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
LACQUER	LACQUER RATING												2.50		2.50		2.50		5.00	
	CLEAN	0																		
	ZONAL RATING				7.50		7.50		7.50											
	LOCATION FACTOR																			
	WEIGHTED RATING		60.00		7.50		7.50		7.50		27.50		5.00		2.50		2.50		5.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-6855-L

RATER E.L. DATE 12-20-78
LABORATORY TEST NUMBER 1
STAND NO. 6 ENGINE NO. LD 465-3904343
FUEL CAT 1-H

PISTON NO. 6

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	125.875

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00																		
CARBON	MHC	0.75	100	75.00							10	7.50								
CARBON	MC	0.50									80	40.00								
CARBON	LC	0.25									10	2.50								
CARBON	VLC	0.15											15	2.25						
	CARBON RATING		75.00								14.00		2.25							
LACQUER	BL	0.100			100	10.0									5	.50				
LACQUER	DBrL	0.075																		
LACQUER	AL	0.050					100	5.00	100	5.00			85	4.25					100	5.00
LACQUER	LAL	0.025													95	2.375	100	2.50		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING				10.00		5.00		5.00				4.25		2.875		2.50		5.00	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		75.00		10.00		5.00		5.00		14.00		6.50		2.875		2.50		5.00	

*WEIGHTED TOTAL DEPOSITS

RING DEPOSITS

Test No. 1 Cell 6

Engine Model Continental LD-465 Serial No. 3904343 Date 12-21-78

Fuel CAT 1-H Lubricant AL-68-55-L Observer Lyons

Cylinder Number			1		2		3		4		5		6	
			CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ
Piston Ring	Top	1	0	2	0	5	0	10	0	50	0	0	0	25
		2	0	15	0	10	0	5	0	0	0	5	0	5
		3	0	95	0	95	0	95	0	100	0	100	0	90
		4												
	ID	1	0	100	0	100	0	100	0	100	0	100	15	85
		2	0	100	0	100	0	100	0	100	0	100	0	100
		3	0	100	0	100	0	100	0	100	0	100	0	100
		4												
	Bottom	1	0	0	0	0	0	0	0	0	0	0	0	0
		2	0	0	0	0	0	0	0	0	0	30	0	30
		3	0	85	0	0	0	90	0	75	0	75	0	60
		4												

See pages 4, 36 and 37 of Manual. Areas previously rated for carbon, rate 0 for lacquer

RING FACE CONDITION

Test No. 1 Cell 6

Engine Model Cont. LD 465 Serial No. 3904343 Date 12-21-78

Fuel CAT 1-H Lubricant AL-6855-L Observer Lyons

	Cylinder Number					
	1	2	3	4	5	6
First Ring	N	N	N	N	N	N
Second Ring	N	N	N	N	N	N
Third Ring	N	N	N	N	N	N
Fourth Ring	N	N	N	N	N	N
Oil Ring Slots—% Open	100	100	100	100	100	100

Pages 1 and 2 and 59 through 65 of Manual.

N = Normal

PISTON GROOVE INSIDE DIAMETER—% RING SUPPORTING CARBON

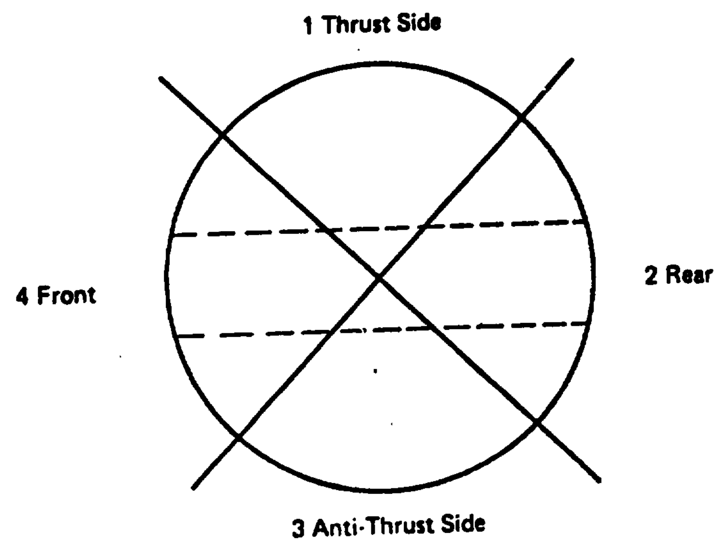
6

Test No.1 Cell 6

Engine Model Cont.LD 465 Serial No. 3904343 Date 12-21-78

Fuel CAT 1-H Lubricant AL-6855-L Observer Lyons

Piston Ring	Quadrant	Piston Number 1	2	3	4	5	6
1	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
2	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0



PISTON SURFACE CONDITION

Test No. 1 Cell 6

Engine Model Cont. LD 465 Serial No. 3904343 Date 12-21-78

Fuel CAT 1-H Lubricant AL-6855-L Observer Lyons

	Piston Number					
	1	2	3	4	5	6
Top Land	N	N	N	N	N	N
Skirt	N	N	N	N	N	N
Piston Pin	N	N	N	N	N	N

Pages 1 through 2 and 59 through 65 of Manual.

N = NORMAL

VALVE SURFACE CONDITIONS

Test No. 1 Cell 6

Engine Model Cont. LD 465 Serial No. 3904343 Date 12-21-78

Fuel CAT 1-H Lubricant AL-6855-L Observer Lyons

	Intake						Exhaust					
	1	2	3	4	5	6	1	2	3	4	5	6
Freeness in Guide	F	F	F	F	F	F	F	F	F	F	F	F
Head	N	N	N	N	N	N	N	N	N	N	N	N
Face	N	N	N	N	N	N	N	N	N	N	N	N
Seat	N	N	N	N	N	N	N	N	N	N	N	N
Stem	N	N	N	N	N	N	N	N	N	N	N	N
Tip	N	N	N	N	N	N	N	N	N	N	N	N

See Pages 1, 2, 16 through 23, and 54 through 65 of Manual.

Tulip Deposit 3.5 4.5 3.5 4.5 3.0 4.5 .5 .5 .5 .5 .5 .5

F = FREE

N = NORMAL

CYLINDERS

Test No. 1 Cell 6

Engine Model Cont. LD 465 | Serial No. 3904343 | Date 12-21-78

Fuel CAT 1-H | Lubricant AL-6855-L | Observer Lyons

		Cylinder Number											
		1		2		3		4		5		6	
Deposits Cylinder Head		CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ
Cylinders	ART	70	10	90	0	70	15	70	15	100	0	70	20
	RTA	0	0	0	0	0	0	0	0	0	0		
	BRT	0	0	0	0	0	0	0	0	0	0		
Surface Condition													
Cylinders	RTA	5% Blaze LT Scratches		10% Glaze LT Scratches		10% Glaze LT Scratches		5% Glaze LT Scratches		10% Glaze LT Scratches		5% Glaze LT Scratches	
	BRTA	N		N		N		N		N		N	

Carbon and Ash: Use Volume Factor Pages 5 and 40 through 47 of Manual. Indicate H, M, or S

Lacquer: Use Pages 4, 36 and 37

For Surface Condition—See Pages 1, 2, 16 through 23 and 54 through 65.

N = NORMAL

SURFACE CONDITION

TEST No. 1 Cell 6

Engine Model Cont LD 465   Serial No. 3904343   Date 12-21-78
Fuel CAT 1-H   Lubricant AL-6855-L   Observer Lyons

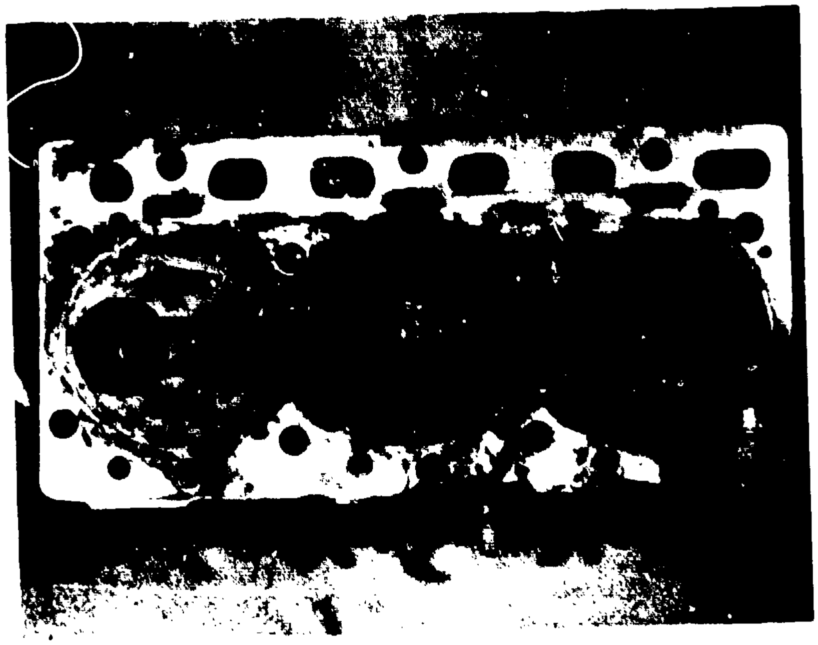
Bearing No.	1	2	3	4	5	6	7
Main–Bearing	Wore Thru To Copper	Wore Thru To Copper; Scratched	Wore thru To Copper; Scratched	Medium Wear; Scratched	Wore Thru To Copper; Scratched	Same as Bearing No. 5	
–Journal	N	N	N	N	N	N	N
Rod–Bearing	ALL HAVE MEDIUM TO HEAVY WEAR ON THRUST SIDE OF BOTTOM AT PART (All used Bearings)						
–Journal	N	N	N	N	N	N	
Piston Pin	N	N	N	N	N	N	
Bushing	N	N	N	N	N	N	

Note surface condition. See pages 1, 2, 16 through 23 and 54 through 65 of Manual.

NOTE: Main bearings and connecting rodbearings all have been run before (replaced all)

N = NORMAL

LD-465
TEST 1
AFTER TEST CONDITION OF CYLINDER HEADS

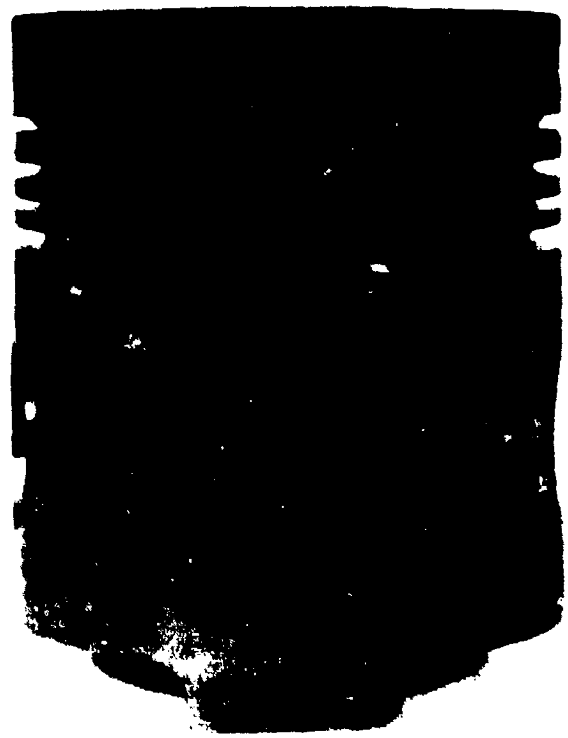


CYLINDERS 1, 2, AND 3

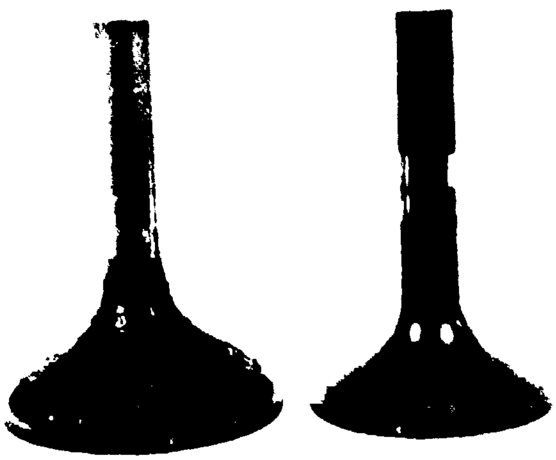
CYLINDERS 4, 5, AND 6

LD-465
TEST 1
AFTER TEST CONDITION OF NO. 1 PISTON AND VALVES

PISTON THRUST SIDE

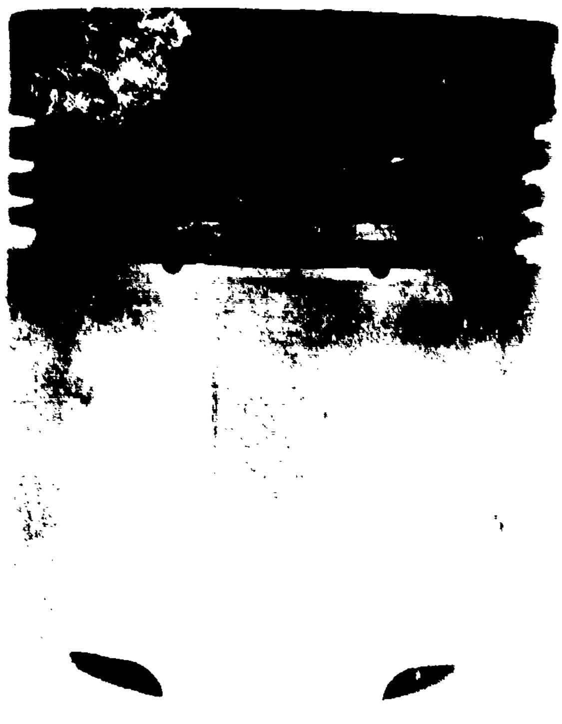


PISTON ANTI-THRUST SIDE



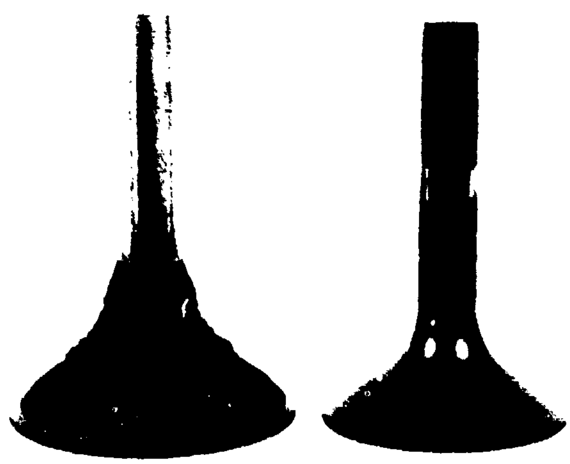
INTAKE AND EXHAUST VALVES

LD–465
TEST 1
AFTER TEST CONDITION OF NO. 2 PISTON AND VALVES



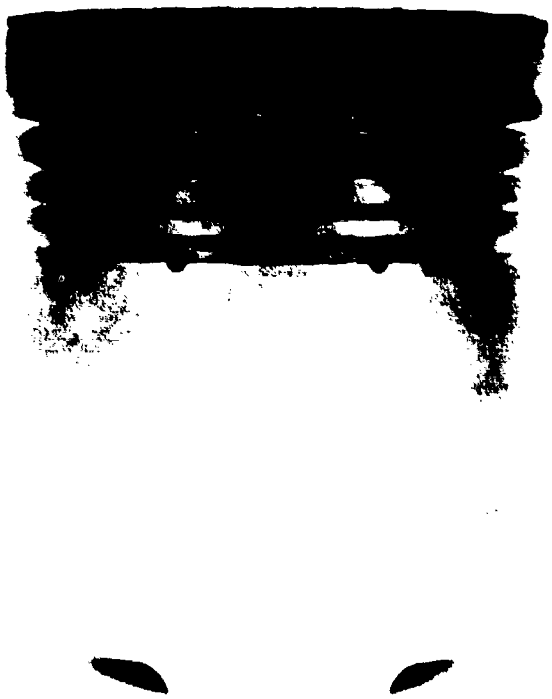
PISTON THRUST SIDE

PISTON ANTI–THRUST SIDE



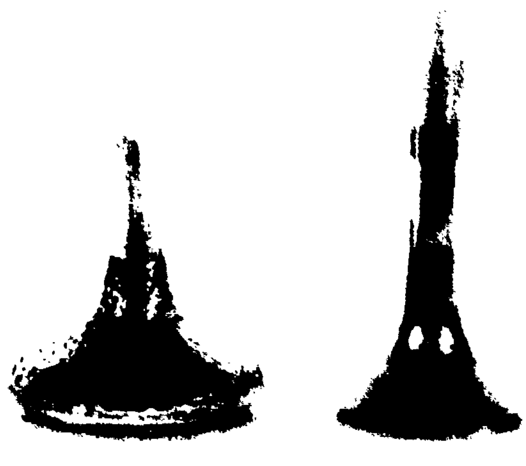
INTAKE AND EXHAUST VALVES

LD-465
TEST 1
AFTER TEST CONDITION OF NO. 3 PISTON AND VALVES



PISTON THRUST SIDE

PISTON ANTI-THRUST SIDE



INTAKE AND EXHAUST VALVES

APPENDIX I

ENGINE-LUBRICANT COMPATIBILITY TEST #2
210-HOUR WHEELED-VEHICLE CYCLE
USING LD 465 DIESEL ENGINE

ENGINE-LUBRICANT COMPATIBILITY TEST
210-HOUR WHEELED-VEHICLE CYCLE
USING LD 465 DIESEL ENGINE

Test Lubricant: AL-6942-L
Test Fuel: AL-7799-F
Engine Test Number: 2
Date Completed: 26 January 1979

Conducted for

U.S. Army Mobility Equipment Research and Development Command
Energy and Water Resources Laboratory
Fort Belvoir, Virginia

by

U.S. Army Fuels & Lubricants Research Laboratory
Southwest Research Institute
San Antonio, Texas 78284

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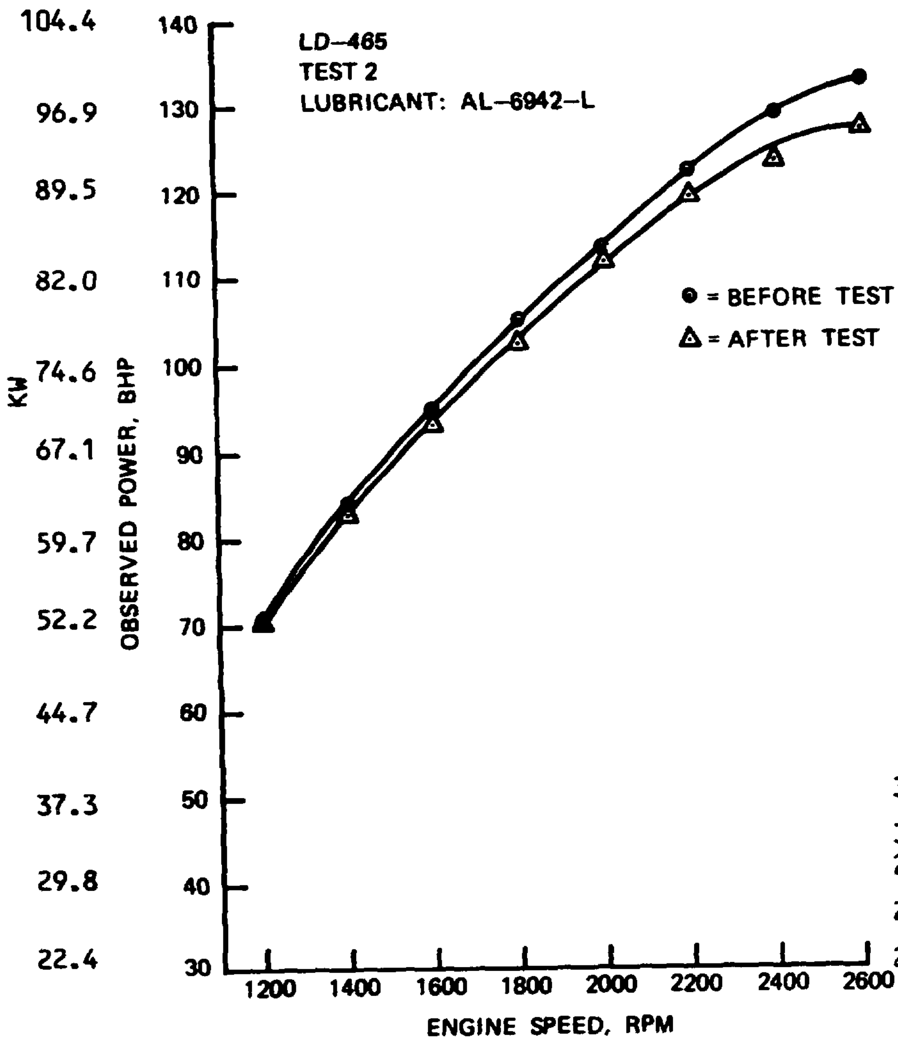
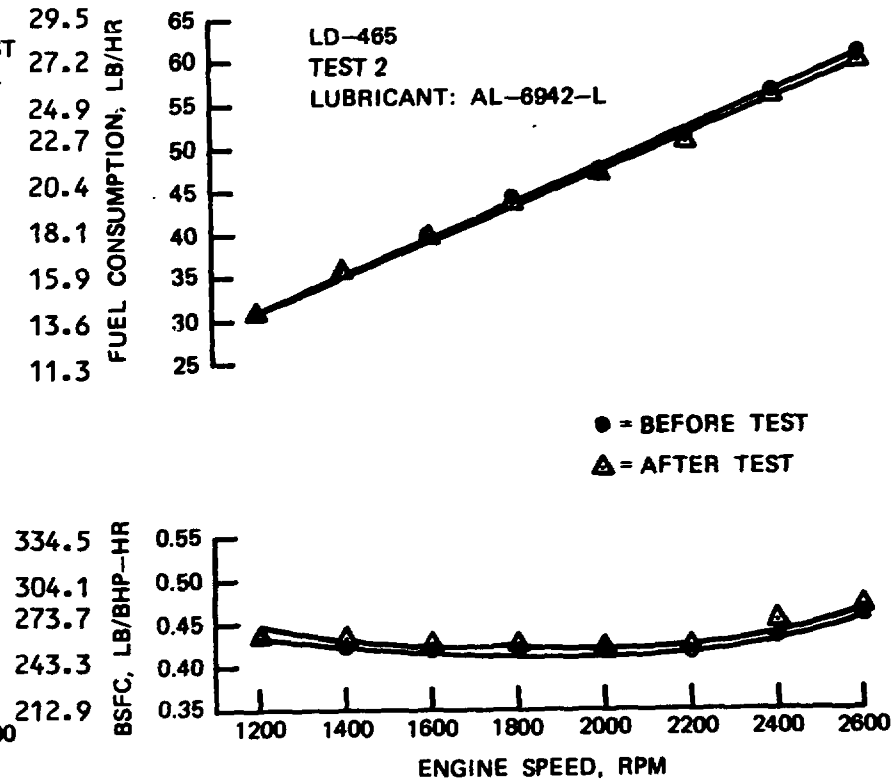
LD 465
TEST 2
LUBRICANT: AL-6942-L

SUMMARY OF OPERATING DATA

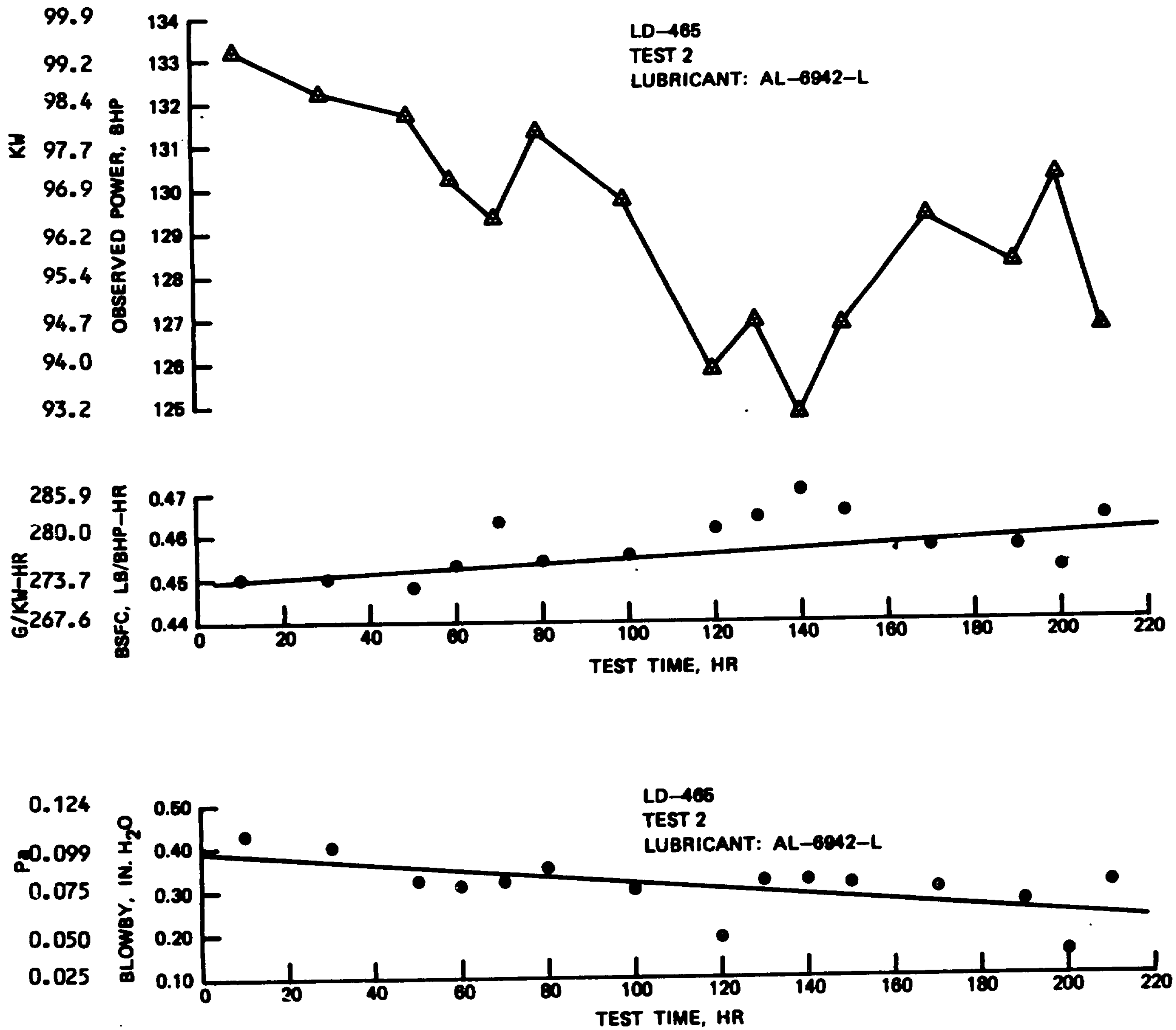
	Power Mode			Idle Mode
	Min.	Avg.	Max.	Avg.
Engine Speed, rpm	2599	2601	2605	762
Engine Torque, ft-lb	252	261	274	13
Fuel Consumption, lb/hr	58.1	59.1	59.8	5.0
BHP (Observed)	124.8	129.1	133.2	1.9
BSFC (Observed)	0.448	0.458	0.470	2.63
Temperatures, °F				
Exhaust Manifold	1220	1270	1320	180
Cooling Water In	170	170	170	95
Cooling Water Out	179	180	180	100
Oil Sump	220	225	226	125
Air In	55	90	110	70
Pressures				
Fuel Transfer Pump, psi	72	73	73	38
Oil Gallery, psi	57	60	63	60
Intake Vacuum, in. H_2O	3.7	3.8	4.0	0.4
Exhaust Pressure, in. Hg	1.1	1.5	2.7	0



LD-465
TEST 2
LUBRICANT: AL-6942-L
● = BEFORE TEST
△ = AFTER TEST
KW
OBSERVED POWER, BHP
ENGINE SPEED, RPM
104.4
96.9
89.5
82.0
74.6
67.1
59.7
52.2
44.7
37.3
29.8
22.4
140
130
120
110
100
90
80
70
60
50
40
30
1200
1400
1600
1800
2000
2200
2400
2600



LD-465
TEST 2
LUBRICANT: AL-6942-L
● = BEFORE TEST
△ = AFTER TEST
FUEL CONSUMPTION, LB/HR
29.5
27.2
24.9
22.7
20.4
18.1
15.9
13.6
11.3
65
60
55
50
45
40
35
30
25
BSFC, LB/BHP-HR
334.5
304.1
273.7
243.3
212.9
0.55
0.50
0.45
0.40
0.35
1200
1400
1600
1800
2000
2200
2400
2600
ENGINE SPEED, RPM



LD-465
TEST 2
LUBRICANT: AL-6942-L
KW
OBSERVED POWER, BHP
99.9
99.2
98.4
97.7
96.9
96.2
95.4
94.7
94.0
93.2
134
133
132
131
130
129
128
127
126
125
G/KW-HR
BSFC, LB/BHP-HR
285.9
280.0
273.7
267.6
0.47
0.46
0.45
0.44
0 20 40 60 80 100 120 140 160 180 200 220
TEST TIME, HR
LD-465
TEST 2
LUBRICANT: AL-6942-L
Pa
BLOWBY, IN. H_2O
0.124
0.099
0.075
0.050
0.025
0.50
0.40
0.30
0.20
0.10
0 20 40 60 80 100 120 140 160 180 200 220
TEST TIME, HR

LD 465
TEST 2
BUILD UP ENGINE MEASUREMENTS

	INCHES			
	MIN	MAX	AVE	SPECIFIED LIMITS
Cylinder Liners (Installed)				
Inside Diameter	4.5523	4.5647	4.5635	4.5630-4.5645
Out of Round	.0005	.0020	.0010	.0015 Max
Piston Skirt Diameter	4.5555	4.5557	4.5557	4.5570-4.5580
#1 Ring				
End Gap	.024	.025	.024	.025-.035
#2 Ring				
End Gap	.024	.030	.025	.025-.035
#3 Ring				
End Gap	.020	.021	.020	.025-.035
Side Clearance	.003	.004	.003	.0025-.0045
#4 Ring				
End Gap	.018	.020	.020	.013-.028
Side Clearance	.001	.002	.002	.0010-.0035

LD465
TEST: 2
LUBRICANT: AL-6942-L

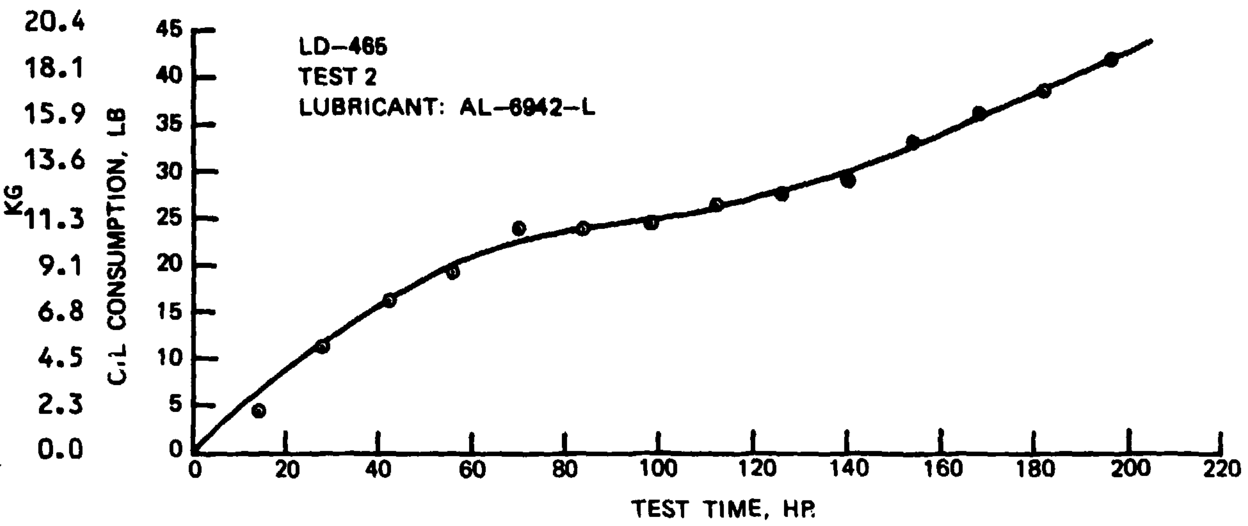
OIL CONSUMPTION, LB

Test Time, Hr.	Oil Consumed	Total Oil Consumed
14	4.48	4.48
28	6.92	11.40
42	4.94	16.34
56	3.10	19.44
70	4.52	23.96
84	0.00	23.96
98	0.56	24.52
112	2.01	26.53
126	0.71	27.24
140	2.19	29.43
154	3.95	33.38
168	3.14	36.52
182	2.30	38.82
196	3.18	42.00

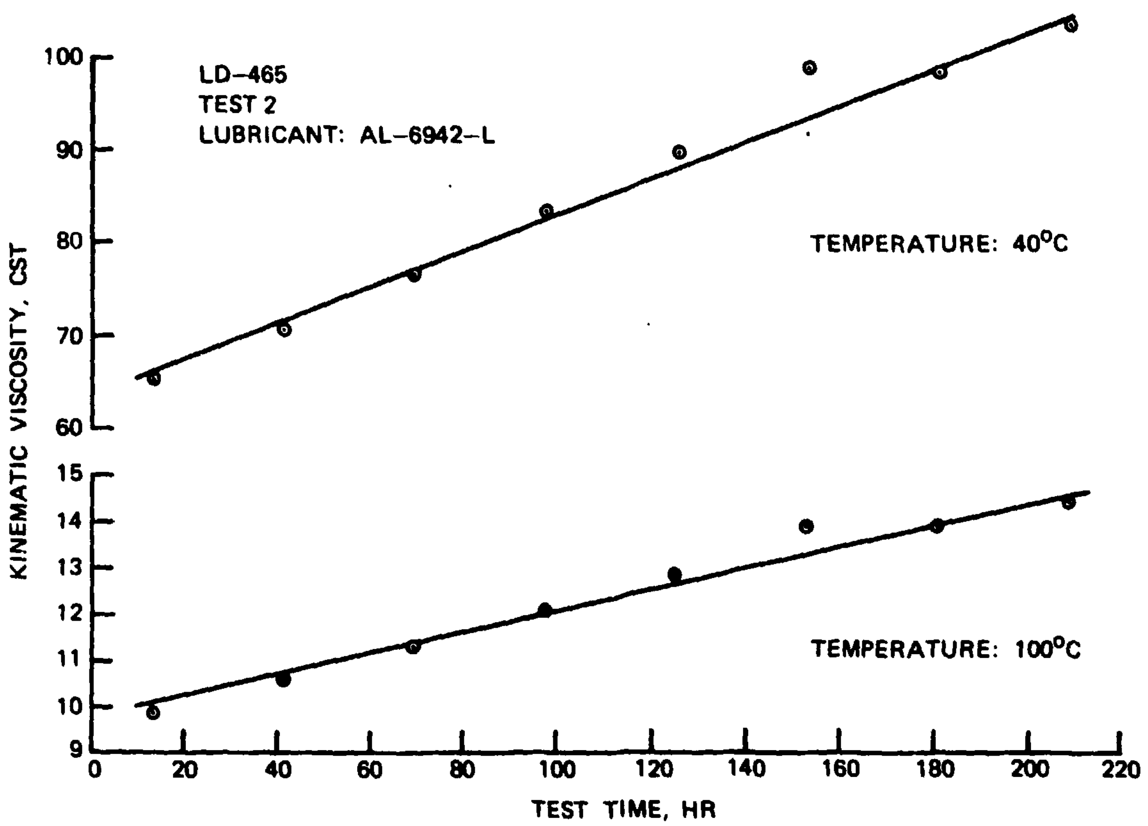
LD 465
TEST 2
LUBRICANT: AL-6942-L

LUBRICANT ANALYSIS

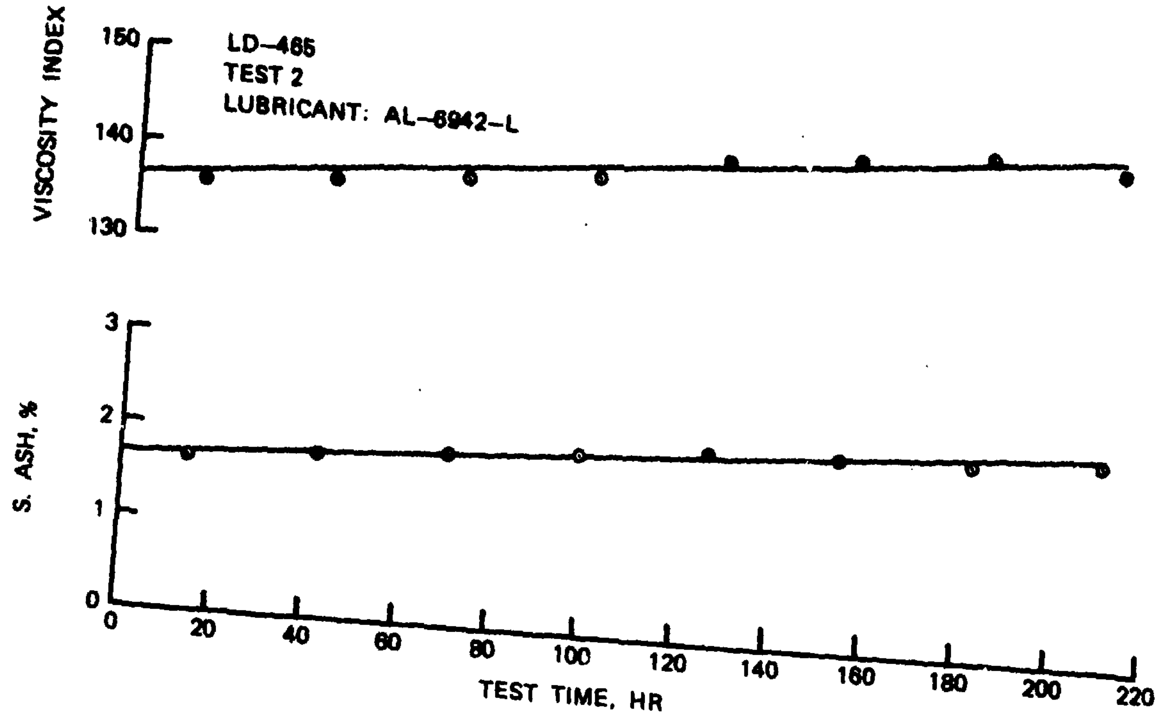
	ASTM TEST METHOD	TEST TIME (Hrs.) 0	14	42	70	98	126	154	182	210
IR Trace No.			1624	1625	1626	1627	1628	1629	1630	1631
K. Vis. Cs @ 40°C	D-445	64.5	65.4	70.7	76.6	83.5	89.9	99.0	98.6	103.7
K. Vis. Cs @ 100°C	D-445	10.2	9.87	10.58	11.30	12.09	12.90	13.95	13.96	14.47
V.I.	D-2270-74	133	136	137	138	139	142	143	144	143
TAN	D-664	3.74	3.03	3.73	3.62	3.65	4.08	4.60	4.15	4.46
TBN	D-2896	10.15	9.74	10.05	10.05	10.05	11.27	8.83	10.66	11.27
S. Ash, %	D-874	1.46	1.66	1.77	1.85	1.96	2.06	2.10	2.12	2.20
Pentane Insol. w/coag, %	D-893	.09	0.11	0.18	0.23	0.39	0.36	0.59	1.07	1.25
Benzene Insol. w/coag, %	D-893	.02	0.09	0.15	0.21	0.33	0.30	0.39	0.68	
Fe, ppm by XRF		N.D.	30	50	77	95	116	153	151	167

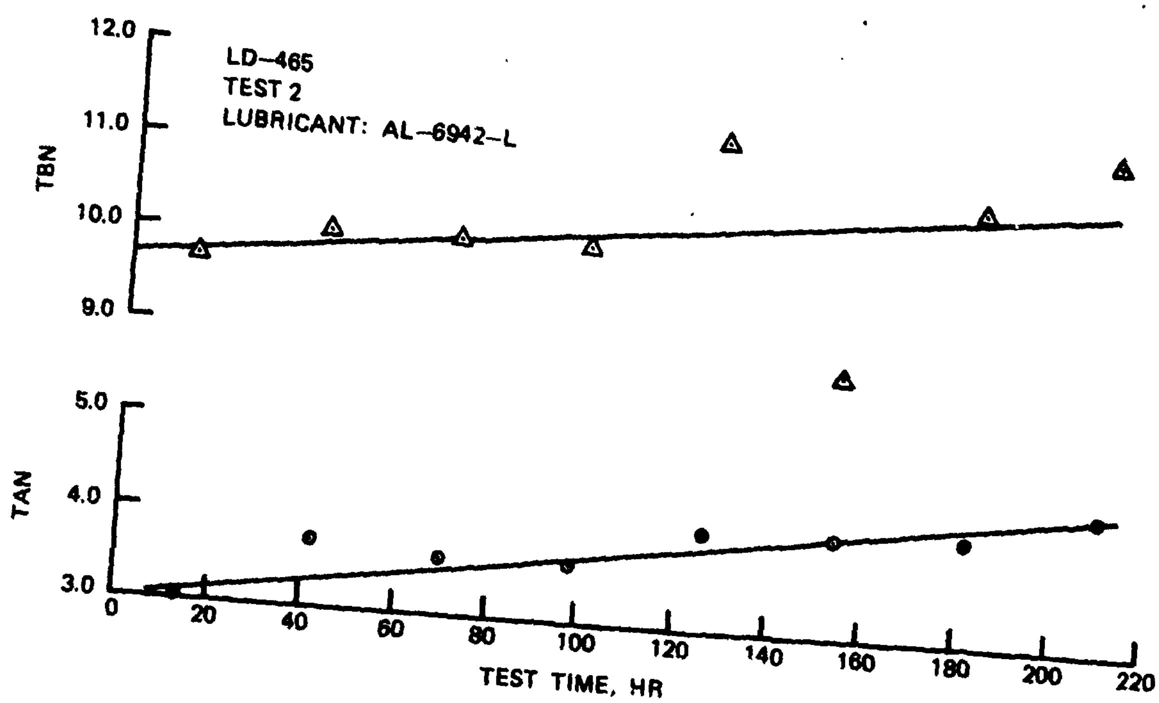


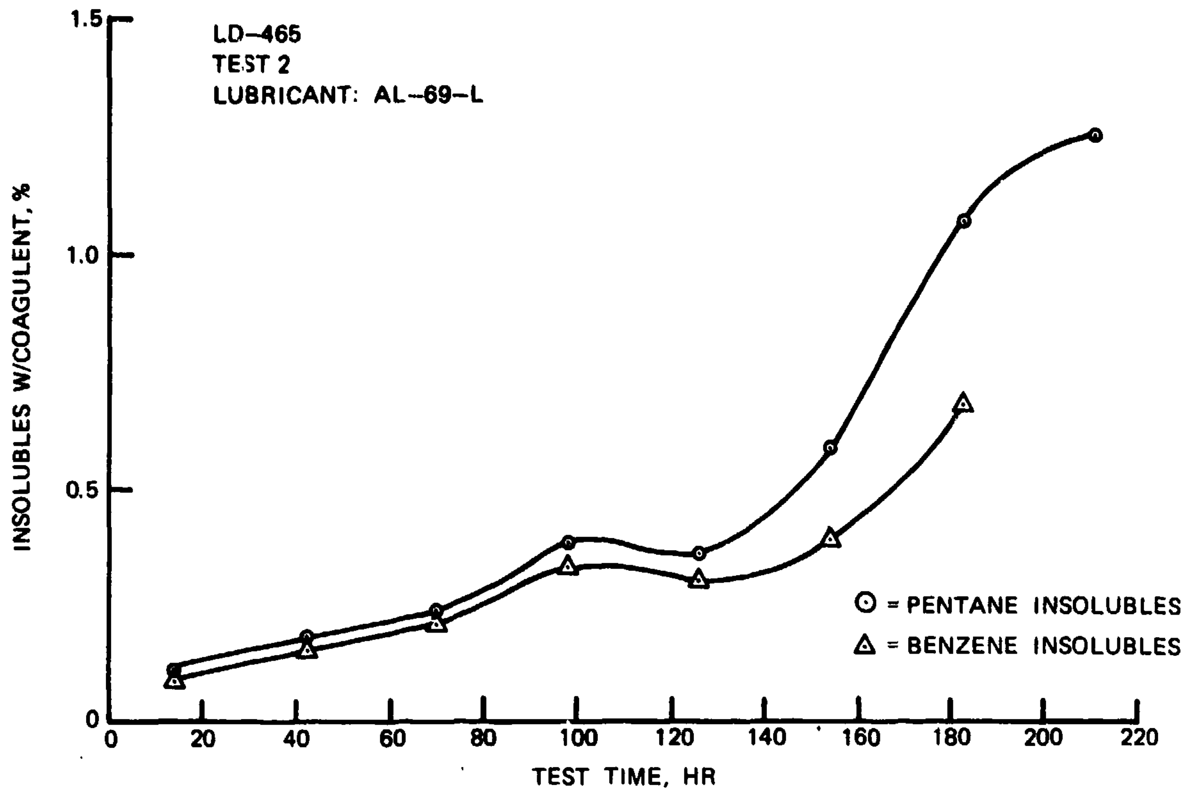
LD-465
TEST 2
LUBRICANT: AL-6942-L
KG
20.4
18.1
15.9
13.6
11.3
9.1
6.8
4.5
2.3
0.0
OIL CONSUMPTION, LB
45
40
35
30
25
20
15
10
5
0
0 20 40 60 80 100 120 140 160 180 200 220
TEST TIME, HR



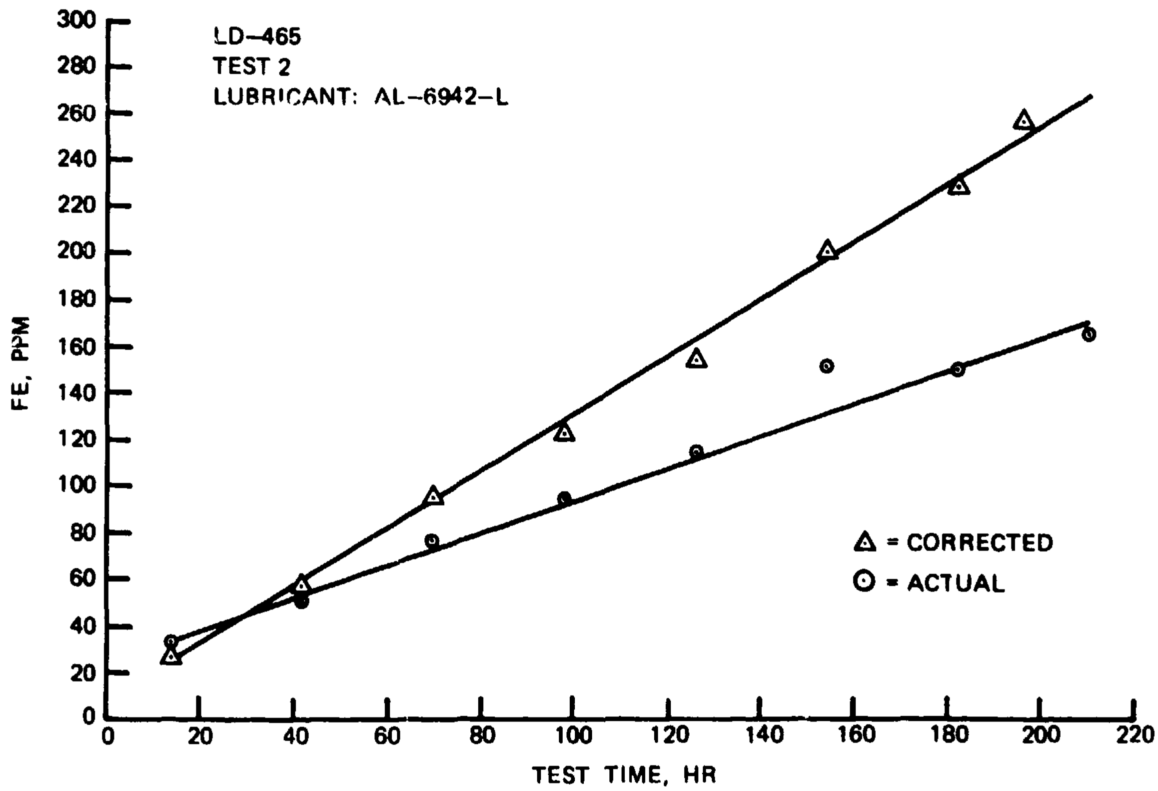
LD-465
TEST 2
LUBRICANT: AL-6942-L
TEMPERATURE: 40°C
TEMPERATURE: 100°C
KINEMATIC VISCOSITY, CST
100
90
80
70
60
15
14
13
12
11
10
9
0 20 40 60 80 100 120 140 160 180 200 220
TEST TIME, HR


LD-465
TEST 2
LUBRICANT: AL-6942-L
VISCOSITY INDEX
150
140
130
S. ASH, %
3
2
1
0
0
20
40
60
80
100
120
140
160
180
200
220
TEST TIME, HR

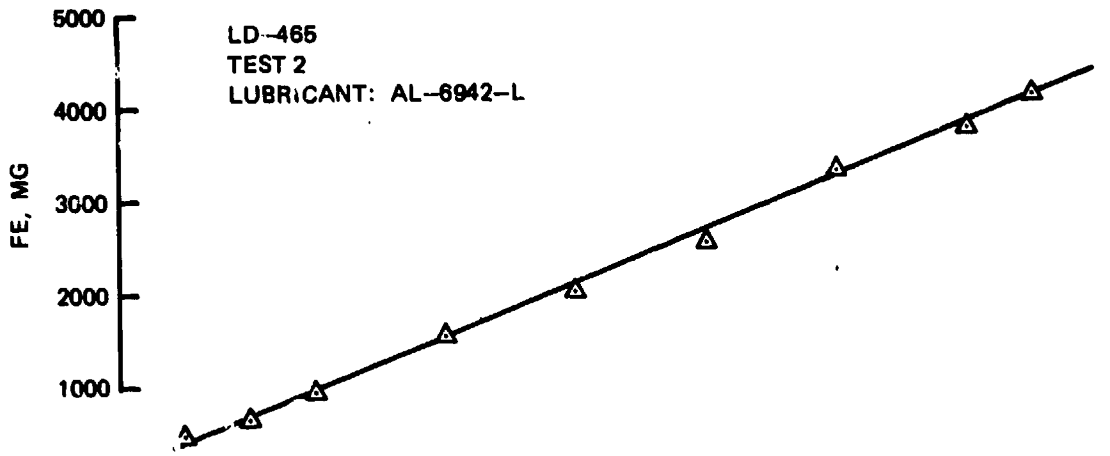

LD-465
TEST 2
LUBRICANT: AL-6942-L
TBN
12.0
11.0
10.0
9.0
TAN
5.0
4.0
3.0
0
20
40
60
80
100
120
140
160
180
200
220
TEST TIME, HR



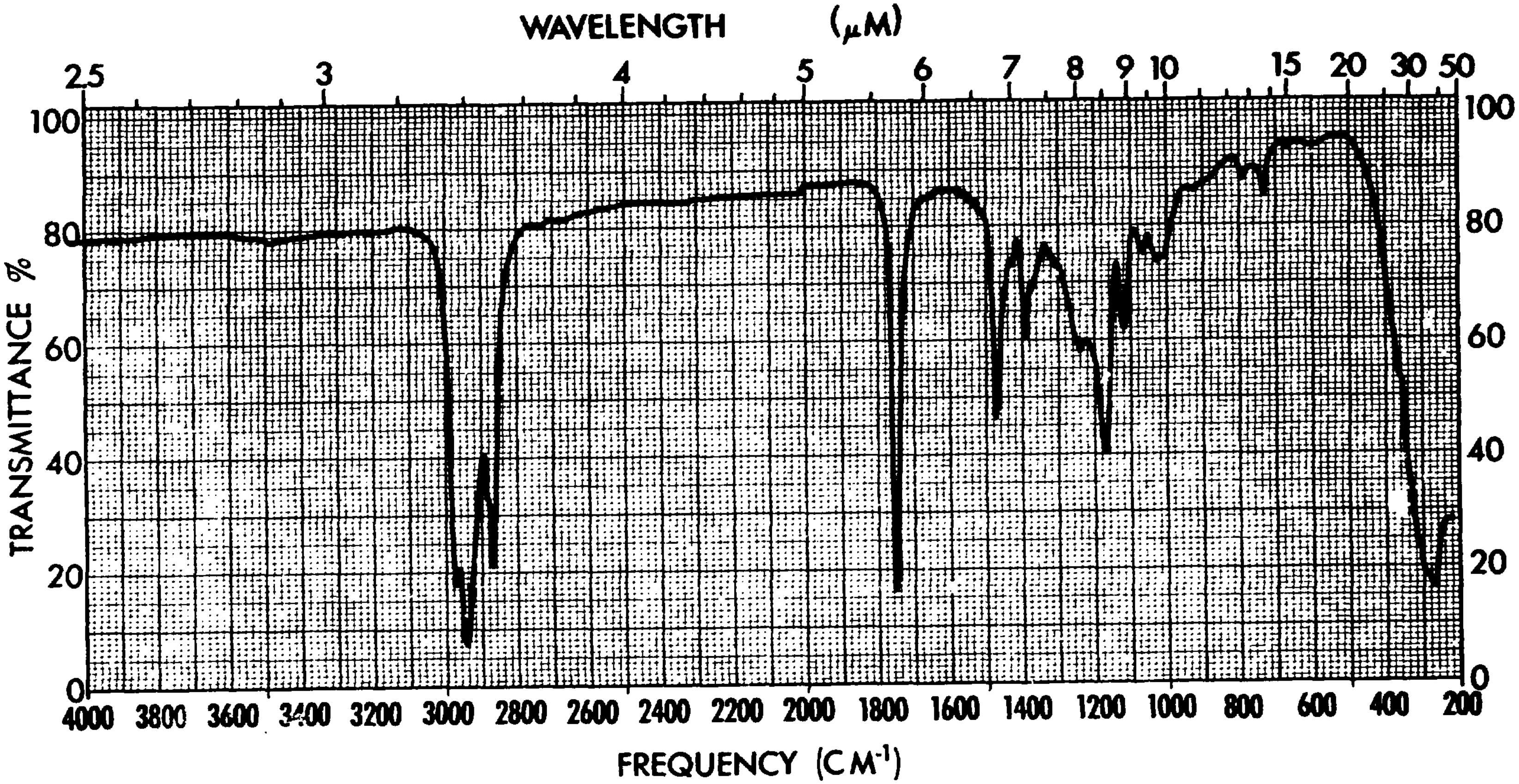
LD-465
TEST 2
LUBRICANT: AL-69-L
INSOLUBLES W/COAGULENT, %
1.5
1.0
0.5
0
0
20
40
60
80
100
120
140
160
180
200
220
TEST TIME, HR
= PENTANE INSOLUBLES
= BENZENE INSOLUBLES



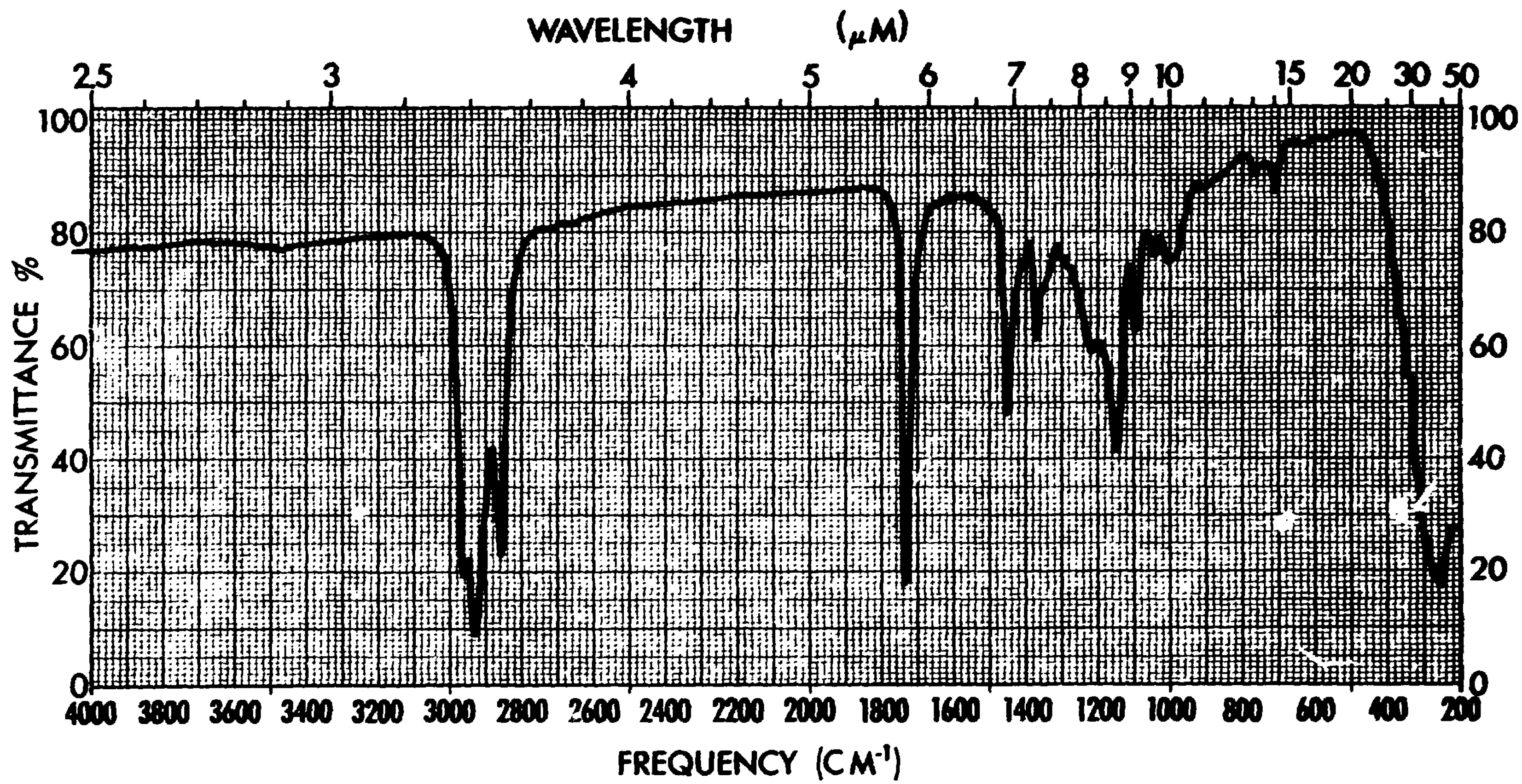
LD-465
TEST 2
LUBRICANT: AL-6942-L
FE, PPM
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
180
200
220
TEST TIME, HR
= CORRECTED
= ACTUAL



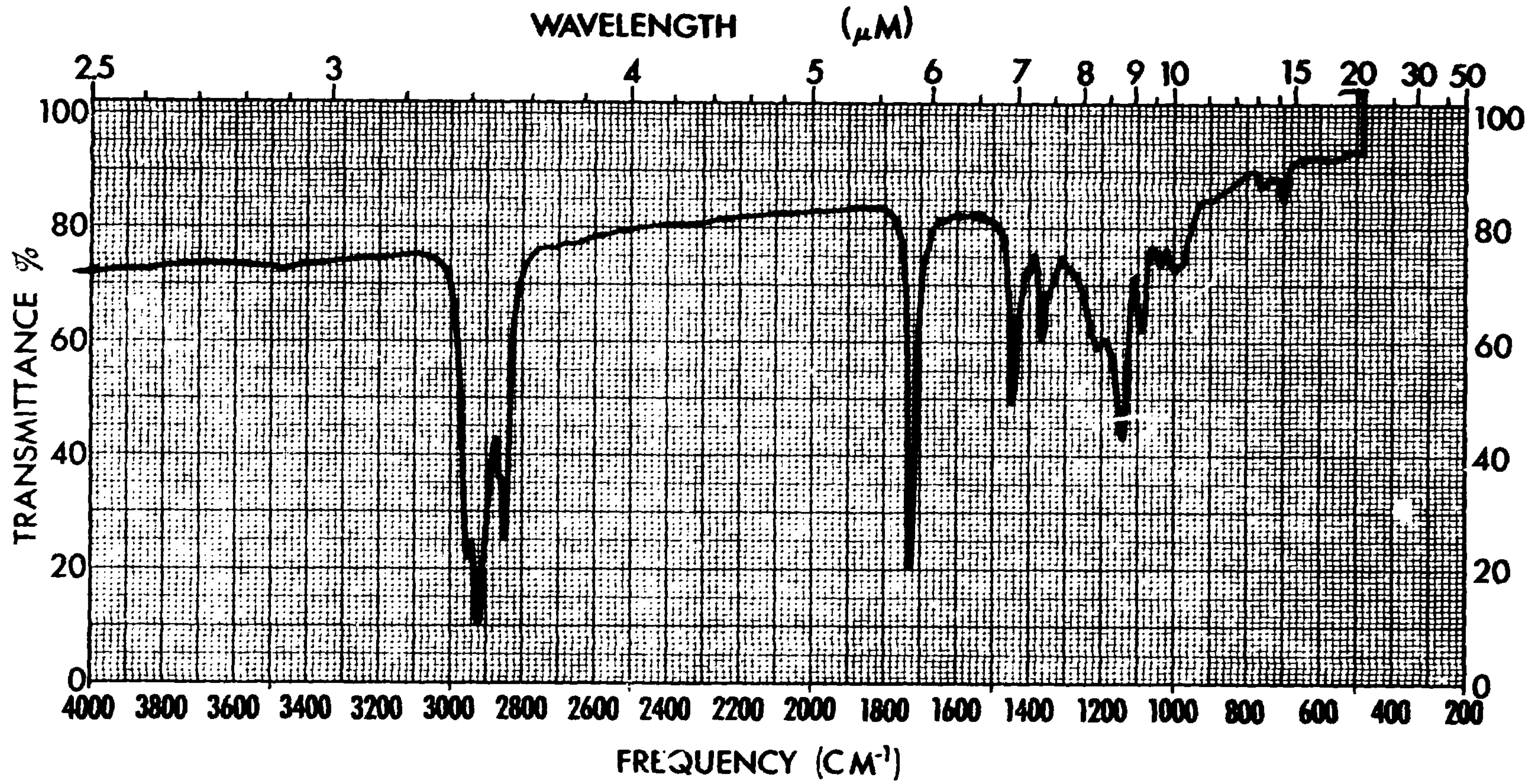
5000
4000
3000
2000
1000
FE, MG
LD-465
TEST 2
LUBRICANT: AL-6942-L



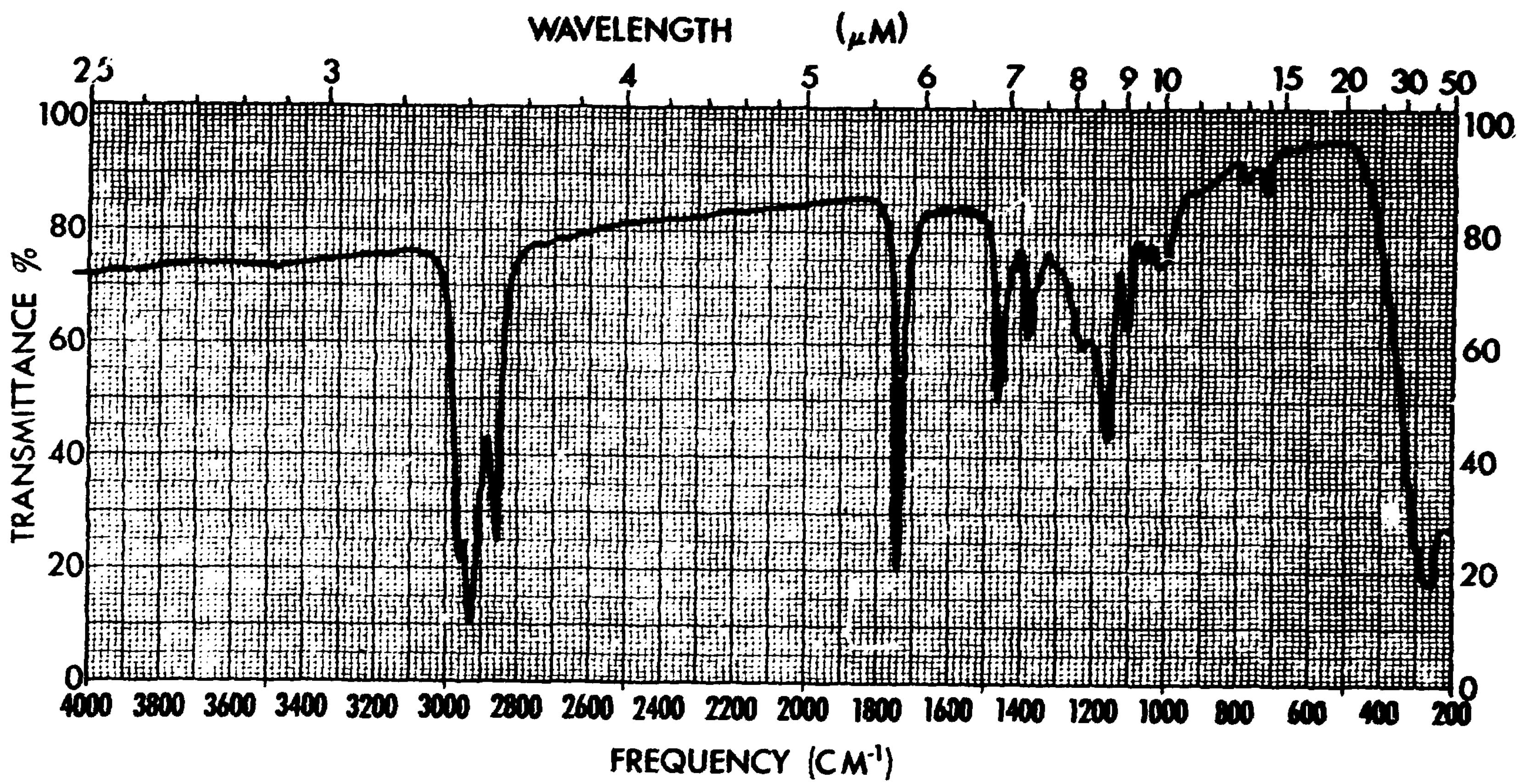
SPECTRUM NO. 1624	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6942-L		1.	
14 HR	PURITY	2.	
TEST 2	PHASE	DATE 2/7/79	
	THICKNESS None	OPERATOR DDD	



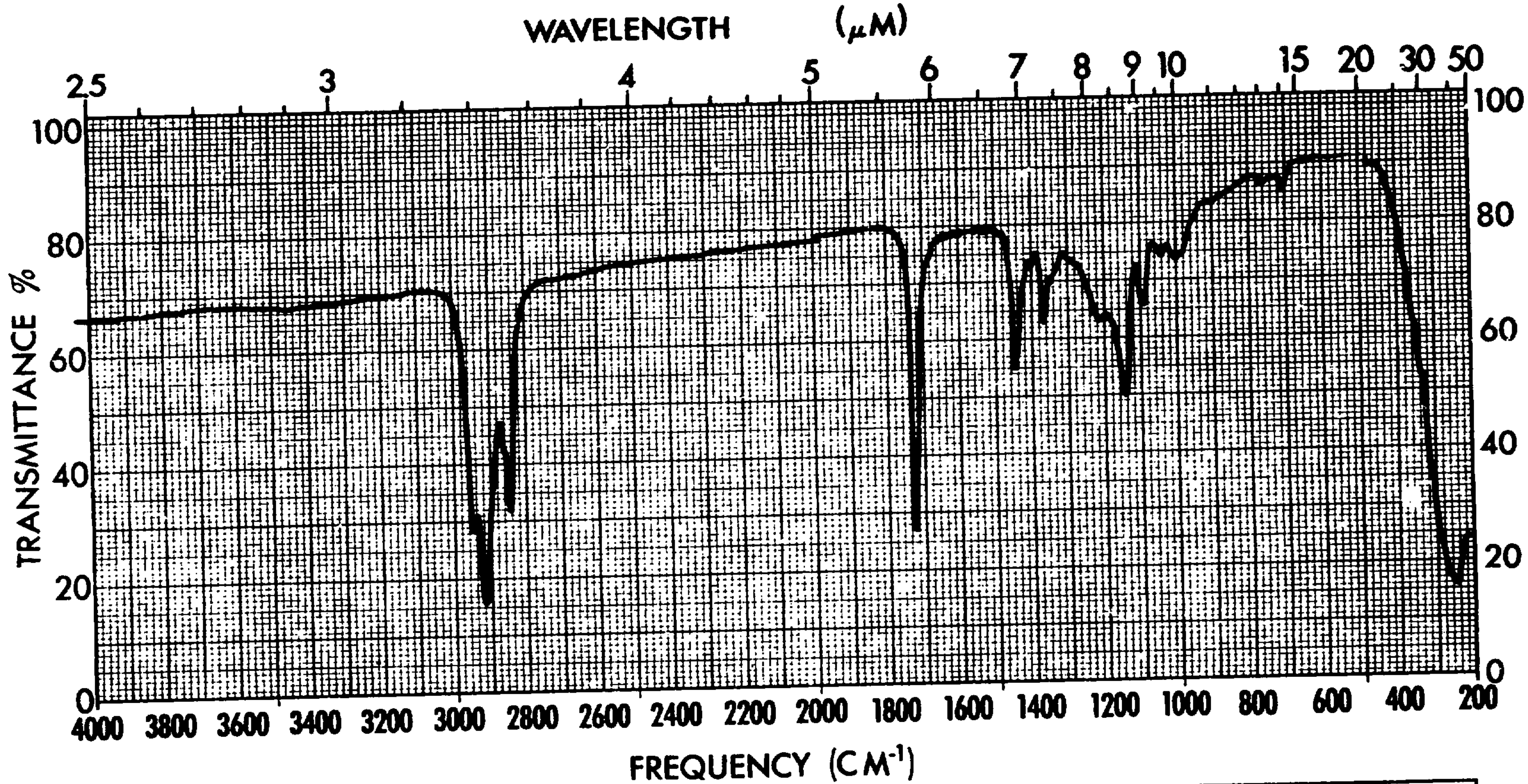
SPECTRUM NO. 1625	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6942-L		1.	
42 HR	PURITY	2.	
TEST 2	PHASE	DATE 2/7/79	
	THICKNESS NONE	OPERATOR DDD	



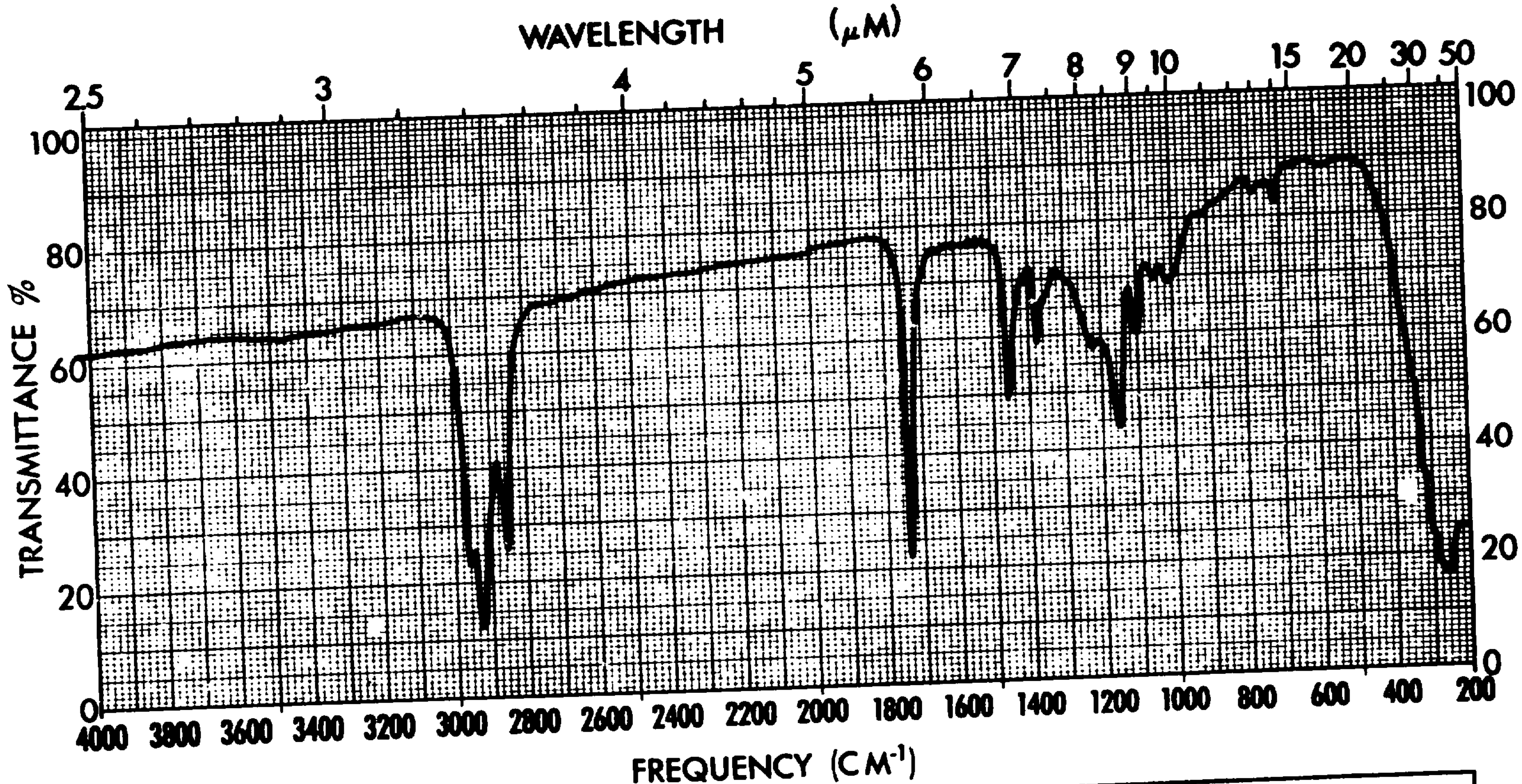
SPECTRUM NO. 1626	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6942-L		1.	
72 HR	PURITY	2.	
TEST 2	PHASE	DATE 2/7/79	
	THICKNESS NONE	OPERATOR DDD	



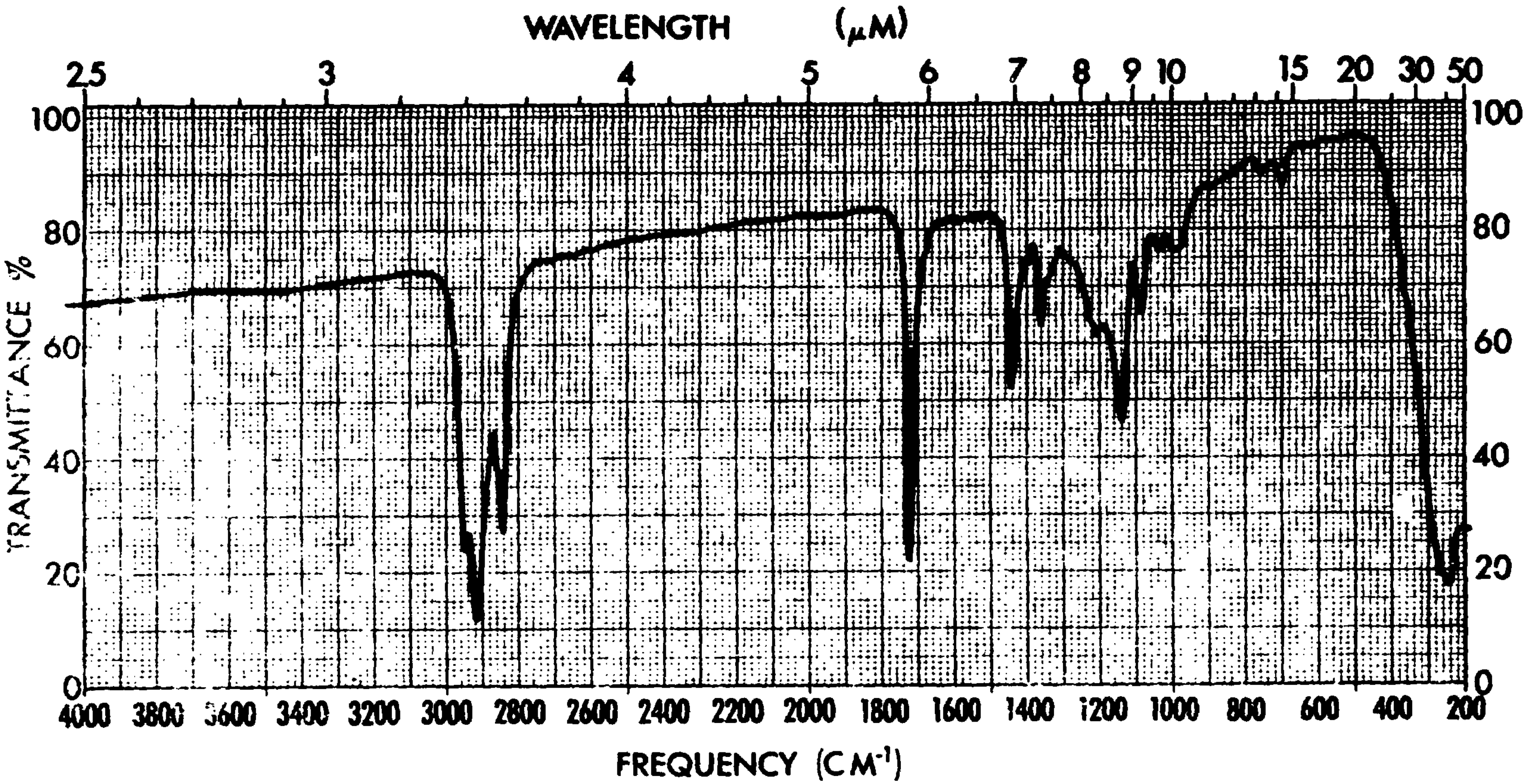
SPECTRUM NO. 1627	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6942-L		1.	
98 HR	PURITY	2.	
TEST 2	PHASE	DATE 2/7/79	
	THICKNESS NONE	OPERATOR DDD	



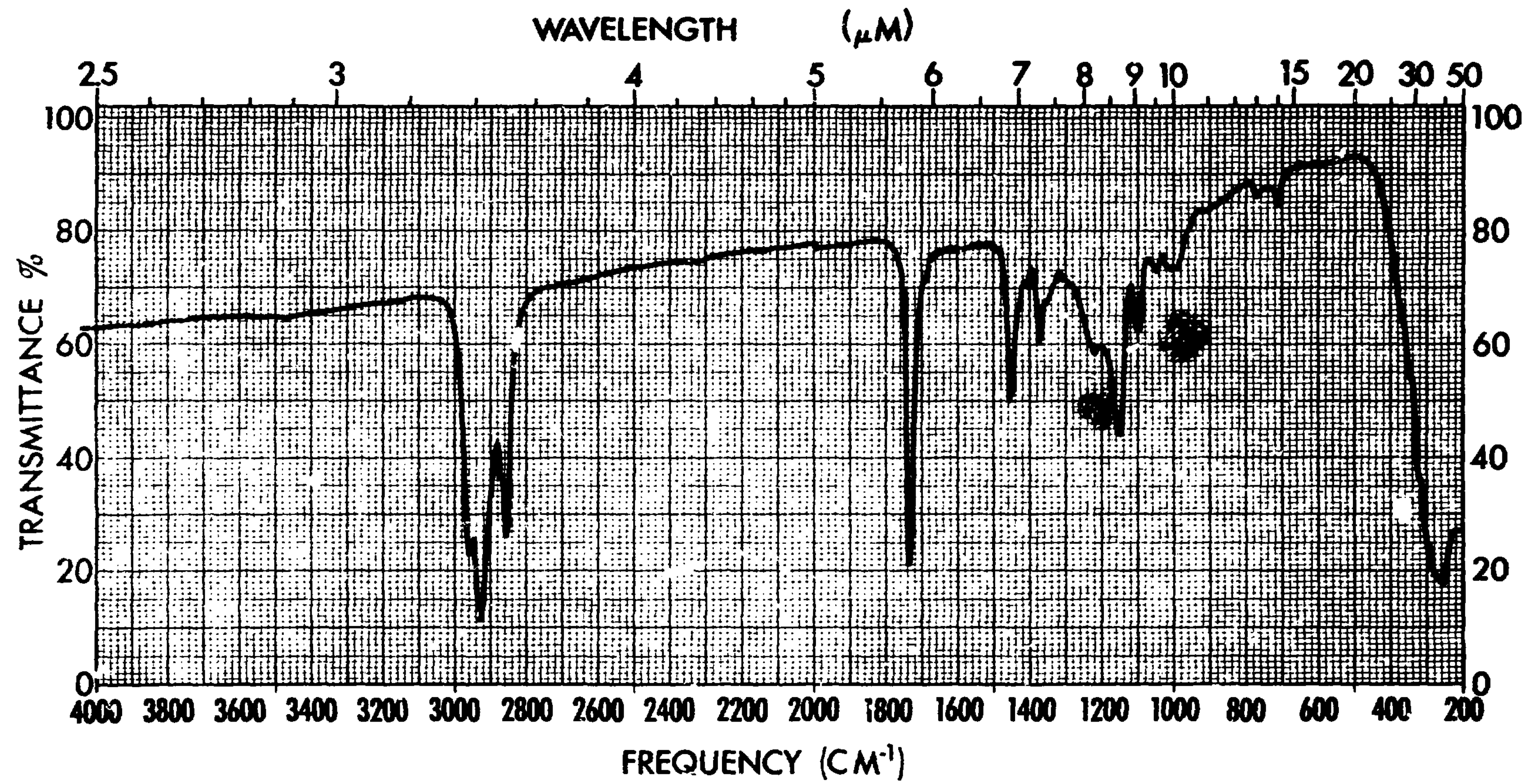
SPECTRUM NO. 1628	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6942-L		1.	
126 HR	PURITY	2.	
TEST 2	PHASE	DATE 2/7/79	
	THICKNESS NONE	OPERATOR DDD	



SPECTRUM NO. 1629	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6942-L		1.	
154 HR	PURITY	2.	
TEST 2	PHASE	DATE 2/7/79	
	THICKNESS NONE	OPERATOR DDD	



SPECTRUM NO. 1630	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6942-L		1.	
182 HR	PURITY	2.	
TEST 2	PHASE	DATE 2/7/79	
	THICKNESS NONE	OPERATOR DDD	



SPECTRUM NO. 1631	ORIGIN	LEGEND	REMARKS
SAMPLE AL-6942-L		1.	
210 HR	PURITY	2.	
TEST 2	PHASE	DATE 2/7/79	
	THICKNESS NONE	OPERATOR DDD	

TEST: 2
LUBRICANT: AL-6942-L

WEAR MEASUREMENTS

CYLINDER LINER BORE DIAMETER (INCHES)

		Longitudinal			Transverse		
		Before	After	Change	Before	After	Change
1)	Top	4.5638	4.5639	0.0001	4.5630	4.5630	0.0000
	Center	4.5632	4.5633	0.0001	4.5637	4.5638	0.0001
	Bottom	4.5628	4.5629	0.0001	4.5642	4.5642	0.0000
2)	Top	4.5633	4.5634	0.0001	4.5640	4.5643	0.0003
	Center	4.5636	4.5633	-0.0003	4.5645	4.4647	0.0002
	Bottom	4.5636	4.5633	-0.0003	4.5646	4.5649	0.0003
3)	Top	4.5634	4.5633	-0.0001	4.5647	4.5650	0.0003
	Center	4.5632	4.5630	-0.0001	4.5645	4.5647	0.0002
	Bottom	4.5630	4.5630	0.0000	4.5645	4.5646	0.0001
4)	Top	4.5625	4.5630	0.0005	4.5629	4.5630	0.0001
	Center	4.5626	4.5627	0.0001	4.5632	4.5633	0.0001
	Bottom	4.5626	4.5627	0.0001	4.5632	4.5634	0.0002
5)	Top	4.5630	4.5639	0.0009	4.5650	4.5649	-0.0001
	Center	4.5629	4.5631	0.0002	4.5642	4.5642	0.0000
	Bottom	4.5634	4.5636	0.0002	4.5642	4.5641	-0.0001
6)	Top	4.5623	4.5629	0.0006	4.5636	4.5637	0.0001
	Center	4.5629	4.5630	0.0001	4.5638	4.5637	-0.0001
	Bottom	4.5631	4.5632	0.0001	4.5637	4.5636	-0.0001

LD465
TEST: 2
LUBRICANT: AL-6942-L

WEAR MEASUREMENTS

PISTON RING END GAP (INCHES)

Ring Number*	PISTON NUMBER 1	2	3	4	5	6
1) Before Test	0.024	0.024	0.024	0.025	0.024	0.025
After Test	0.025	0.026	0.025	0.026	0.027	0.028
Change	0.001	0.002	0.001	0.001	0.003	0.003
2) Before Test	0.030	0.025	0.024	0.025	0.025	0.025
After Test	0.031	0.027	0.024	0.026	0.028	0.027
Change	0.001	0.002	0.000	0.001	0.003	0.002
3) Before Test	0.020	0.021	0.020	0.020	0.020	0.020
After Test	0.022	0.021	0.022	0.020	0.021	0.022
Change	0.002	0.000	0.002	0.000	0.001	0.002
4) Before Test	0.020	0.020	0.020	0.020	0.018	0.020
After Test	0.026	0.025	0.024	0.026	0.025	0.025
Change	0.006	0.005	0.004	0.006	0.007	0.005

* From Top of Piston

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-6942-L

RATER Lyons DATE 1-30-79
LABORATORY TEST NUMBER 2
STAND NO. 6 ENGINE NO. 3904343
FUEL AL-7799-F

PISTON NO. 1

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	99.00

			GROOVES								LANDS								UNDER-CROWN	
	DEPOSIT TYPE	DEPOSIT FACTOR	NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
			AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON	HC	1.00																		
	MHC	0.75																		
	MC	0.50	10	5.00							80	40.00								
	LC	0.25	70	17.50									15	3.75						
	VLC	0.15																		
	CARBON RATING		22.50								40.00		3.75							
LACQUER	BL	0.100									20	2.00								
	DBrL	0.075	20	1.50																
	AL	0.050			100	5.00	100	5.00	100	5.00			85	4.25					100	5.00
	LAL	0.025													100	2.50	100	2.50		
	VLAL	0.010																		
	RL	0.001																		
	LACQUER RATING		1.50		5.00		5.00		5.00		2.00		4.25		2.50		2.50		5.00	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		24.00		5.00		5.00		5.00		42.00		8.00		2.50		2.50		5.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-6942-L

RATER Lyons DATE 1-30-79
LABORATORY TEST NUMBER 2
STAND NO. 6 ENGINE NO. 3904343
FUEL AL-7790 - F

PISTON NO. 2

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	74.125

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES								LANDS								UNDER-CROWN	
			NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
			AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON	HC	1.00	10	10.00																
	MHC	0.75																		
	MC	0.50	10	2.50							80	20.00								
	LC	0.25									20	5.00								
	VLC	0.15																		
	CARBON RATING		12.50								25.00									
LACQUER	BL	0.100											5	5.50						
	DBrL	0.075	85	6.375																
	AL	0.050			100	5.00	100	5.00	100	5.00			95	4.75					100	5.00
	LAL	0.025													100	2.50	100	2.50		
	VLAL	0.010																		
	RL	0.001																		
	LACQUER RATING		6.375		5.00		5.00		5.00				5.25		2.50		2.50		5.00	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		18.875		5.00		5.00		5.00		25.00		5.25		2.50		2.50		5.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-6942-L

RATER Lyons DATE 1-30-79
LABORATORY TEST NUMBER 2
STAND NO. 6 ENGINE NO. 3904343
FUEL AL-7799-F

PISTON NO. 3

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	84.50

			GROOVES								LANDS								UNDER-CROWN	
	DEPOSIT TYPE	DEPOSIT FACTOR	NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
			AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON	HC	1.00																		
CARBON	MHC	0.75																		
CARBON	MC	0.50									85	42.50								
CARBON	LC	0.25	15	3.75																
CARBON	VLC	0.15																		
CARBON	CARBON RATING		3.75								42.50									
LACQUER	BL	0.100									10	1.00								
LACQUER	DBrL	0.075	85	6.375	20	1.50					5	.375								
LACQUER	AL	0.050			80	4.00	100	5.00	100	5.00			100	5.00					100	5.00
LACQUER	LAL	0.025													100	2.50	100	2.50		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
LACQUER	LACQUER RATING		6.375		5.50						1.375		5.00		2.50		2.50		5.00	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		10.125		5.50		5.00		5.00		43.875		5.00		2.50		2.50		2.50	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-6942-L

RATER Lyons DATE 1-30-79
LABORATORY TEST NUMBER 2
STAND NO. 6 ENGINE NO. 3904343
FUEL AL-7799-F

PISTON NO. 4

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	93.875

			GROOVES								LANDS								UNDER-CROWN	
	DEPOSIT TYPE	DEPOSIT FACTOR	NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
			AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON	HC	1.00																		
	MHC	0.75	25	18.75																
	MC	0.50									75	37.50								
	LC	0.25	10	2.50																
	VLC	0.15																		
	CARBON RATING		21.25								37.50									
LACQUER	BL	0.100																		
	DBrL	0.075	65	4.875																
	AL	0.050			100	5.00	100	5.00	100	5.00			100	5.00					100	5.00
	LAL	0.025													100	2.50	100	2.50		
	VLAL	0.010									25	.25								
	RL	0.001																		
	LACQUER RATING		4.875		5.00		5.00		5.00		.25		5.00		2.50		2.50		5.00	
CLEAN		0																		
ZONAL RATING																				
LOCATION FACTOR																				
WEIGHTED RATING			26.125		5.00		5.00		5.00		37.75		5.00		2.50		2.50		5.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-6942-L

RATER Lyons DATE 1-30-79
LABORATORY TEST NUMBER 2
STAND NO. 6 ENGINE NO. 3904343
FUEL AL-7799-F

PISTON NO. 5

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	94.975

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00																		
CARBON	MHC	0.75																		
CARBON	MC	0.50	20	10.00							90	45.00								
CARBON	LC	0.25	10	2.50																
CARBON	VLC	0.15																		
	CARBON RATING		12.50								45.00									
LACQUER	BL	0.100	70	7.00									5	5.00						
LACQUER	DBrL	0.075											5.	.375						
LACQUER	AL	0.050			100	5.00	100	5.00	100	5.00			90	4.50					100	5.00
LACQUER	LAL	0.025													100	2.50	100	2.50		
LACQUER	VLAL	0.010									10	.10								
LACQUER	RL	0.001																		
	LACQUER RATING		7.00		5.00		5.00		5.00		.10		5.375		2.50		2.50		5.00	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		19.50		5.00		5.00		5.00		45.10		5.375		2.50		2.50		5.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-6942-L

RATER Lyons DATE 1-30-79
LABORATORY TEST NUMBER 2
STAND NO. 6 ENGINE NO. 3904343
FUEL AL-7799-F

PISTON NO. 6

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	100.10

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES								LANDS								UNDER-CROWN	
			NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
			AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON	HC	1.00																		
CARBON	MHC	0.75																		
CARBON	MC	0.50	10	5.00							90	45.00								
CARBON	LC	0.25	90	22.50									5							
CARBON	VLC	0.15																		
	CARBON RATING		27.50								45.00									
LACQUER	BL	0.100											5	.50						
LACQUER	OBrL	0.075																		
LACQUER	AL	0.050			100	5.00	100	5.00					90	4.50					100	5.00
LACQUER	LAL	0.025							100	2.50					100	2.50	100	2.50		
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING				5.00		5.00		2.50		.10		5.00		2.50		2.50		5.00	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		27.50		5.00		5.00		2.50		45.10		5.00		2.50		2.50		5.00	

*WEIGHTED TOTAL DEPOSITS

RING DEPOSITS
TEST 2

Engine Model Continental LD 465 Serial No. 3904343 Date 1-30-79
Fuel AL-7799-F Lubricant AL-6942-L Observer Lyons

Cylinder Number			1		2		3		4		5		6	
			CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ
Piston Ring	Top	1	0	0	0	0	0	0	0	0	0	10	0	5
		2	0	10	0	20	0	10	0	15	0	15	0	25
		3	0	100	0	100	0	90	0	95	0	95	0	95
		4												
	ID	1	0	100	0	100	0	100	0	100	0	95	0	60
		2	0	100	0	100	0	100	0	100	0	100	0	100
		3	0	100	0	100	0	100	0	100	0	100	0	100
		4												
	Bottom	1	0	0	0	0	0	0	0	0	0	0	0	0
		2	0	40	0	50	0	30	0	0	0	75	0	75
		3	0	75	0	85	0	80	0	0	0	90	0	90
		4												

See pages 4, 36 and 37 of Manual. Areas previously rated for carbon, rate 0 for lacquer

RING FACE CONDITION

TEST 2

Engine Model LD 465 Serial No. 3904343 Date 1-30-79

Fuel AL-7799 -F Lubricant AL-6942-L Observer Lyons

	Cylinder Number					
	1	2	3	4	5	6
First Ring	N	N	N	N	N	N
Second Ring	N	N	N	N	N	N
Third Ring	N	N	N	N	N	N
Fourth Ring	N	N	N	N	N	N
Oil Ring Slots—% Open	100	100	100	100	100	100

Pages 1 and 2 and 59 through 65 of Manual.

N = NORMAL

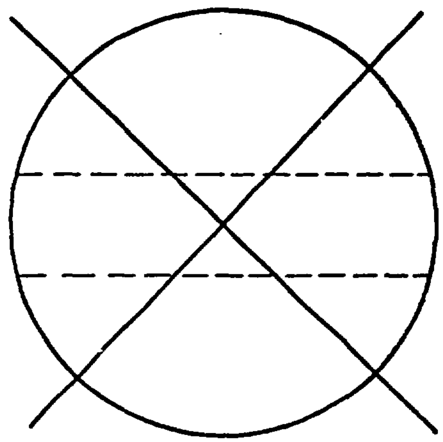
PISTON GROOVE INSIDE DIAMETER—% RING SUPPORTING CARBON
TEST 2

Engine Model Continental LD-465 Serial No. 3904343 Date 1-30-78
Fuel AL-7799-F Lubricant AL-6942-L Observer Lyons

Piston Ring	Quadrant	Piston Number 1	2	3	4	5	6
1	1	0	5	0	0	0	0
	2	0	0	0	0	0	0
	3	80	0	0	0	0	0
	4	0	10	0	0	0	0
2	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0

1 Thrust Side

4 Front



2 Rear

3 Anti-Thrust Side

PISTON SURFACE CONDITION

TEST 2

Engine Model Continental LD-465 Serial No. 3904343 Date 1-30-79

Fuel AL-7799-F Lubricant AL-6942-L Observer Lyons

	Piston Number					
	1	2	3	4	5	6
Top Land	N	N	N	N	N	N
Skirt	N	N	N	N	N	N
Piston Pin	N	N	N	N	N	N

Pages 1 through 2 and 59 through 65 of Manual.

N = NORMAL

VALVE SURFACE CONDITIONS
TEST 2

Engine Model CONTINENTAL LD 465 Serial No. 3904343 Date 1-29-79
Fuel AL-7799-F Lubricant AL-6942-L Observer Lyons

	Intake						Exhaust					
	1	2	3	4	5	6	1	2	3	4	5	6
Freeness in Guide	F	F	F	F	F	F	F	F	F	F	F	F
Head	N	N	N	N	N	N	N	N	N	N	N	N
Face	N	N	N	N	N	N	N	N	N	N	N	N
Seat	N	N	N	N	N	N	N	N	N	N	N	N
Stem	N	N	N	N	N	N	N	N	N	N	N	N
Tip	N	N	N	N	N	N	N	N	N	N	N	N

See Pages 1, 2, 16 through 23, and 54 through 65 of Manual.

Tulip Deposit 2.8 2.5 3.0 2.3 2.5 3.0 .5 .5 .5 .5 .5 .5

F = FREE

N = NORMAL

CYLINDERS

TEST 2

Engine Model Continental LD-465 Serial No. 3904343 Date 1-30-79

Fuel AL-4499-F Lubricant AL-6942-L Observer Lyons

		Cylinder Number											
		1		2		3		4		5		6	
Deposits Cylinder Head		CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ
Cylinders	ART	50	50	70	30	70	20	70	30	85	15	75	25
	RTA	0	0	0	0	0	0	0	0	0	0	0	0
	BRT	0	0	0	0	0	0	0	0	0	0	0	0
Surface Condition													
Cylinders	RTA	5% LT Glaze LT Scratches		LT Scratches		LT Scratches		LT Scratches		LT Scratches		LT Scratches	
	BRTA	N		N		N		N		N		N	

Carbon and Ash: Use Volume Factor Pages 5 and 40 through 47 of Manual.
Indicate H, M, or S

Lacquer: Use Pages 4, 36 and 37

For Surface Condition—See Pages 1, 2, 16 through 23 and 54 through 65.

SURFACE CONDITION

TEST 2

Engine Model Continental LD 465 Serial No. 3904343 Date 1-30-79

Fuel AL-7799-F Lubricant AL-6942-L Observer LYons

Bearing No.	1	2	3	4	5	6	7
Main—Bearing	THE	ONE	REMOVED	LOOKS	VERY	GOOD	
—Journal							
Rod—Bearing	NORMAL						
—Journal							
Piston Pin	NORMAL						
Bushing							

Note surface condition. See pages 1, 2, 16 through 23 and 54 through 65 of Manual.

LD-465
TEST 2
AFTER TEST CONDITION OF CYLINDER HEADS

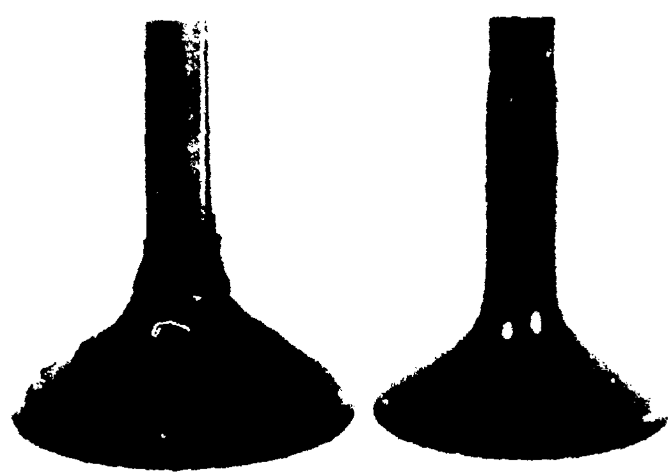
CYLINDERS 3, 2, AND 1

CYLINDERS 6, 5, AND 4

LD-465
TEST 2
AFTER TEST CONDITION OF NO. 1 PISTON AND VALVES

PISTON THRUST SIDE

PISTON ANTI-THRUST SIDE

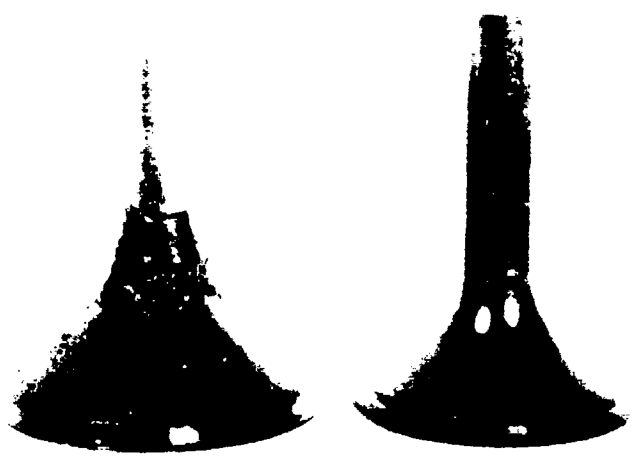


INTAKE AND EXHAUST VALVES

LD–465
TEST 2
AFTER TEST CONDITION OF NO. 2 PISTON AND VALVES

PISTON THRUST SIDE

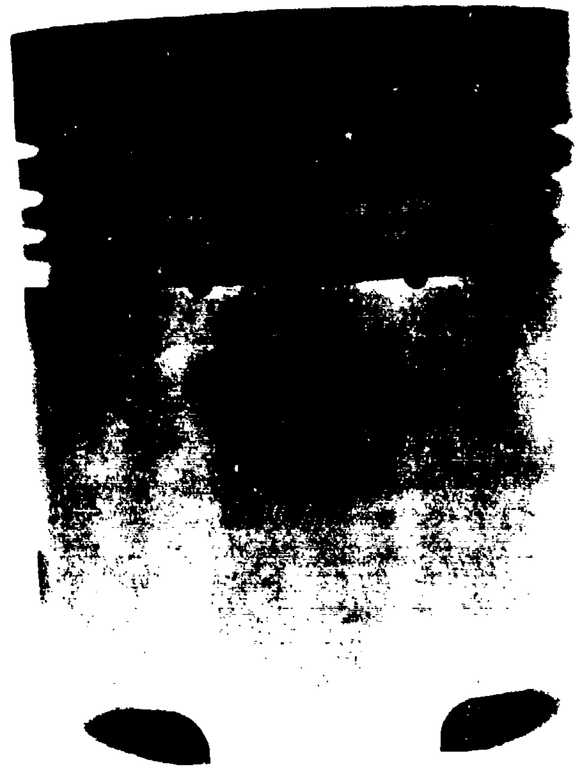
PISTON ANTI–THRUST SIDE



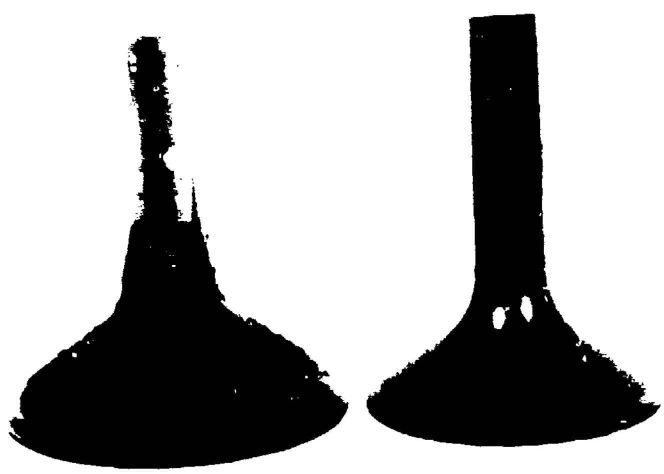
INTAKE AND EXHAUST VALVES

LD-465
TEST 2
AFTER TEST CONDITION OF NO. 3 PISTON AND VALVES

PISTON THRUST SIDE

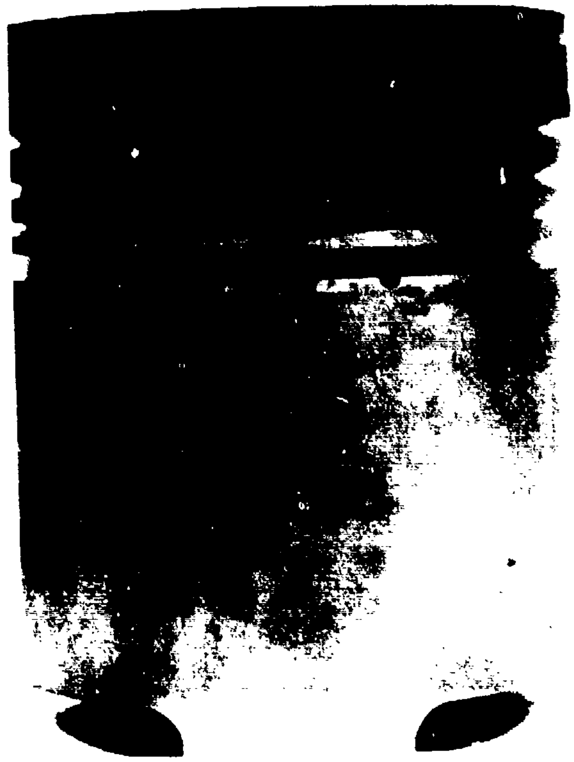


PISTON ANTI-THRUST SIDE

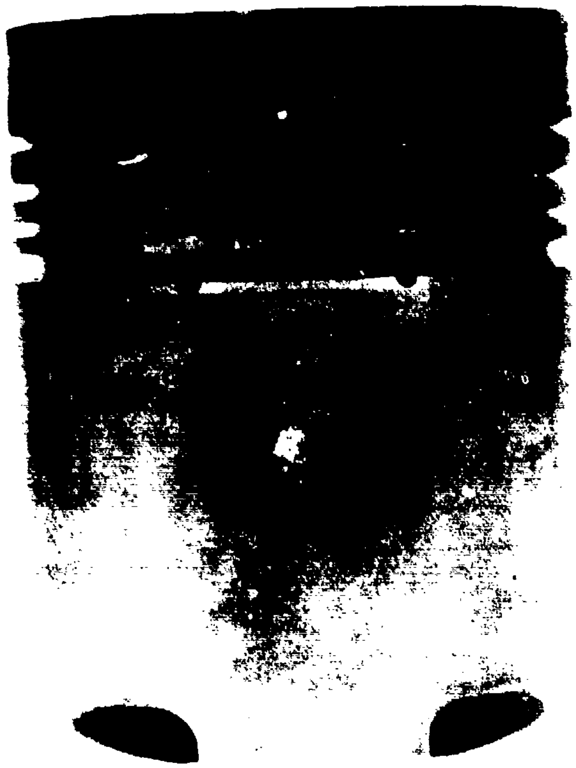


INTAKE AND EXHAUST VALVES

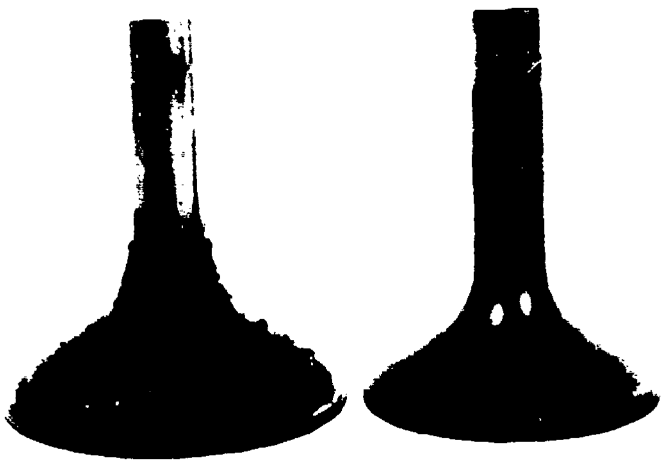
LD-465
TEST 2
AFTER TEST CONDITION OF NO. 4 PISTON AND VALVES



PISTON THRUST SIDE



PISTON ANTI-THRUST SIDE

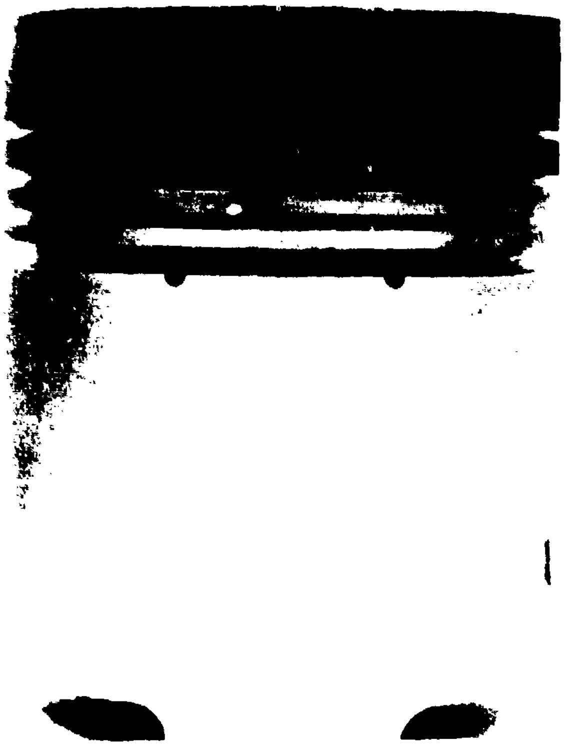


INTAKE AND EXHAUST VALVES

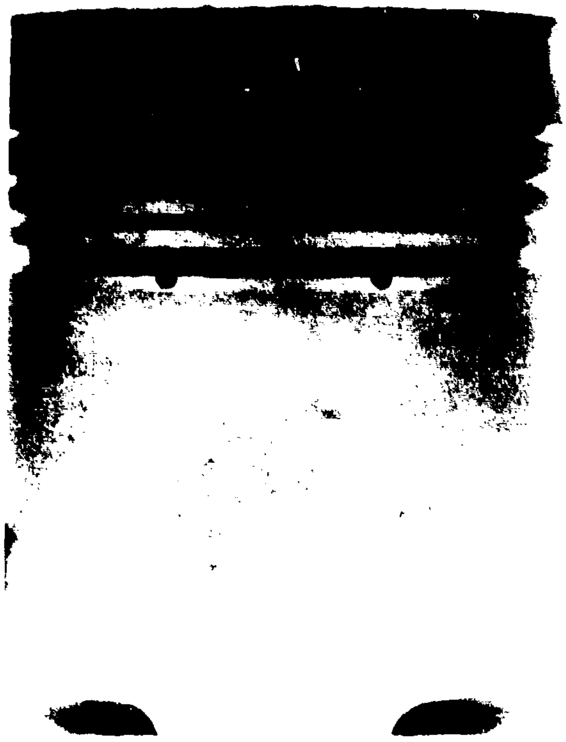
LD-465

TEST 2

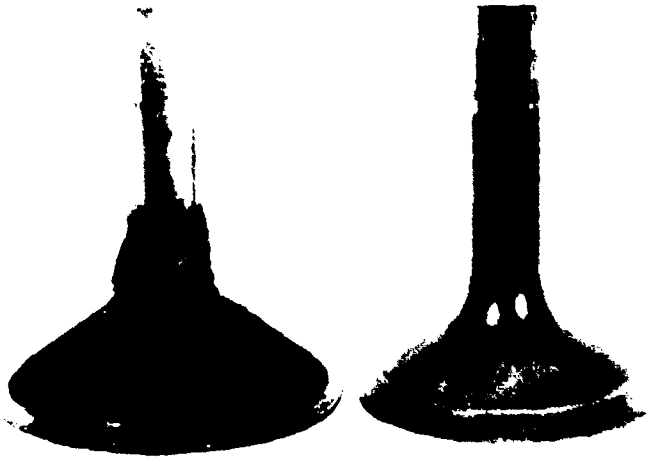
AFTER TEST CONDITION OF NO. 5 PISTON AND VALVES



PISTON THRUST SIDE



PISTON ANTI-THRUST SIDE

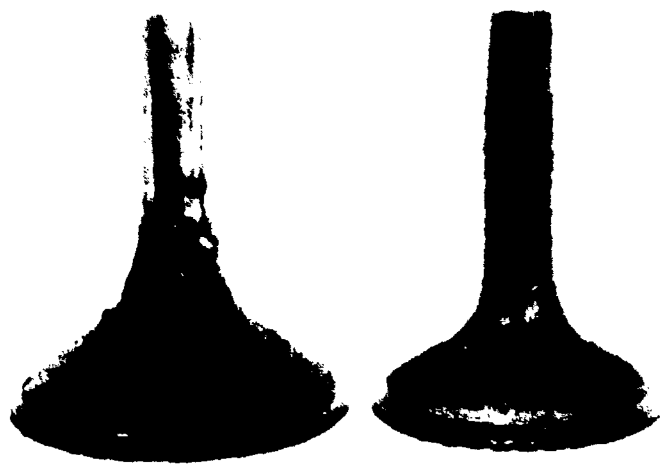


INTAKE AND EXHAUST VALVES

LD–465
TEST 2
AFTER TEST CONDITION OF NO. 6 PISTON AND VALVES

PISTON THRUST SIDE

PISTON ANTI–THRUST SIDE



INTAKE AND EXHAUST VALVES

APPENDIX J

ENGINE-LUBRICANT COMPATIBILITY TEST #3

210-HOUR WHEELED-VEHICLE CYCLE

USING LD 465 DIESEL ENGINE

ENGINE-LUBRICANT COMPATIBILITY TEST
210-HOUR WHEELED-VEHICLE CYCLE
USING LD 465 DIESEL ENGINE

Test Lubricant: AL-7288-L
Test Fuel: AL-8060-F
Engine Test Number: 3
Date Completed: 5 March 1979

Conducted for

U.S. Army Mobility Equipment Research and Development Command
Energy and Water Resources Laboratory
Fort Belvoir, Virginia

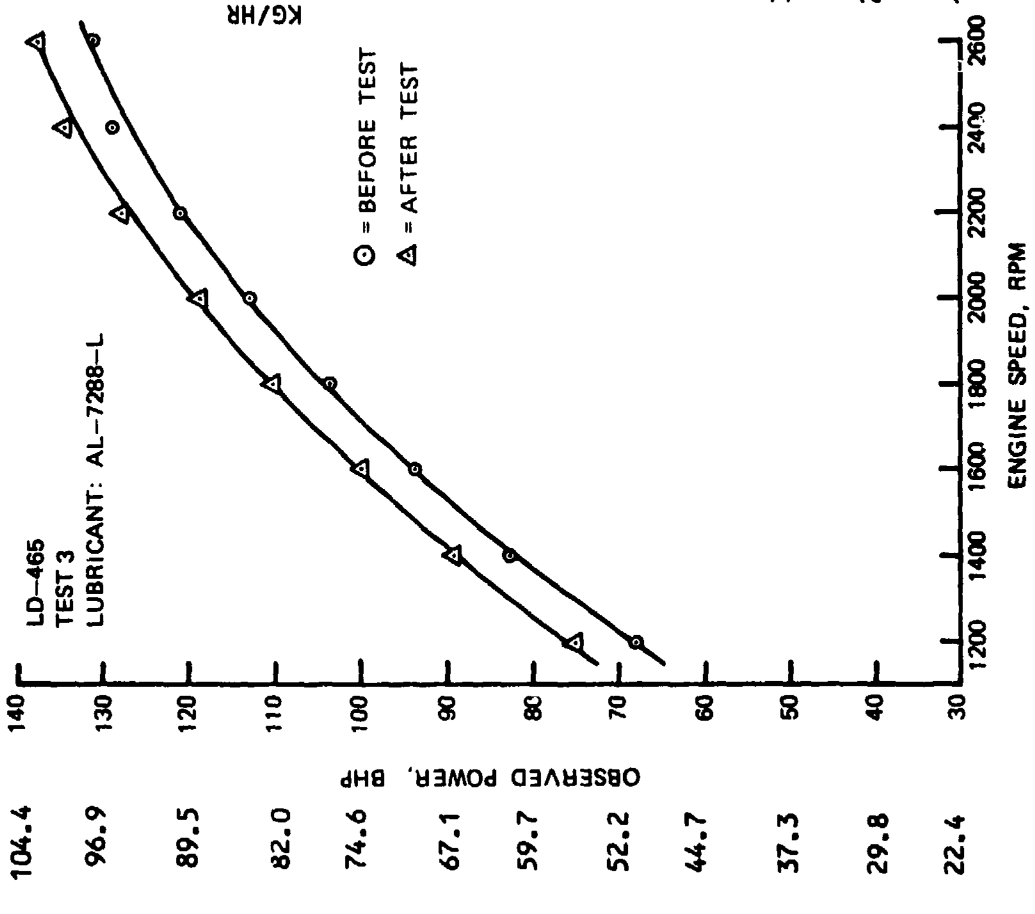
by

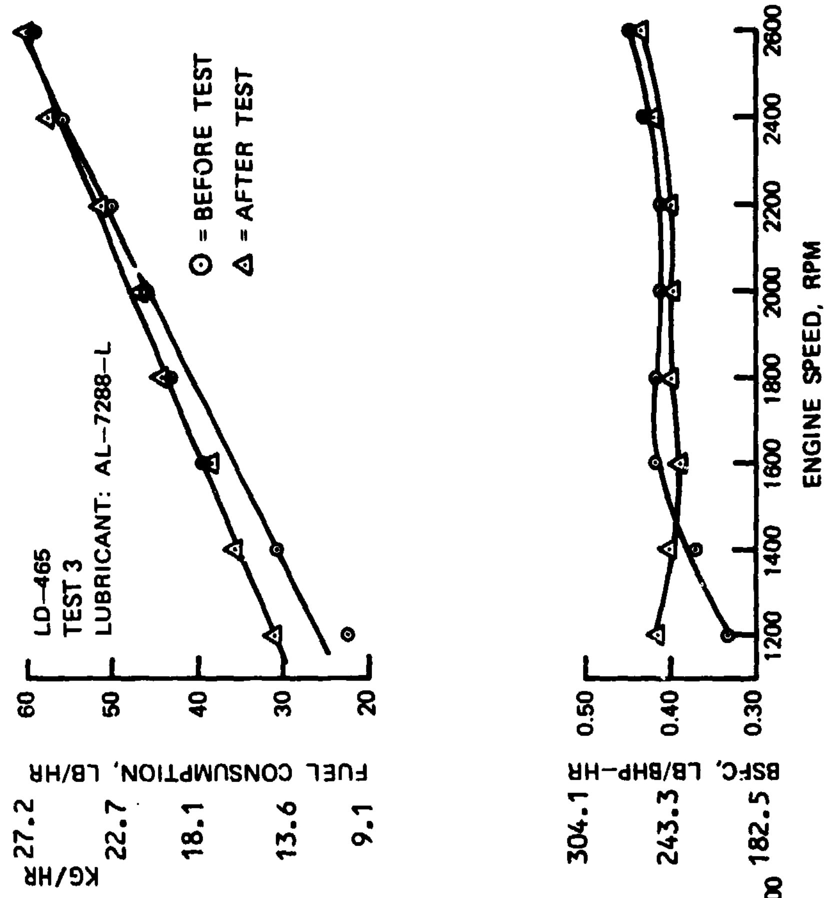
U.S. Army Fuels & Lubricants Research Laboratory
Southwest Research Institute
San Antonio, Texas 78284

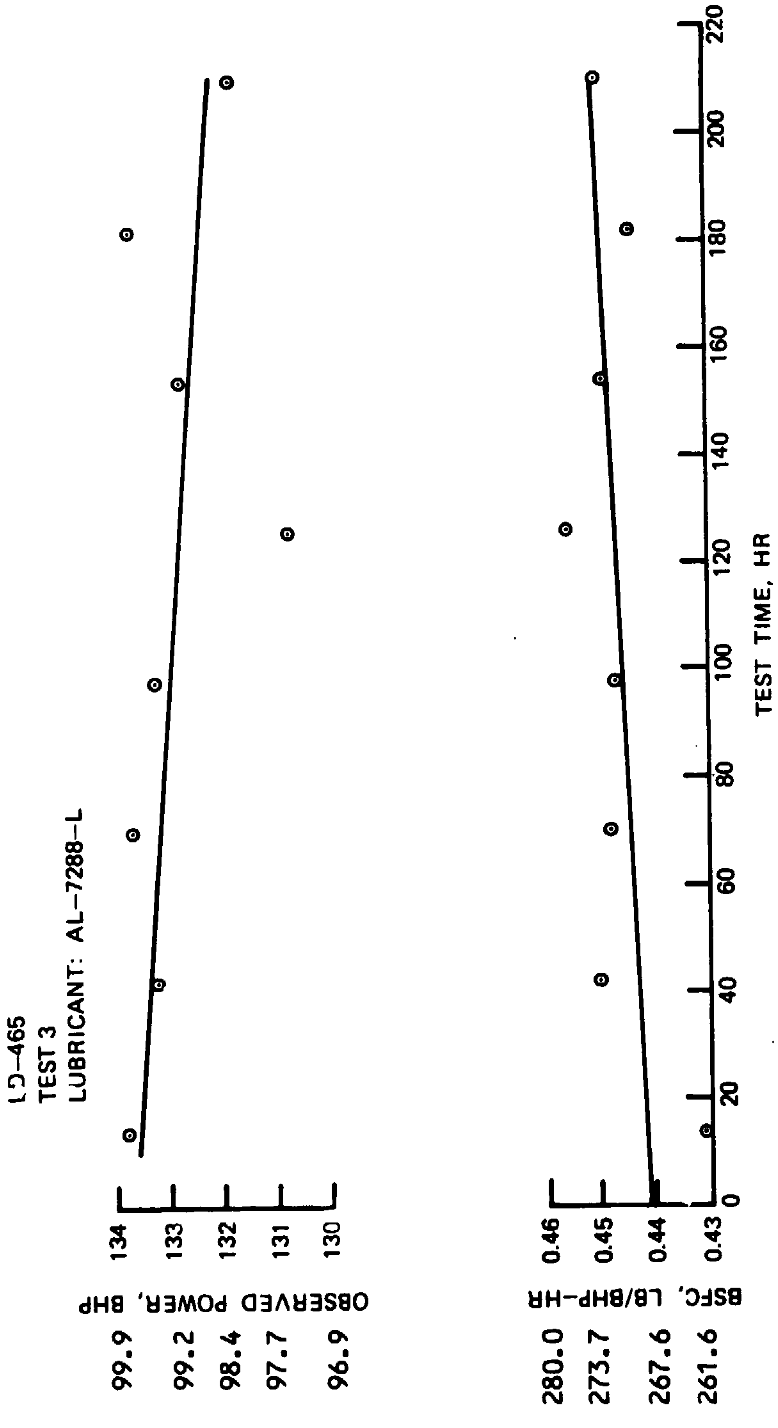
LD 465
TEST 3
LUBRICANT: AL-7288-L

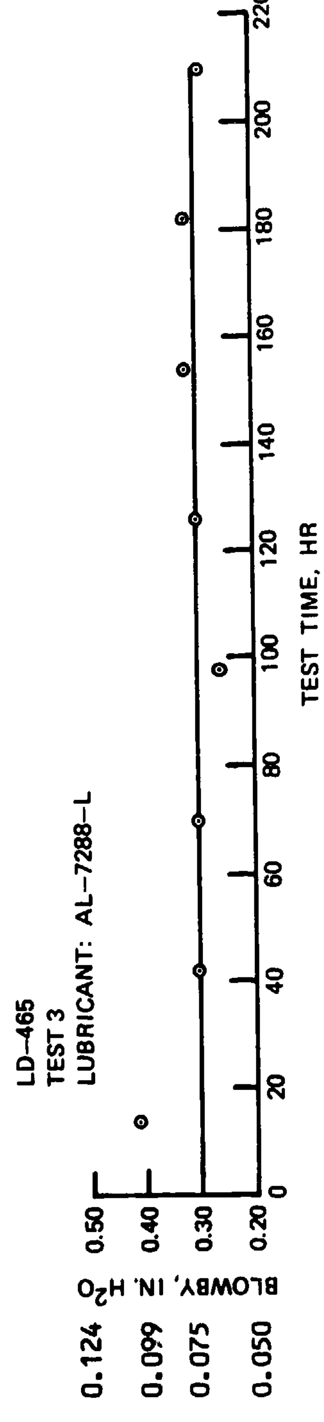
SUMMARY OF OPERATING DATA

	Power Mode			Idle Mode
	Min.	Avg.	Max.	Avg.
Engine Speed, rpm	2599	2601	2605	758
Engine Torque, ft-lb	261	267	281	11
Fuel Consumption, lb/hr	57.7	59.6	60.5	4.7
BHP (Observed)	130.8	133.0	133.8	1.6
BSFC (Observed)	0.431	0.450	0.456	2.94
Temperatures, °F				
Exhaust Manifold	1210	1270	1310	170
Cooling Water In	170	170	170	95
Cooling Water Out	180	180	180	100
Oil Sump	222	225	226	125
Air In	64	85	111	75
Pressures				
Fuel Transfer Pump, psi	72	73	73	37
Oil Gallery, psi	57	58	60	53
Intake Vacuum, in. H_2O	3.4	3.5	3.6	0.3
Exhaust Pressure, in. Hg	1.4	1.7	2.1	0


LD-465
TEST 3
LUBRICANT: AL-7288-L
⊙ = BEFORE TEST
Δ = AFTER TEST
OBSERVED POWER, BHP
140 130 120 110 100 90 80 70 60 50 40 30
104.4 96.9 89.5 82.0 74.6 67.1 59.7 52.2 44.7 37.3 29.8 22.4
1200 1400 1600 1800 2000 2200 2400 2600
ENGINE SPEED, RPM


LD-465
TEST 3
LUBRICANT: AL-7288-L
⊙ = BEFORE TEST
Δ = AFTER TEST
FUEL CONSUMPTION, LB/HR
60 50 40 30 20
KG/HR
27.2 22.7 18.1 13.6 9.1
BSFC, LB/BHP-HR
0.50 0.40 0.30
304.1 243.3 182.5
1200 1400 1600 1800 2000 2200 2400 2600
ENGINE SPEED, RPM


LD-465
TEST 3
LUBRICANT: AL-7288-L
OBSERVED POWER, BHP
134 133 132 131 130
99.9 99.2 98.4 97.7 96.9
BSFC, LB/BHP-HR
0.46 0.45 0.44 0.43
280.0 273.7 267.6 261.6
0 20 40 60 80 100 120 140 160 180 200 220
TEST TIME, HR


LD-465
TEST 3
LUBRICANT: AL-7288-L
BLOWBY, IN. H2O
0.50 0.40 0.30 0.20
0.124 0.099 0.075 0.050
0 20 40 60 80 100 120 140 160 180 200 220
TEST TIME, HR

LD 465
TEST 3
BUILD UP ENGINE MEASUREMENTS

	INCHES			
	MIN	MAX	AVE	SPECIFIED LIMITS
CYLINDER LINERS (INSTALLED)				
Inside Diameter	4.5625	4.5644	4.5635	4.5630~4.5645
Out of Round	.0000	.0016	.0006	.0015 MAX
Piston Skirt Diameter	4.5555	4.5558	4.5556	4.5570~4.5580
# 1 Ring				
End Gap	.020	.025	.024	.025~.035
# 2 Ring				
End Gap	.021	.024	.023	.025~.035
# 3 Ring				
End Gap	.019	.024	.021	.025~.035
Side Clearance	.003	.003	.003	.0025~.0045
# 4 Ring				
End Gap	.016	.023	.020	.013~.028
Side Clearance	.0015	.0015	.0015	.0010~.0035

LD465
TEST: 3
LUBRICANT: AL-7288-L

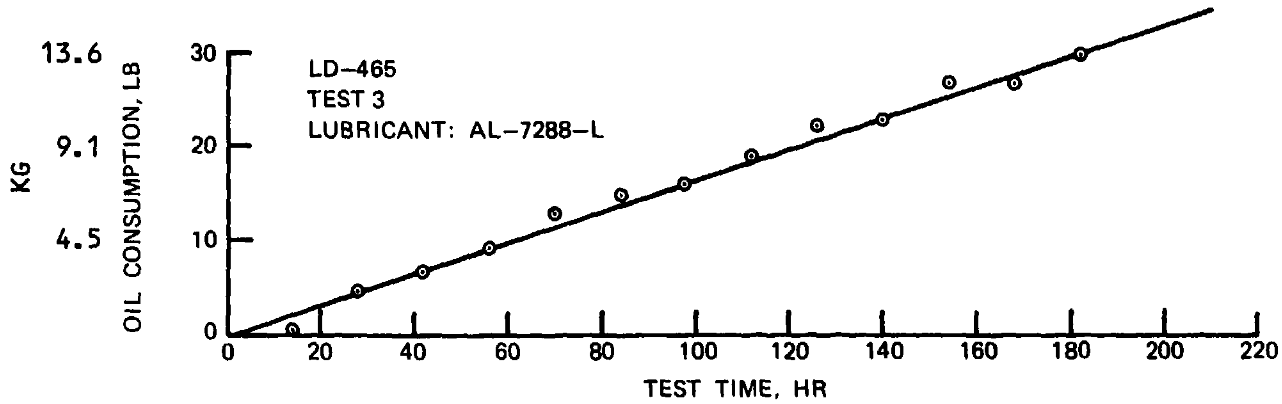
OIL CONSUMPTION, LB

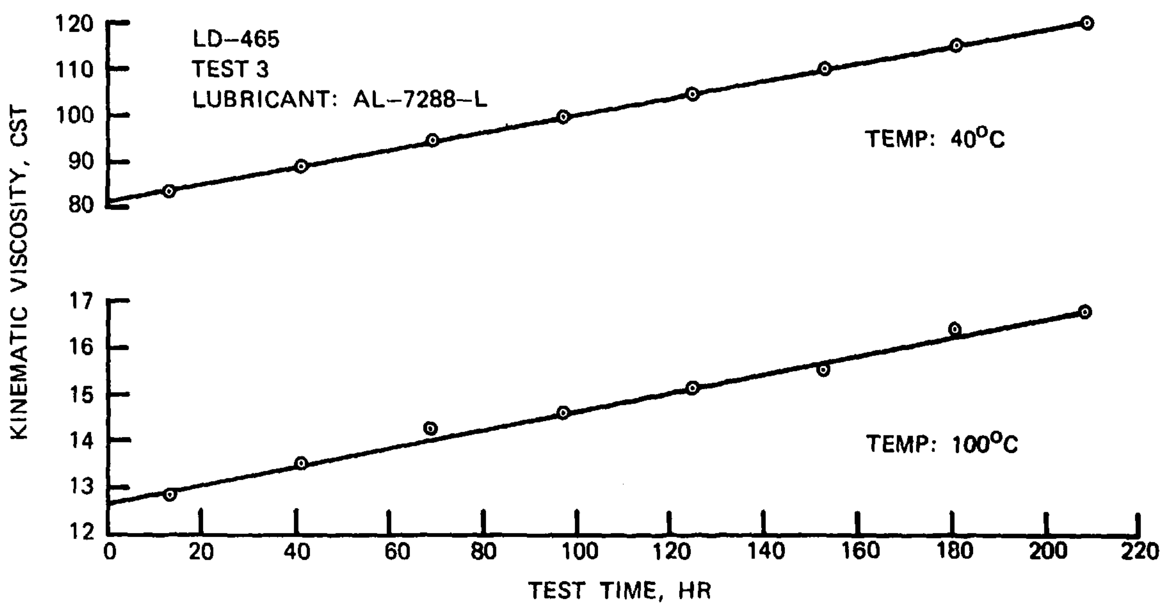
Test Time, Hr.	Oil Consumed	Total Oil Consumed
14	0.0	0.0
28	4.64	4.64
42	1.86	6.50
56	2.72	9.22
70	3.34	12.56
84	2.32	14.88
98	1.27	16.15
112	2.8	18.95
126	3.16	22.11
140	0.83	22.94
154	3.90	26.84
168	0.0	26.84
182	3.30	30.14
196	0.0	30.14

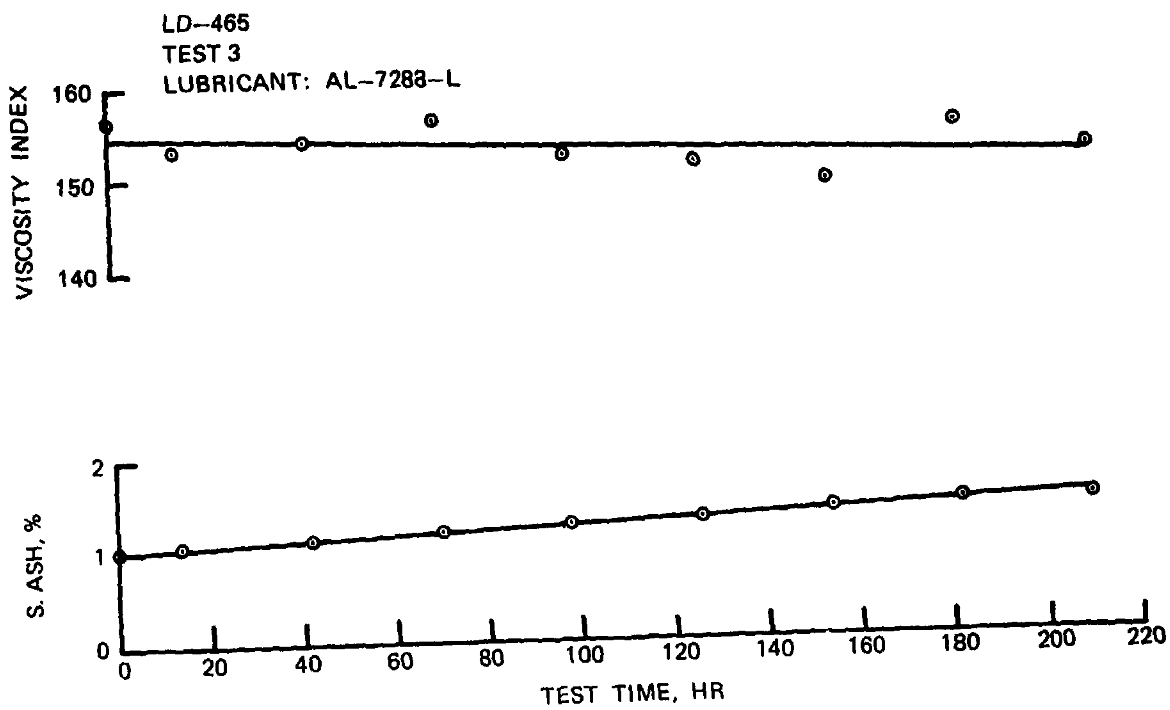
LD 465
TEST 3
LUBRICANT: AL-7288-L

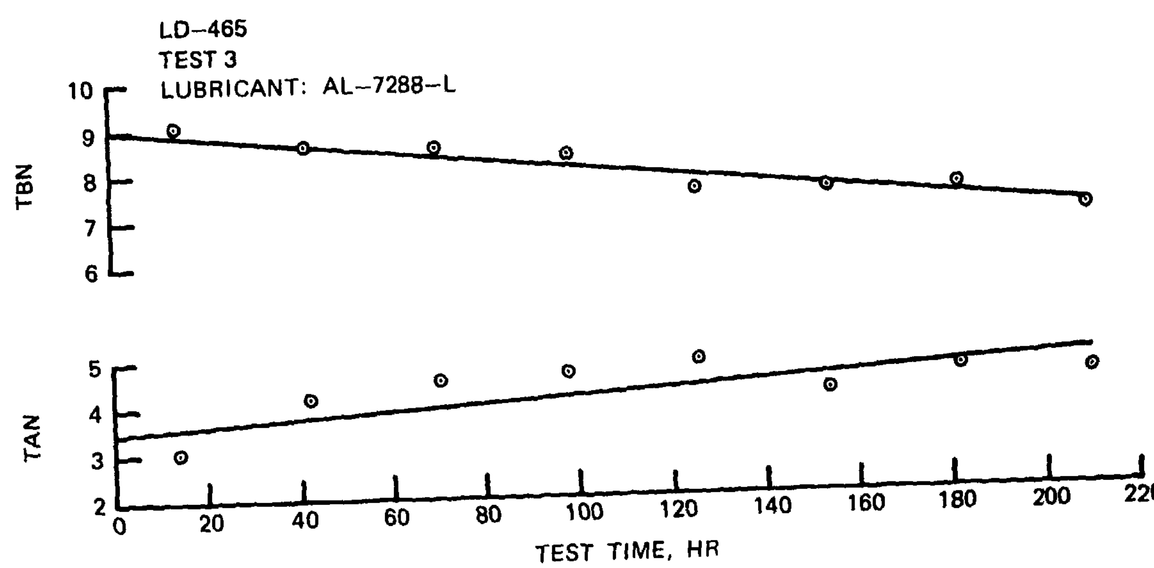
LUBRICANT ANALYSIS

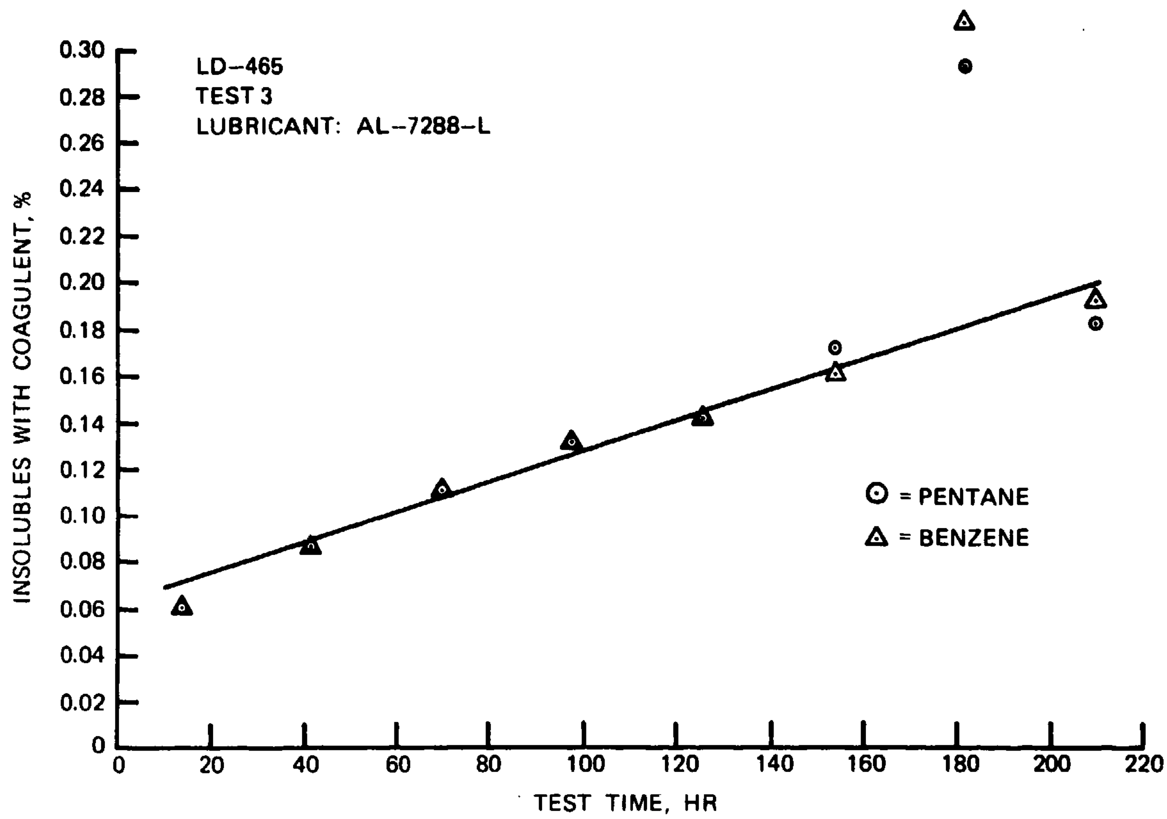
	ASTM TEST METHOD	Test Time (Hrs.) 0	14	42	70	98	126	154	182	210
IR Trace No.			1637	1638	1639	1640	1641	1642	1643	1644
K. Vis. Cs @ 40°C	D-445	81.64	83.26	88.84	94.35	99.79	105.21	110.64	115.02	120.62
K. Vis. Cs @ 100°C	D-445	12.77	12.81	13.50	14.25	14.63	15.16	15.57	16.47	16.86
V.I.	D-2270-74	156	153	154	156	152	151	149	155	152
TAN	D-664	3.02	3.03	4.15	4.54	4.60	4.89	4.26	4.70	4.58
TBN	D-2896	9.05	8.56	8.56	8.56	8.32	7.58	7.58	7.58	7.09
S. Ash, %	D-874	0.99	1.04	1.13	1.20	1.25	1.30	1.40	1.42	1.47
Pentane Insol. w/coag, %	D-893	---	0.06	0.09	0.11	0.13	0.14	0.17	0.29	0.18
Benzene Insol. w/coag, %	D-893	---	0.06	0.09	0.11	0.13	0.14	0.16	0.31	0.19
Fe, ppm by XRF		---	33	65	118	162	188	212	233	247
Cold Cranking, 0°F, cp	D-2602	1800				2510				3100
Cold Cranking, -20°F, cp	D-2602	8300				11600				15800

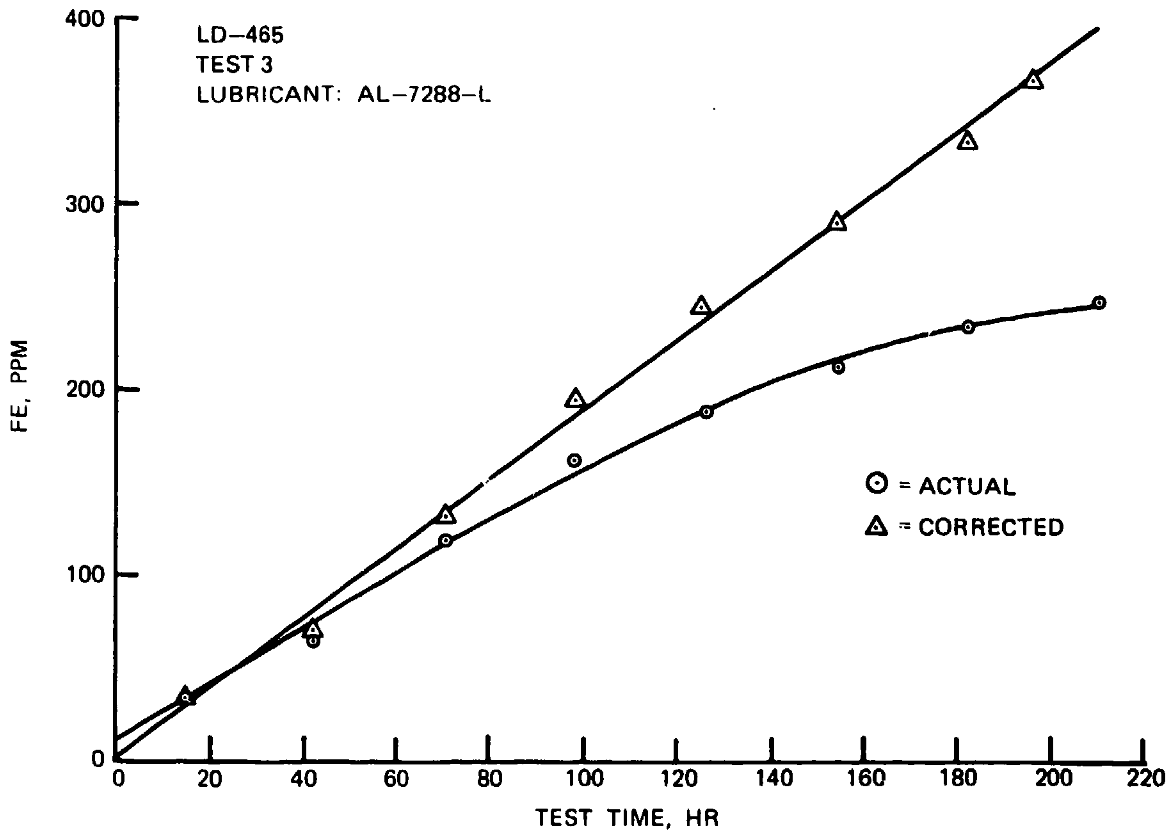

LD-465
TEST 3
LUBRICANT: AL-7288-L
KG
13.6
9.1
4.5
OIL CONSUMPTION, LB
30
20
10
0
0 20 40 60 80 100 120 140 160 180 200 220
TEST TIME, HR

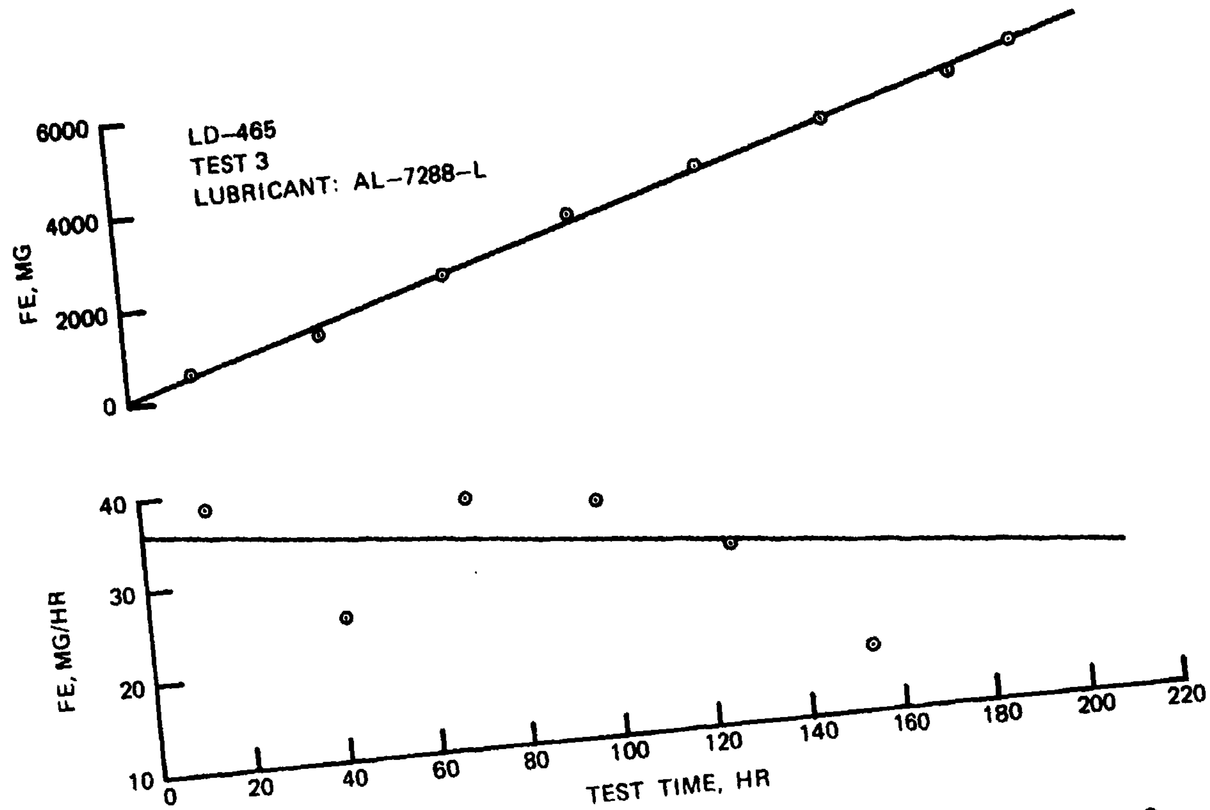

LD-465
TEST 3
LUBRICANT: AL-7288-L
TEMP: 40°C
TEMP: 100°C
KINEMATIC VISCOSITY, CST
120
110
100
90
80
17
16
15
14
13
12
0 20 40 60 80 100 120 140 160 180 200 220
TEST TIME, HR

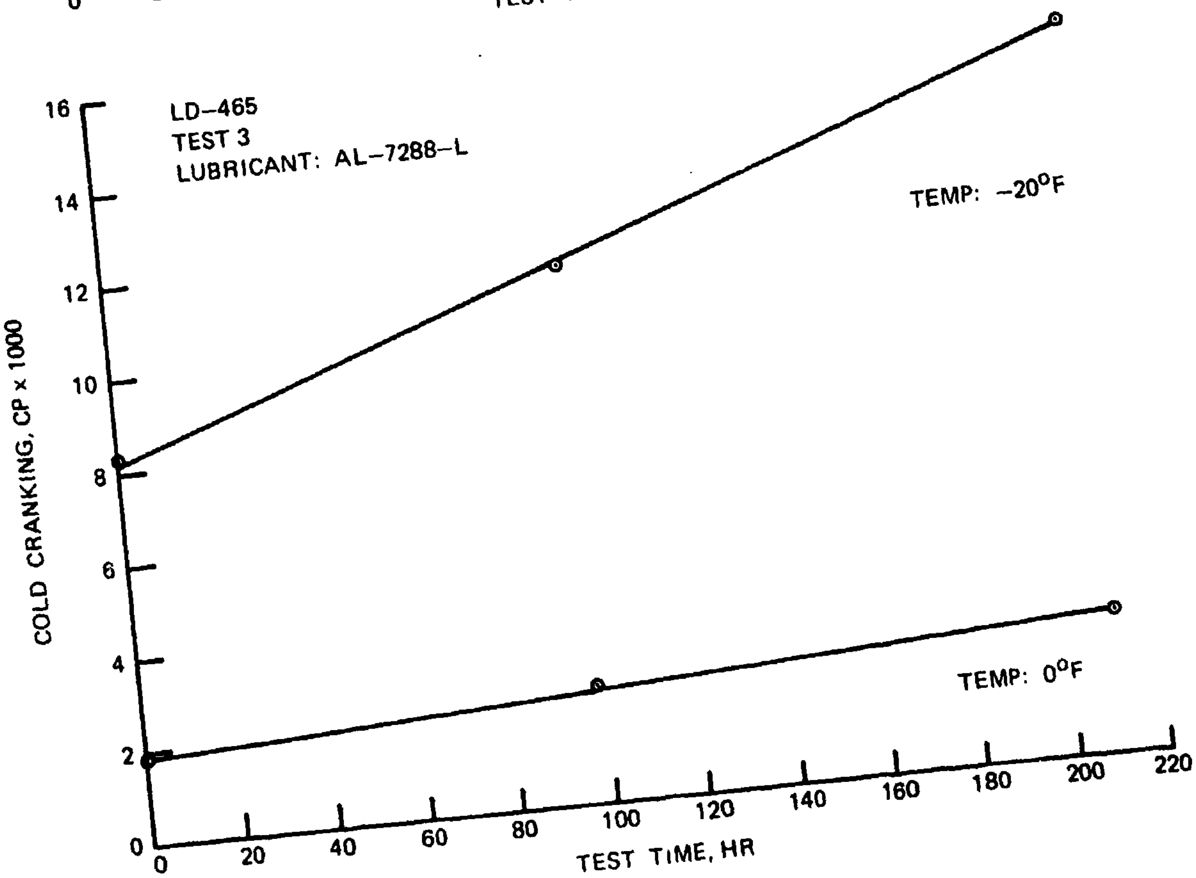

LD–465
TEST 3
LUBRICANT: AL–7288–L
VISCOSITY INDEX
160
150
140
S. ASH, %
2
1
0
0
20
40
60
80
100
120
140
160
180
200
220
TEST TIME, HR

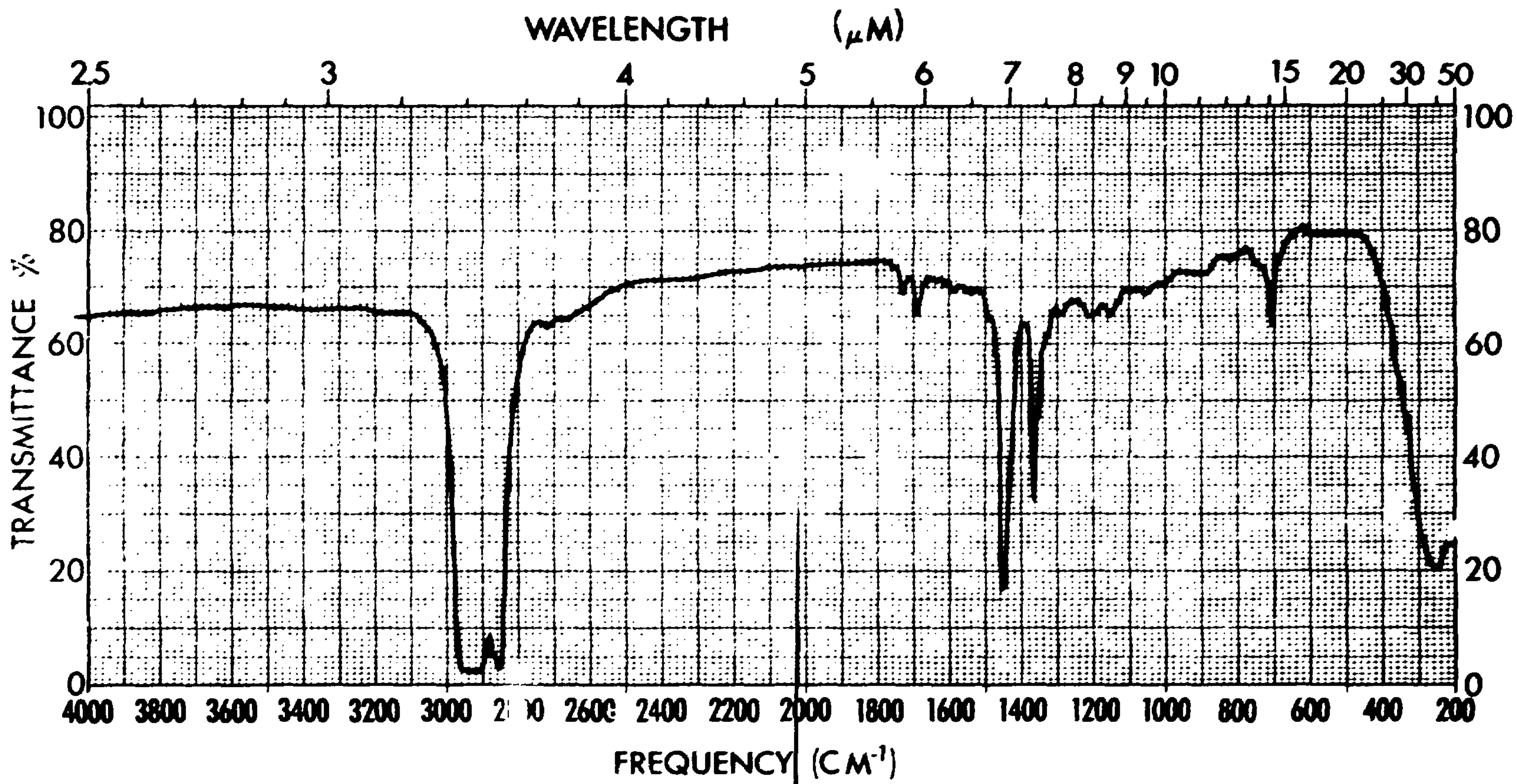

LD–465
TEST 3
LUBRICANT: AL–7288–L
TBN
10
9
8
7
6
TAN
5
4
3
2
0
20
40
60
80
100
120
140
160
180
200
220
TEST TIME, HR


LD–465
TEST 3
LUBRICANT: AL–7288–L
INSOLUBLES WITH COAGULENT, %
TEST TIME, HR
= PENTANE
= BENZENE

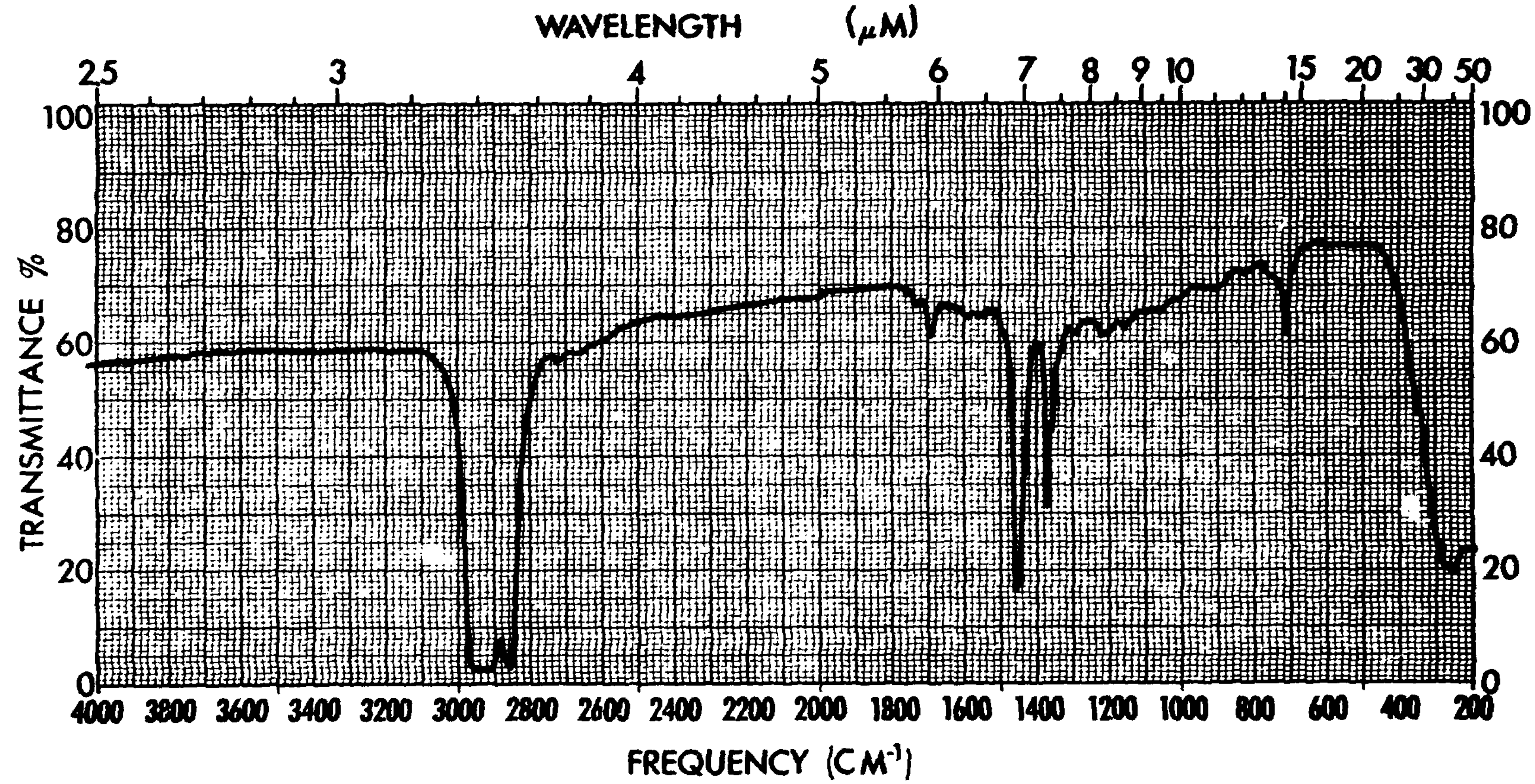

LD–465
TEST 3
LUBRICANT: AL–7288–L
FE, PPM
TEST TIME, HR
= ACTUAL
= CORRECTED


LD-465
TEST 3
LUBRICANT: AL-7288-L
FE, MG
6000
4000
2000
0
FE, MG/HR
40
30
20
10
0
20
40
60
80
100
120
140
160
180
200
220
TEST TIME, HR

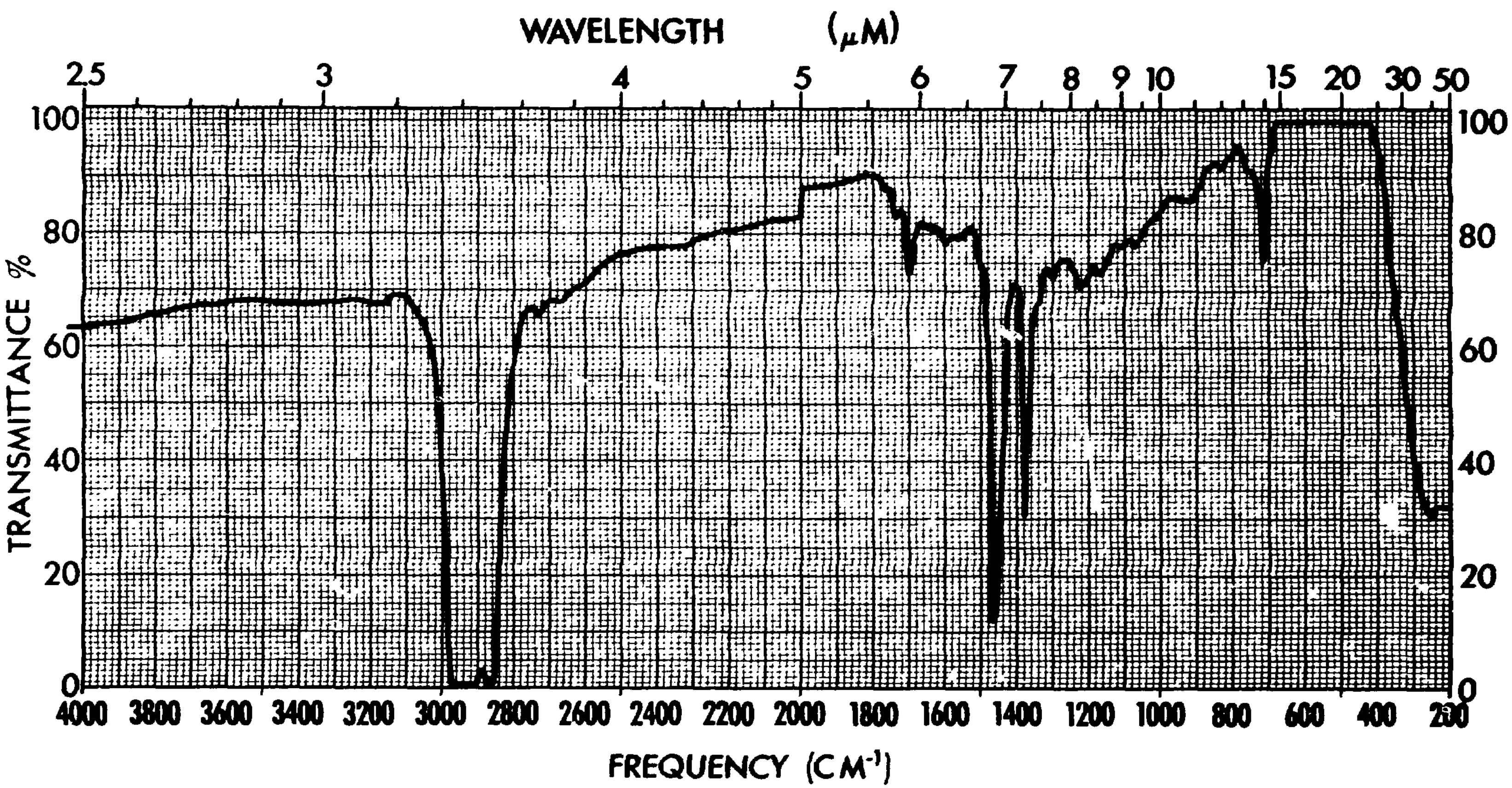

LD-465
TEST 3
LUBRICANT: AL-7288-L
TEMP: -20°F
TEMP: 0°F
COLD CRANKING, CP x 1000
16
14
12
10
8
6
4
2
0
0
20
40
60
80
100
120
140
160
180
200
220
TEST TIME, HR



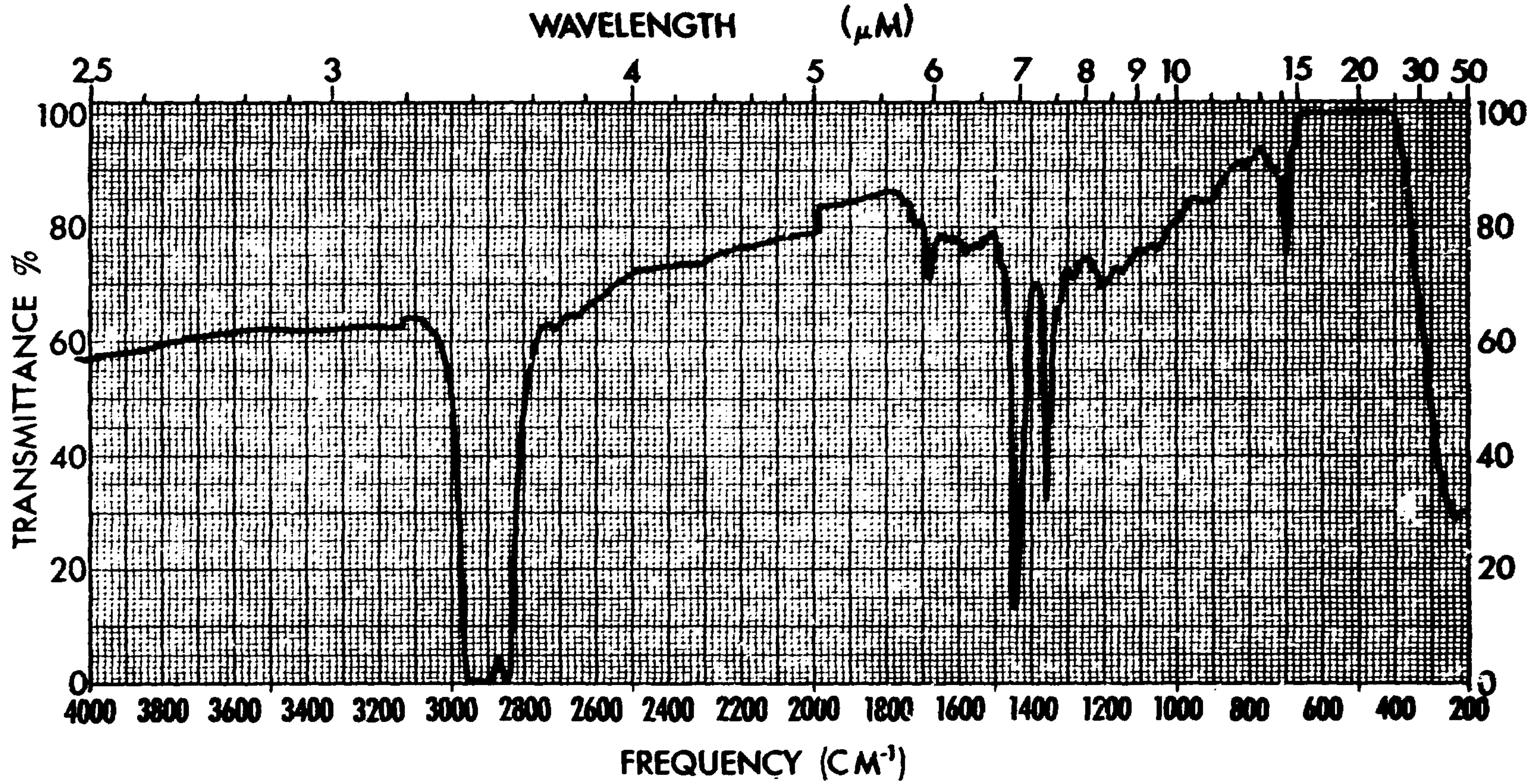
SPECTRUM NO. 1637	ORIGIN	LEGEND	REMARKS
SAMPLE AL-7288-5		1.	
14 Hr Test #3	PURITY	2.	
	PHASE	DATE 2/15/79	
	THICKNESS 0.015	OPERATOR DDD	



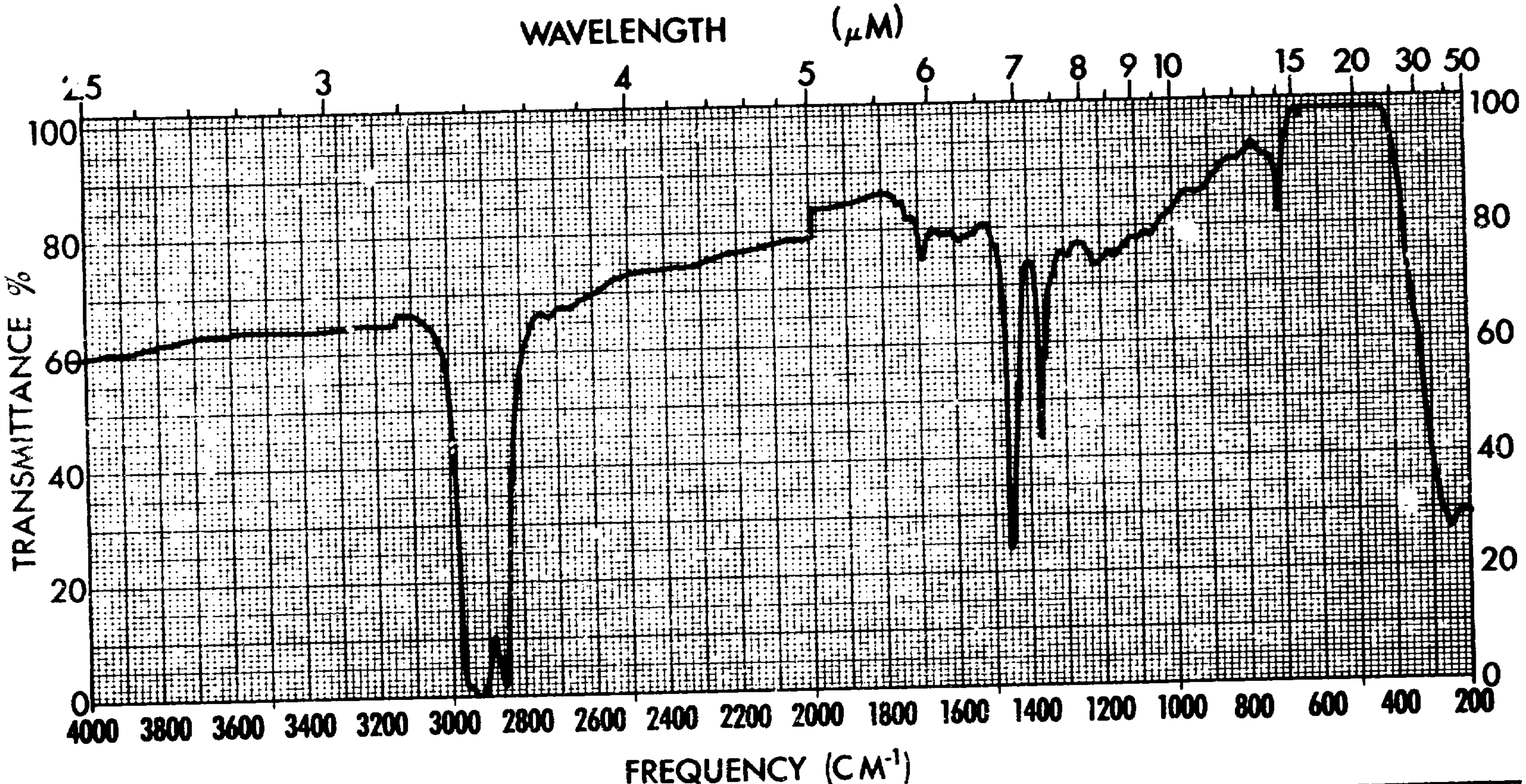
SPECTRUM NO. 1638	ORIGIN	LEGEND	REMARKS
SAMPLE AL-7288-L		1.	
42 Hr. Test No. 3	PURITY	2.	
	PHASE	DATE 2/15/79	
	THICKNESS 0.015	OPERATOR DDD	



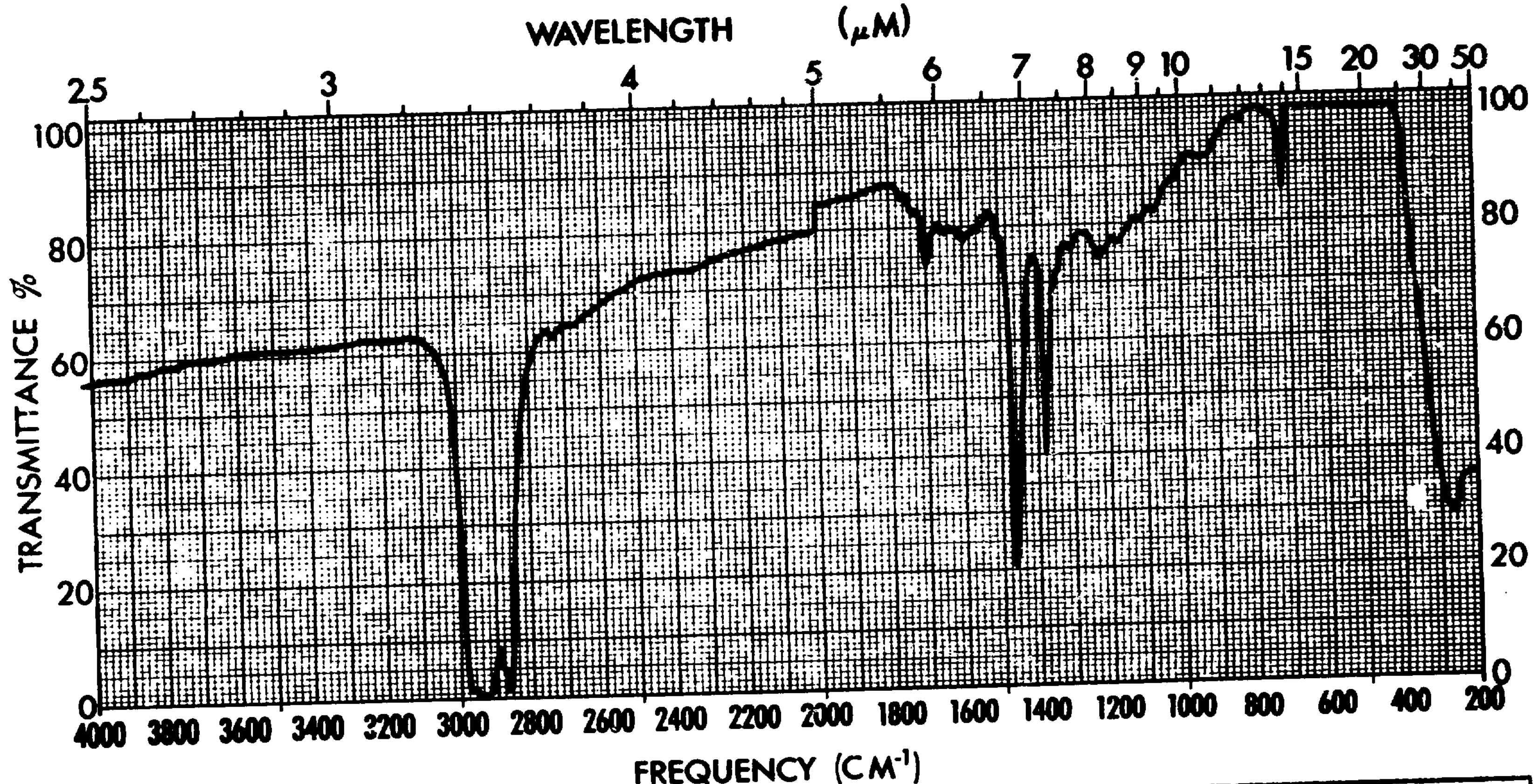
SPECTRUM NO. 1639	ORIGIN	LEGEND	REMARKS
SAMPLE AL-7288-L		1.	
40 Hr. Test No. 3	PURITY	2.	
	PHASE	DATE 2/26/79	
	THICKNESS 0.015	OPERATOR DDD	



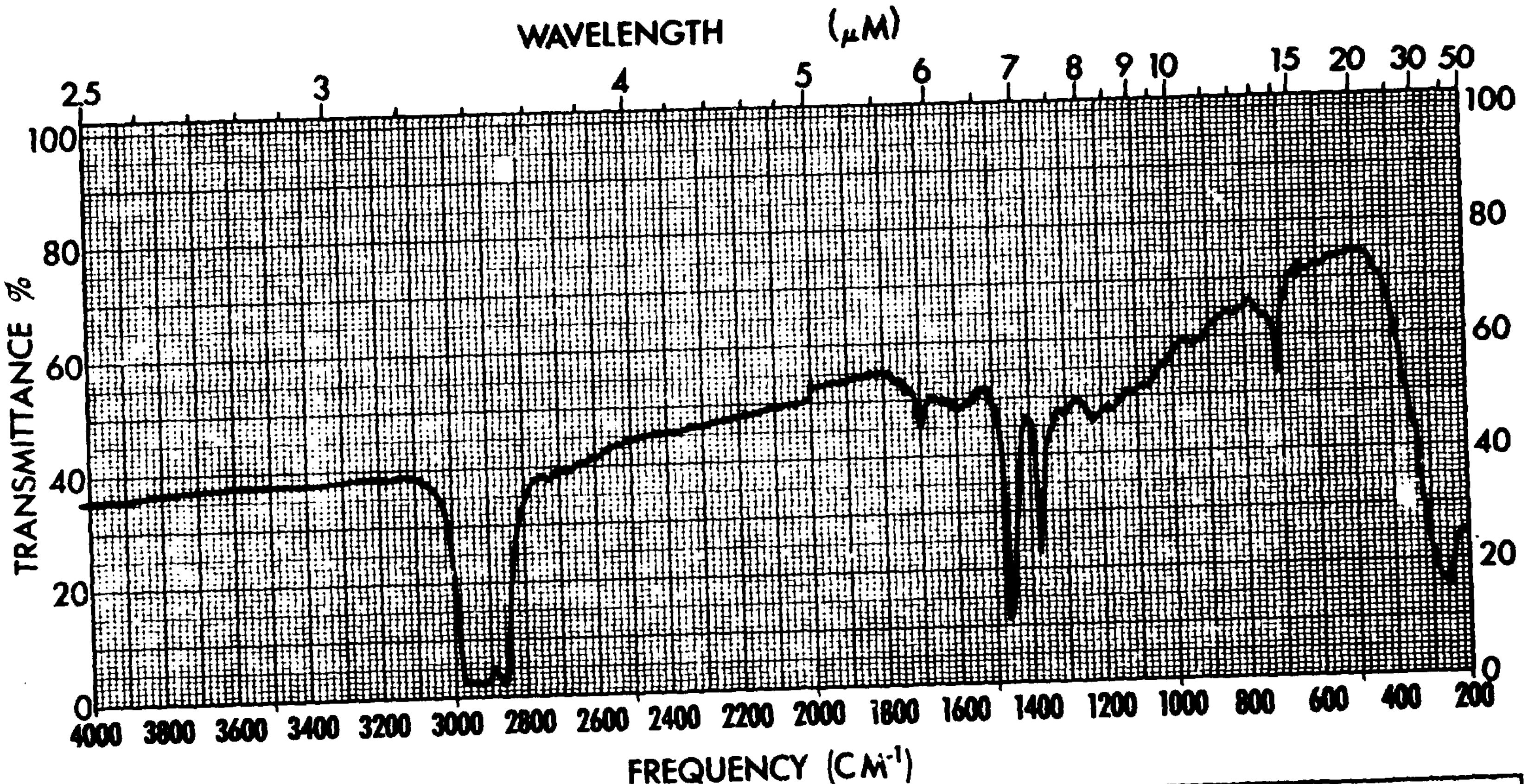
SPECTRUM NO. 1640	ORIGIN	LEGEND	REMARKS
SAMPLE AL-7288-L		1.	
98 Hr. Test No. 3	PURITY	2.	
	PHASE	DATE 2/26/79	
	THICKNESS 0.015	OPERATOR DDD	



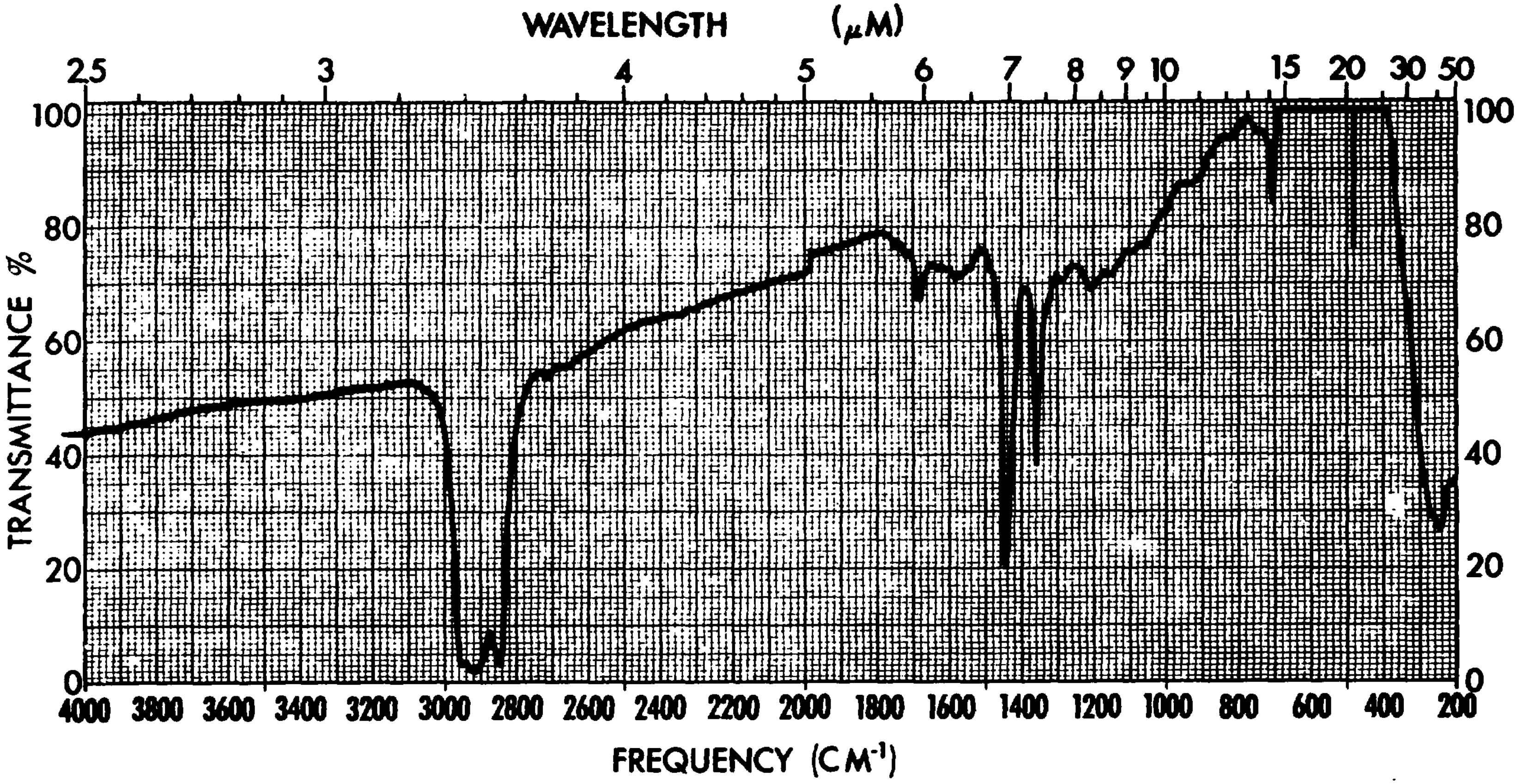
SPECTRUM NO. 1641	ORIGIN	LEGEND	REMARKS
SAMPLE AL-7288-L		1.	
126 Hr. Test No. 3	PURITY	2.	
	PHASE	DATE 2/26/79	
	THICKNESS 0.015	OPERATOR DDD	



SPECTRUM NO. 1642	ORIGIN	LEGEND	REMARKS
SAMPLE AL-7288-L 154 Hr. Test No. 3		1.	
	PURITY	2.	
	PHASE	DATE 2/27/79	
	THICKNESS 0.015	OPERATOR DDD	



SPECTRUM NO. 1643	ORIGIN	LEGEND	REMARKS
SAMPLE AL-7288-L		1.	
182 Hr. Test #3	PURITY	2.	
	PHASE	DATE 3/1/79	
	THICKNESS 0.015	OPERATOR DDD	



SPECTRUM NO. 1644

SAMPLE AL-7288-L

210 Hr. Test No. 3

ORIGIN

PURITY

PHASE

THICKNESS 0.015

LEGEND

1.

2.

DATE 3/5/79

OPERATOR DDD

REMARKS

TEST: 3
LUBRICANT: AL-7288-L

WEAR MEASUREMENTS

CYLINDER LINER BORE DIAMETER (INCHES)

		Longitudinal			Transverse		
		Before	After	Change	Before	After	Change
1)	Top	4.5631	4.5571	-0.0060	4.5636	4.5580	-0.0056
	Center	4.5632	4.5570	-0.0062	4.5640	4.5581	-0.0060
	Bottom	4.5634	4.5572	-0.0062	4.5641	4.5582	-0.0059
2)	Top	4.5627	4.5569	-0.0058	4.5637	4.5580	-0.0057
	Center	4.5629	4.5566	-0.0063	4.5638	4.5579	-0.0059
	Bottom	4.5630	4.5566	-0.0064	4.5638	4.5581	-0.0057
3)	Top	4.5633	4.5574	-0.0059	4.5638	4.5584	-0.0054
	Center	4.5634	4.5572	-0.0062	4.5635	4.5577	-0.0058
	Bottom	4.5634	4.5574	-0.0060	4.5637	4.5577	-0.0060
4)	Top	4.5633	4.5567	-0.0066	4.5634	4.5581	-0.0053
	Center	4.5633	4.5567	-0.0066	4.5635	4.5578	-0.0057
	Bottom	4.5634	4.5571	-0.0063	4.5636	4.5576	-0.0060
5)	Top	4.5625	4.5570	-0.0055	4.5641	4.5584	-0.0057
	Center	4.5628	4.5569	-0.0059	4.5644	4.5585	-0.0059
	Bottom	4.5635	4.5573	-0.0062	4.5644	4.5585	-0.0059
6)	Top	4.5632	4.5577	-0.0055	4.5639	4.5582	-0.0057
	Center	4.5633	4.5575	-0.0058	4.5637	4.5578	-0.0059
	Bottom	4.5637	4.5578	-0.0059	4.5637	4.5575	-0.0062

LD465
TEST: 3
LUBRICANT: AL-7288-L

WEAR MEASUREMENTS

PISTON RING END GAP (INCHES)

Ring Number*		PISTON NUMBER 1	2	3	4	5	6
1)	Before Test	0.025	0.024	0.020	0.024	0.024	0.024
	After Test	0.030	0.028	0.030	0.028	0.028	0.028
	Change	0.005	0.004	0.010	0.004	0.004	0.004
2)	Before Test	0.024	0.022	0.021	0.023	0.024	0.023
	After Test	0.028	0.028	0.030	0.030	0.028	0.028
	Change	0.004	0.006	0.009	0.007	0.004	0.005
3)	Before Test	0.020	0.020	0.019	0.024	0.022	0.021
	After Test	0.020	0.022	0.024	0.022	0.026	0.025
	Change	0.000	0.002	0.005	-0.002	0.004	0.004
4)	Before Test	0.016	0.018	0.020	0.021	0.020	0.023
	After Test	0.018	0.016	0.024	0.024	0.026	0.025
	Change	0.002	-0.002	0.004	0.003	0.006	0.002

* From Top of Piston

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-7288-L

RATER E.L. DATE 3-13-79
LABORATORY TEST NUMBER 3
STAND NO. 6 ENGINE NO. 465
FUEL AL-8060-F

PISTON NO. 1

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	91.625

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1		GROOVES NO. 2		GROOVES NO. 3		GROOVES NO. 4		LANDS NO. 1		LANDS NO. 2		LANDS NO. 3		LANDS NO. 4		UNDER-CROWN	
			AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON	HC	1.00									15	15.00								
	MHC	0.75																		
	MC	0.50									70	35.00								
	LC	0.25	25	6.25									5	1.25						
	VLC	0.15											5	.75						
	CARBON RATING		6.25								50.00		2.00							
LACQUER	BL	0.100	75	7.50							10	1.00								
	DBrL	0.075																		
	AL	0.050			100	5.00	100	5.00											100	5.00
	LAL	0.025							100	2.50	5	.125	90	2.25	100	2.50	100	2.50		
	VLAL	0.010																		
	RL	0.001																		
	LACQUER RATING		7.50		5.00		5.00		2.50		1.125		2.25		2.50		2.50		5.00	
CLEAN		0																		
ZONAL RATING																				
LOCATION FACTOR																				
WEIGHTED RATING			13.75		5.00		5.00		2.50		51.125		4.25		2.50		2.50		5.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-7288-L

RATER EL DATE 3-13-79
LABORATORY TEST NUMBER 3
STAND NO. 6 ENGINE NO. 465
FUEL AL-8060-F

PISTON NO. 2

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	117.505

DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON HC	1.00																		
CARBON MHC	0.75																		
CARBON MC	0.50	65	32.50							80	40.00								
CARBON LC	0.25	10	2.50																
CARBON VLC	0.15																		
CARBON RATING		35.00								40.00									
LACQUER BL	0.100	2.5	2.50	100	10.00	100	10.00			10	1.00	15	1.50						
LACQUER DBrL	0.075									5	.375								
LACQUER AL	0.060							100	5.00									100	5.00
LACQUER LAL	0.025											85	2.125	100	2.50	100	2.50		
LACQUER VLAL	0.010																		
LACQUER RL	0.001									5	.005								
LACQUER RATING		2.50		10.00		10.00		5.00		1.380		3.625		2.50		2.50		5.00	
CLEAN	0																		
ZONAL RATING																			
LOCATION FACTOR																			
WEIGHTED RATING		37.50		10.00		10.00		5.00		41.380		3.625		2.50		2.50		5.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-7288-L

RATER E.L. DATE 3-13
LABORATORY TEST NUMBER 3
STAND NO. 6 ENGINE NO. 465
FUEL A1-8060-F

PISTON NO. 3

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	96.250

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00																		
CARBON	MHC	0.75																		
CARBON	MC	0.50									90	45.00								
CARBON	LC	0.25	40	10.00																
CARBON	VLC	0.15																		
	CARBON RATING		10.00								45.00									
LACQUER	BL	0.100	60	6.00																
LACQUER	DBrL	0.075																		
LACQUER	AL	0.050			100	5.00	100	5.00	100	5.00			100	5.00	100	5.00	100	5.00	100	5.00
LACQUER	LAL	0.025									10	.25								
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
	LACQUER RATING		6.00		5.00		5.00		5.00		.25		5.00		5.00		5.00		5.00	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		16.00		5.00		5.00		5.00		45.25		5.00		5.00		5.00		5.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-7288--L

RATER E.L. DATE 3-13-79
LABORATORY TEST NUMBER 3
STAND NO. 6 ENGINE NO. 465
FUEL AL-8060-F

PISTON NO. 4

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	161.25

	DEPOSIT TYPE	DEPOSIT FACTOR	GROOVES NO. 1 AREA-%	GROOVES NO. 1 DEMERIT	GROOVES NO. 2 AREA-%	GROOVES NO. 2 DEMERIT	GROOVES NO. 3 AREA-%	GROOVES NO. 3 DEMERIT	GROOVES NO. 4 AREA-%	GROOVES NO. 4 DEMERIT	LANDS NO. 1 AREA-%	LANDS NO. 1 DEMERIT	LANDS NO. 2 AREA-%	LANDS NO. 2 DEMERIT	LANDS NO. 3 AREA-%	LANDS NO. 3 DEMERIT	LANDS NO. 4 AREA-%	LANDS NO. 4 DEMERIT	UNDER-CROWN AREA-%	UNDER-CROWN DEMERIT
CARBON	HC	1.00																		
CARBON	MHC	0.75																		
CARBON	MC	0.50	50	25.00							90	45.00								
CARBON	LC	0.25																		
CARBON	VLC	0.15																		
CARBON	CARBON RATING		25.00								45.00									
LACQUER	BL	0.100	50	5.00	100	10.00	100	10.00					10	1.00						
LACQUER	DBrL	0.075																		
LACQUER	AL	0.050							100	5.00			90	45.00	100	5.00	100	5.00	100	5.00
LACQUER	LAL	0.025									10	.25								
LACQUER	VLAL	0.010																		
LACQUER	RL	0.001																		
LACQUER	LACQUER RATING		5.00		10.00		10.00		5.00			.25	46.00		5.00		5.00		5.00	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		30.00		10.00		10.00		5.00		45.25		46.00		5.00		5.00		5.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-7288-L

RATER E. L. DATE 3-13-79
LABORATORY TEST NUMBER 3
STAND NO. 6 ENGINE NO. 465
FUEL AL-8060-F

PISTON NO. 5

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	100.85

			GROOVES								LANDS								UNDER-CROWN	
			NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
	DEPOSIT TYPE	DEPOSIT FACTOR	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON	HC	1.00	5	5.00																
	MHC	0.75																		
	MC	0.50	5	2.50							90	45.00	5	1.25						
	LC	0.25	15	3.75																
	VLC	0.15																		
	CARBON RATING		11.25								45.00		1.25							
LACQUER	BL	0.100	75	7.50	100	10.00							20	2.00						
	DBrL	0.075																	100	5.00
	AL	0.050					100	5.00	100	5.00			75	3.75	100	2.50	100	2.50		
	LAL	0.025																		
	VLAL	0.010									10	.100								
	RL	0.001																		
	LACQUER RATING		7.50		10.00		5.00		5.00		.100		5.75		2.50		2.50		5.00	
	CLEAN	0																		
	ZONAL RATING																			
	LOCATION FACTOR																			
	WEIGHTED RATING		18.75		10.00		5.00		5.00		45.100		7.00		2.50		2.50		5.00	

*WEIGHTED TOTAL DEPOSITS

CRC DIESEL RATING SYSTEM

STANDARD COMPUTATION SHEET FOR PISTON RATING

TEST PROCEDURE Wheeled
TEST HOURS 210
TEST LABORATORY AFLRL
LUBRICANT AL-7288-L

RATER E.L. DATE 3-13-79
LABORATORY TEST NUMBER 3
STAND NO. 6 ENGINE NO. 465
FUEL AL-8060-F

PISTON NO. 6

NO. 1 GROOVE, VOLUME-%	
PISTON WTD* RATING	104.76

		GROOVES								LANDS								UNDER-CROWN	
		NO. 1		NO. 2		NO. 3		NO. 4		NO. 1		NO. 2		NO. 3		NO. 4			
DEPOSIT TYPE	DEPOSIT FACTOR	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT	AREA-%	DEMERIT
CARBON HC	1.00																		
CARBON MHC	0.75																		
CARBON MC	0.50									90	45.00								
CARBON LC	0.25	100	25.00																
CARBON VLC	0.15																		
CARBON RATING		25.00								45.00									
LACQUER BL	0.100											5	.500						
LACQUER DBrL	0.075																	100	5.00
LACQUER AL	0.050			100	5.00	100	5.00	100	5.00			95	4.75						
LACQUER LAL	0.025													100	2.50	100	2.50		
LACQUER VLAL	0.010																		
LACQUER RL	0.001									10	.010								
LACQUER RATING				5.00		5.00		5.00		.010		9.75		2.50		2.50		5.00	
CLEAN	0																		
ZONAL RATING																			
LOCATION FACTOR																			
WEIGHTED RATING		25.00		5.00		5.00		5.00		45.010		9.75		2.50		2.50		5.00	

*WEIGHTED TOTAL DEPOSITS

TEST 3

RING DEPOSITS

Engine Model Continental LD-465 Serial No. 390-4343 Date 3-13-79
Fuel AL-8060-F Lubricant AL-7288-L Observer Lyons

Cylinder Number			1		2		3		4		5		6	
			CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ
Piston Ring	Top	1	0	30	0	30	0	15	0	15	0	5	0	20
		2	0	10	0	20	0	10	0	10	0	5	0	10
		3	0	100	0	95	0	95	0	95	0	95	0	90
		4												
	ID	1	0	100	0	100	0	50	0	100	0	75	0	0
		2	0	100	0	100	0	100	0	100	0	100	0	100
		3	0	100	0	100	0	100	0	10	0	100	0	100
		4												
	Bottom	1	0	0	0	0	0	5	0	5	0	0	0	0
		2	0	20	0	50	0	0	0	20	0	10	0	20
		3	0	90	0	75	0	25	0	85	0	85	0	60
		4												

See pages 4, 36 and 37 of Manual. Areas previously rated for carbon, rate 0 for lacquer

Test 3

RING FACE CONDITION

Engine Model Continental LD-465 Serial No. 390-4343 Date 3-13-79

Fuel AL-8060-F Lubricant AL-7288-L Observer Lyons

	Cylinder Number					
	1	2	3	4	5	6
First Ring	N	N	N	N	N	N
Second Ring	N	N	N	N	N	N
Third Ring	N	N	N	N	N	N
Fourth Ring	N	N	N	N	N	N
Oil Ring Slots—% Open	100	<----	----	----	----	---->

Pages 1 and 2 and 59 through 65 of Manual.

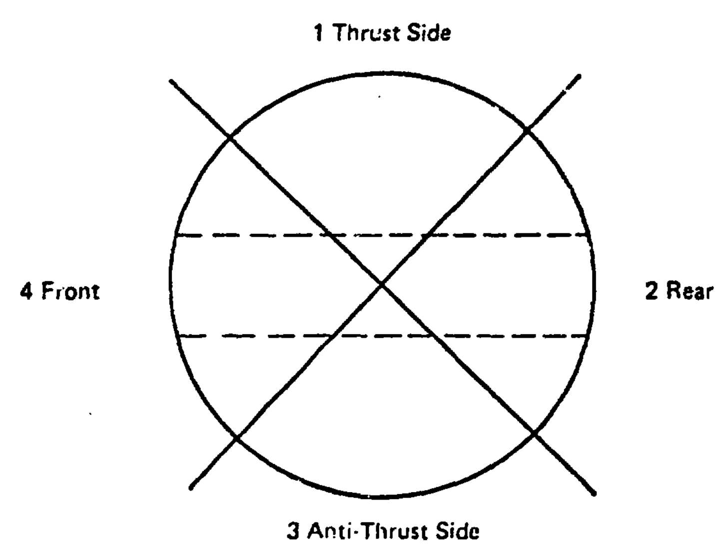
N = NORMAL

PISTON GROOVE INSIDE DIAMETER—% RING SUPPORTING CARBON

Test 3

Engine Model Continental LD-465 Serial No. 390-4343 Date 3-13-79
Fuel AL-8060-F Lubricant AL-7288-L Observer Lyons

Piston Ring	Quadrant	Piston Number					
		1	2	3	4	5	6
1	1	0	0	0	5	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
2	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0



PISTON SURFACE CONDITION   Test 3

Engine Model Continental LD-465   Serial No. 390-4343   Date 3-13-79

Fuel AL-8060-F   Lubricant AI-7288-L   Observer Lyons

	Piston Number					
	1	2	3	4	5	6
Top Land	N	N	N	N	N	N
Skirt	N	N	N	N	N	N
Piston Pin	N	N	N	N	N	N

Pages 1 through 2 and 59 through 65 of Manual.

N = NORMAL

VALVE SURFACE CONDITIONS Test 3

Engine Model Continental LD-465 Serial No. 390-4343 Date 3-13-79
Fuel AL-8060-F Lubricant AL-7288-L Observer Lyons

	Intake						Exhaust					
	1	2	3	4	5	6	1	2	3	4	5	6
Freeness in Guide	F	F	F	F	F	F	F	F	F	F	F	F
Head	N	N	N	N	N	N	N	N	N	N	N	N
Face	N	N	N	N	N	N	N	N	N	N	N	N
Seat	N	N	N	N	N	N	N	N	N	N	N	N
Stem	N	N	N	N	N	N	N	N	N	N	N	N
Tip	N	N	N	N	N	N	N	N	N	N	N	N

See Pages 1, 2, 16 through 23, and 54 through 65 of Manual.

Tulip Deposit 3.0 2.5 3.5 3.5 3.0 2.0 .5 .5 .5 .5 .5 .5

F = FREE
N = NORMAL

CYLINDERS Test 3

Engine Model Continental LD-465 Serial No. 390-4343 Date 3-1-79
Fuel AL-8060-F Lubricant AL-7288-L Observer Lyons

Cylinder Number													
		1L		2L		3L		4 1R		5 2R		6 3R	
Deposits Cylinder Head		CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ	CARB	LACQ
Cylinders	ART	100	0	100	0	90	10	100	0	100	0	100	0
	RTA	0	100	0	100	0	100	0	100	0	100	0	100
	BRT	0	100	0	100	0	100	0	100	0	100	0	100
Surface Condition													
Cylinders	RTA	LT Scratches		LT Scratches		MED Scuff		LT Scuff		Lt Scratches		LT Scuff	
	BRTA	LT Scratches		LT Scratches		LT Scuff		LT Scratches		LT Scratches		LT Scratches	

Carbon and Ash: Use Volume Factor Pages 5 and 40 through 47 of Manual.
Indicate H, M, or S
Lacquer: Use Pages 4, 36 and 37
For Surface Condition—See Pages 1, 2, 16 through 23 and 54 through 65.

SURFACE CONDITION Test 3

Engine Model Continental LD 465 Serial No. 390-4343 Date 3-13-79

Fuel AL-8060-F Lubricant AL-7288-L Observer Lyons

Bearing No.	1	2	3	4	5	6	7
Main—Bearing	N	N	N	N	N	N	N
—Journal	N	N	N	N	N	N	N
Rod—Bearing	N	N	N	N	N	N	
—Journal	N	N	N	N	N	N	
Piston Pin	N	N	N	N	N	N	
Bushing	N	N	N	N	N	N	

Note surface condition. See pages 1, 2, 16 through 23 and 54 through 65 of Manual.

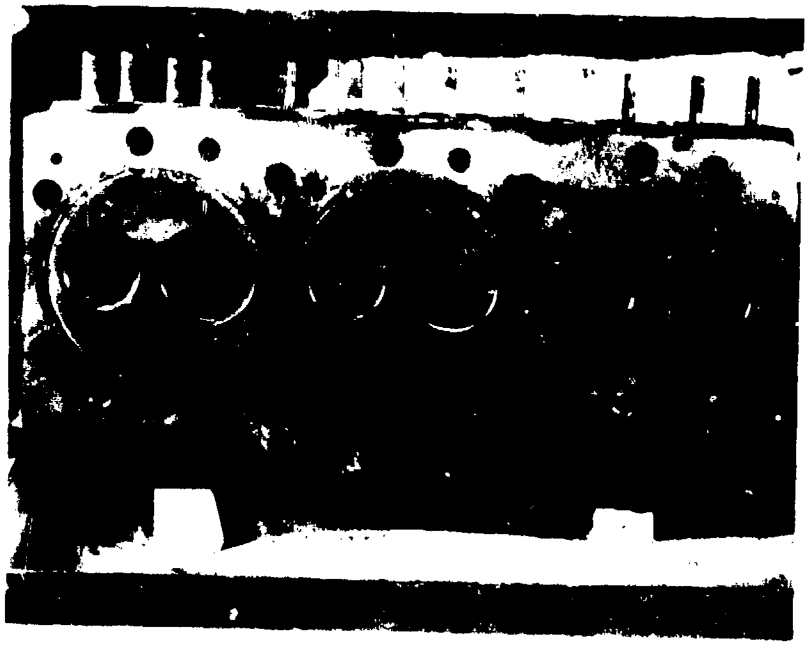
N = NORMAL

LD–465

TEST 3

AFTER TEST CONDITION OF CYLINDER HEADS

CYLINDERS 3, 2, AND 1

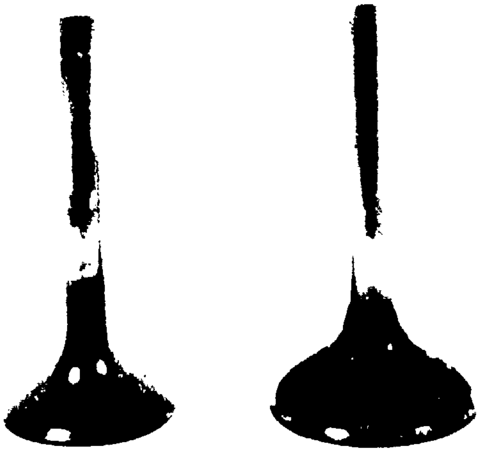


CYLINDERS 6, 5, AND 4

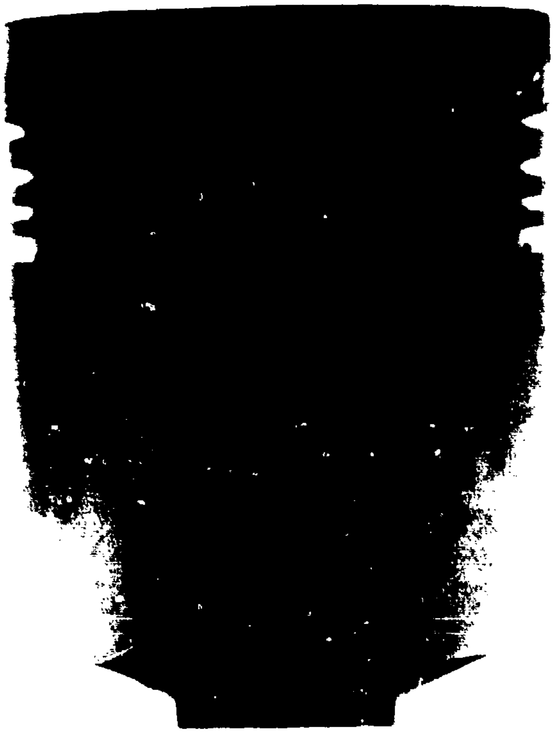
LD-465
TEST 3
AFTER TEST CONDITION OF NO. 1 PISTON AND VALVES


PISTON THRUST SIDE


PISTON ANTI-THRUST SIDE

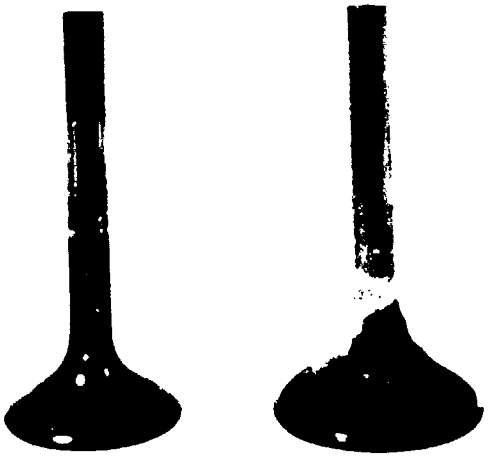

INTAKE AND EXHAUST VALVES

LD-465
TEST 3
AFTER TEST CONDITION OF NO. 2 PISTON AND VALVES



PISTON THRUST SIDE

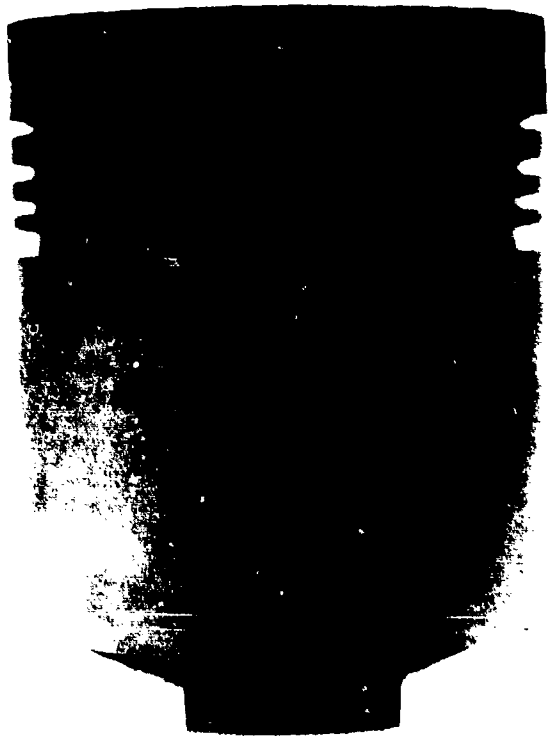
PISTON ANTI-THRUST SIDE



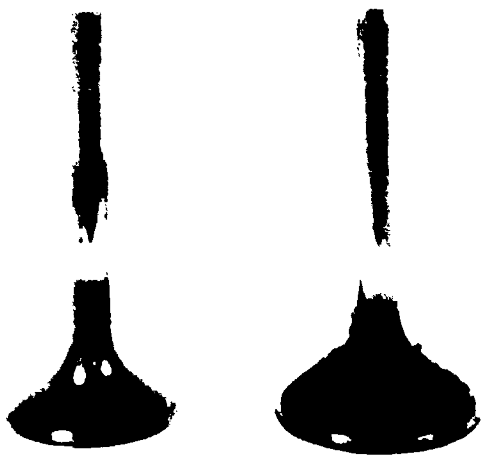
INTAKE AND EXHAUST VALVES

LD–465
TEST 3
AFTER TEST CONDITION OF NO. 3 PISTON AND VALVES

PISTON THRUST SIDE



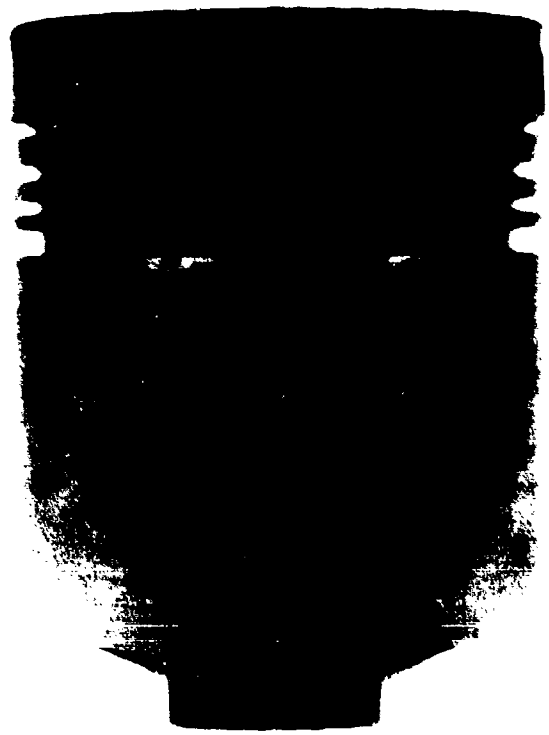
PISTON ANTI–THRUST SIDE



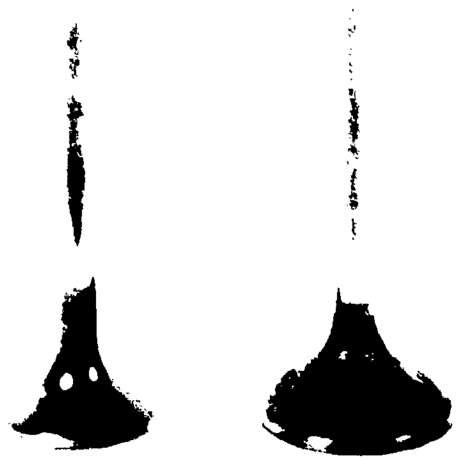
INTAKE AND EXHAUST VALVES

LD-465
TEST 3
AFTER TEST CONDITION OF NO. 4 PISTON AND VALVES

PISTON THRUST SIDE

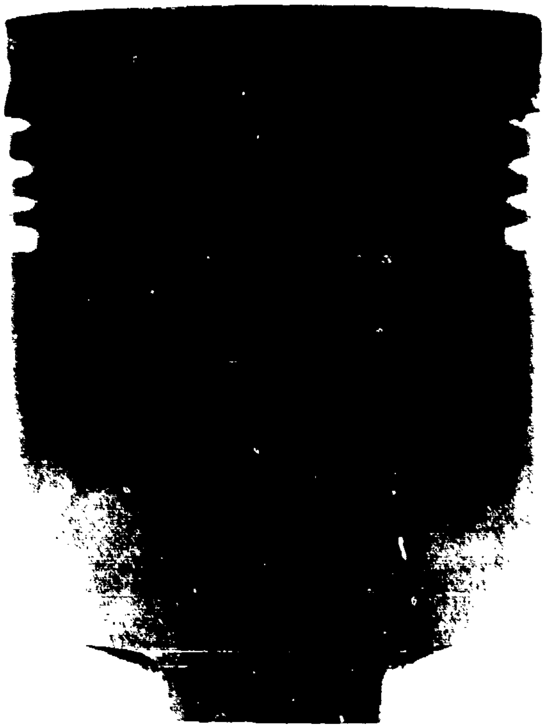


PISTON ANTI-THRUST SIDE



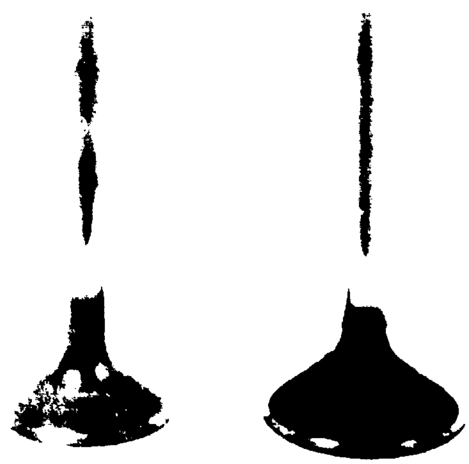
INTAKE AND EXHAUST VALVES

LD-465
TEST 3
AFTER TEST CONDITION OF NO. 5 PISTON AND VALVES



PISTON THRUST SIDE

PISTON ANTI-THRUST SIDE

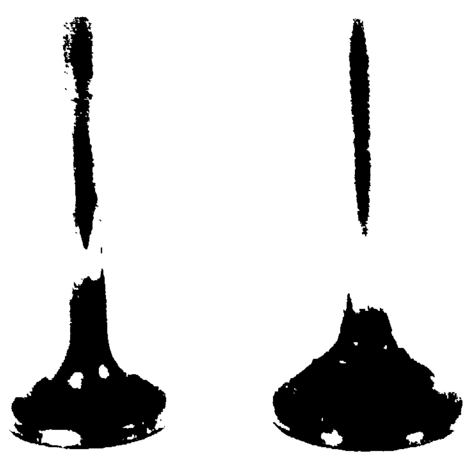


INTAKE AND EXHAUST VALVES

LD-465
TEST 3
AFTER TEST CONDITION OF NO. 6 PISTON AND VALVES

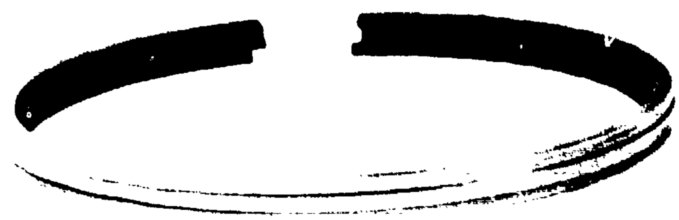
PISTON THRUST SIDE

PISTON ANTI-THRUST SIDE

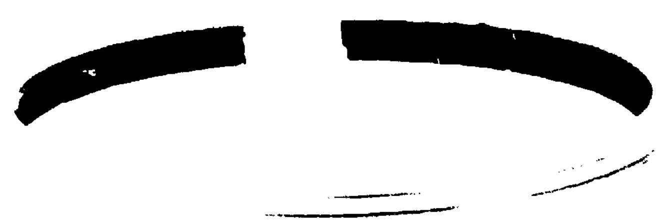


INTAKE AND EXHAUST VALVES

LD-465
TEST 3
AFTER TEST CONDITION OF PISTON RINGS

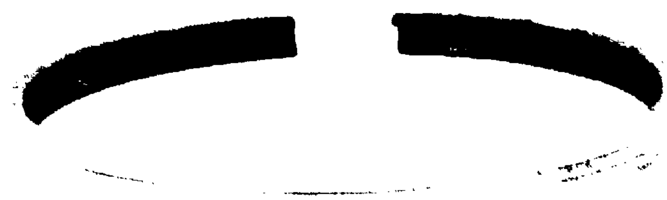


CYLINDER 1



CYLINDER 2

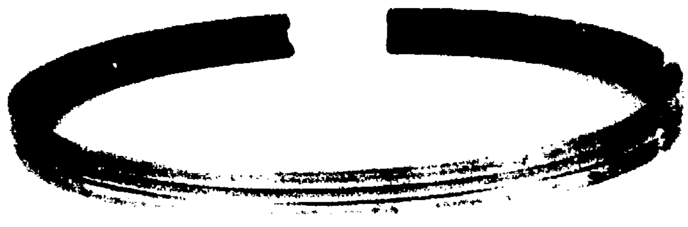
LD-465
TEST 3
AFTER TEST CONDITION OF PISTON RINGS



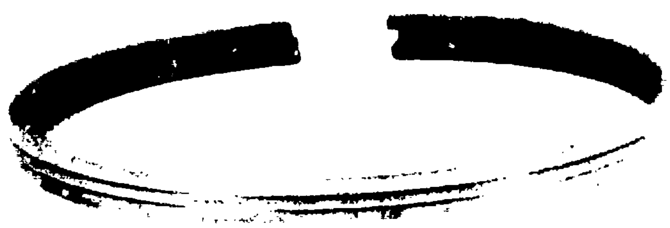
CYLINDER 3

CYLINDER 4

LD-465
TEST 3
AFTER TEST CONDITION OF PISTON RINGS



CYLINDER 5



CYLINDER 6

APPENDIX K

ENGINE-LUBRICANT COMPATIBILITY TEST #4

210-HOUR WHEELED-VEHICLE CYCLE

USING LDT-465-1C DIESEL ENGINE

ENGINE-LUBRICANT COMPATIBILITY TEST
210-HOUR WHEELED-VEHICLE CYCLE
USING LDT-465-1C DIESEL ENGINE

Test Lubricant: AL-8980-L
Test Fuel: Caterpillar 1-H
Engine Test Number: 4
Date Completed: 14 January 1980

Conducted for

U.S. Army Mobility Equipment Research and Development Command
Energy and Water Resources Laboratory
Fort Belvoir, Virginia

by

U.S. Army Fuels and Lubricants Research Laboratory
Southwest Research Institute
San Antonio, Texas 78284

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LDT-465-1C
TEST 4
ENGINE REBUILD MEASUREMENTS

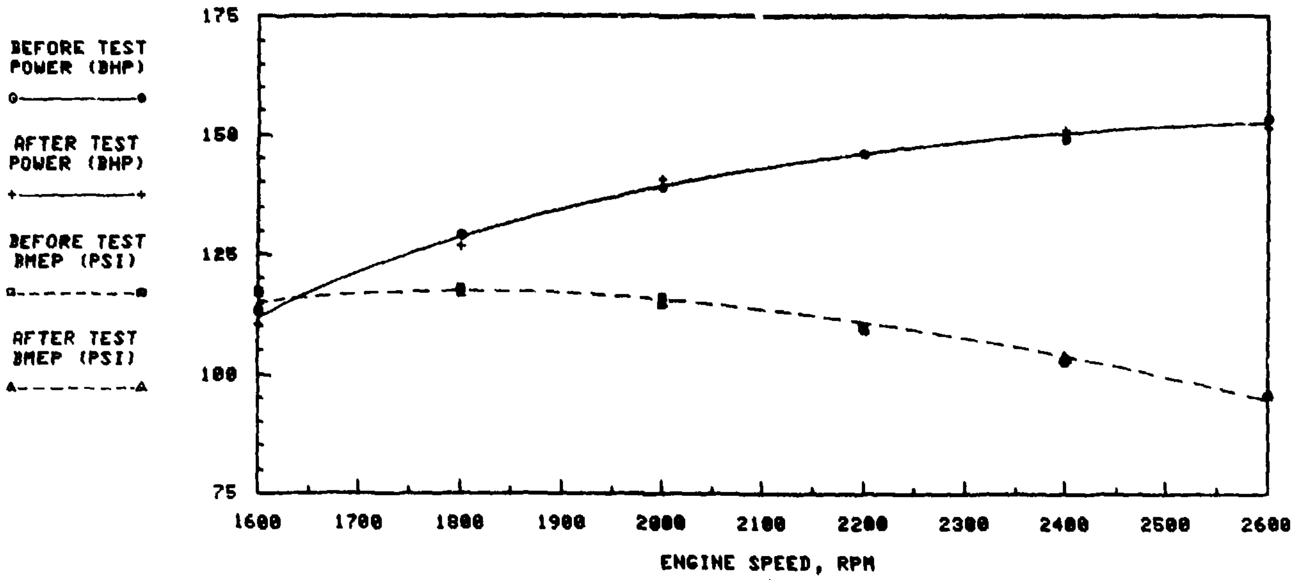
	Inches			
	Min	Max	Avg	Specified Limits
Cylinder Liners (Installed)				
Inside Diameter	4.5621	4.5644	4.5634	4.5630-4.5645
Out of Round	0.0002	0.0016	0.0010	0.0015 max
Piston Skirt Diameter (at bottom)	4.5554	4.5558	4.5556	4.5530-4.5580
No. 1 Ring				
End Gap	0.022	0.024	0.023	0.022-0.035
No. 2 Ring				
End Gap	0.021	0.025	0.023	0.022-0.035
No. 3 Ring				
End Gap	0.018	0.021	0.020	0.010-0.028
Side Clearance	0.002	0.002	0.002	0.0025-0.0045
No. 4 Ring				
End Gap	0.018	0.022	0.020	0.010-0.028
Side Clearance	0.0015	0.0015	0.0015	0.0010-0.0035

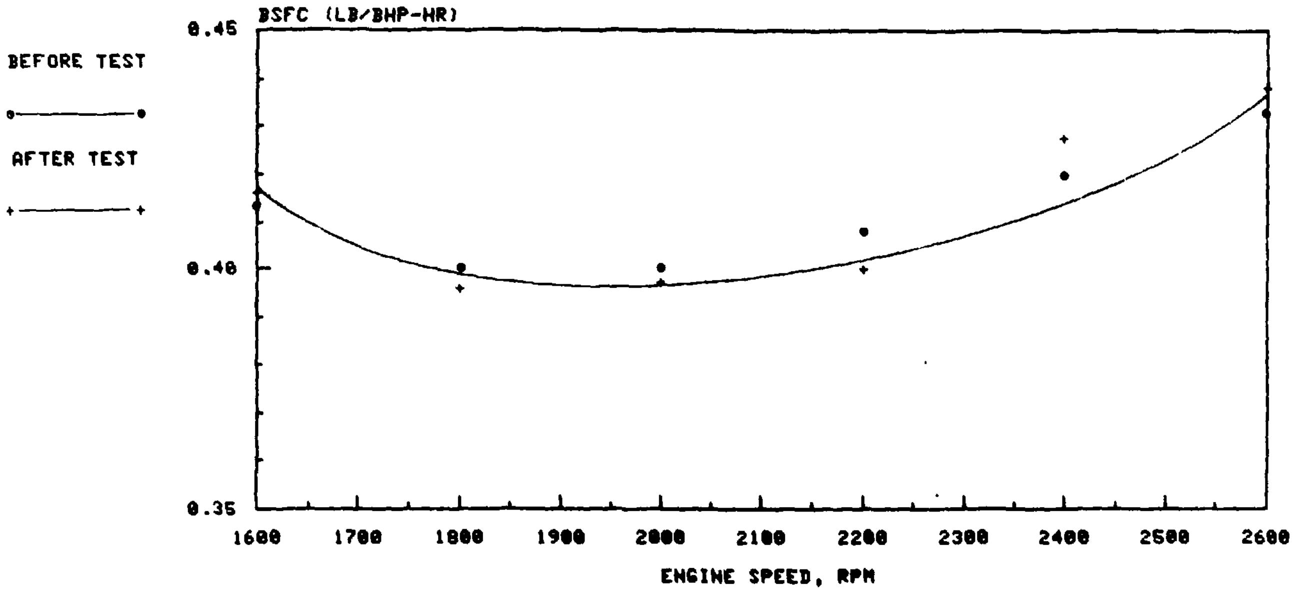
LDT-465-1C 210-HOUR WHEELED-VEHICLE CYCLE ENDURANCE TEST
TEST 4
OPERATING CONDITIONS SUMMARY
Fuel: AL-8764-F   Lubricant: AL-8980-L

	Power Mode			Idle Mode
	Min	Max	Avg	Avg
Engine Speed, rpm	2602	2614	2608	803
Torque, ft-lb (N-m)	308(418)	316(428)	311(422)	10(14)
Observed Power, Bhp (kW)	151(113)	158(118)	154(115)	1.5(1.1)
Fuel Consumption, lb/hr (kg/hr)	66.2(30.1)	67.3(30.6)	66.8(30.3)	7.1(3.2)
BSFC, lb/Bhp-hr (g/kW-hr)	0.422(268)	0.442(280)	0.433(275)	4.8(3046)
Temperatures, °F(°C)				
Exhaust before turbocharger	954(512)	978(526)	964(518)	292(144)
Water Jacket Inlet	168(76)	172(78)	170(77)	99(37)
Water Jacket Outlet	180(82)	182(83)	180(82)	104(40)
Oil Sump	229(109)	234(112)	232(111)	129(54)
Fuel In	91(33)	96(36)	93(34)	84(29)
Inlet Air	80(27)	92(33)	87(31)	81(27)
Intake Manifold	220(104)	238(114)	229(109)	85(29)
Pressures				
Intake Vacuum, in. H_2O (Pa)	2.6(650)	2.7(670)	2.7(670)	0.1(20)
Exhaust Common, in. Hg (kPa)	0.7(2.4)	0.9(3.1)	0.8(2.7)	0.0(0.0)
Intake Manifold, psi (kPa)	9.6(66.1)	10.2(70.3)	9.9(68.2)	0.0(0.0)
Exhaust Manifold, psi (kPa)	12.5(86.1)	13.0(89.6)	12.8(88.2)	1.0(6.9)
Fuel Transfer Pump, psi (kPa)	69(475)	70(482)	70(482)	38(262)
Oil Gallery, psi (kPa)	64(441)	68(469)	67(462)	76(524)
Blowby, in. H_2O (Pa)	0.6(140)	1.2(290)	0.8(200)	0.1(30)
Ambient Conditions				
Wet Bulb Temperature, °F(°C)			67(19)	
Dry Bulb Temperture, °F(°C)			75(24)	
Barometric Pressure, in. Hg (kPa)			29.08(98.6)	

LDT-465 210 HOUR WHEELED VEHICLE CYCLE

BEFORE AND AFTER TEST 4 PERFORMANCE DATA





LDT-465-1C
TEST 4
LUBRICANT ANALYSIS
Lubricant: AL-8980-L

	ASTM Test Method	0	70	140	210
Apparent Viscosity at -29°C(-20°F), cP	D 2602	>26500	>26500	>26500	>26500*
Apparent Viscosity at -18°C(0°F), cP	D 2602	>9670	>9670	>9670	>9670 *
Kinematic Viscosity at 40°C(104°F), cSt	D 445	110	199	292	297
Kinematic Viscosity at 100°C(212°F), cSt	D 445	11.6	17.7	22.4	23.2
Viscosity Index	D 2270	92	96	94	97
Total Acid Number, mg KOH/g	D 664	5.4	4.8	5.7	6.0
Total Base Number, mg KOH/g	D 664	13.1	5.4	5.1	5.5
Pentane B Insolubles, wt%	D 893	0.02	2.80	5.62	6.71
Toluene B Insolubles, wt%	D893	0.02	2.16	4.74	5.31
Flash Point, °C(°F)	D 92	214(417)	204(399)	222(432)	214(417)
Density at 16°C(60°F), g/ml	D 287	0.90	0.93	0.94	0.94
Carbon Residue, wt%	D 524	1.5	4.5	6.3	7.1
Sulfated Ash, wt%	D 874	1.8	2.4	3.2	3.6

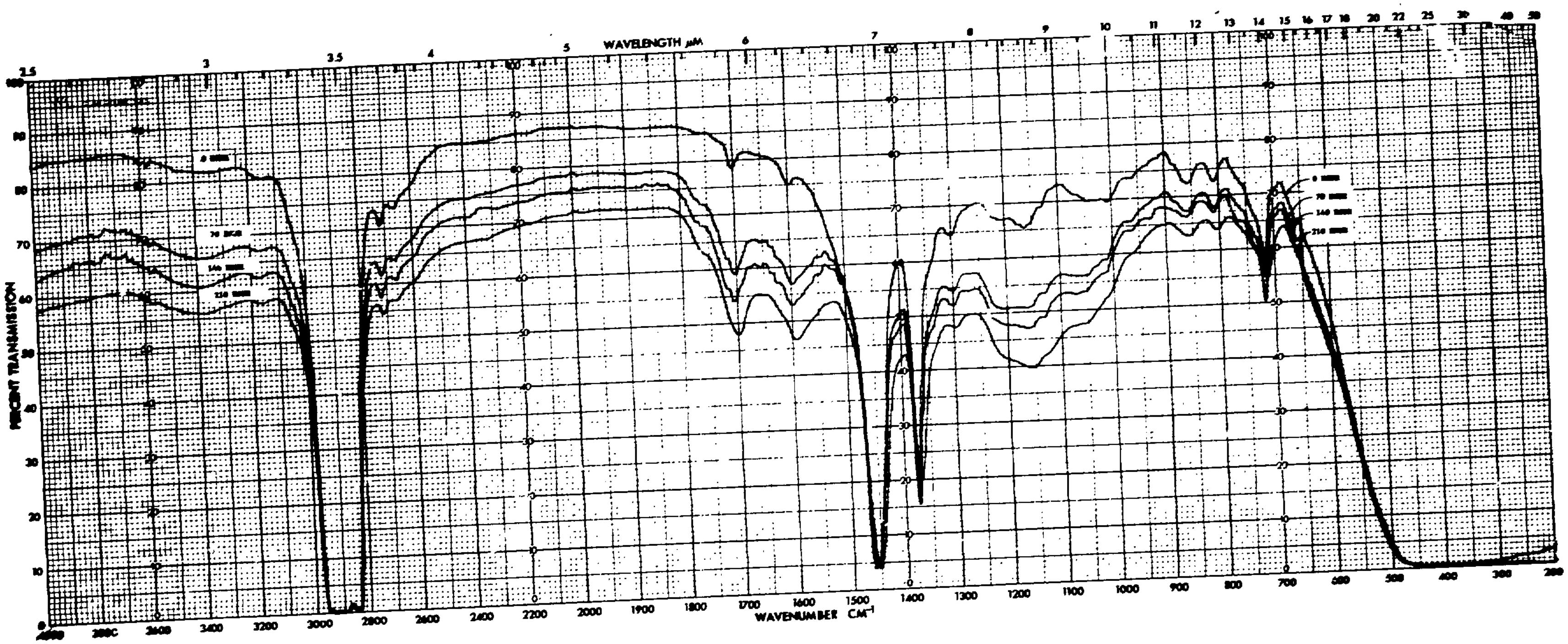
*The reason for unchanging viscosities with time is that the lubricant viscosity, at all test times, exceeded the limits of the viscosity standards currently available.

LDT-465-1C
TEST 4
TOTAL OIL CONSUMPTION AND WEAR METALS
Lubricant: AL-8980-L

Test Time, Hours	Total Oil Consumed, lb (kg)	Wear Metals+, ppm Fe (Iron)	Cu (Copper)
14	6.8(3.1)	25	---*
28	19.0(8.6)	24	---
42	27.4(12.4)	34	19
56	38.2(17.3)	41	---
70	49.2(22.3)	52	---
84	59.2(26.9)	53	---
98	71.6(32.5)	62	---
112	79.2(35.9)	62	---
126	87.9(39.9)	74	13
140	99.6(45.2)	93	---
154	111.1(50.4)	84	10
168	123.9(56.2)	87	10
182	134.6(61.1)	98	8
196	145.4(66.0)	98	10
210	155.8(70.7)	108	---

Average Oil Consumption Rate: 0.74 lb/hr (0.34kg/hr)
+ No other wear metals detected.
* --- = Not Detected.

LDT-465-1C
TEST 4
Lubricant: AL-8980-L



LDT-465-1C
TEST 4
WEAR MEASUREMENTS
Lubricant: AL-8980-L

Cylinder Liner Bore Diameter, inches

	Before Test			After Test			Change		
	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
1 T-AT	4.5639	4.5642	4.5644	4.5650	4.5652	4.5653	0.0011	0.0010	0.0009
F-B	4.5629	4.5629	4.5629	4.5633	4.5630	4.5632	0.0004	0.0001	0.0003
2 T-AT	4.5692	4.5638	4.5636	4.5646	4.5642	4.5639	0.0004	0.0004	0.0003
F-B	4.5632	4.5634	4.5638	4.5637	4.5638	4.5640	0.0005	0.0004	0.0002
3 T-AT	4.5635	4.5636	4.5635	4.5642	4.5641	4.5641	0.0007	0.0005	0.0006
F-B	4.5625	4.5623	4.5625	4.5632	4.5617	4.5628	0.0007	-0.0006	0.0003
4 T-AT	4.5640	4.5641	4.5640	4.5645	4.5644	4.5643	0.0005	0.0003	0.0003
F-B	4.5622	4.5625	4.5632	4.563[illegible]	4.5633	4.5636	0.0011	0.0008	0.0004
5 T-AT	4.5635	4.5637	4.5638	4.5643	4.5642	4.5639	0.0008	0.0005	0.0001
F-B	4.5621	4.5623	4.5626	4.5631	4.5630	4.5632	0.0010	0.0007	0.0007
6 T-AT	4.5633	4.5640	4.5641	4.5644	4.5646	4.5645	0.0011	0.0006	0.0007
F-B	4.5628	4.5633	4.5637	4.5634	4.5636	4.5639	0.0006	0.0002	0.0002

Average Change, in.: +0.0005

LDT-465-1C
TEST 4
WEAR MEASUREMENTS
Lubricant: AL-8980-L

Piston Ring End Gap, inches

Piston No.	Ring No.	Before Test End Gap	After Test End Gap	Change
1	1	0.022	0.024	0.002
	2	0.021	0.024	0.003
	3	0.018	0.020	0.002
	4	0.020	0.024	0.004
2	1	0.022	0.025	0.003
	2	0.021	0.024	0.003
	3	0.019	0.020	0.001
	4	0.018	0.020	0.002
3	1	0.024	0.027	0.003
	2	0.023	0.024	0.001
	3	0.021	0.023	0.002
	4	0.022	Broke	---
4	1	0.023	0.025	0.002
	2	0.025	0.028	0.003
	3	0.020	0.022	0.002
	4	0.021	0.026	0.005
5	1	0.024	0.027	0.003
	2	0.023	0.025	0.002
	3	0.020	0.021	0.001
	4	0.022	0.024	0.002
6	1	0.023	0.025	0.002
	2	0.023	0.024	0.001
	3	0.020	0.021	0.001
	4	0.019	0.020	0.001

Average Change, in.: +0.002

POST TEST ENGINE CONDITION AND DEPOSITS
LDT-465-1C TEST 4
Engine SN: 3904343
Lubricant: AL-8980-L
Fuel: Cat 1-H
Date Started: 19 Dec 1979
Date Completed: 14 Jan 1980
Test: 210 Hour Wheeled Vehicle Cycle

A. CYLINDER RATINGS

		Cylinder Number					
		1		2		3	
Deposits		Carb	Lacq	Carb	Lacq	Carb	Lacq
Cylinder Head		10% AHC* 90% Soot	0	5% AHC 95% Soot	0	10% AHC 95% Soot	0
Cylinders	ART**	15% ½AHC 10% ¼AHC	10% 5+	15% ½AHC 5% ¼AHC	5% 5 5% 9	15% ½AHC	5% 5 5% 7 5% 9
	RTA	0	0	0	0	0	0
	BRT[1]	0	100% 7	0	100% 7	0	100% 7

		Cylinder Numbers					
		4		5		6	
Deposits		Carb	Lacq	Carb	Lacq	Carb	Lacq
Cylinder Head		10% AHC 90% Soot	0	5% AHC 95% Soot	0	5% AHC 95% Soot	0
Cylinders	ART**	10% ½AHC 20% ¼AHC	5% 5 5% 7 5% 8	10% ½AHC 20% ¼AHC	5% 4 5% 9	15% ½AHC 5% ¼AHC	5% 8
	RTA	0	0	0	0	0	0
	BRT[1]	0	100% 7	0	100% 7	0	100% 7

Surface Condition		1	2	3
Cylinders	RTA	5% G, LS++	LS	LS
	BRT	N	N	N

Surface Condition		4	5	6
Cylinders	RTA	5% G, LS	LS	LS
	BRT	N	N	N

* HC = Hard carbon, and the number-letter prefix indicates carbon depth with ¼A = least, through the alphabet to J = most.
** ART = Above ring travel, RTA = Ring travel area, BRT = Below ring travel.
\+ The higher the number, the darker the lacquer (0 = lightest, 9 = darkest).
++ V = Very, L = Light, H = Heavy, G = Glazing, P = Pitting, W = Wiping, F = Flaking, S = Scratched, T = Thrust side, AT = Anti-thrust side.
1 Accurate evaluation difficult due to the metal treatment given new cylinders.

B. PISTON RATINGS

Ring Face Condition	Cylinder Number 1	2	3	4	5	6
No. 1	N[a]	N	N	N	N	N
No. 2	N	N	N	N	N	N
No. 3	N	N	N	N	N	N
No. 4 (oil control)	N	N	–[c]	N	N	N
Oil Ring Slots, % Open	100	100	100	100	100	100

Ring Deposits

Piston Deposits		Cylinder Number 1 Carb	1 Lacq	2 Carb	2 Lacq	3 Carb	3 Lacq
Top	1	0	1% 5	0	1% 8	0	0
	2	0	0	0	1% 3	0	10% 3
	3	0	80% 5 20% 7	0	100% 7	0	75% 5 25% 7
ID	1	0	30% 3 55% 6 15% 8	50% AHC	15% 3 35% 9	45% AHC	35% 4 20% 9
	2	100% AHC	0	70% AHC 30% ½AHC	0	25% ½AHC	75% 9
	3	0	100% 9	0	100% 9	0	100% 9
Bottom	1	0	0	0	0	0	0
	2	0	5% 3	0	10% 3	0	5% 3
	3	0	100% 7	0	85% 6 15% 7	0	65% 5 35% 7

Piston Deposits		Cylinder Number 4 Carb	4 Lacq	5 Carb	5 Lacq	6 Carb	6 Lacq
Top	1	0	15% 5 2% 9	0	0	0	1% 5
	2	0	10% 4	0	0	0	0
	3	0	85% 5 15% 7	0	50% 4 50% 6	0	100% 6
ID	1	10% ½AHC 40% ½AHC	50% 5	0	25% 3 15% 6 15% 7 45% 9	0	35% 4 65% 9
	2	40% ½AHC	60% 9	100% ½AHC	0	100% ½AHC	0
	3	0	100% 9	0	100% 9	0	100% 9
Bottom	1	0	10% 5	0	0	0	0
	2	0	0	0	20% 3	0	0
	3	0	95% 6 5% 7	0	80% 4 20% 6	0	85% 4 15% 7

[a] N = Normal condition, no scuffing
[b] sc = Scuffed
[c] – = Ring broke while removing

Piston Surface Condition

	Piston Number 1	2	3	4	5	6
Top Ring Land	N	N	N	N	N	N
Skirt	N, LS	N, LS	N, LS	N, LS	N, LS	N, LS
Piston Pin	N	N	N	N	N	N

CRC Diesel Engine Piston Rating

	Piston Number 1	2	3	4	5	6
WTD[d] rating	289	195	288	312	316	241

Av. WTD rating: 274

C. VALVE RATINGS

	Cylinder Number 1		2		3		4		5		6	
	INT	EXH	INT	EXH	INT	EXH	INT	EXH	INT	EXH	INT	EXH
Freeness in Guide	F[e]	F	F	S[f]	F	S	F	S	F	S	F	F
Head	-All Normal-											
Face	-All Normal, Light Pitting-											
Seat	-All Normal, Light Pitting-											
Stem	N	LG[g]	N	LG	N	LG	N	LG	N	LG	N	LG
Tip	-All Normal-											

D. OTHER RATINGS

Bearing Surface Condition - All normal

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[d] WTD = Weighted Total Deposits, 0 = Clean, 900 = maxinum possible deposits

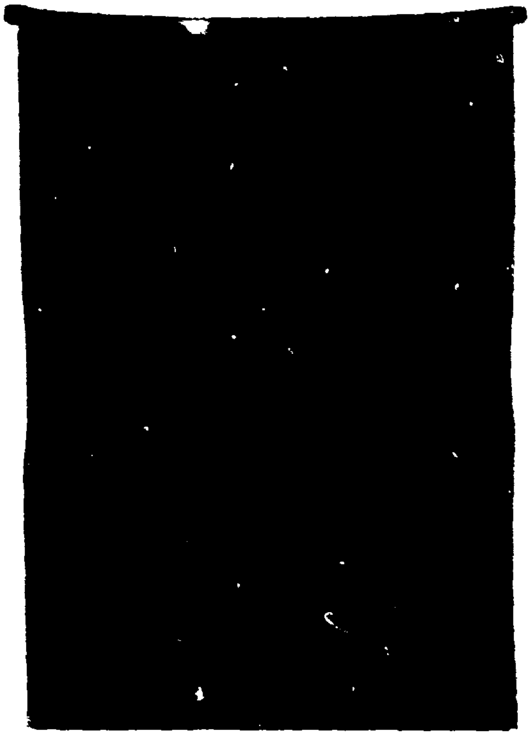
[e] F = Free

[f] S = Stuck (The stuck valves came loose with a light tap)

[g] LG = Light Gauling

LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



1-Thrust

LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

1 Anti-Thrust

LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF PISTON AN) CYLINDER LINER

2 Thrust*

* No. 2 Piston had the lowest Weighted Total Deposit (WTD) rating.

LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

2 Anti-Thrust*

* No. 2 Piston had the lowest Weighted Total Deposit (WTD) rating.

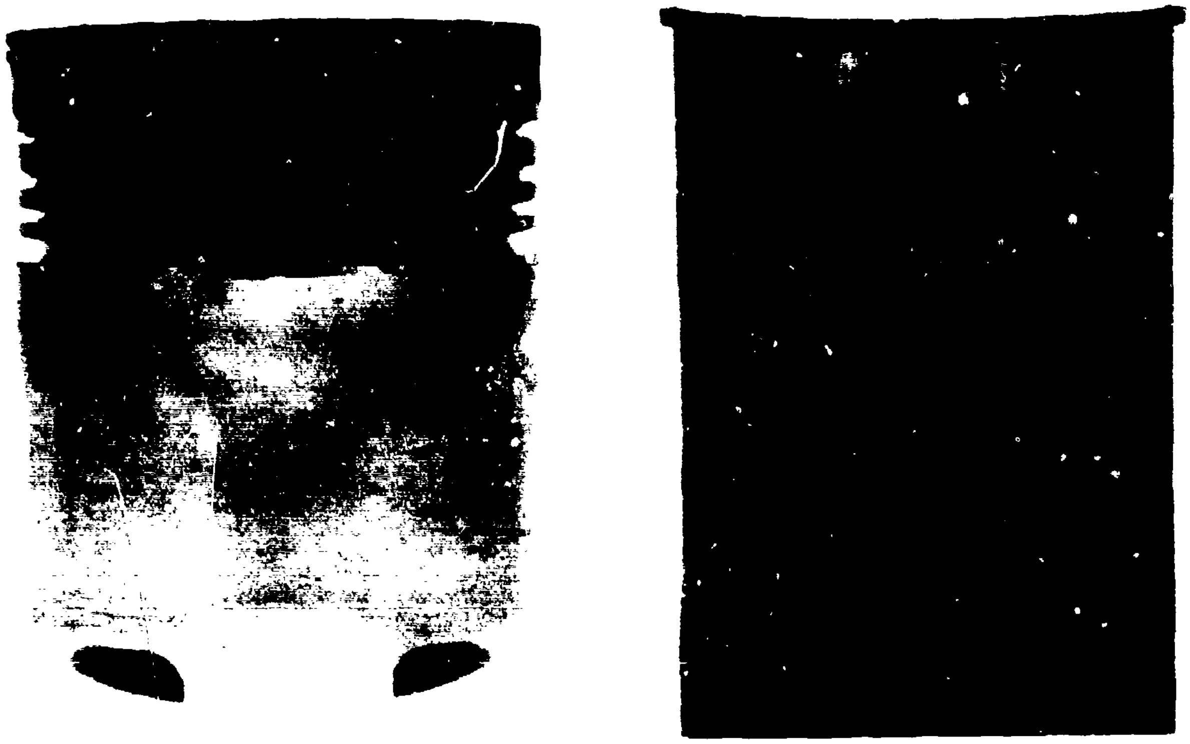
LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

3 Thrust

LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



3 Anti-Thrust

LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

4 Thrust

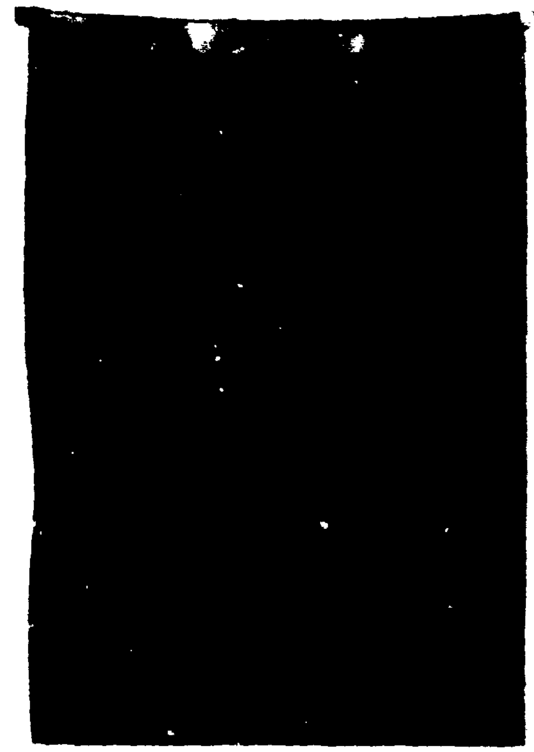
LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

4 Anti-Thrust

LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

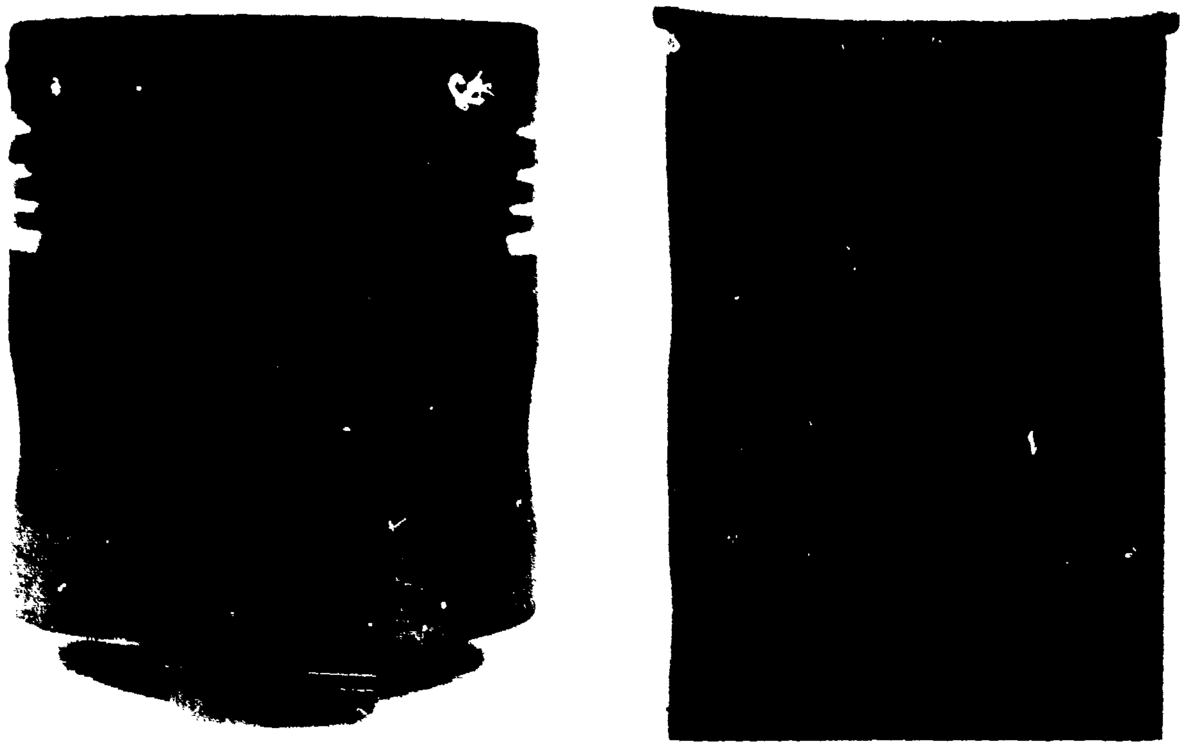


5 Thrust*

* No. 5 Piston had the highest Weighted Total Deposits (WTD) rating.

LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

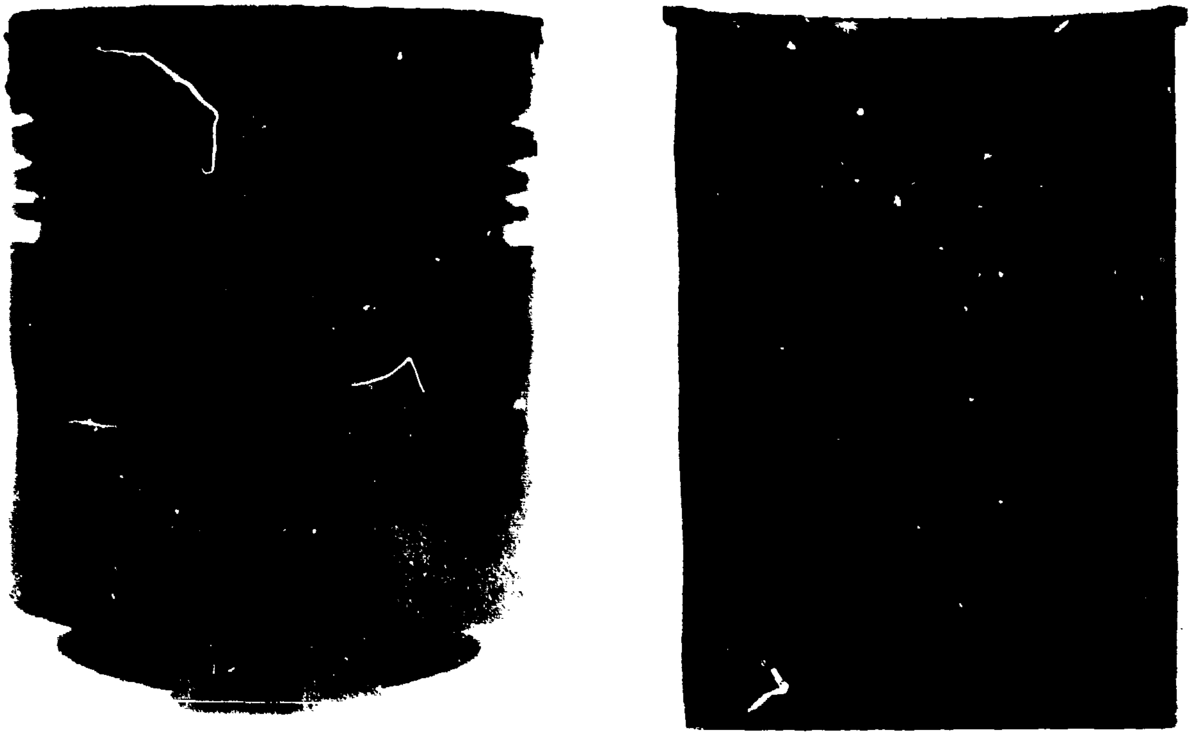


5 Anti-Thrust*

* No. 5 Piston had the highest Weighted Total Deposits (WTD) rating.

LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



6 Thrust

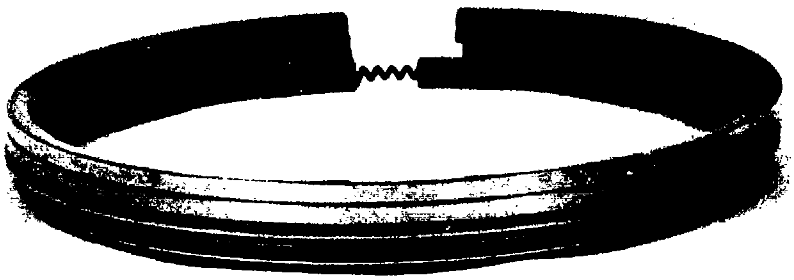
LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

6 Anti-Thrust

LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF PISTON RINGS



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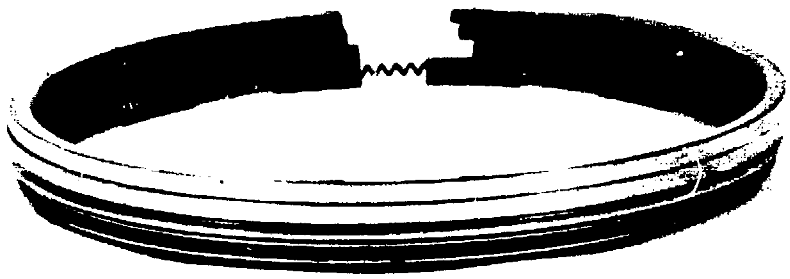
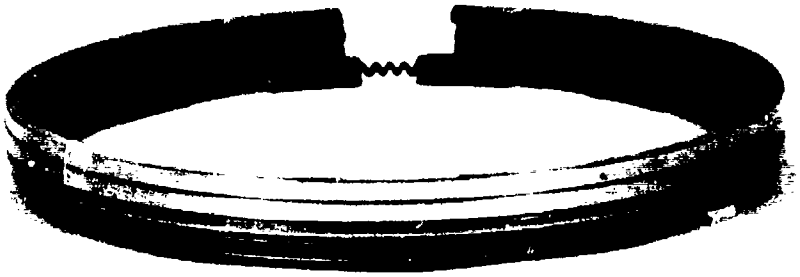


No. 2

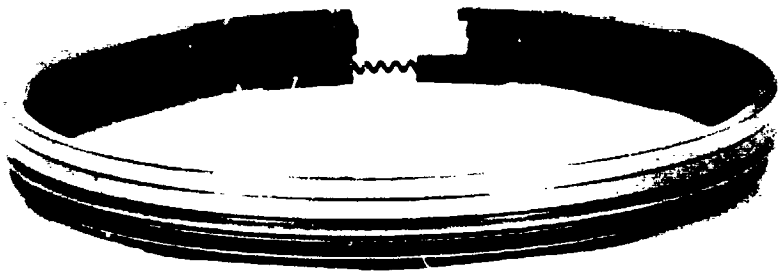
No. 3

LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF PISTON RINGS



No. 4
(largest increase in end gap)



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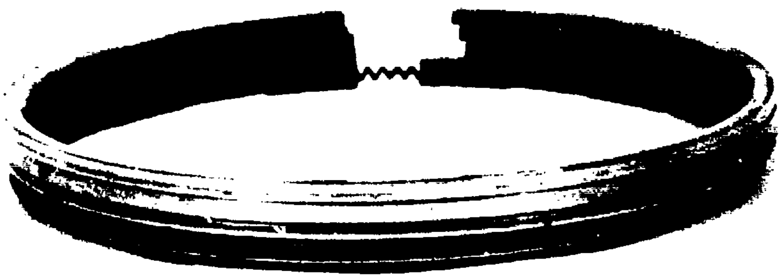
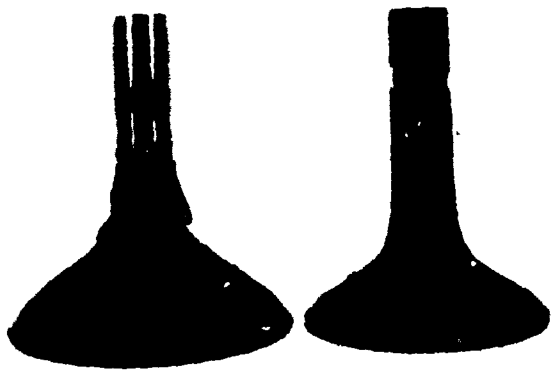


No. 6
(least increase in end gap)

LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF INTAKE AND EXHAUST VALVES



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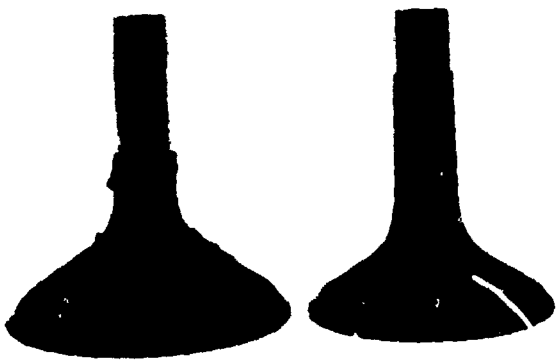
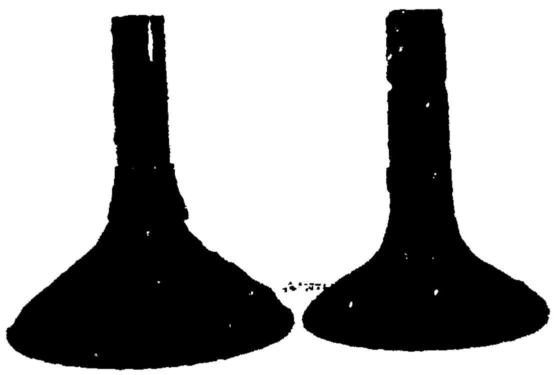


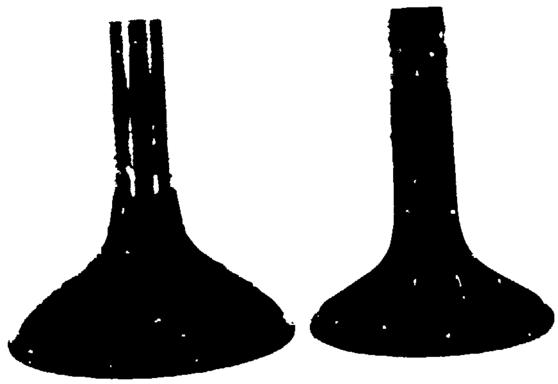
No. 2
(lowest valve deposit rating)



No. 3

LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF INTAKE AND EXHAUST VALVES



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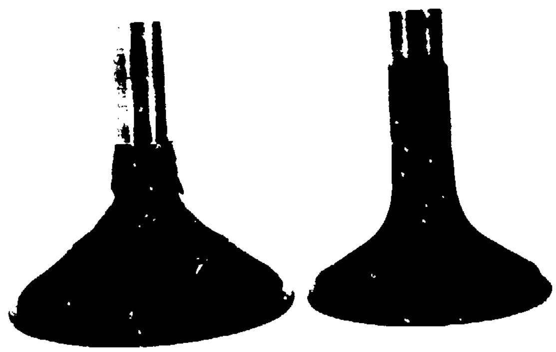

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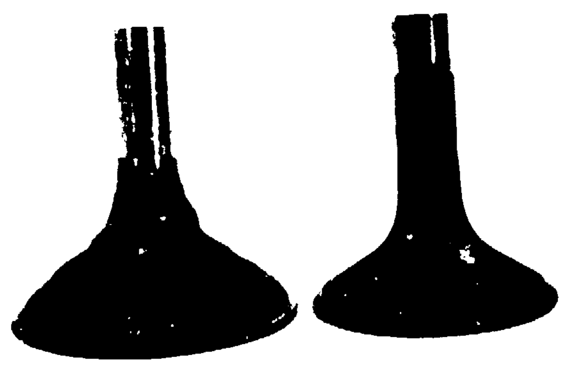
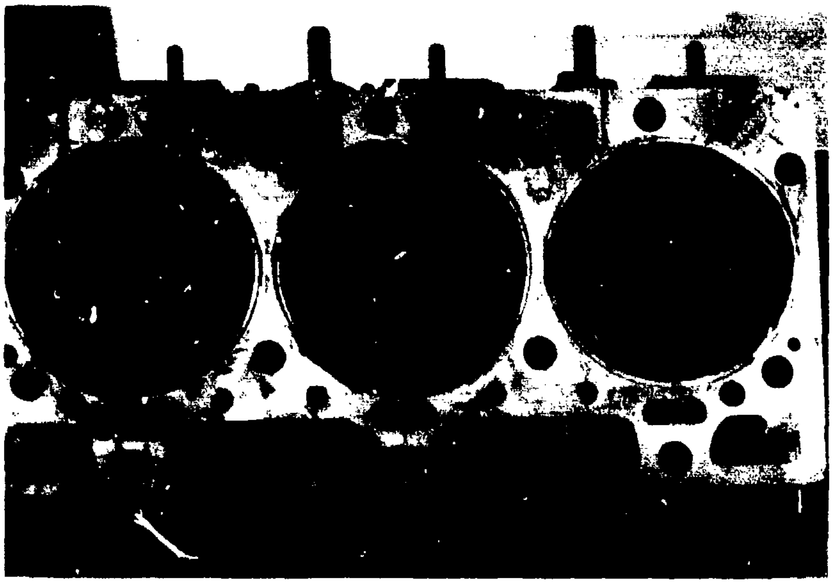


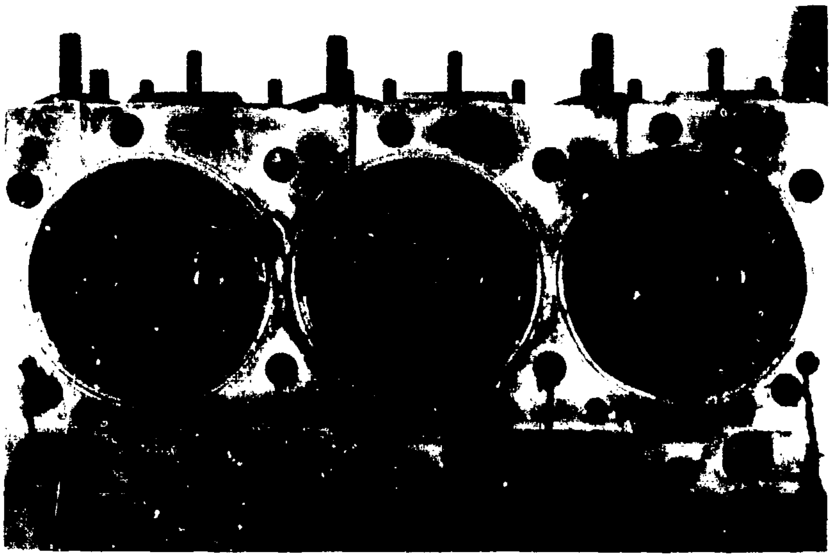
No. 6
(highest valve deposit rating)

LDT-465-1C
TEST 4
Lubricant: AL-8980-L

AFTER TEST CONDITION OF CYLINDER HEADS



Cylinders 3, 2, 1



Cylinders 6, 5, 4

APPENDIX L

ENGINE-LUBRICANT COMPATIBILITY TEST #5

210-HOUR WHEELED-VEHICLE CYCLE

USING LDT-465-1C DIESEL ENGINE

ENGINE-LUBRICANT COMPATIBILITY TEST
210-HOUR WHEELED-VEHICLE CYCLE
USING LDT-465-1C DIESEL ENGINE

Test Lubricant: AL-8924-L
Test Fuel: Caterpillar 1-H
Engine Test Number: 5
Date Completed: 27 February 1980

Conducted for

U.S. Army Mobility Equipment Research and Development Command
Energy and Water Resources Laboratory
Fort Belvoir, Virginia

by

U.S. Army Fuels & Lubricants Research Laboratory
Southwest Research Institute
San Antonio, Texas 78284

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LDT-465-1C
TEST 5
ENGINE REBUILD MEASUREMENTS

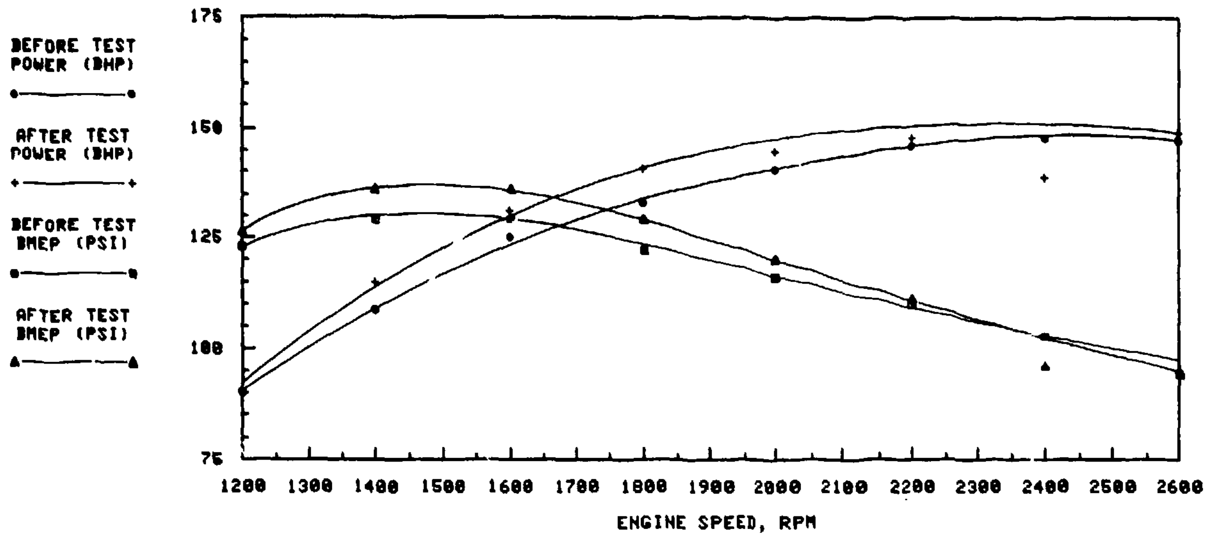
	Inches			
Cylinder Liners (Installed)	Min.	Max	Avg.	Specified Limits
Inside Diameter	4.5630	4.5646	4.5639	4.5630 - 4.5645
Out of Round	0.0001	0.0012	0.0006	0.0015 Max
Taper	0.0001	0.0006	0.0004	0.0015 Max
Piston Skirt Diameter (@ bottom)	4.5552	4.5558	4.5555	4.5530 - 4.5580
No. 1 Ring				
End Gap	0.022	0.027	0.024	0.022 - 0.035
No. 2 Ring				
End Gap	0.023	0.027	0.024	0.022 - 0.035
No. 3 Ring				
End Gap	0.020	0.027	0.023	0.022 - 0.035
Side Clearance	0.0030	0.0040	0.0033	0.0025 - 0.0045
No. 4 Ring				
End Gap	0.018	0.026	0.020	0.010 - 0.028
Side Clearance	0.0015	0.0020	0.0016	0.0010 - 0.0035

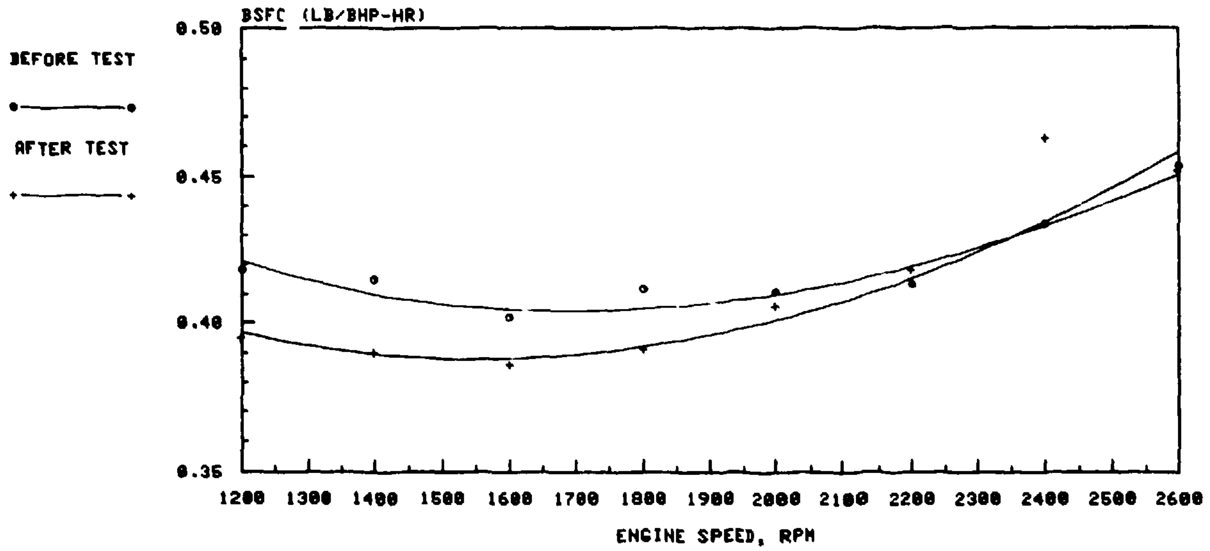
LDT-465-1C 210-HOUR WHEELED VEHICLE CYCLE ENDURANCE TEST
TEST 5
OPERATING CONDITIONS SUMMARY
Fuel: AL-8764-F   Lubricant: AL-8924-L

	Power Mode			Idle Mode
	Min	Max	Avg	Avg
Engine Speed, RPM	2602	2607	2605	811
Torque, Ft-lb,(N-m)	298(404)	316(428)	307(416)	18(24)
Observed Power, Bhp(kW)	148(110)	156(116)	152(113)	2.7(2.0)
Fuel Consumption, lb/hr (kg/hr)	66.6(30.2)	68.0(30.9)	67.1(30.5)	4.9(2.2)
BSFC, lb/Bhp-hr (g/kW-hr)	0.43(273)	0.46(292)	0.44(279)	1.9(1206)
Temperatures, $^{o}F(^{o}C)$				
Exhaust Manifold	1004(540)	1075(579)	1049(565)	237(114)
Water Jacket Inlet	166(74)	169(76)	168(76)	95(35)
Water Jacket Outlet	177(81)	181(83)	180(82)	100(38)
Oil Sump	221(105)	227(108)	224(107)	118(48)
Fuel In	83(28)	90(32)	88(31)	73(23)
Inlet Air	69(21)	88(31)	79(26)	67(19)
Intake Manifold	227(108)	242(117)	234(112)	69(21)
Pressures				
Intake Vacuum, in. H_2O(Pa)	2.9(720)	2.9(720)	2.9(720)	0.1(20)
Exhaust Common, in. Hg(kPa)	0.8(2.7)	0.9(3.1)	0.9(3.1)	0.0(0.0)
Intake Manifold, psi (kPa)	10.6(73.0)	11.1(76.5)	10.7(73.7)	0.0(0.0)
Exhaust Manifold, psi (kPa)	12.0(82.7)	13.4(92.3)	13.0(89.6)	0.0(0.0)
Fuel Transfer Pump, psi (kPa)	73(503)	73(503)	73(503)	39(269)
Oil Gallery, psi (kPa)	59(407)	62(427)	61(420)	65(448)
Blowby, in. H_2O(Pa)	1.6(400)	2.2(550)	2.0(500)	0.2(50)
Ambient Conditions				
Wet Bulb Temperature $^{o}F(^{o}C)$			67(19)	
Dry Bulb Temperature, $^{o}F(^{o}C)$			75(24)	
Barometric Pressure, in. Hg(kPa)			29.18(98.9)	

LDT-465 210 HOUR WHEELED VEHICLE CYCLE

BEFORE AND AFTER TEST 5 PERFORMANCE DATA





LDT-465-1C
TEST 5
LUBRICANT ANALYSIS

LUBRICANT: AL-8924-L

	ASTM Test Method	Test Hour 0	70	140	210
Apparent Viscosity at $-29^{o}C(-20^{o}F)$, cP	D 2602	3480	4200	4650	5300
Apparent Viscosity at $-18^{o}C(0^{o}F)$, cP	D 2602	1180	1300	1530	1750
Kinematic Viscosity at $40^{o}C(104^{o}F)$, cSt	D 445	56.3	56.0	60.2	64.6
Kinematic Viscosity at $100^{o}C(212^{o}F)$, cSt	D 445	10.0	9.8	10.3	10.8
Viscosity Index	D 2270	165	162	160	158
Total Acid Number, mg KOH/g	D 664	2.4	3.9	3.6	4.4
Total Base Number, mg KOH/g	D 664	6.3	2.4	2.8	2.3
Pentane B Insolubles, wt%	D 893	-*	0.5	1.3	2.4
Toluene B Insolubles, wt%	D 893	-	0.5	1.2	2.1
Flash Point, $^{o}C(^{o}F)$	D 92	220(428)	220(428)	220(428)	220(428)
Density at $16^{o}C(60^{o}F)$, gm/ml	D 287	0.87	0.88	0.88	0.89
Carbon Residue, wt%	D 524	1.1	1.9	2.5	3.1
Sulfated Ash, wt%	D 874	1.0	1.2	1.5	1.8

*Not Determined

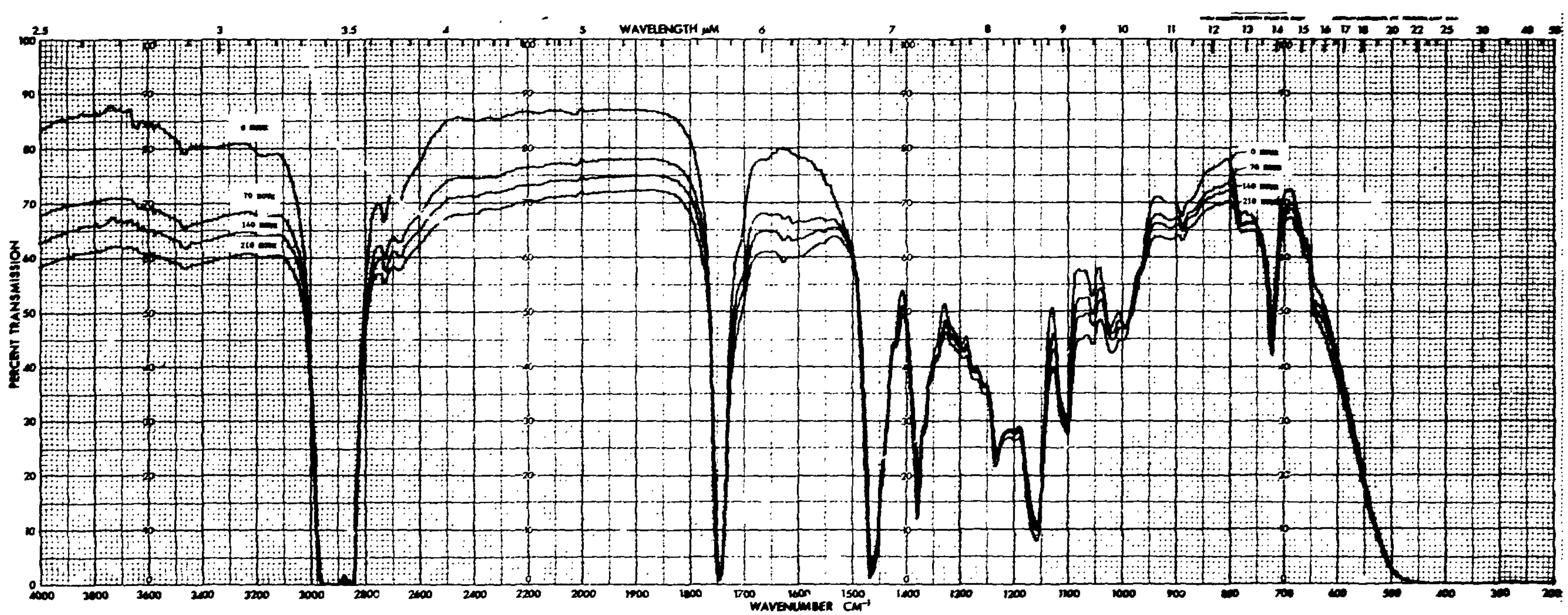
LDT-465-1C
TEST 5
Lubricant: AL-8924-L

Total Oil Consumption and Wear Metals

Test Time, Hours	Total Oil Consumed, lb. (kg)	Wear Metals,* PPM Fe	Cu	Cr
14	1.4 (0.6)	44	-**	-
28	5.1 (2.3)	61	-	-
42	8.7 (4.0)	82	13	-
56	13.4 (6.1)	97	-	-
70	18.7 (8.5)	105	18	12
84	25.3 (11.5)	111	-	26
98	29.4 (13.3)	119	-	-
112	36.0 (16.3)	127	14	-
126	41.3 (18.7)	149	13	-
140	46.1 (20.9)	146	-	-
154	49.6 (22.5)	162	19	-
168	55.5 (25.2)	187	12	-
182	62.8 (28.5)	228	-	-
196	67.8 (30.7)	226	13	-
210	72.6 (32.9)	252	-	31

Average Oil Consumption Rate: 0.35 LB/HR (0.16 KG/HR).
* No Other Wear Metals Detected.
**Not Detected.

LDT-465-1C
TEST 5
Lubricant: AL-8924-L



LDT-465-1C
TEST 5

Lubricant: AL-8924-L

Wear Measurements

Cylinder Liner Bore Diameter, inches

	Before Test			After Test			Change		
	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
1. T-AT	4.5638	4.5639	4.5641	4.5629	4.5633	4.5640	-0.0009	-0.0006	-0.0001
F-B	4.5634	4.5634	4.5639	4.5644	4.5641	4.5637	0.0010	0.0007	-0.0002
2. T-AT	4.5633	4.5636	4.5637	4.5632	4.5633	4.5636	-0.0001	-0.0003	-0.0001
F-B	4.5636	4.5635	4.5639	4.5628	4.5629	4.5636	-0.0008	-0.0006	-0.0003
3. T-AT	4.5645	4.5645	4.5644	4.5647	4.5644	4.5642	0.0002	-0.0001	-0.0002
F-B	4.5633	4.5638	4.5640	4.5629	4.5633	4.5636	-0.0004	-0.0005	-0.0004
4. T-AT	4.5640	4.5645	4.5645	4.5647	4.5647	4.5646	0.0007	0.0002	0.0001
F-B	4.5635	4.5638	4.5641	4.5635	4.5634	4.5637	0.0000	-0.0004	-0.0004
5. T-AT	4.5642	4.5645	4.5646	4.5644	4.5646	4.5646	0.0002	0.0001	0.0000
F-B	4.5630	4.5631	4.5635	4.5632	4.5631	4.5634	0.0002	0.0000	-0.0001
6. T-AT	4.5641	4.5638	4.5637	4.5646	4.5638	4.5637	0.0005	0.0000	0.0000
F-B	4.5637	4.5640	4.5641	4.5639	4.5637	4.5639	0.0002	-0.0003	-0.0002

Average Change, in.: -0.0001

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

Wear Measurements

Piston Ring End Gap, inches

Piston No.	Ring No.	Before Test End Gap	After Test End Gap	Change
1	1	0.022	0.023	0.001
	2	0.023	0.024	0.001
	3	0.022	0.023	0.001
	4	0.019	0.020	0.001
2	1	0.023	0.024	0.001
	2	0.022	0.023	0.001
	3	0.022	0.024	0.002
	4	0.018	0.023	0.005
3	1	0.027	0.029	0.002
	2	0.027	0.028	0.001
	3	0.002	0.023	0.001
	4	0.026	0.029	0.003
4	1	0.022	0.023	0.003
	2	0.024	0.025	0.001
	3	0.020	0.021	0.001
	4	0.018	0.024	0.006
5	1	0.025	0.026	0.001
	2	0.025	0.026	0.001
	3	0.022	0.023	0.001
	4	0.021	0.024	0.003
6	1	0.022	0.024	0.002
	2	0.023	0.025	0.002
	3	0.027	0.030	0.003
	4	0.016	0.026	0.010

Average Changes, in.: +0.002

POST TEST ENGINE CONDITION AND DEPOSITS
LDT-465-1C
Engine SN: 3904343
Lubricant: AL-8924-L
Fuel: Cat 1-H
Date Started: 7 February 1980
Date Completed: 27 February 1980
Test: 210 Hour Wheeled Vehicle Cycle

A. CYLINDER RATINGS

		Cylinder Number					
		1		2		3	
Deposits		Carb	Lacq	Carb	Lacq	Carb	Lacq
Cylinder Head		5% AHC* 15% ½AHC	0	100% ½AHC	0	10% BHC 15% AHC 75% ½AHC	0
Cylinders	ART**	10% AHC 15% ½AHC	5% 9+	75% AHC	5% 9	75% AHC	0
	RTA	0	100% 8	0	100% 7	0	100% 7
	BRT[1]	0	0	0	0	0	0

		Cylinder Number					
		4		5		6	
Deposits		Carb	Lacq	Carb	Lacq	Carb	Lacq
Cylinder Head		10% AHC 90% ½AHC	0	100% ½AHC	0	10% AHC 90% ½AHC	0
Cylinders	ART**	25% AHC	0	70% AHC	0	80% AHC	5% 9
	RTA	0	100% 8	0	100% 7	0	20% 5 80% 7
	BRT[1]	0	0	0	0	0	0

Surface Condition		1	2	3
Cylinders	RTA	5% G, LS	LS	5%G, LS
	BRT	VLS	LS	LS

Surface Condition		4	5	6
Cylinders	RTA	P to LS	LS	LS
	BRT	LS	LS	LS

1 Accurate evaluation difficult due to the metal treatment given new cylinders.
* HC=Hard Carbon, and the number-letter prefix indicates carbon depth with ½A=least, through the alphabet to J=most.
** ART=Above Ring Travel, RTA=Ring Travel Area, BRT=Below Ring Travel.
\+ The higher the number, the darker the lacquer. (0=lightest, 9=darkest).
++ V=very, L=light, H=heavy, G=glazing, P=pitting, W=wiping, F=flaking, S=scratched, T=thrust side, AT=Anti thrust side

B. PISTON RATINGS

Ring Face Condition	Cylinder Number 1	2	3	4	5	6
No. 1	N[a]	N	N	N	<1% SC[b]	2% SC
No. 2	N	N	N	N	N	N
No. 3	N	N	N	N	N	N
No. 4 (Oil control)	N	N	N	N	N	N
Oil Ring Slots, % Open	100%	100%	100%	100%	100%	100%

Ring Deposits

Piston Ring		Cylinder Number 1 Carb	1 Lacq	2 Carb	2 Lacq	3 Carb	3 Lacq
Top	1	0	1% 9	0	0	0	3% 3 2% 9
	2	0	25% 2	0	45% 3 5% 7	5% ½AHC	30% 3
	3	0	90% 7 10% 8	0	100% 7	0	100% 7
ID	1	0	25% 5 75% 9	85% AHC	15% 9	0	70% 3 30% 9
	2	0	100% 9	50% ½AHC 50% AHC	0	100% ½AHC	0
	3	0	100% 9	0	100% 9	0	100% 9
Bottom	1	0	0	0	5% 4	0	10% 3
	2	0	0	0	0	1% ½AHC	50% 3
	3	0	50% 4 50% 7	0	25% 6	0	55% 6

Piston Ring		Cylinder Number 4 Carb	4 Lacq	5 Carb	5 Lacq	6 Carb	6 Lacq
Top	1	0	0	0	0	0	1% 3
	2	0	15% 3	0	50% 3	0	65% 3
	3	0	100% 7	0	100% 6	0	60% 5 40% 6
ID	1	80% ½AHC	20% 5	100% ½AHC	0	100% AHC	0
	2	100% ½AHC	0	50% ½AHC 50% ½AHC	0	100% ½AHC	0
	3	0	100% 9	0	100% 9	0	100% 9
Bottom	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	35% 7	0	80% 6	0	50% 4

[a]N=Normal condition,
[b]SC=scuffed.

Piston Surface Condition

	Piston Number 1	2	3	4	5	6
Top Ring Land	N	N	N	N	N	N
Skirt	LST	N	N	N	N	N
Piston Pin	N	N	N	N	N	N

CRC Diesel Engine Piston Rating

	Piston Number 1	2	3	4	5	6
WTD[c] rating	199	198	166	184	162	151

Av. WTD rating: 177

C. VALVE RATINGS

	Cylinder Number 1		2		3		4		5		6	
	INT	EXH	INT	EXH	INT	EXH	INT	EXH	INT	EXH	INT	EXH
Freeness in Guide	All Free											
Head	All Normal											
Face	All Normal											
Seat	All Normal											
Stem	All Normal											
Tip	All Normal											
Tulip Demerit Rating[f]	0.50	0.10	0.50	0.10	0.25	0.10	0.50	0.10	0.25	0.10	0.50	0.10

[c] WTD = Weighted Total Deposits, 0 = Clean, 900 = Maximum possible deposits.

[d] F = Free.

[f] 1 = Least, 9 = Most (<1 = very clean).

D. OTHER RATINGS

Tappets, Cams, and Rocker Arms

	Cylinder Number 1	2	3	4	5	6
Tappet Deposit	All ¼A Sludge					
Rocker Arm Tip	Normal					
Bushing	Normal					
Shaft	Normal					

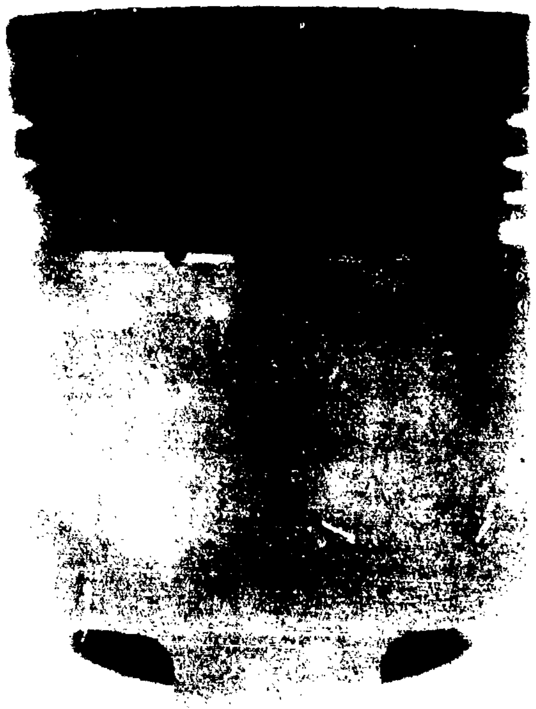
Bearing Surface Condition

	Bearing Number 1	2	3	4	5	6	7
Main Bearing	S	NR[e]	S	NR			
Main Journal	N	NR	N	NR			
Rod Bearing	N	LS,W	N	S,P,F	W,S	S	
Rod Journal	Normal						
Piston Pin	Normal						
Pin Bushing	Normal						

[e]NR = Not Rated.

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



1 THRUST*

* Piston 1 had the highest weighted total deposit (WTD) rating

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

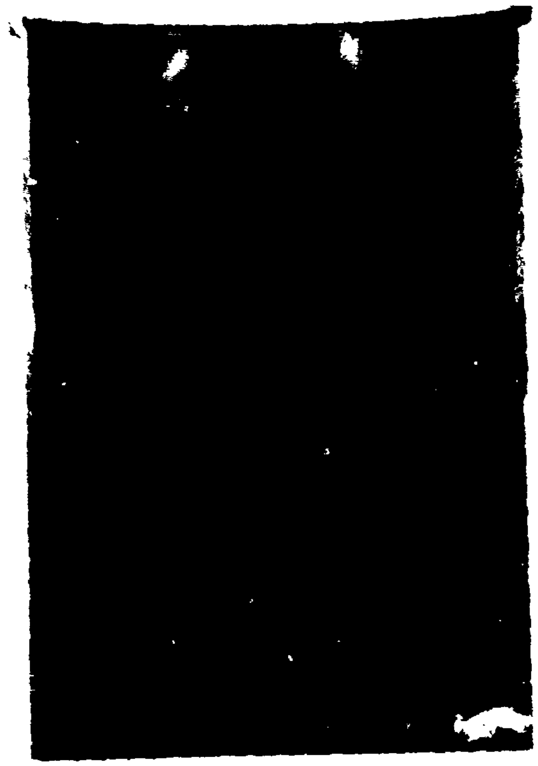
AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

1 Anti-thrust*

* Piston 1 had the highest weighted total deposit (WTD) rating

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

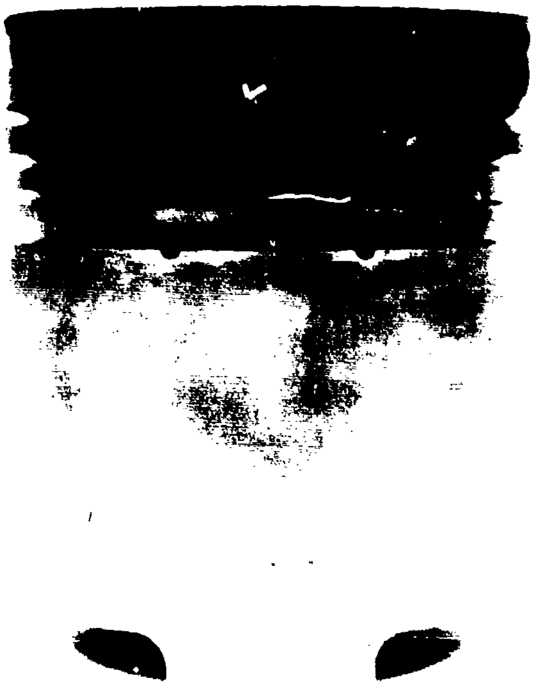
AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



2 Thrust

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

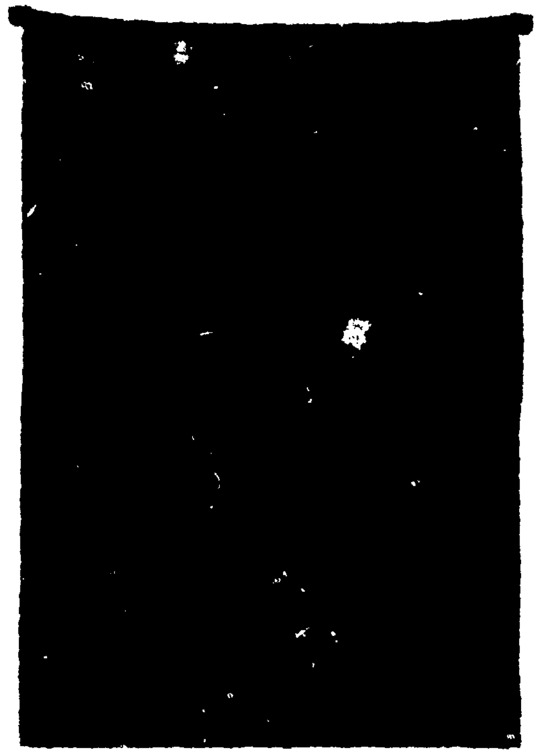
AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



2 Anti-thrust

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

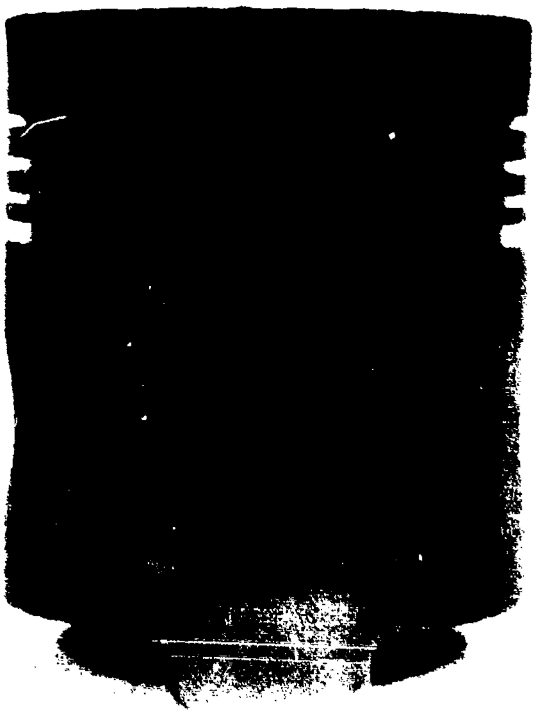


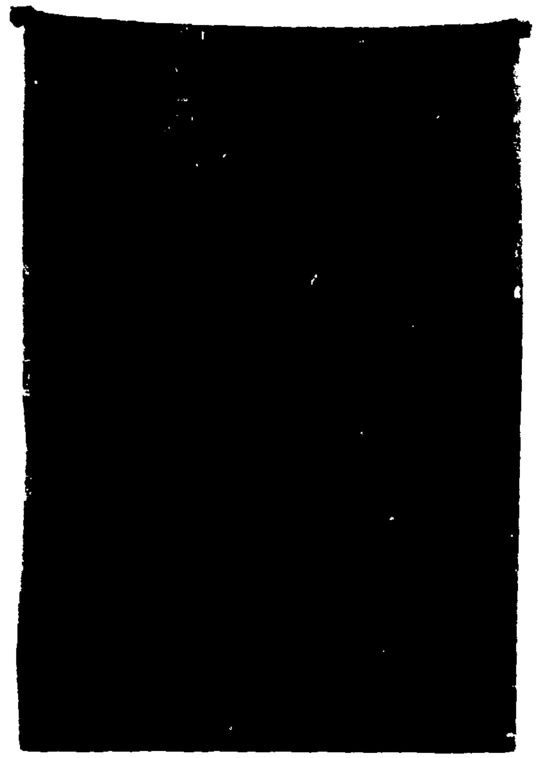
3 Thrust

LDT-465-1C
TEST 5

Lubricant: AL-8924-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

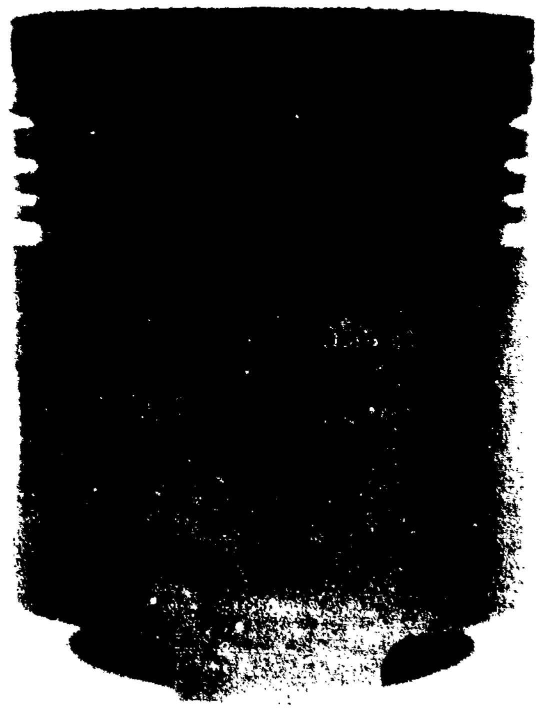




3 Anti-thrust

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



4 Thrust

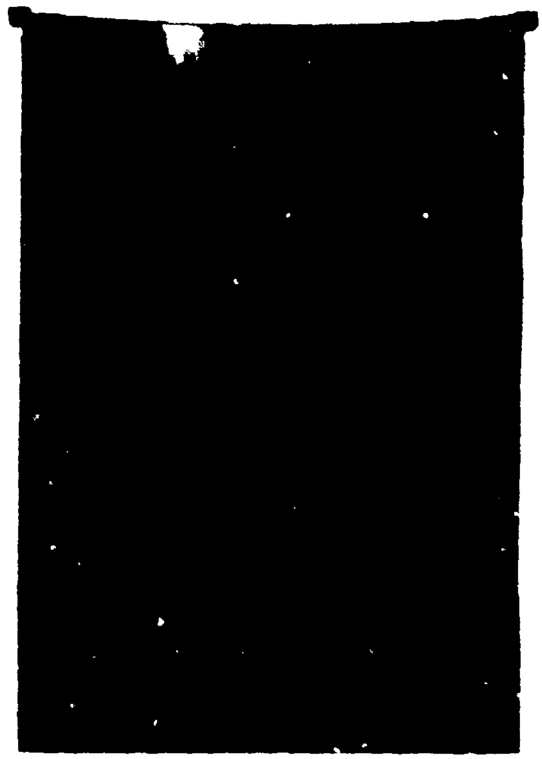
LDT-465-1C
TEST 5
Lubricant: AL-8924-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

4 Anti-thrust

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



5 Thrust

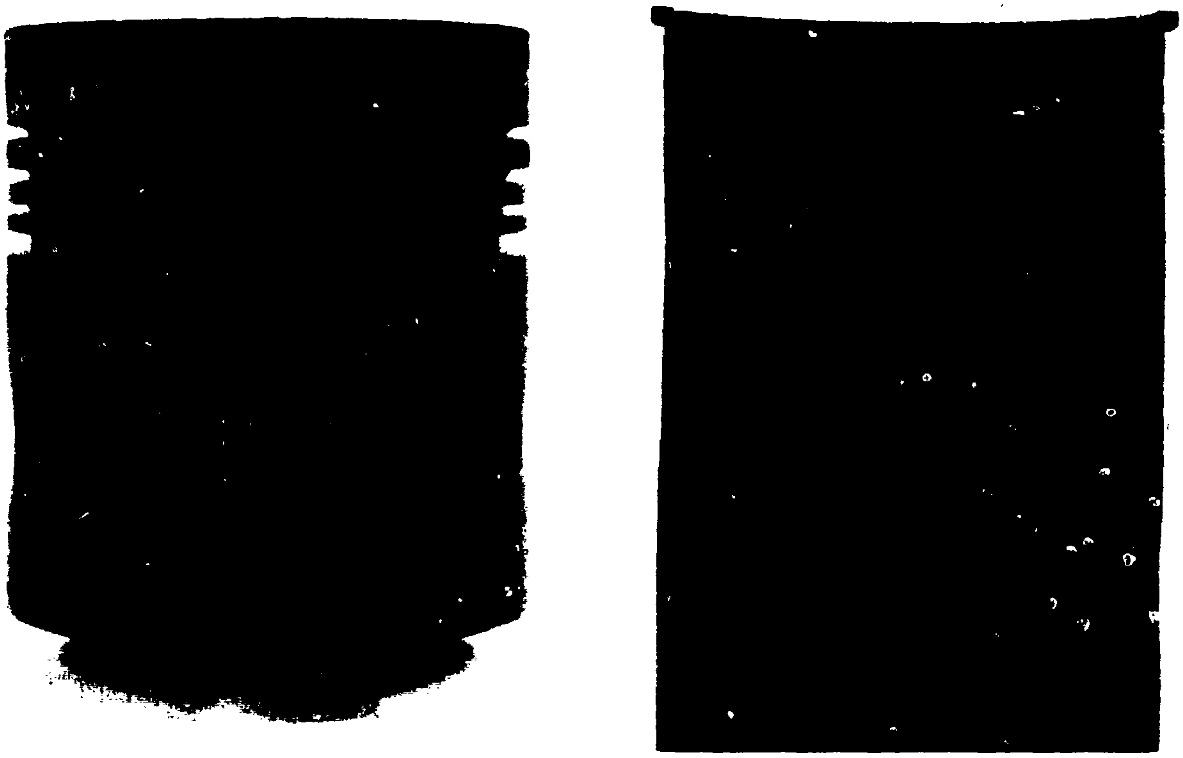
LDT-465-1C
TEST 5
Lubricant: AL-8924-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

5 Anti-thrust

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

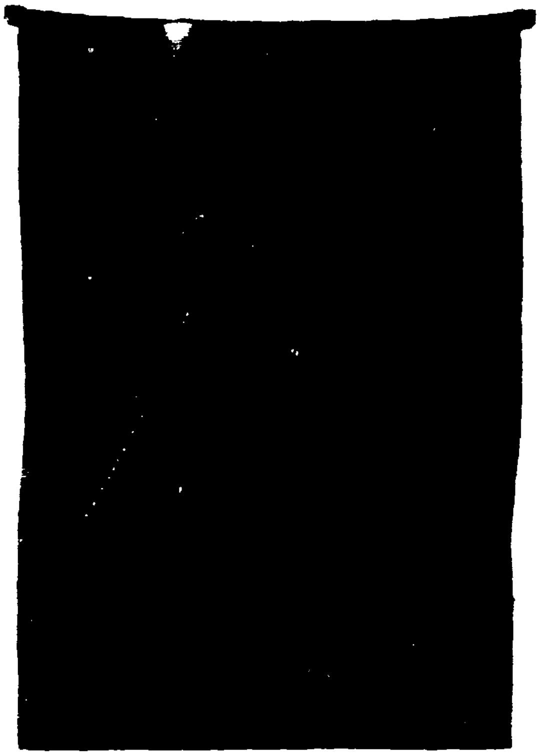


6 Thrust*

* Piston 6 had the lowest WTD rating.

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



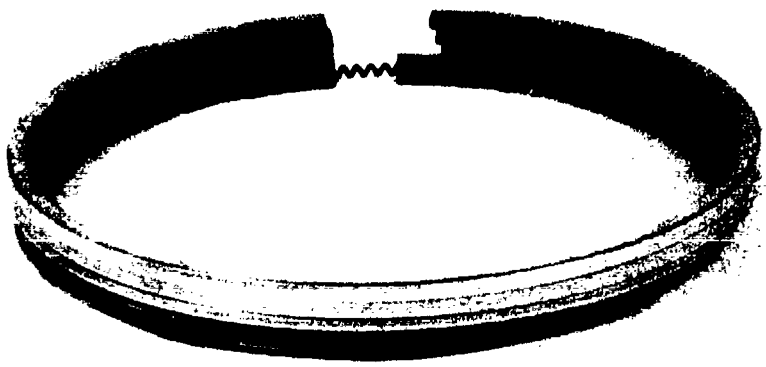
6 Anti-thrust*

* Piston 6 had the lowest WTD rating.

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

AFTER TEST CONDITION OF RINGS

Piston No. 1



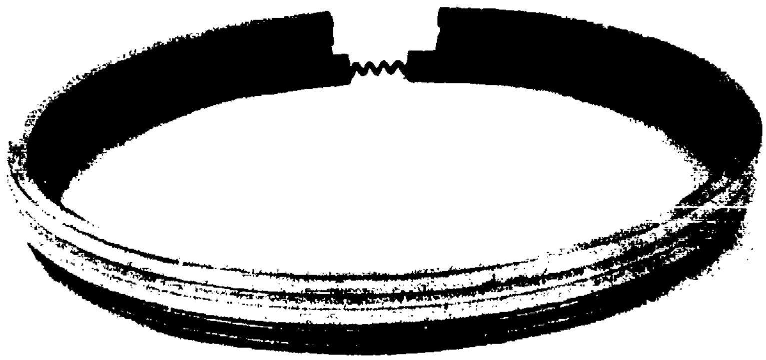
Piston No. 2

Piston No. 3

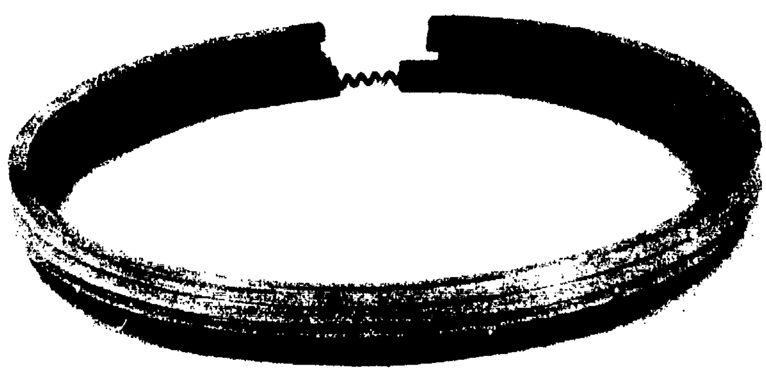
LDT-465-1C
TEST 5
Lubricant: AL-8924-L

AFTER TEST CONDITION OF RINGS

Piston No. 4



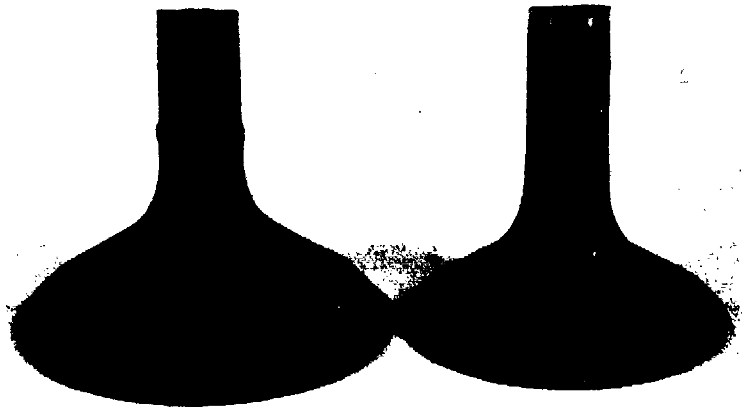
Piston No. 5



Piston No. 6

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

AFTER TEST CONDITION OF INTAKE AND EXHAUST VALVES



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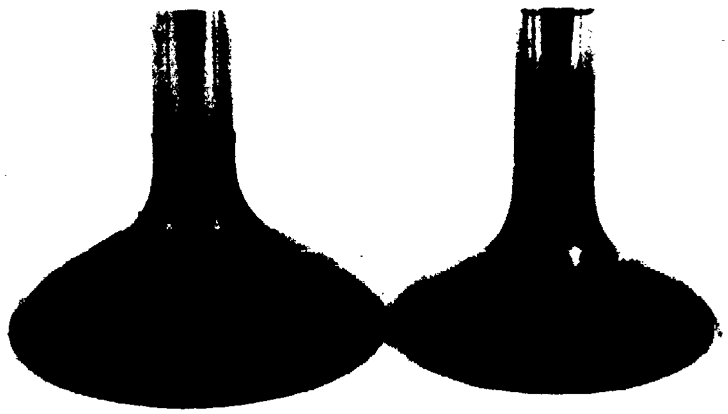

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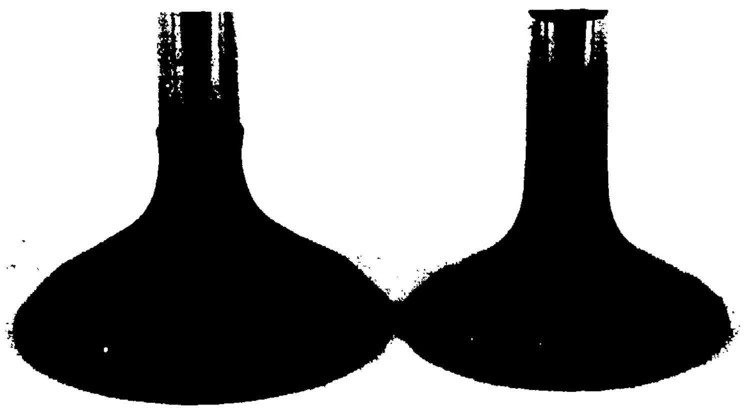
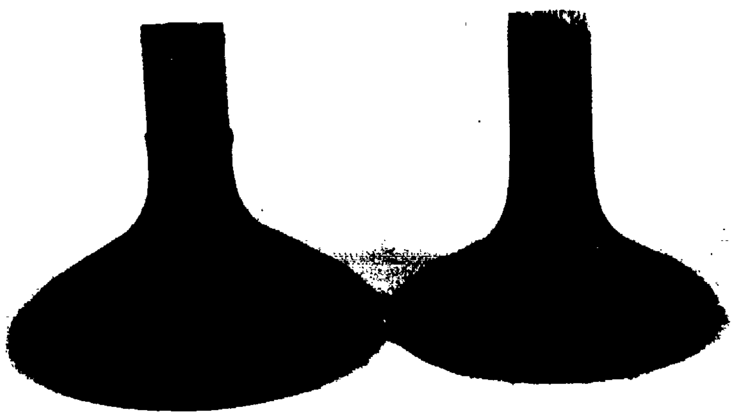


No. 3

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

AFTER TEST CONDITION OF INTAKE AND EXHAUST VALVES



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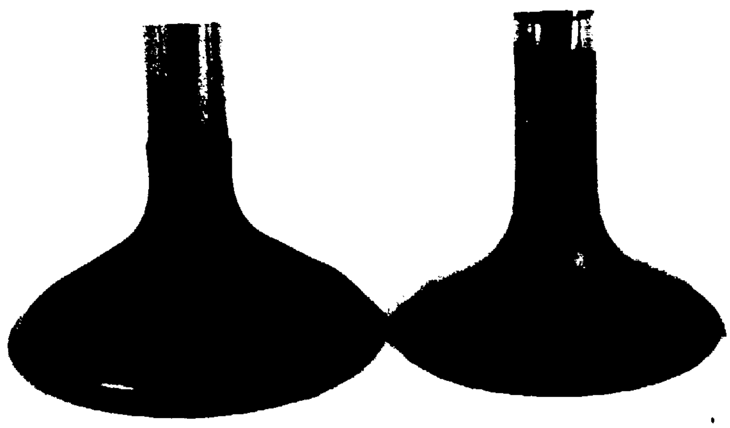
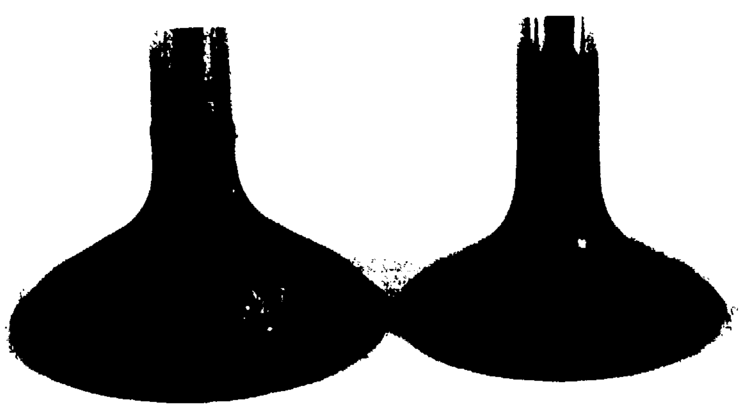


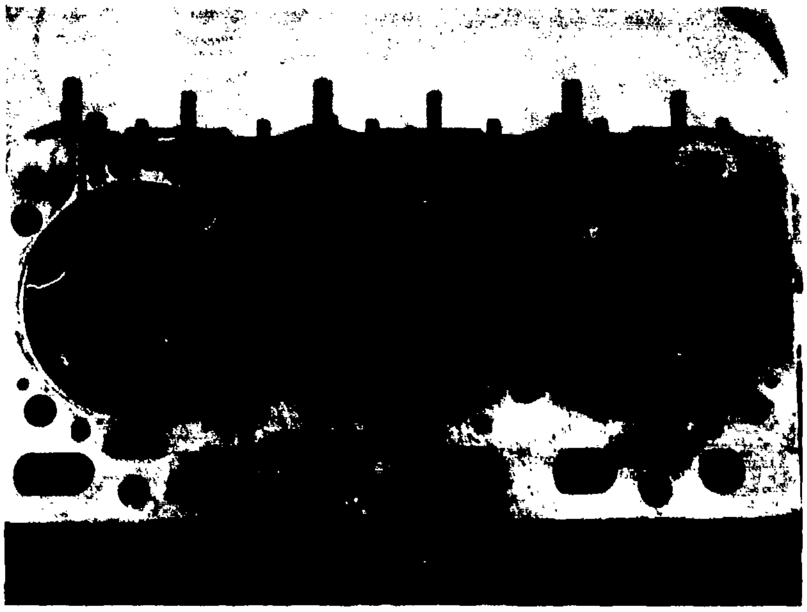
No. 5



No. 6

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

AFTER TEST CONDITION OF CYLINDER HEADS



Cylinders 3, 2, 1

Cylinders 6, 5, 4

LDT-465-1C
TEST 5
Lubricant: AL-8924-L

No. 4

No. 5
AFTER TEST CONDITION OF NOS. 4 and 5 CONNECTING ROD BEARINGS

APPENDIX M

ENGINE-LUBRICANT COMPATIBILITY TEST #6

210-HOUR WHEELED-VEHICLE CYCLE

USING LDT-465-1C DIESEL ENGINE

ENGINE-LUBRICANT COMPATIBILITY TEST
210-HOUR WHEELED-VEHICLE CYCLE
USING LDT-465-1C DIESEL ENGINE

Test Lubricant: AL-9249-L
Test Fuel: Caterpillar 1-H
Engine Test Number: 6
Date Completed: 10 April 1980

Conducted for

U.S. Army Mobility Equipment Research and Development Command
Energy and Water Resources Laboratory
Fort Belvoir, Virginia

by

U.S. Army Fuels & Lubricants Research Laboratory
Southwest Research Institute
San Antonio, Texas 78284

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LDT-465-1C
Test 6
ENGINE REBUILD MEASUREMENTS

	Inches			
Cylinder Liners (Installed)	Min	Max	Avg	Specified Limits
Inside Diameter	4.5630	4.5641	4.5637	4.5630-4.5645
Out of Round	0.0001	0.0010	0.0005	0.0015 Max.
Taper	0.0000	0.0008	0.0003	0.0015 Max.
Piston Skirt Diameter (@ bottom)	4.5550	4.5554	4.5552	4.5530-4.5580
No. 1 Ring				
End Gap	0.021	0.026	0.024	0.022-0.035
No. 2 Ring				
End Gap	0.020	0.026	0.023	0.022-0.035
No. 3 Ring				
End Gap	0.021	0.024	0.022	0.010-0.028
Side Clearance	0.02	0.03	0.03	0.0025-0.0045
No. 4 Ring				
End Gap	0.020	0.021	0.021	0.010-0.028
Side Clearance	0.01	0.02	0.02	0.0010-0.0035

LDT-465-1C 210-HOUR WHEELED VEHICLE CYCLE ENDURANCE TEST

TEST 6

OPERATING CONDITIONS SUMMARY

Fuel: Cat 1-H Lubricant: AL-9249-L

	Power Mode			Idle Mode
	Min.	Max.	Avg.	Avg.
Engine Speed, RPM	2599	2610	2603	802
Torque, ft-lb (N-m)	253 (343)	295 (400)	279 (378)	13 (18)
Observed Power, Bhp (kW)	126 (94)	146 (109)	138 (103)	2.0 (15)
Fuel Consumption, lb/hr (kg/hr)	66.1 (30.0)	68.9 (31.3)	66.7 (30.3)	5.2 (2.4)
BSFC, lb/Bhp-hr (g/kW-hr)	0.456 (289)	0.516 (327)	0.484 (307)	2.6 (1650)
Temperatures, °F (°C)				
Exhaust Manifold	1057 (569)	1160 (627)	1087 (586)	251 (122)
Water Jacket Inlet	167 (75)	171 (77)	169 (76)	93 (34)
Water Jacket Outlet	179 (82)	182 (83)	181 (83)	99 (37)
Oil Sump	231 (111)	237 (114)	233 (122)	121 (49)
Fuel In	83 (29)	95 (35)	90 (32)	79 (26)
Inlet Air	84 (29)	97 (36)	89 (32)	79 (26)
Intake Manifold	236 (113)	267 (131)	251 (122)	81 (27)
Pressures				
Intake Vacuum, in. H_2O (Pa)	2.8 (700)	3.0 (750)	2.9 (720)	0.0 (0.0)
Exhaust Common, in. Hg (kPa)	0.9 (3.1)	1.1 (3.7)	0.9 (3.1)	0.0 (0.0)
Intake Manifold, psi (kPa)	10.5 (72.3)	12.3 (84.7)	11.0 (75.8)	0.0 (0.0)
Exhaust Manifold, psi (kPa)	12.0 (82.7)	13.5 (93.0)	12.6 (86.8)	0.0 (0.0)
Fuel Transfer Pump, psi (kPa)	72 (496)	73 (503)	73 (503)	38 (262)
Oil Gallery, psi (kPa)	64 (441)	66 (455)	65 (448)	74 (510)
Blowby, in. H_2O (Pa)	1.3 (320)	1.5 (370)	1.4 (350)	0.2 (50)
Ambient Conditions				
Wet Bulb Temperature, °F (°C)			68 (20)	
Dry Bulb Temperature, °F (°C)			78 (26)	
Barometric Pressure, in. Hg (kPa)			29.07	

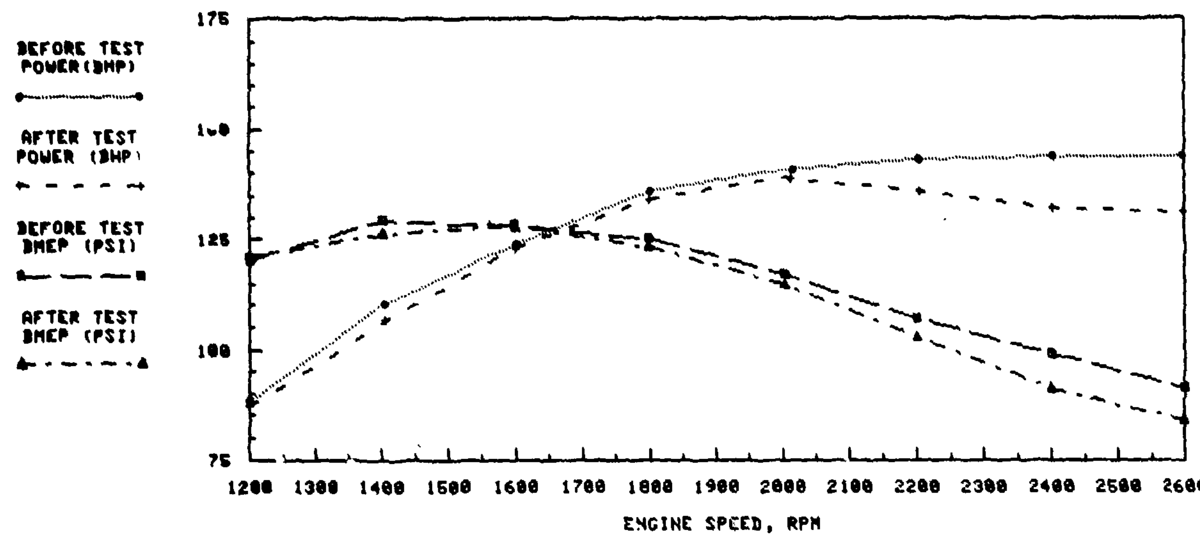
Unscheduled Shutdowns

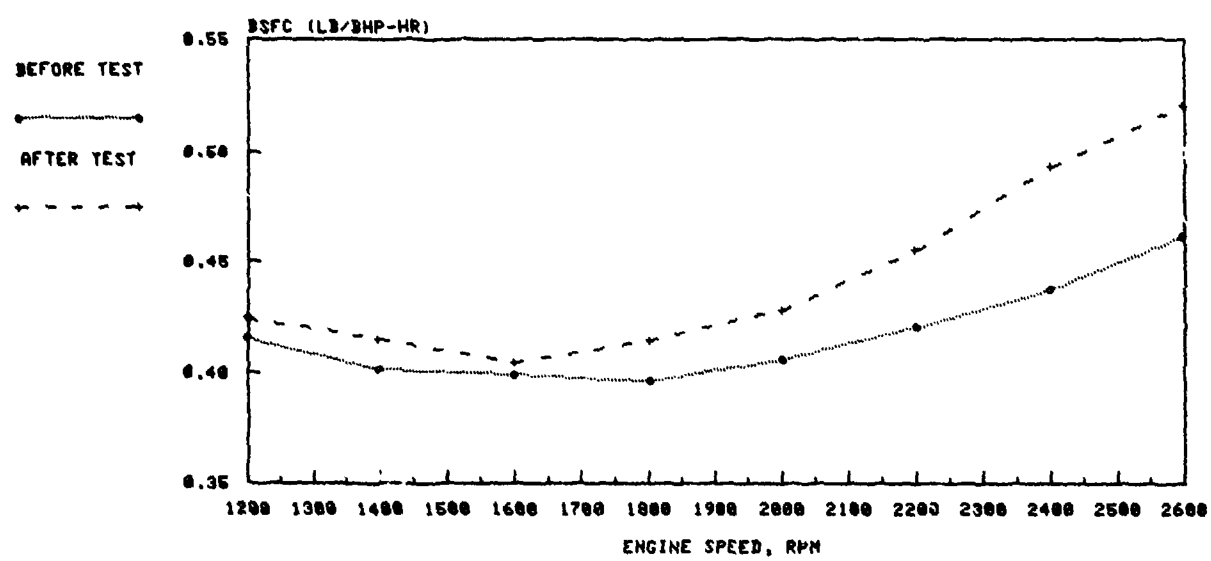
35 hrs. - broken oil pump idler gear shaft

47 hrs. - broken oil pump idler gear shaft

LDT-465 210 HOUR WHEELED VEHICLE CYCLE

BEFORE AND AFTER TEST 6 PERFORMANCE DATA





LDT-465-1C
TEST 6
LUBRICANT ANALYSIS

Lubricant: AL-9249-L

	ASTM Test Method	Test Time, Hours 0	70	140	210
Apparent Viscosity at -29°C (-20°F), cP	D 2602	22800	39600	>78900*	>78900*
Apparent Viscosity at -18°C (0°F), cP	D 2602	3900	6400	11000	14900
Kinematic Viscosity at 40°C (104°F), cSt	D 445	96.7	116.9	150.1	179.9
Kinematic Viscosity at 100°C (212°F), cSt	D 445	13.9	15.4	18.0	20.3
Viscosity Index	D 2270	146	139	134	131
Total Acid Number, mg KOH/g	D 664	3.3	4.0	5.5	5.8
Total Base Number, mg KOH/g	D 664	6.5	3.7	2.6	2.6
Pentane B Insolubles, wt %	D 893	-	0.6	1.9	3.2
Toluene B Insolubles, wt %	D 893	-	0.5	1.5	2.4
Flash Point, °C (°F)	D 92	209 (408)	220 (428)	220 (428)	224 (435)
Density at 16°C (60°F), gm/ml	D 287	0.88	0.89	0.90	0.91
Carbon Residue, wt %	D 524	1.2	2.0	3.0	3.9
Sulfated Ash, wt %	D 874	1.0	1.2	1.6	1.9

*The lubricant viscosities at these test times exceeded the currently available Cold Cranking Simulator viscosity standards.

LDT-465-1C
TEST 6
Lubricant: AL-9249-L

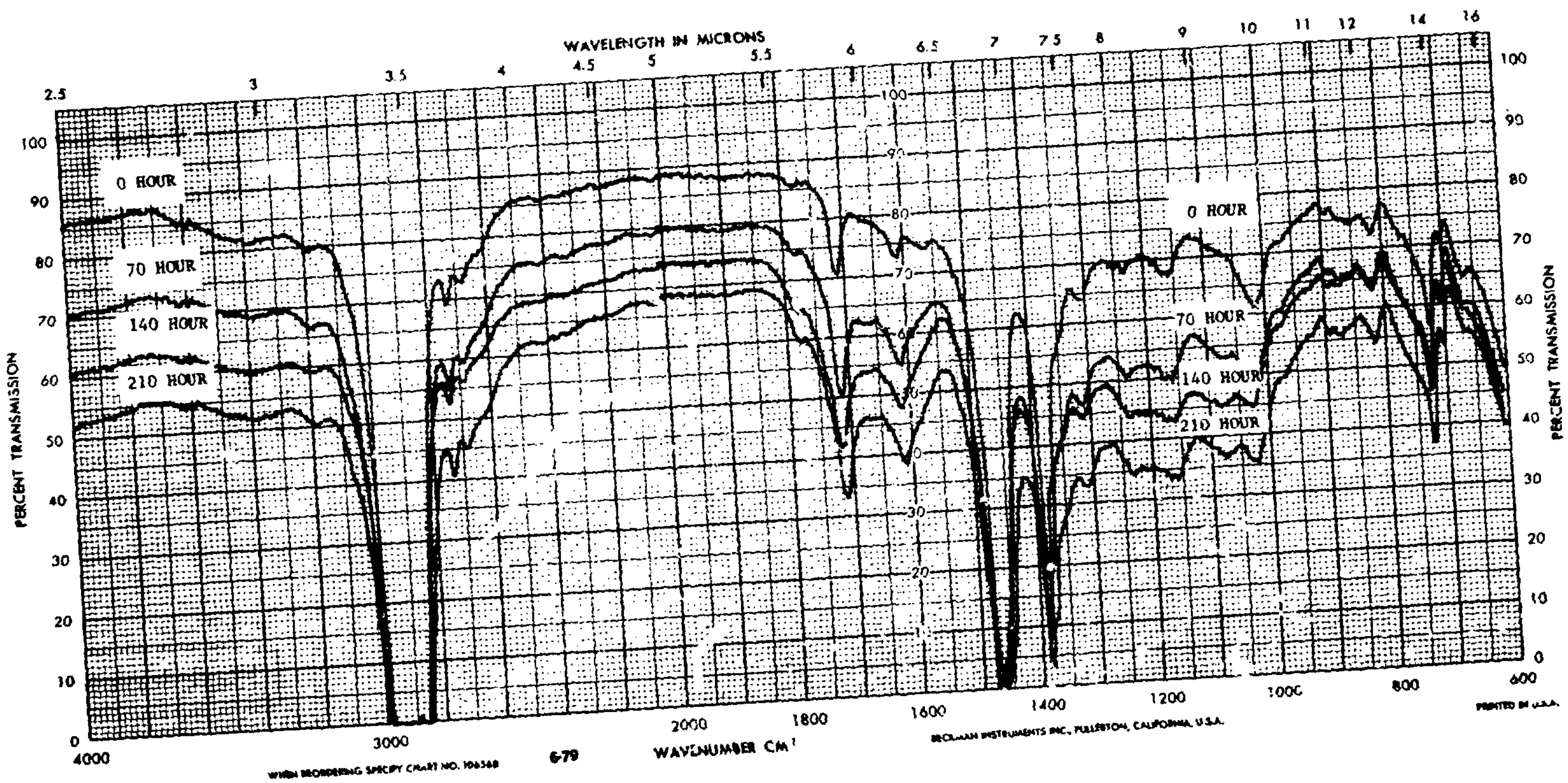
TOTAL OIL CONSUMPTION AND WEAR METALS

Test Time, Hours	Total Oil Consumed, lb (kg)	Wear Metals[+], ppm Fe (Iron)
14	5.0 (2.3)	33
28	9.8 (4.4)	28
42	12.1[*] (5.5)	43
56	12.1 (5.5)	50
70	14.5 (6.6)	61
84	18.4 (8.3)	64
98	26.5 (12.0)	72
112	30.8 (14.0)	83
126	36.3 (16.5)	107
140	43.5 (19.7)	120
154	50.3 (22.8)	117
168	56.5 (25.6)	136
182	64.8 (29.4)	140
196	73.2 (33.2)	156
210	80.4 (36.5)	157

Average Oil Consumption Rate: 0.38 lb/hr (0.17 kg/hr)

[+]No other wear metals detected
[*]When the oil pan was removed to repair the oil pump idler gear shaft at 35 and 47 hours, the oil sump was refilled to "Full", taking 8.5 and 10.5 lb, respectively.

LDT-465-1C
TEST 6
Lubricant: AL-9249-L



LDT-465-1C
TEST 6

Lubricant: AL-9249-L

WEAR MEASUREMENTS

CYLINDER LINER BORE DIAMETER, INCHES

		Before Test			After Test			Change		
		Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
1	T-AT	4.5640	4.5641	4.5638	4.5648	4.5646	4.5643	+0.0008	+0.0005	+0.0005
	F-B	4.5630	4.5636	4.5636	4.5635	4.5637	4.5637	+0.0005	+0.0001	+0.0001
2	T-AT	4.5640	4.5641	4.5644	4.5651	4.5650	4.5652	+0.0011	+0.0009	+0.0008
	F-B	4.5637	4.5636	4.5638	4.5638	4.5634	4.5635	+0.0001	-0.0002	-0.0003
3	T-AT	4.5633	4.5638	4.5638	4.5643	4.5644	4.5646	+0.0010	+0.0006	+0.0008
	F-B	4.5632	4.5631	4.5632	4.5638	4.5633	4.5633	+0.0006	+0.0003	+0.0001
4	T-AT	4.5637	4.5639	4.5643	4.5647	4.5644	4.5646	+0.0010	+0.0005	+0.0003
	F-B	4.5641	4.5641	4.5639	4.5648	4.5643	4.5643	+0.0007	+0.0002	+0.0004
5	T-AT	4.5639	4.5640	4.5637	4.5647	4.5645	4.5642	+0.0008	+0.0005	+0.0005
	F-B	4.5631	4.5630	4.5635	4.5636	4.5634	4.5638	+0.0005	+0.0004	+0.0003
6	T-AT	4.5636	4.5635	4.5636	4.5644	4.5642	4.5641	+0.0008	+0.0007	+0.0005
	F-B	4.5641	4.5636	4.5633	4.5644	4.5639	4.5636	+0.0003	+0.0003	+0.0003

Average Change, in.: +0.0005

LDT-465-1C
TEST 6

Lubricant: AL-9249-L

WEAR MEASUREMENTS

PISTON RING END GAP, INCHES

Piston No.	Ring No.	Before Test End Gap	After Test End Gap	Change
1	1	0.025	0.027	+0.002
	2	0.025	0.028	+0.003
	3	0.022	0.024	+0.002
	4	0.021	0.024	+0.003
2	1	0.023	0.025	+0.002
	2	0.022	0.023	+0.001
	3	0.024	0.025	+0.001
	4	0.020	0.022	+0.002
3	1	0.020	0.022	+0.002
	2	0.021	0.022	+0.001
	3	0.023	0.025	+0.002
	4	0.022	0.023	+0.001
4	1	0.026	0.027	+0.001
	2	0.025	0.027	+0.002
	3	0.021	0.022	+0.001
	4	0.021	0.024	+0.003
5	1	0.021	0.022	+0.001
	2	0.020	0.021	+0.001
	3	0.021	0.021	0.000
	4	0.020	0.024	+0.004
6	1	0.026	0.027	+0.001
	2	0.026	0.027	+0.001
	3	0.022	0.024	+0.002
	4	0.021	0.025	+0.004

Average Change , in.: +0.002

TEST 6

Lubricant: AL-9249-L

POST TEST ENGINE CONDITION AND DEPOSITS

CYLINDER NUMBER

A. Cylinder Rating	1 Carb	1 Lacq	2 Carb	2 Lacq	3 Carb	3 Lacq	4 Carb	4 Lacq	5 Carb	5 Lacq	6 Carb	6 Lacq
Deposits												
Cylinder Head	10%AHC* 90% ¼AHC	0	10%AHC 90% ¼AHC	0	10%AHC 90% ¼AHC	0	5%AHC 95% ¼AHC	0	5%AHC 95% ¼AHC	0	5%AHC 95% ¼AHC	0
Cylinders ART**	35%AHC	30%-3+ 25%-5 10%-7	60%AHC	20%-2 20%-4	30%AHC	70%-3	30%AHC	40%-2 20%-4 10%-6	40%AHC	55%-2	40%AHC	20%-2 30%-4 10%-8
RTA	0	73%-4 5%-5 20%-6 2%-8	0	95%-4 5%-8	0	100%-4	0	95%-4 5%-8	0	100%-4	0	95%-4 5%-8
BRT	0	100%-7	0	100%-7	0	100%-7	0	100%-7	0	100%-7	0	100%-7

Surface Condition++	1	2	3	4	5	6
Cylinder RTA	5%-G 95%-LS	10%-LSC 90%-LS	20%-G 80%-LS	5%-G 5%-SC 90%-LS	5%-LSC 95%-LS	50%-LSC 50%-LS

B. Piston Ratings												
Ring Face Condition	-------------------- All Rings Normal, All Oil Slots Open 100% ----------------											
Ring Deposits	Carb	Lacq	Carb	Lacq	Carb	Lacq	Carb	Lacq	Carb	Lacq	Carb	Lacq
Top Ring 1	0	0	0	0	0	0	0	5%-6	0	5%-6	0	0
2	0	10%-3 5%-5	0	15%-3	0	10%-3	5% ¼AHC	10%-3	0	40%-4	5% ¼AHC	10%-3 5%-4
3	0	100%-7	0	95%-6 5%-8	0	95%-7 5%-8	0	100%-7	0	70%-6 30%-7	0	15%-[illegible] 85%-7

*HC = Hard Carbon; the number-letter prefix indicates carbon depth; with ¼A = least, through the alphabet, to J = most.

**ART = Above Ring Travel, RTA = Ring Travel Area, BRT = Below Ring Travel.

+The higher the number, the darker the lacquer. (0 = lightest, 9 = darkest).

++V = very, L = light, H = heavy, G = glazing, P = pitting, W = wiping, F = flaking, S = scratched, SC = scuffed, T = thrust side, AT = antithrust side, RS = ring supporting.

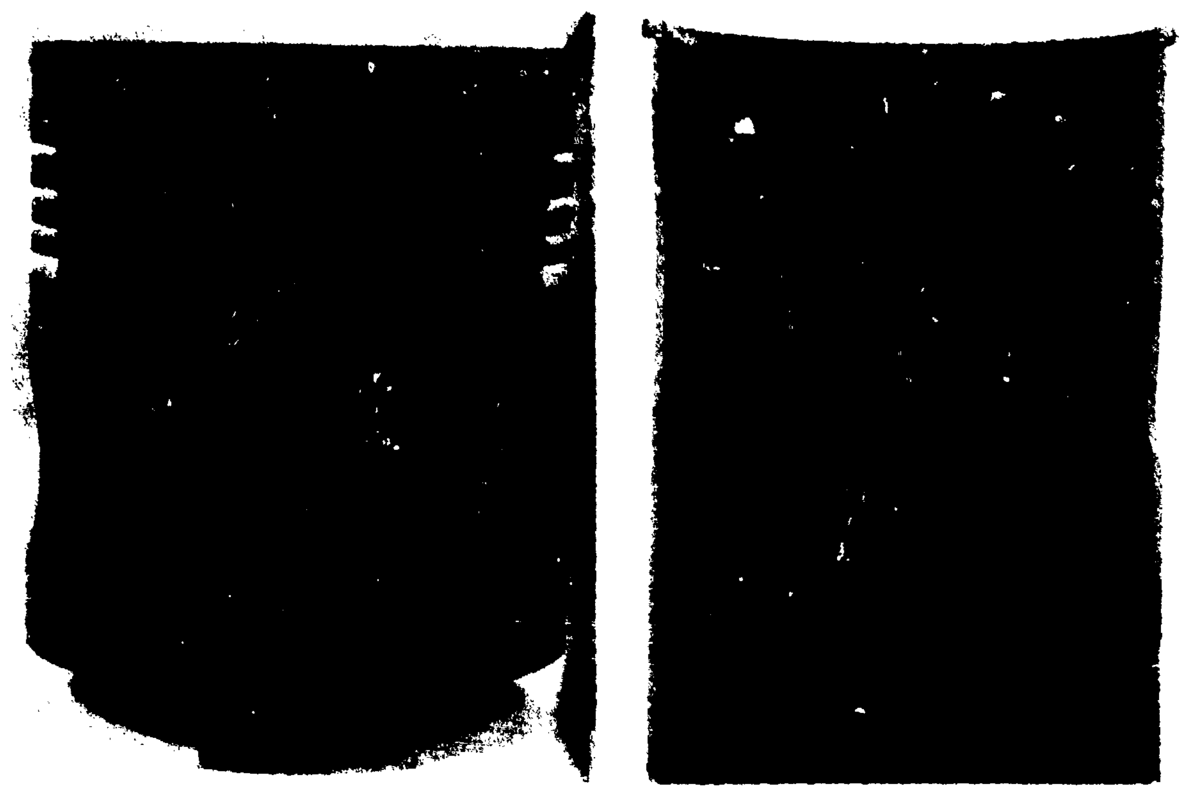
Piston Ratings		1		2		3		4		5		6	
Ring Deposit; con		Carb	Lacq	Carb	Lacq	Carb	Lacq	Carb	Lacq	Carb	Lacq	Carb	Lacq
ID	Ring												
	1	100%RS	0	5%RS 95%AHC	0	75% ¼AHC	25%-2	30%AHC 20% ¼AHC	50%-3	100% ½AHC	0	100%AHC	0
	2	80%AHC	20%-5	100% ¼AHC	0	100%AHC	0	100%AHC	0	45%RS 55% ½AHC	0	100% ½AHC	0
	3	100% ¼AHC	0	100% ¼AHC	0	100% ¼AHC	0	100% ¼AHC	0	100% ¼AHC	0	100% ¼AHC	0
Bottom	Ring												
	1	0	15%-4	0	0	0	0	0	0	0	0	0	0
	2	0	15%-2	0	10%-3	0	0	0	50%-2	0	10%-2	0	15%-3
	3	0	40%-3 60%-7	0	25%-4	0	10%-7	0	50%-2 50%-7	0	15%-6	0	10%-4 10%-7
Piston Surface Condition													
Top Ring Land		Normal											
Skirt		Normal											
Piston Pin		Normal											
CRC Diesel Engine Piston Rating (WTD)		266		300		282		314		263		220	

C. Valve Ratings	Int	Exh	Int	Exh	Int	Exh	Int	Exh	Int	Exh	Int	Exh
Freeness in Guide	F	*	F	F	F	F	F	*	F	F	F	*
Head	Normal											
Face	Normal											
Seat	Normal											
Stem	Normal											
Tip	Normal											
Tulip Demerit Rating	2.0	0.5	1.5	0.5	1.5	0.5	2.0	1.0	2.0	0.5	2.0	0.5

D. Other Ratings					
Tappets, Cams, Rocker Arms					
Tappet Deposit	Clean				
Rocker Arm					
Tip	Normal				
Bushing	Normal				
Shaft	Normal				
Bearing Surface Condition					
Main Bearing	N	N	S	S	No. 5, 6, 7, Not Rated
Main Journal	N	N	N	N	"
Rod Bearing	Normal				
Rod Journal	Normal				
Piston Pin	Normal				
Pin Bushing	Normal				

LDT-465-1C
TEST 6
Lubricant: AL-9249-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



1 - Thrust

LDT-465-1C
TEST 6
Lubricant: AL-9249-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

1 - Anti-Thrust

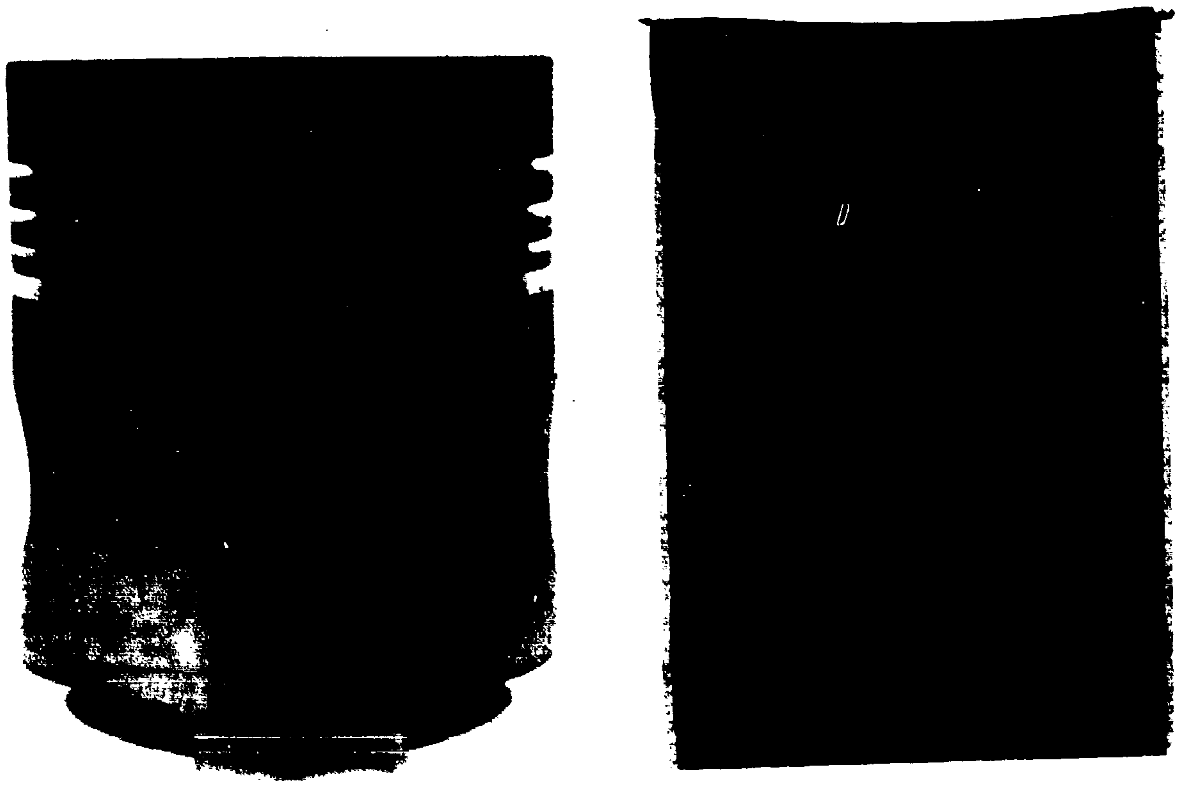
LDT-465-1C
TEST 6
Lubricant: AL-9249-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

2 - Thrust

LDT-465-1C
TEST 6
Lubricant: AL-9249-L

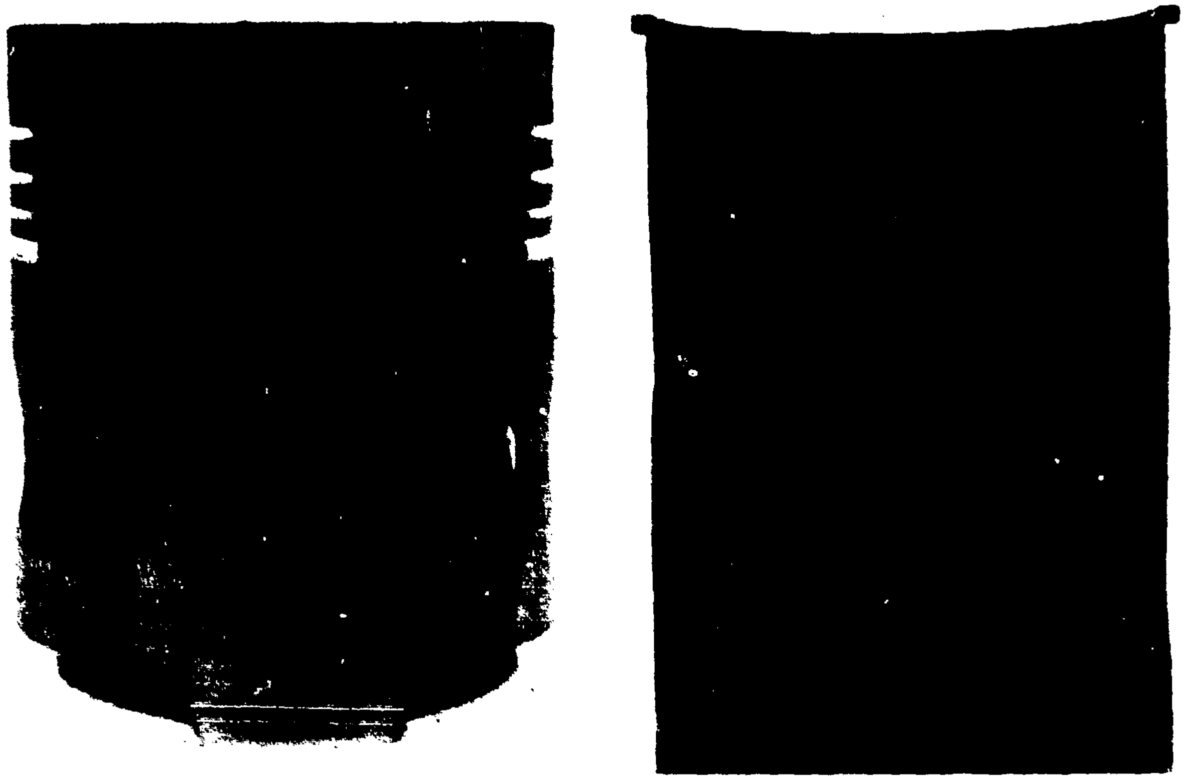
AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



2 - Anti-Thrust

LDT-465-1C
TEST 6
Lubricant: AL-9249-L

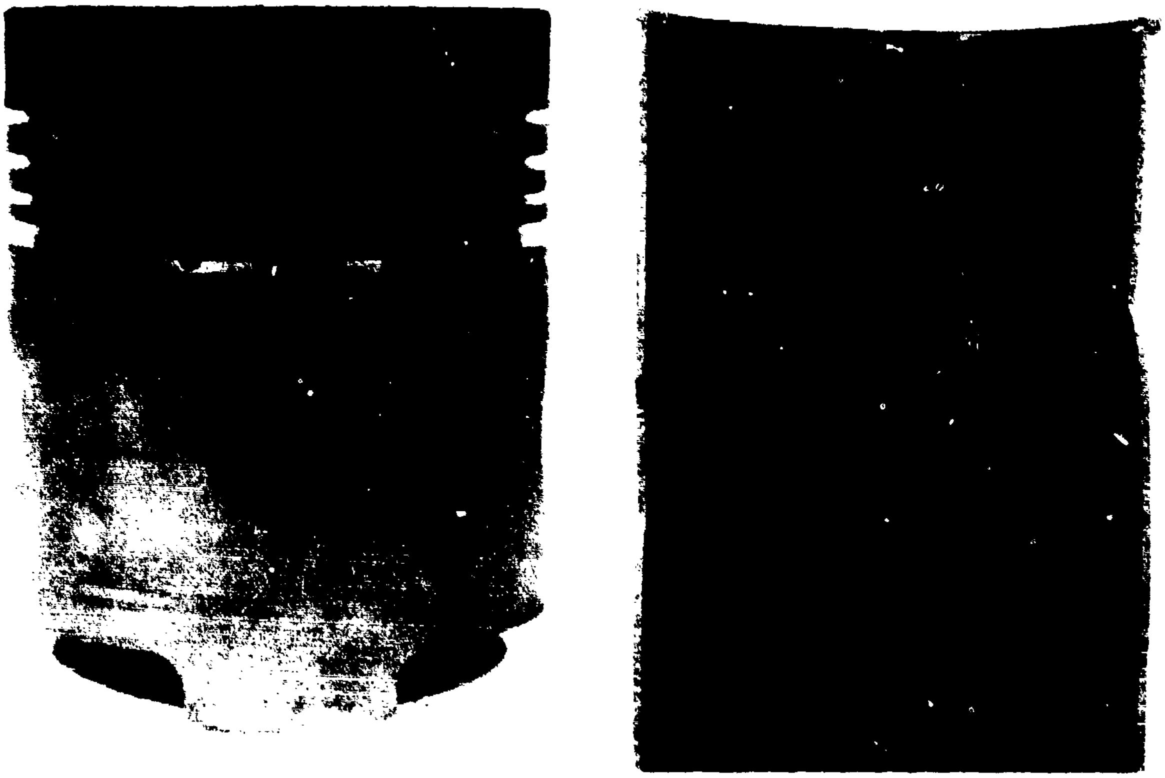
AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



3 - Thrust

LDT-465-1C
TEST 6
Lubricant: AL-9249-L

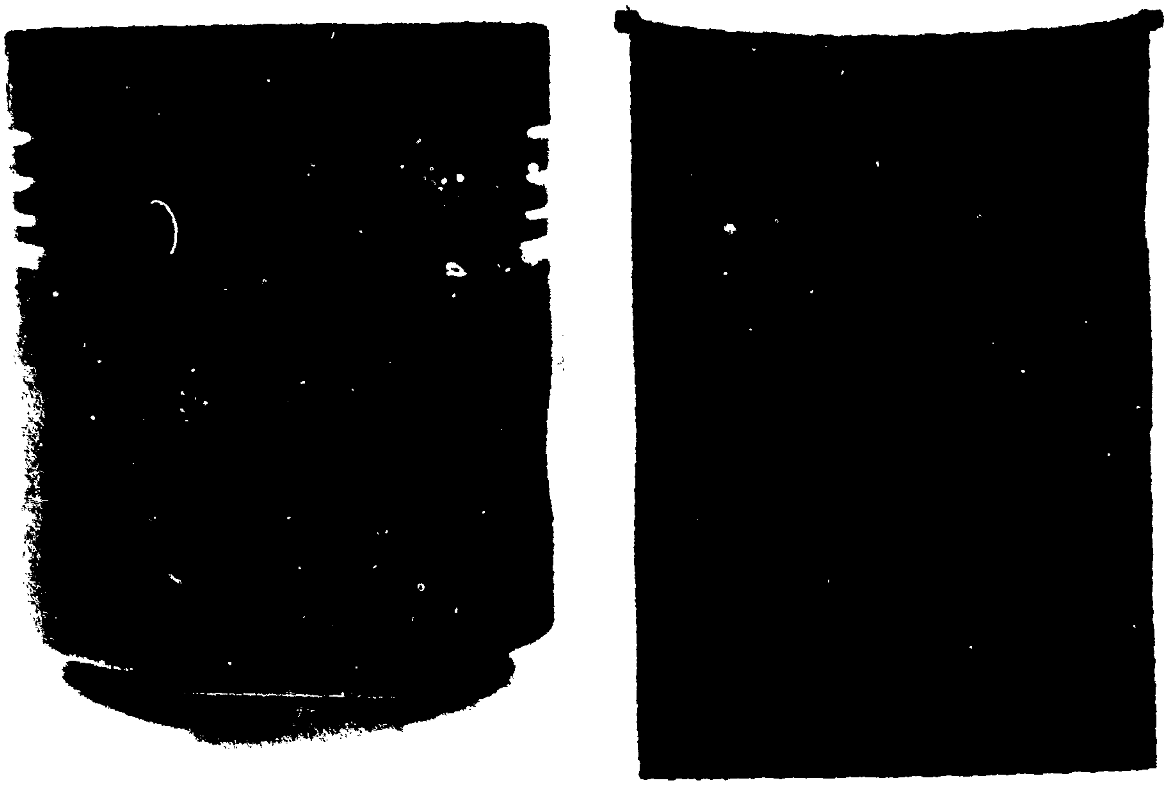
AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



3 - Anti-Thrust

LDT-465-1C
TEST 6
Lubricant: AL-9249-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



4 - Thrust*

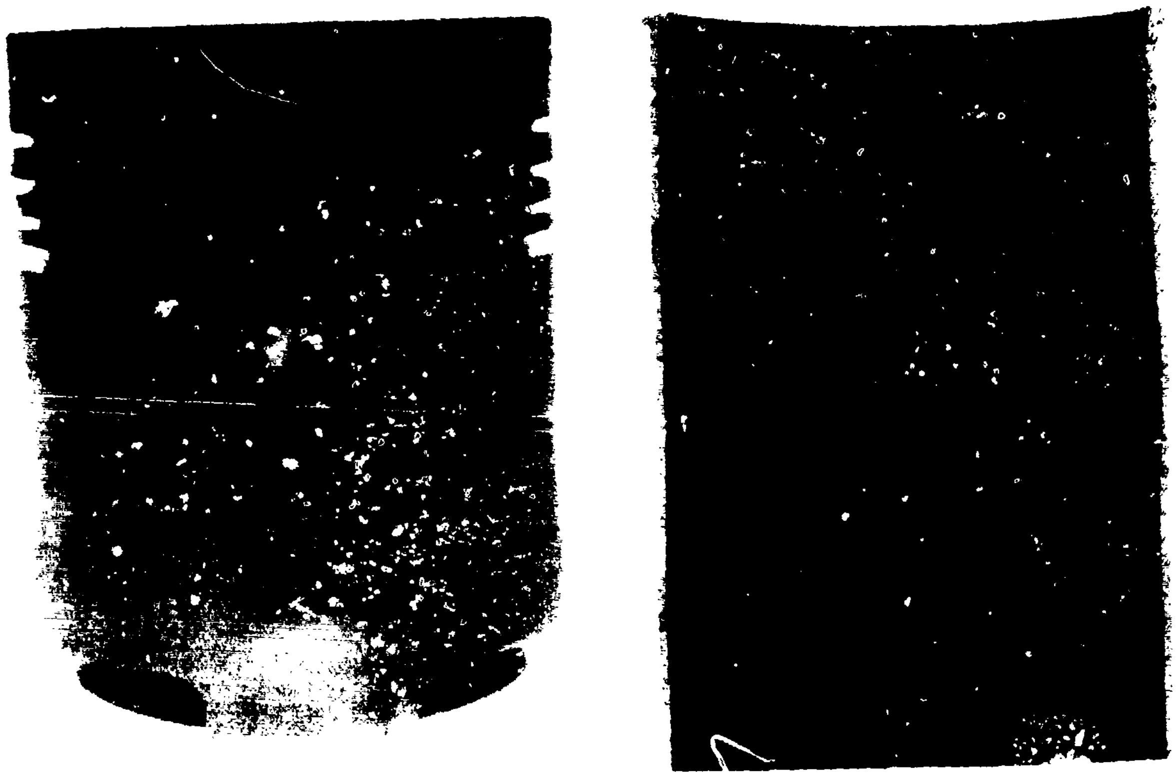
*Piston No. 4 had the highest Weighted Total Deposits (WTD) rating.

LDT-465-1C

TEST 6

Lubricant: AL-0240-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



4 - Anti-Thrust*

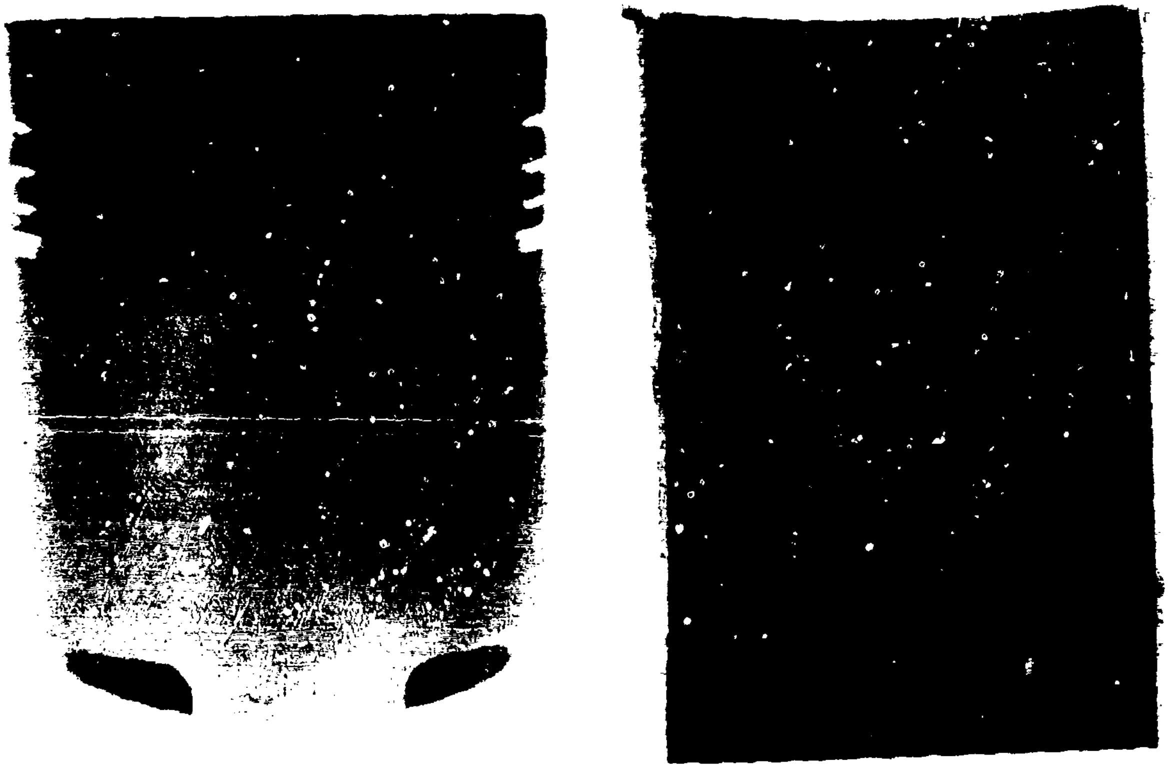
*Piston No. 4 had the highest Weighted Total Deposits (WTD) rating.

LDT-465-1C

TEST 6

Lubricant: AL-9249-L

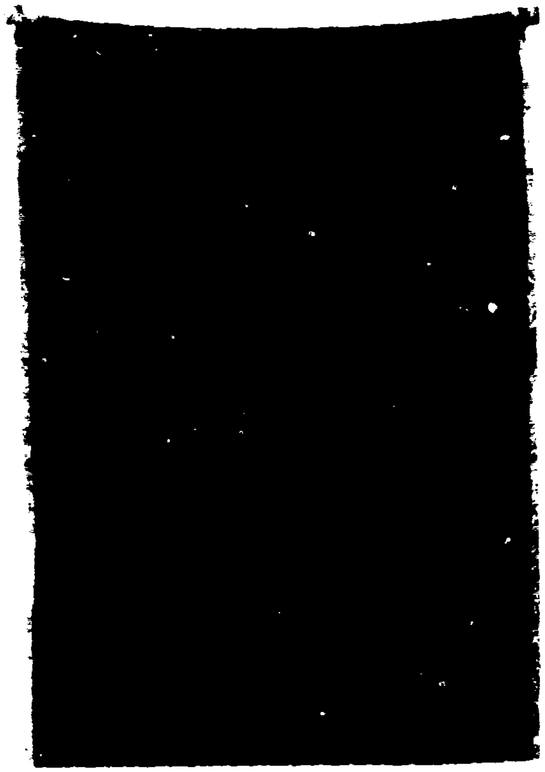
AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



5 - Thrust

LDT-465-1C
TEST 6
Lubricant: AL-9249-L

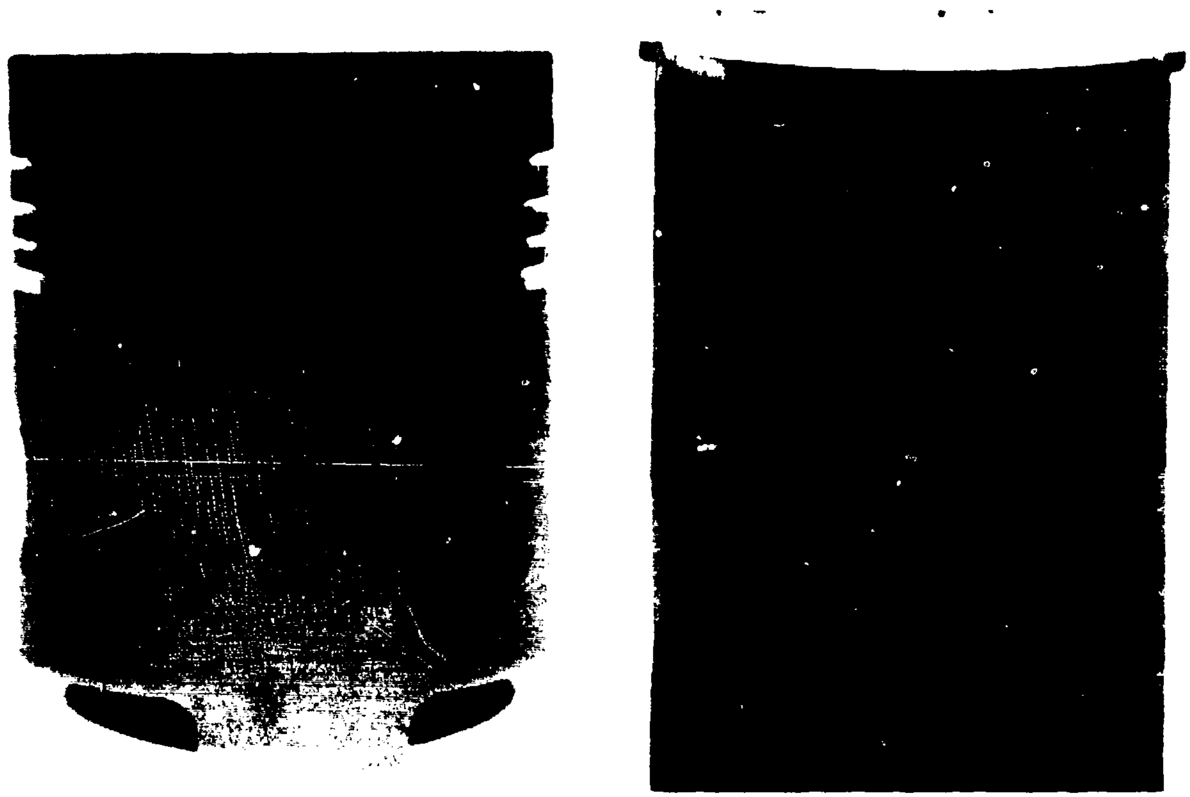
AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



5 - Anti-Thrust

LDT-465-1C
TEST 6
Lubricant: AL-9249-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER

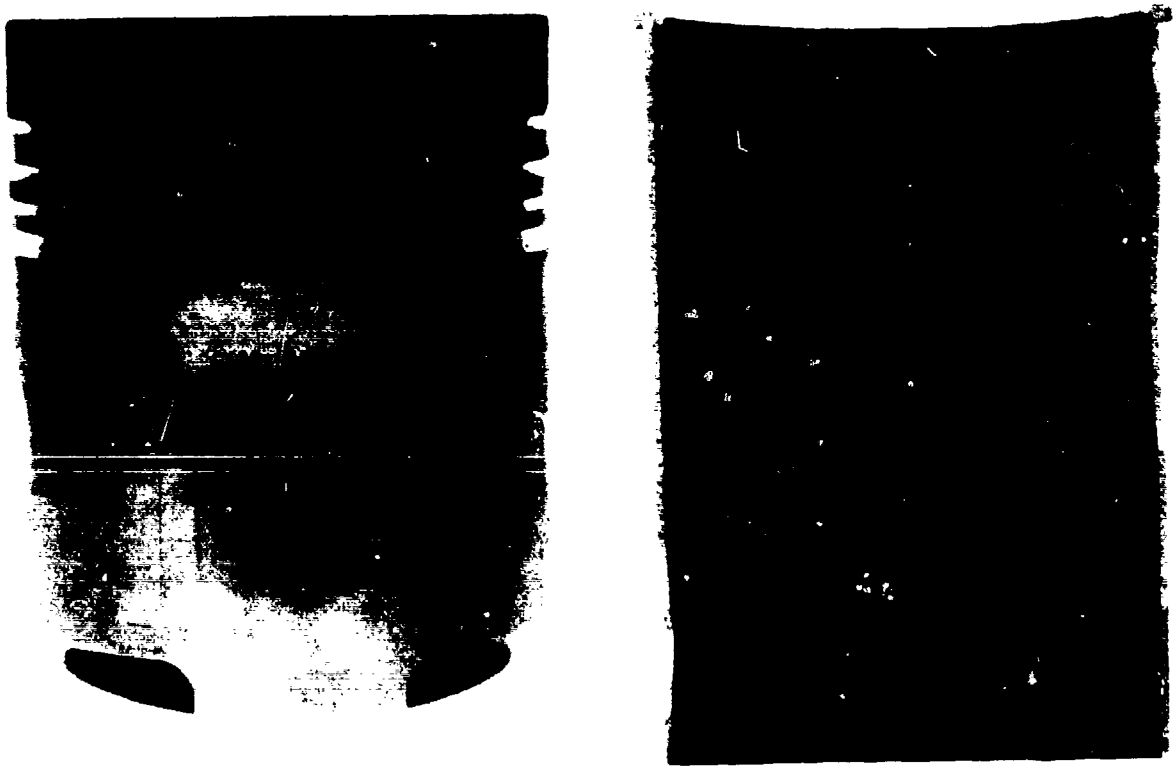


6 - Thrust*

*Piston No. 6 had the lowest Weighted Total Deposits (WTD) rating.

LDT-465-1C
TEST 6
Lubricant: AL-9249-L

AFTER TEST CONDITION OF PISTON AND CYLINDER LINER



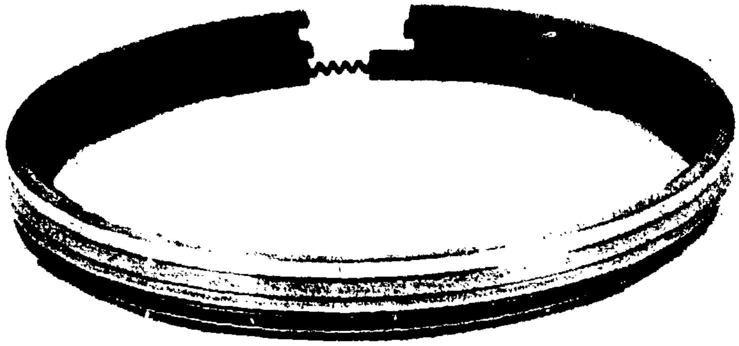
6 - Anti-Thrust*

*Piston No. 6 had the lowest Weighted Total Deposits (WTD) rating.

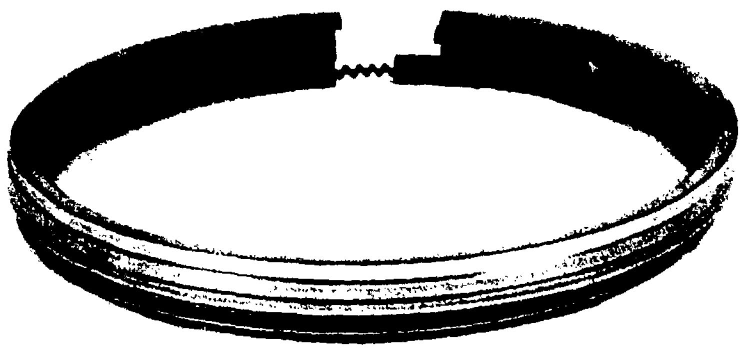
LDT-465-1C
TEST 6

Lubricant: AL-9249-L

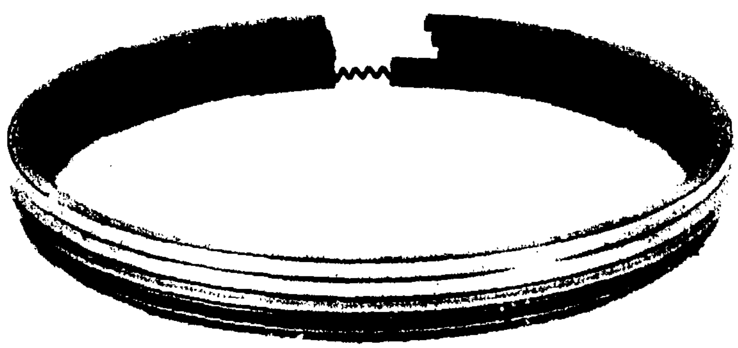
AFTER TEST CONDITION OF PISTON RINGS



Piston No. 1 (largest increase in end gap)



Piston No. 2 (least increase in end gap)



Piston No. 3 (least increase in end gap)

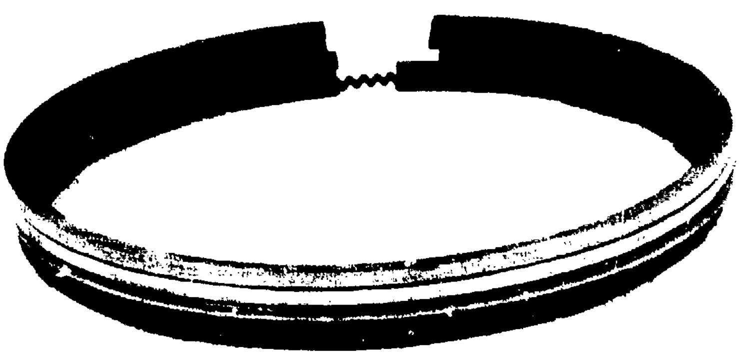
LDT-465-1C
TEST 6

Lubricant: AL-9249-L

AFTER TEST CONDITION OF PISTON RINGS

Piston No. 4

Piston No. 5

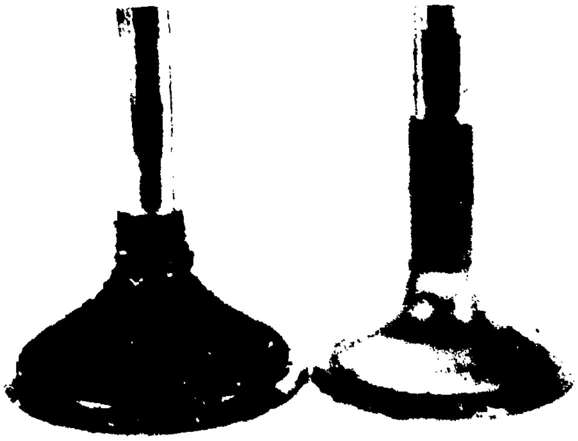


Piston No. 6

LDT-465-1C
TEST 6

Lubricant: AL-9249-L

AFTER TEST CONDITION OF INTAKE AND EXHAUST VALVES



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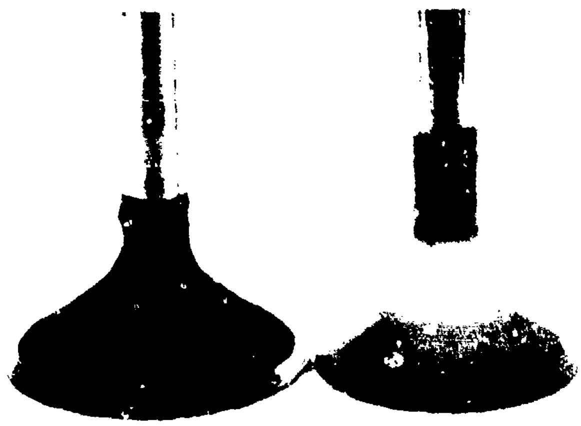

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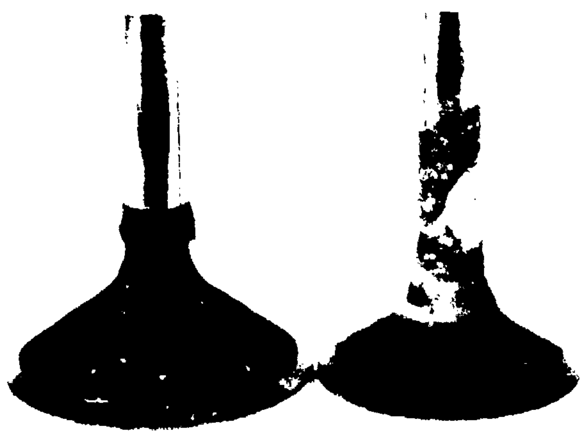
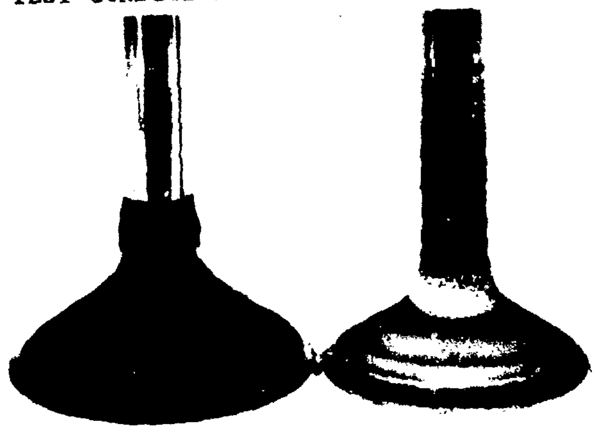


Cylinder No. 3

LDT-465-1C
TEST 6

Lubricant: AL-9249-L

AFTER TEST CONDITION OF INTAKE AND EXHAUST VALVES



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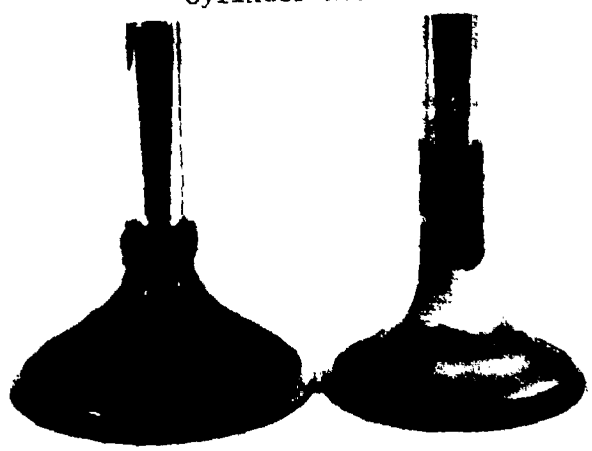

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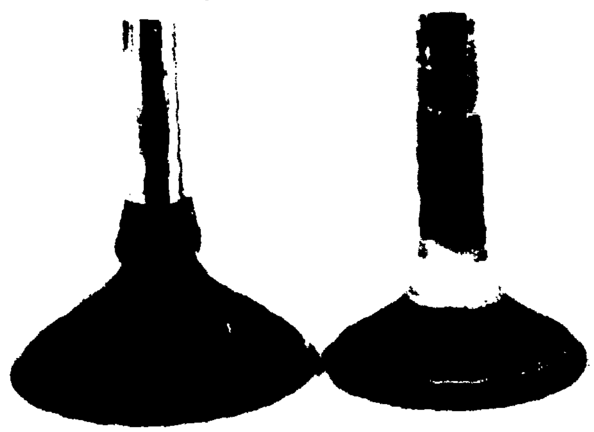

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